Greetings from the Chairman

Dear professors and distinguished delegates,

It is our great honor and pleasure to welcome you to the 13th International Symposium on Advanced Science and Technology in Experimental Mechanics (13th ISEM’18) held in Kaohsiung, Taiwan on October 30- November 2, 2018. The theme of ISEM’18 is to proclaim knowledge and share new thoughts among the professionals, industrialists and students from research areas of Experimental Mechanics.

The Japanese Society for Experimental Mechanics (JSEM) was founded in 2001 by reorganizing the former Japan Society for Photoelasticity to extend its covering area of Experimental Mechanics not only to Solid Mechanics but also to various areas of Applied Mechanics such as Fluid Mechanics, Thermal Engineering, Medical Engineering, Biomechanics, Construction and Civil Engineering and so on. The first Symposium was successfully held in Sapporo, Japan (2006) to attain its main purpose of the new establishment. The Symposium was subsequently held in Osaka, Japan (2007), Tainan, Taiwan (2008), Niigata, Japan (2009), Kyoto, Japan (2010), Sendai/Kansai, Japan (2011), Taipei, Taiwan (2012), Sendai, Japan (2013), New Delhi, India (2014), Matsue, Japan (2015), Ho Chi Minh, Vietnam (2016) and Kanazawa City, Japan (2017). The present Symposium aims to promote an exchange of recent and advanced information among scientists and engineers in the wide field of Experimental Mechanics with special focus on Environmental, Medical and Welfare Engineering. The Symposium is also aimed particularly at promoting communication and collaboration between fundamental researchers and those engaged in the development of practical technology in respective areas of Experimental Mechanics.

We are pleased to have accepted 145 papers and 113 presentation which provide a wide spectrum of researches in various areas such as Fluid Dynamics, Thermodynamics, Heat and Mass Transfer, Solid Mechanics, Material Engineering, Bioengineering, Civil Engineering, Sound and Vibration, Instrumentation and Testing, Visualization and Image Processing, and others, etc. All the presentations are peer-reviewed, and it has really been a difficult task to select the most representative papers.

Apart from this, the conference program is highlighted by the keynote speakers: Prof. Byoung-Ho Choi from Korea university, Korea; Prof. Prof. MIAU, Jiun-Jih from National Cheng Kung University, Taiwan and Prof. MONJI, Hideaki from University of Tsukuba, Japan. Located in southwestern Taiwan,
Kaohsiung is a city of a longish shape. It is cast in sunshine throughout a year and its weather is amiable. Mountains, oceans, rivers and ports make the city's geology and culture highly diverse. Kaohsiung used to enjoy a thriving economy for its steel and petrochemical industries, but now it is gearing towards cultural tourism, touting its history, nature and hospitality. An oceanic tourist capital it is! We hope you will enjoy your stay in the conference as well as in Kaohsiung, Taiwan.

Yours sincerely,

Prof. Chang-Hsien TAI
Program Chairman of ISEM'18
President, National Pingtung University of Science & Technology, Taiwan (ROC)
Chang-Hsien Tai  
President, and Professor of Vehicle Engineering  
National Pingtung University of Science and Technology,  
Neipu Township, Pingtung County 912, Taiwan (R.O.C.)

Prof. Tai earned his bachelor degree in mechanical engineering from Chung-Cheng Institute of Technology (CCIT), and his master’s degree in mechanical engineering from National Taiwan University. Later, he went to USA to pursue his other advanced degree under scholarship. He earned his Ph.D. in aerospace engineering from University of Michigan in USA. With this academic background, his previous research has mainly focused on the algorithm development of the computational fluid dynamics and its application related to shock wave, two phase flow, fluid-structure interaction, turbo-machinery, wind turbine, and green power system.

Prof. Tai has become the president of the National Pingtung University of Science and Technology (NPUST) since August 2014. Before becoming the President, Prof. Tai has served in many positions. For over 30 years, he was a chairperson of the Department of Mechanical Engineering (CCIT), a chairperson of the Department of Vehicle Engineering (NPUST), a dean of the College of Engineering (NPUST), and a vice-president for academic affairs (NPUST). As a matter of fact, he was also appointed a Chinese army colonel at CCIT from 1996 to 1999, right before his retirement from the army.

Throughout his career, Prof. Tai has been very active in promoting the application of CFD on solving practical industrial problems. This has led to his numerous invention patents. After his inauguration of the president of NPUST, he vowed to improve the financial status of the university by offering more workshops through extension education programs. Not only so, he also has working towards the upgrade of agriculture industry through the combinations with engineering, management, and humanity. So far, there are many projects in the university aim to integrate agriculture with other disciplines. Not only so, Prof. Tai is also planning on making the campus of NPUST a pilot plan for smart agriculture so that the concept of smart agriculture can be widely accepted among the domestic farmers and their confidence on smart agriculture can be built.
13th International Symposium on
Advanced Science and Technology in
Experimental Mechanics (13th ISEM'18)

Oct. 30-Nov. 2, 2018 | Kaohsiung City, Taiwan (ROC)

VENUE:
85 Sky Tower Hotel
37F~85F, No.1, Tzu-Chiang 3rd Road, Kaohsiung, Taiwan
TEL: 886-7-566-8000 FAX: 886-7-566-8080
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Tong-Shyng LEU, National Cheng Kung University (Taiwan)
# 13th ISEM’18 — Technical Program and Contents

<table>
<thead>
<tr>
<th>Date</th>
<th>Oct. 30 Tuesday</th>
<th>Oct. 31 Wednesday</th>
<th>Nov. 1 Thursday</th>
<th>Nov. 2 Friday</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a.m.</strong></td>
<td>Registration 08:30-</td>
<td>Registration 08:30-</td>
<td>Registration 08:30-</td>
<td>Registration 08:30-</td>
</tr>
<tr>
<td></td>
<td>Opening Ceremony 09:00-09:20</td>
<td>Keynote Lecture 09:20-10:10</td>
<td>Keynote Lecture 09:00-9:50</td>
<td>Keynote Lecture 09:00-9:50</td>
</tr>
<tr>
<td></td>
<td>Session A 10:20-12:30</td>
<td>Session C 10:10-12:20</td>
<td>Session D 10:10-12:20</td>
<td></td>
</tr>
<tr>
<td><strong>p.m.</strong></td>
<td>Registration 16:00-</td>
<td>Session B 14:00-17:00</td>
<td>Excursion 13:30-18:00</td>
<td>Session E 14:00-15:00</td>
</tr>
<tr>
<td></td>
<td>Welcome Reception 14:30-17:00</td>
<td>Poster 18:00-20:30</td>
<td></td>
<td>Closing Address 15:15-15:30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Event</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welcome Reception</td>
<td>41F Diamond I</td>
</tr>
<tr>
<td>Opening Ceremony</td>
<td>38F Opal Ballroom</td>
</tr>
<tr>
<td>Keynote Lecture</td>
<td>38F Opal Ballroom</td>
</tr>
<tr>
<td>Banquet</td>
<td>38F Opal Ballroom</td>
</tr>
<tr>
<td>Session A-E</td>
<td>42F meeting Center, Room A-D</td>
</tr>
<tr>
<td>Closing Address</td>
<td>41F Diamond I</td>
</tr>
</tbody>
</table>
Tips for Participants:

1. Your punctual arrival and active involvement in each session will be highly appreciated.
2. The listeners are welcome to register at any working time during the conference.
3. Get your presentation PPT or PDF files prepared.
4. Each paper has 20 minutes including presentation and discussion.
5. For keynote speakers, each lecture has 50 minutes including discussion.
6. For invited speakers indicated in red in the Technical Program, each talk has 25 minutes including discussion.
7. Laptop (with MS-Office & Adobe Reader), projector & screen, laser pointer will be provided by the conference organizer.
8. Please keep all your belongings (laptop and camera etc.) with you in the public places, buses, metro.
<table>
<thead>
<tr>
<th>Time</th>
<th>Events</th>
<th>Venues</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2018.10.30 (TUE)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16:00-17:00</td>
<td>Registration</td>
<td>41F- Diamond I</td>
</tr>
<tr>
<td>17:00-19:00</td>
<td>Welcome Reception</td>
<td>41F- Diamond I</td>
</tr>
<tr>
<td><strong>2018.10.31 (WED)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>08:30-09:00</td>
<td>Registration</td>
<td>38F- Opal Ballroom</td>
</tr>
<tr>
<td>09:00-09:20</td>
<td>Opening Ceremony</td>
<td>38F- Opal Ballroom</td>
</tr>
</tbody>
</table>
| 09:20-10:10 | **Keynote Lecture** (1)  
Title: Characterization and Modeling of  
Mechano-Chemical Cracking  
Behaviors of Polyethylene  
**Professor Byoung-Ho Choi**  
School of Mechanical Engineering, Korea University, Korea | 38F- Opal Ballroom |
| 10:20-11:00 | **Session I**  
1A-1 Fluid Dynamics I  
Chair: Yohsuke TANAKA  
2A-1 Mechanical Properties I  
Chair: Satoru MIZUNO  
3A-1 Renewable Energy  
Chair: Tamio IDA  
4A-1 Composite Materials I  
Chair: Kenji NAKAI | 42F-Room A  
42F-Room B  
42F-Room C  
42F-Room D |
| 11:30-12:30 | 1A-2 Fluid Dynamics II  
Chair: Osamu MOCHIZUKI  
2A-2 Mechanical Properties II  
Chair: Jun KOYANAGI  
3A-2 Thermal Engineering I  
Chair: Hiroyuki KINOSHITA  
4A-2 Composite Materials II  
Chair: Takashi YOKOYAMA | 42F-Room A  
42F-Room B  
42F-Room C  
42F-Room D |
<p>| 12:30-14:00 | Lunch                                                                 | 42F Meeting Room |</p>
<table>
<thead>
<tr>
<th>Time</th>
<th>Events</th>
<th>Venues</th>
</tr>
</thead>
</table>
| 14:00-15:00  | 1B-1 Fluid Dynamics III  
Chair: Kazuo OHMI  
2B-1 Mechanics of Composite Materials I  
Chair: Toshiro KOBYASHI  
3B-1 Thermal Engineering II  
Chair: Taro HIRASAWA  
4B-1 Stress Measurement and Analysis  
Chair: Shuichi ARIKAWA  
1B-2 Fluid Dynamics IV  
Chair: Kung-Ming Chung  
2B-2 Mechanics of Composite Materials II  
Chair: Yoshifumi OHBUCHI  
3B-2 Bioengineering I  
Chair: Makoto SAKAMOTO  
4B-2 Biocoke  
Chair: Yuichi ONO | 42F- Room A  
42F-Room B  
42F-Room C  
42F-Room D  
42-Room A  
42-Room B  
42F-Room C  
42F-Room D |
| 15:10-16:10  | 1B-1 Fluid Dynamics III  
Chair: Kazuo OHMI  
2B-1 Mechanics of Composite Materials I  
Chair: Toshiro KOBYASHI  
3B-1 Thermal Engineering II  
Chair: Taro HIRASAWA  
4B-1 Stress Measurement and Analysis  
Chair: Shuichi ARIKAWA  
1B-2 Fluid Dynamics IV  
Chair: Kung-Ming Chung  
2B-2 Mechanics of Composite Materials II  
Chair: Yoshifumi OHBUCHI  
3B-2 Bioengineering I  
Chair: Makoto SAKAMOTO  
4B-2 Biocoke  
Chair: Yuichi ONO | 42F-Room A  
42-Room B  
42F-Room C  
42F-Room D |
| 16:10-17:00  | The End                                                                |                |

2018.11.01 (THU)

<table>
<thead>
<tr>
<th>Time</th>
<th>Events</th>
<th>Venues</th>
</tr>
</thead>
<tbody>
<tr>
<td>08:30-09:00</td>
<td>Registration</td>
<td>38F- Opal Ballroom</td>
</tr>
</tbody>
</table>
| 09:00-09:50  | Keynote Lecture (2)  
Title: On Critical Transition of Blunt-Body Drag  
Professor Jiun-Jih Miau  
Department of Aeronautics and Astronautics , National Cheng Kung University , Taiwan | 38F- Opal Ballroom |
<table>
<thead>
<tr>
<th>Time</th>
<th>Events</th>
<th>Venues</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:10-11:10</td>
<td><strong>Session III</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1C-1 Fluid Dynamics V</td>
<td>42F- Room A</td>
</tr>
<tr>
<td></td>
<td>Chair: Jong-Shinn Wu</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2C-1 Collision/ Impact and other I</td>
<td>42F- Room B</td>
</tr>
<tr>
<td></td>
<td>Chair: Tetsuya HIROTOMI</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3C-1 Bioengineering II</td>
<td>42F- Room C</td>
</tr>
<tr>
<td></td>
<td>Chair: Kazuhiko SASAGAWA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4C-1 Environmental Science and Engineering I</td>
<td>42F-Room D</td>
</tr>
<tr>
<td></td>
<td>Chair: Toru SAWAI</td>
<td></td>
</tr>
<tr>
<td>10:20-12:20</td>
<td>1C-2 Fluid Dynamics VI</td>
<td>42F-Room A</td>
</tr>
<tr>
<td></td>
<td>Chair: Keh-Chin Chang</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2C-2 Collision/ Impact and other II</td>
<td>42F-Room B</td>
</tr>
<tr>
<td></td>
<td>Chair: Masatoshi FUTAKAWA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3C-2 Bioengineering III</td>
<td>42F-Room C</td>
</tr>
<tr>
<td></td>
<td>Chair: Takenobu SAKAI</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4C-2 Environmental Science and Engineering II</td>
<td>42F-Room D</td>
</tr>
<tr>
<td></td>
<td>Chair: Hiroshi TAKAHASHI</td>
<td></td>
</tr>
<tr>
<td>12:20-13:30</td>
<td>Lunch</td>
<td>42F Meeting Room</td>
</tr>
<tr>
<td>13:30-18:00</td>
<td>Excursion</td>
<td>Fo Guang Shan Buddha Museum</td>
</tr>
<tr>
<td>18:00-20:30</td>
<td>Banquet</td>
<td>38F- Opal Ballroom</td>
</tr>
<tr>
<td>2018.11.02 (FRI)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>08:30-0:900</td>
<td>Registration</td>
<td>38F- Opal Ballroom</td>
</tr>
<tr>
<td>09:00-09:50</td>
<td><strong>Keynote Lecture (3)</strong></td>
<td>38F- Opal Ballroom</td>
</tr>
<tr>
<td></td>
<td><strong>Title:</strong> Study on Particle Motion in Dispersed Two-Phase Flow and its Application</td>
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<td><strong>Professor Monji Hideaki</strong></td>
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<td></td>
<td>Department of Engineering Mechanics and Energy, University of Tsukuba, Japan</td>
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</tr>
<tr>
<td>Time</td>
<td>Events</td>
<td>Venues</td>
</tr>
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<td>-----------------</td>
</tr>
</tbody>
</table>
| 10:10-11:10  | 1D-1 Fluid Dynamics VII  
Chair: Yasushi UEMATSU | 42F-Room A      |
|              | 2D-1 Materials and Processing  
Chair: Ayako YANO | 42F-Room B      |
|              | 3D-1 Bioengineering IV  
Chair: Ei YAMAMOTO | 42F-Room C      |
|              | 4D-1 Measurement Techniques I  
Chair: Motoharu FUJIGAKI | 42F-Room D     |
|              | **Session D**                             |                 |
| 10:20-12:20  | 1D-2 Fluid Dynamics VIII  
Chair: Tatsuro WAKIMOTO | 42F-Room A      |
|              | 2D-2 Materials and Processing  
Chair: Tatsuya OHMI | 42F-Room B      |
|              | 3D-2 Thermal Engineering III  
Chair: Hiroshi YAMAGUCHI | 42F-Room C     |
|              | 4D-2 Measurement Techniques II  
Chair: Yasushi NIITSU | 42F-Room D     |
|              | **Lunch**                                 | 42F Meeting Room|
| 12:20-14:00  |                                             |                 |
| 14:00-15:00  | 1E-1 Fluid Dynamics IX  
Chair: Yi-Chung LIU | 42F-Room A      |
|              | 2E-1 Bubble  
Chair: Hideaki Monji | 42F-Room B      |
|              | 3E-1 Adhesion and Friction  
Chair: Takashi YOKOYAMA | 42F-Room C     |
|              | **Session E**                             |                 |
| 15:15-15:30  | Announcement on the next ISEM 2019  
-Tsukuba (Japan) and Closing Address | 41F-Diamond I   |
38樓 珍鑽宴會廳 Opal Ballroom

41樓 星鑽宴會廳 Diamond Ballroom
42F 会议中心 Meeting Center
Keynote Lecture 1

Byoung-Ho Choi, Ph. D.
Professor
Director, Advanced Materials Characterization Laboratory
School of Mechanical Engineering, College of Engineering
Korea University
1 5-ga, Anam-dong, Sungbuk-ku
Seoul 136-701, Republic of Korea
Tel.: +82-2-3290-3378 (Office), +82-10-8339-4755 (Cell)
E-mail: bhchoi@korea.ac.kr, cqbiho@gmail.com
http://amcl.korea.ac.kr

Education Background

✧ **Ph. D.**, Applied Mechanics/Fracture Mechanics, Korea University, Seoul, Republic of Korea (February, 2001)
✧ **M. S.**, Mechanical Engineering, Korea University, Seoul, Republic of Korea (February, 1996)
✧ **B. S.**, Mechanical Engineering, Korea University, Seoul, Republic of Korea (February, 1994)

Working Experience

✧ Sep. 2014 – present: Professor, School of Mechanical Engineering, Korea University, Seoul, Republic of Korea
✧ Sep. 2009 – Aug. 2014: Associate Professor, School of Mechanical Engineering, Korea University, Seoul, Republic of Korea
✧ Sep. 2007 – Aug. 2009: Assistant Professor, School of Mechanical Engineering, Korea University, Seoul, Republic of Korea
Characterization and Modeling of Mechano-Chemical Cracking Behaviors of Polyethylene

Byoung-Ho Choi
Professor, School of Mechanical Engineering, Korea University

http://amcl.korea.ac.kr

Abstract

Due to the complexity of the detail mechanism of mechanical properties of various polymers, in-depth researches based on the evaluation of long-term durability of polymeric materials are still required. The long-term durability of polymeric materials is one of most important properties for seeking new applications. But, very frequently, the long-term durability of polymeric materials is not sufficiently evaluated before commercializing a product which uses polymers due to the complexity of analyzing the root causes of unexpected long-term failures. Because the lifetime prediction of polymers is a multi-disciplinary science, so it is very important to combine relevant sciences such as polymer science, chemistry, physics as well as mechanics. Especially, stress corrosion cracking (SCC) in polyethylene pipes usually starts as a microcrack network within a layer of degraded polymer adjacent to the pipe surface exposed to combine action of mechanical stress and chemically aggressive environment. In this presentation, the effect of mechano-chemical degradation on the lifetime of polyethylene pipe will be described based on fracture mechanics concepts. In addition, some key accelerated tests for evaluating the long-term durability of polyethylene will be addressed during the presentation.
Keynote Lecture 2

Prof. Jiun-Jih Miau

Jiun-Jih Miau obtained his B.S. degree in Mechanical Engineering from National Taiwan University, Taiwan, in 1976, and M.S. and Ph.D degrees in Engineering from Brown University, USA, in 1981 and 1984, respectively. Since 1984, he has engaged in teaching and research at the Department of Aeronautics and Astronautics, National Cheng Kung University (NCKU), Taiwan. His research interests are mainly in the areas of fluid dynamics and space engineering.

Dr. Miau is an Associate Fellow of AIAA, a Corresponding Member of IAA (International Academy of Astronautics), and a Fellow of AASRC (Aeronautical and Astronautical Society of Republic of China). He has published more than 90 journal papers and more than 200 conference papers. He also holds six patents of Taiwan, Republic of China, and four patents of USA.

In the past years, Professor Miau has served a number of administrative positions. In 1995-1998, he served as the Chairman of Department of Aeronautics and Astronautics, NCKU. In 1996-1997 and 1998-2004, he served as the Director of Aerospace Science and Technology Research Center, NCKU. In 2007, he served as the Deputy Director of Research and Services Headquarters, NCKU. During the years of 2008 and 2009, he served as the Director General of National Space Organization, Taiwan. In 2011-2017, he served as the CEO of the NCKU Research and Development Foundation. In addition, it is worthwhile to mention that in 1998-1999 he served as the President of the Aeronautical and Astronautical Society of the Republic of China, and during 2015-2017 he served as the Coordinator of the Aerospace and Thermal-Fluid Programs of Ministry of Science and Technology. Currently, he serves as a Board Member of the Aviation Safety Council, Taiwan.
On critical transition of blunt-body drag

Department of Aeronautics and Astronautics, National Cheng Kung University, Taiwan (ROC)
jjmiau@mail.ncku.edu.tw

Abstract

Aerodynamic flow around a blunt body is featured with flow separation taking place on its contoured surface where the adverse pressure gradient is in effect. For such a flow, the aerodynamic drag is dominated by the form drag which is basically determined by the extent of the flow separation region. In the sub-critical range, which can be described in terms of Reynolds number based on the characteristic length of the blunt body and the incoming freestream velocity, the drag coefficient of the blunt body stays almost constant. This signifies that the phenomenon of flow separation, or the extent of the flow separation region noted, is not sensitive to the Reynolds number. Nevertheless, as the Reynolds number is further increased and falls in the critical regime, a drastic reduction in drag coefficient is discerned. This pronounced transition in drag is known as the drag crisis. Physically, this phenomenon is involved with the development of laminar separation bubbles on the contoured surface, followed by turbulent reattachment, then turbulent separation further downstream. As a result, the extent of the flow separation region is much reduced. Meanwhile, flow in the critical regime is characterized as highly unsteady, even non-stationary, which is intimately linked with the development of the laminar separation bubbles.

This paper provides new experimental data with regard to two blunt models, aiming to explore the unsteady nature of flows in the critical transition regime. Both models are of two-dimensional configurations, one of which is a circular cylinder and the other in a teardrop shape. The flow parameters considered include the Reynolds number, the freestream turbulence intensity, surface roughness of the model and the wind-tunnel blockage ratio. On the blunt model of a two-dimensional circular cylinder, experiments were actually made in two wind tunnels of different sizes in test section. Thus, the cases of which the circular cylinder was subjected to different geometric blockage ratios, freestream turbulence intensities and surface roughness were considered. For each of the cases, analysis on the instantaneous pressure signals obtained on the model surface was carried out with emphasis on unveiling the characteristics of intermittent switching of flow states. On the experiment of flow over a teardrop shaped model, a method of oil-film flow visualization was first applied to reveal the development of laminar separation bubble at Reynolds numbers in the critical transition range. Subsequently, instantaneous pressure measurements were made at 22 locations on the model surface simultaneously. The unsteady characteristics of the separation bubble were confirmed and further analyzed.
Keynote Lecture 3

Hideki Monji, Ph.D.
Professor,
Department of Engineering Mechanics and Energy,
Univ. of Tsukuba, Japan
monji@kz.tsukuba.ac.jp

Education:
✧ 1984 University of Tsukuba Third Cluster of College
✧ 1989 University of Tsukuba Graduate School, Division of Engineering

Work history:
✧ 1989 - 1992 University of Tsukuba Research Assistant
✧ 1992 - 2001 University of Tsukuba Assistant Professor
✧ 2008 - 2013/03 University of Tsukuba
✧ 2013/04 - University of Tsukuba Professor

Major: Multi-phase flow engineering, Thermo-fluid engineering
Study on characteristics of dispersed two-phase flow: phase distribution of bubbly flow, separation process by centrifugal force for solid-liquid two-phase flow.
Study on Particle Motion in Dispersed Two-Phase Flow and its Application

Hideaki MONJI and Goichi MATSUI
Department of Engineering Mechanics and Energy, University of Tsukuba, Japan
monji@kz.tsukuba.ac.jp

Abstract

Dispersed two-phase flow such as bubbly flow and solid-fluid two-phase flow was frequently used and important in engineering plants. In order to increase the efficiency of equipment to use the dispersed two-phase flow and to keep the safety of the equipment, it needs to know the characteristic of the dispersed two-phase flow. The dispersed two-phase flow, however, is a complicated flow. Therefore, we study experimentally the elementary process of the dispersed flow.

In the study, as the elementary process, the interactions between dispersed particles and fluid, and between particles, between the particle and a pipe wall were investigated. In the experiment to study their interactions, image processing called as MOFIA (Moving Object-flow Image Analyzer) was used. It is a measurement system combining PIV (Particle Image Velocimetry) for the fluid motion and a stereo image processing for the particle motion. As an application of the study on the dispersed two-phase flow, a line of cars was investigated. The study on drag force on a car in a line of cars is required at the moment to development of an automatic driving system. Reduction of drag force acting on a car by making a line of cars is attractive on the viewpoint of the energy saving and efficiency of transportation. The study using car models in a wind tunnel and a passing water tank was done to investigate the drag force acting on a car in a line of cars. The drag reduction mechanism was discussed with the result of numerical simulation for the same situation on the car models.
13th ISEM 2018 - Kaohsiung, Technical Program and Contents

October 30, 2018
16:00-18:00 Registration (85-Sky Tower Hotel / 41F Room: Diamond I)
17:00-19:00 Welcome reception (85-Sky Tower Hotel / 41F Room: Diamond I)

October 31, 2018
8:30- Registration (85-Sky Tower Hotel / 38F Opal Ballroom)
9:00-9:20 Opening Ceremony (85-Sky Tower Hotel / 38F Opal Ballroom)
9:20-10:10 Keynote Lecture 1 (85-Sky Tower Hotel / 38F Opal Ballroom)
Title: Characterization and Modeling of Mechano-Chemical Cracking Behaviors of Polyethylene
Professor Byoung-Ho Choi
School of Mechanical Engineering, Korea University, Korea

Technical Program

<table>
<thead>
<tr>
<th>Session</th>
<th>Fluid Dynamics I</th>
<th>Chair: Yohsuke TANAKA (Kyoto Institute of Technology, Japan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A01125</td>
<td>Relationship Between Vortex Shedding from Rotating Body in Uniform Flow and Fluid Force Acting on the Rotation Axis - on S Shape Blade Vertical Axis Turbine</td>
<td></td>
</tr>
<tr>
<td>F01001</td>
<td>Observation of Particle Behaviors in Extrusion Flow of Concentrated Particle Suspensions</td>
<td></td>
</tr>
<tr>
<td>F01009</td>
<td>Wind Loads on Offshore Floating Photovoltaic Panels</td>
<td></td>
</tr>
</tbody>
</table>

Tomoya NAKAJIMA (Osaka Prefecture University, Japan), Yoshiaki UEDA (Setsunan University, Japan)
Takashi KOSHIBA (National Institute of Technology, Nara College, Japan), Takehiro YAMAMOTO (Osaka Electro-Communication University, Japan)
### Session 2A-1 (Room B) Mechanical Properties I
Chair: Satoru MIZUNO (Kindai University, Japan)

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>A09126</td>
<td>Mechanical Properties of Polymer Thin Films Prepared by Wet and Dry Processes</td>
<td>Toshiro KOBAYASHI (Tsuyama College, Japan), Hideaki FURUMOTO (Hiroshima Kokusai Gakuin University, Japan), Akinobu YAMAGUCHI (University of Hyogo, Japan), Hideyuki KANEMATSU (Suzuka College, Japan), Ion Cosmin GRUESCU (Institut Universitaire de Technologie A de Lille, France)</td>
</tr>
<tr>
<td>F05046</td>
<td>Influence of Graze Layer on Bending Fracture Strength of Clay Roof Tile Specimen</td>
<td>Yoshifumi MATSUDA, Ichiro SHIMIZU (Okayama University of Science, Japan), Toshio EGI (Hamada Technology Center, Japan)</td>
</tr>
<tr>
<td>F05055</td>
<td>Experimental Study on Mechanical Property Control in Local Area of AZ31 Magnesium Alloy Thin-Walled Circular Tube</td>
<td>Xinming ZHAO, Ichiro SHIMIZU (Okayama University of Science, Japan), Akira WADA (Japan Medical Device Technology)</td>
</tr>
</tbody>
</table>

### Session 3A-1 (Room C) Renewable Energy
Chair: Tamio IDA (Kindai University, Japan)

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>A04012</td>
<td>Estimation of Energy Properties of Thermally Treated Biomass by Pyrolysis Model</td>
<td>Toru SAWAI, Fumiya MORIYAMA (Kindai University, Japan)</td>
</tr>
<tr>
<td>A03130</td>
<td>The Change in Qualities of Densified Biomass Fuel (Bio-coke) Affected by Alkali Lignin Ratio on Cedar Powder</td>
<td>Supitchaya CHERDKEATTIKUL, Tamio IDA, Yusuke MORISAWA, Satoru MIZUNO (Kindai University, Japan), Jintawat CHAICHANAWONG Thai-Nichi Institute of Technology, Thailand</td>
</tr>
<tr>
<td>A04074</td>
<td>Process Development and Evaluation for Upgrading Heavy Pyrolytic Oils from Industrial Waste into High-Valued Fuels</td>
<td>Sia Sheng Qiang, Pei-Hsun Lin, Cheng-Ting Hsieh, Wei-Cheng Wang (National Cheng Kung University, Taiwan)</td>
</tr>
</tbody>
</table>

### Session 4A-1 (Room D) Composite Materials I
Chair: Kenji NAKAI (Okayama University of Science, Japan)

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>A09007</td>
<td>Numerical Modeling for Time and Temperature Dependence on Flexural Strength of Polyimide CFRP</td>
<td>Sakie SHIRAI, Mio SATO, Jun KOYANAGI, Yuichi ISHIDA (Tokyo University of Science, Japan)</td>
</tr>
<tr>
<td>A09033</td>
<td>Characterization of Triaxial Woven Carbon Fiber Reinforced Polymeric Composites under Uniaxial Tension by Experiments and Numerical Simulation</td>
<td>Yuta YAMAZAKI, Jun KOYANAGI, Akinori YOSHIMURA, Satoru YONEYAMA (Tokyo University of Science, Japan)</td>
</tr>
<tr>
<td>F05095</td>
<td>Mechanism of Repairing of Delamination via Thermal Fusion Bonding in CF/PA6 Laminates</td>
<td>Takatoshi UEDA, Shingo OI, Keita KUSABIRAKI, Manato KANESAKI, Hiroshi SAITO, Kiyoshi UZAWA, Isao KIMPARA (Kanazawa Institute of Technology, Japan)</td>
</tr>
</tbody>
</table>

### Session 1A-2 (Room A) Fluid Dynamics II
Chair: Osamu MOCHIZUKI (Toyo University, Japan)

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
</tr>
</thead>
</table>

10:20-11:20
<table>
<thead>
<tr>
<th>Session 2A-2 (Room B)</th>
<th>Mechanical Properties II</th>
<th>Chair: Jun KOYANAGI (Tokyo University of Science, Japan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F05117</td>
<td>Effect on Fundamental Property of EFB Biocoke Based on Additional Pectin</td>
<td>Koji YOSHIKUNI, Satoru MIZUNO, Tamio IDA, Toru SAWAI (Kindai University, Japan)</td>
</tr>
<tr>
<td>A03110</td>
<td>Improvement of Mechanical Properties on Bio-Coke Produced by Green Tea Grounds Mixed with Bamboo Fiber</td>
<td>M. Akmal AMRAN, Tamio IDA, Satoru MIZUNO (Kindai University, Japan)</td>
</tr>
<tr>
<td>A03112</td>
<td>Influences of Material Characteristics on Mechanical Properties of Mixed Biocoke (BIC)</td>
<td>M. Ámirul Aimān M. ISA, Tamio IDA, Satoru MIZUNO (Kindai University, Japan)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Session 3A-2 (Room C)</th>
<th>Thermal Engineering I</th>
<th>Chair: Hiroyuki KINOSHITA (University of Miyazaki, Japan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F04024</td>
<td>Verification of Simulator for Designing Stone Heat Storage Tank</td>
<td>Weichen ZHANG, Ryan Naldo PRATAMA, Rendy Silva RENATA, Hideharu TAKAHASHI, Yutaka TAMURA, Hiroshige KIKURA (Tokyo Institute of Technology, Japan)</td>
</tr>
<tr>
<td>F04106</td>
<td>Influence of Thermal Radiation on Transient Heat Transfer between Spherical Heat Reservoirs</td>
<td>Shigehito. OKABE (Chubu University, Japan), Taro HIRASAWA (Chubu University, Japan), Taketomo KAGEYAMA (TYK Corporation, Japan), Osame TAKAGI (TYK Corporation, Japan)</td>
</tr>
<tr>
<td>A05022</td>
<td>Development of a 300kgf Bypass Hydrogen Peroxide Hybrid Rocket System</td>
<td>Yi-Liang, Chen, Yei-Chin, Chao, Hung-Wei Hsu (National Cheng Kung University, Taiwan)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Session 4A-2 (Room D)</th>
<th>Composite Materials II</th>
<th>Chair: Takashi YOKOYAMA (Okayama University of Science, Japan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A09047</td>
<td>Delamination Caused by Internal Gas Pressure for Heat-Resistant CFRP Subjected to Rapid Heating</td>
<td>Kenta SHINBA, Jun KOYANAGI, Yasuo KOGO (Tokyo University of Science, Japan)</td>
</tr>
<tr>
<td>A09100</td>
<td>Fundamental Study on Repair of CFRTP Laminates from One Side using Thermal Fusion Bonding</td>
<td>Manato KANESAKI, Shintaro TANIMOTO Yusuke, KUWAHARA, Takatoshi UEDE, Hiroshi SAITO, Kiyoshi UZAWA, Isao KIMPARA (Kanazawa Institute of Technology, Japan)</td>
</tr>
<tr>
<td>Session</td>
<td>Title</td>
<td>Speaker(s)</td>
</tr>
<tr>
<td>---------</td>
<td>-------</td>
<td>------------</td>
</tr>
<tr>
<td>1B-1 (Room A)</td>
<td>Fluid Dynamics III</td>
<td>Chair: Kazuo OHMI (Osaka Sangyo University, Japan)</td>
</tr>
<tr>
<td>F01015</td>
<td>Couette Flow between Cylindrical Surfaces</td>
<td>Vadim LEBIGA, Vitaly ZINOVYEV, Alexey PAK (Khristianovich Institute of Theoretical and Applied Mechanics SB RAS, Russia)</td>
</tr>
<tr>
<td>F01016</td>
<td>Investigation of Aerodynamic Coefficients of a Rocket Model with Rotation Rate in Tri-Sonic Wind Tunnel</td>
<td>Hung-Yen CHOU, Hsuan-Wei LIAO, Jung-Nan HSU (National Chung-Shan Institute of Science and Technology, Taiwan)</td>
</tr>
</tbody>
</table>

14:00-15:00

<table>
<thead>
<tr>
<th>Session 2B-1 (Room B)</th>
<th>Mechanics of Composite Materials I</th>
<th>Chair: Toshiro KOBAYASHI (Tsuyama College, Japan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F05080</td>
<td>Representation of CFRP Anisotropic Characteristics by Simple Lamination Model for New Product Design</td>
<td>Hiroki KATO, Yoshifumi OHBUCHI (Kumamoto University, Japan), Hidetoshi SAKAMOTO (Doshisha University, Japan), Tomoki MORI (Kumamoto University, Japan), and Haruhiko IIDA (Sojo University, Japan)</td>
</tr>
<tr>
<td>A09045</td>
<td>Evaluation of Mechanical Properties of Fiber/ Matrix Interface by Micro-Bond-Test and Molecular Dynamics</td>
<td>Norie ITANO (Tokyo University of Science, Japan), Kazuki MORI (Itchochu Techno-Solutions Corporation, Japan), Jun KOYANAGI (Tokyo University of Science, Japan)</td>
</tr>
<tr>
<td>F05096</td>
<td>Experimental Study of Meso Fracture Mechanism in Carbon Fiber/Epoxy Cross-Ply Laminates Based on Digital Image Correlation Method</td>
<td>Yusei SATO, Yoshiki NISHIDA, Ryotaro KIMURA, Kohei SHIMMURA, Hiroshi SAITO, Issao KIMPARA (Kanazawa Institute of Technology, Japan)</td>
</tr>
</tbody>
</table>

14:00-15:05

<table>
<thead>
<tr>
<th>Session 3B-1 (Room C)</th>
<th>Thermal Engineering II</th>
<th>Chair: Taro HIRASAWA (Chubu University, Japan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A05069</td>
<td>Design and Ground Tests of a High-Test Peroxide Mono-Propellant Thruster for Satellite Reactive Control (Invited)</td>
<td>Chan-I Wang, Yei-Chin Chao, Chien-An Chen (National Cheng Kung University, Taiwan)</td>
</tr>
<tr>
<td>Session 4B-1 (Room D)</td>
<td>Stress Measurement and Analysis</td>
<td>Chair: Shuichi ARIKAWA (Meiji University, Japan)</td>
</tr>
<tr>
<td>-----------------------</td>
<td>---------------------------------</td>
<td>------------------------------------------------</td>
</tr>
<tr>
<td>A10060</td>
<td>Effect of Load Frequency on Cyclic Stress Measurement Method using Electrodeposited Copper Foil</td>
<td>Yuichi ONO (Tottori University, Japan)</td>
</tr>
<tr>
<td>F07028</td>
<td>Finite Element Study on Effect of Cross-Sectional Shape of Stent Strut on Internal Deformation of Coronary Artery</td>
<td>Haruna KITAGAWA, Ichiro SHIMIZU (Okayama University of Science, Japan)</td>
</tr>
<tr>
<td>A11132</td>
<td>Residual Stress Estimation of CFRP materials by X-ray Diffraction Method</td>
<td>Masayuki NISHIDA, Tatsuya MATSUE, Takao HANABUSA (Kobe City College of Technology, Japan)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Session 1B-2 (Room A)</th>
<th>Fluid Dynamics IV</th>
<th>Chair: Kung-Ming Chung (National Cheng Kung University, Taiwan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F01118</td>
<td>Investigation of the Characteristics of the Flow round the Circular Cylinder in the Critical Regime</td>
<td>Y.H. Lai, J.J. Miau (National Cheng Kung University, Taiwan)</td>
</tr>
<tr>
<td>F01017</td>
<td>The Velocity Measurement of the Detonation Wave Induced by Combustion of the Air-Acetylene Mixture by Ion Probes</td>
<td>Yushun SUDA, Kotaro MURAKANI, Tatsuro INAGE, Masanori Ota, Shinsuke UDAGAWA (Tokyo Metropolitan College of Industrial Technology, Japan)</td>
</tr>
<tr>
<td>F01019</td>
<td>Accreditation of a Cup Anemometer Calibration System</td>
<td>W-F Chen, C-C Hu, J-J Miau, Y-J Chen, Y-R Chen (National Cheng Kung University, Taiwan)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Session 2B-2 (Room B)</th>
<th>Mechanics of Composite Materials II</th>
<th>Chair: Yoshifumi OHBUCHI (Kumamoto University, Japan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Session 3B-2 (Room C) Bioengineering I</td>
<td>Chair: Makoto SAKAMOTO (Niigata University, Japan)</td>
<td></td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>---------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>A07027 Analysis of Relation for Kinetic Load and Knee/Ankle Joint Angle using PAFO during Stance Phase</td>
<td>Daisuke MORIOKA, Ichiro KITAYAMA, Miyuki KAWAMURA, Minami TSUTSUI, Hideyo KOYAMA, Takashi MORIMOTO, Hideki SONOBE (Kindai University, Japan), Noriyuki MIYAZAKI (Kotonoura Rehabilitation Center Hospital, Japan)</td>
<td></td>
</tr>
<tr>
<td>A07030 A Finite Element Parametric Study of the Contact Pressure Distribution on Palm During Grasping</td>
<td>Kazuki HOKARI, Ryosuke ARIMOTO, Jonas A. PRAMUDITA (Niigata University, Japan), Masato ITO (Panasonic Corporation, Japan), Satoshi NODA (Panasonic Corporation, Japan), Yuji TANABE (Niigata University, Japan)</td>
<td></td>
</tr>
<tr>
<td>A07049 Evaluation of Attenuation Properties of Degraded Porcine Cartilage</td>
<td>Takenobu SAKAI, Kohei AKABANE, Katsuya KODAMA, Kensuke KAGEYAMA (Saitama University, Japan), Hiroaki NAKAMURA (Tokyo Metropolitan University, Japan), Keita AIMOTO (National Center for Geriatrics and Gerontology, Japan), Kazunori HASE (Tokyo Metropolitan University, Japan), Susumu OTA (Seijoh University, Japan)</td>
<td></td>
</tr>
</tbody>
</table>

15:10-16:10

<table>
<thead>
<tr>
<th>Session 4B-2 (Room D) Biocoke</th>
<th>Chair: Yuichi ONO (Tottori University, Japan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A03039 Combustion Characteristics of Biocoke in Different Apparent Density</td>
<td>Nami TAGAMI, Tamio IDA (Kindai University, Japan)</td>
</tr>
<tr>
<td>A03123 An Anisotropy of Compressive Strength Based on Biocoke</td>
<td>Ryutaro YONEDA (Kindai University, Japan)</td>
</tr>
<tr>
<td>A07121 Estimation of Long-Term Stockpilling Characteristics Based on Biocoke</td>
<td>Shunsuke NAKAMURA, Tamio IDA, Takashi SUZUKI (Kindai University, Japan)</td>
</tr>
</tbody>
</table>
### November 1st, 2018

8:30- Registration (85-Sky Tower Hotel / 38F Opal Ballroom)

9:00-9:50 Keynote Lecture 2 (38F Opal Ballroom)
**Title:** On Critical Transition of Blunt-Body Drag
**Professor Jiun-Jih Miau**
Department of Aeronautics and Astronautics, National Cheng Kung University, Taiwan

10:10-11:15

<table>
<thead>
<tr>
<th>F01151</th>
<th>Observation of Acute and Chronic Wound Healing of Rat Model Using Argon Atmospheric-Pressure Plasma Jet</th>
<th>Kuang-Yao Cheng, Zhi-Hua Lin, Yu-Pin Cheng, Hsien-Yi Chiu, Nai-Lun Yeh, Tung-Kung Wu, Jong-Shinn Wu (National Chiao Tung University, Taiwan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F01029</td>
<td>Unsteady Upstream Flow Effects on Vehicle Aerodynamics</td>
<td>Masaru SUMIDA, Kento HAYAKAWA (Kindai University, Japan)</td>
</tr>
<tr>
<td>F01035</td>
<td>Effects of a Wind Concentrator on the Performance of a Cross Flow Wind Turbine</td>
<td>Yuki MORITA, Takaaki KONO, Takahiro KIWATA, Nobuyoshi KOMATSU (Kanazawa University)</td>
</tr>
</tbody>
</table>

10:10-11:15

<table>
<thead>
<tr>
<th>F06026</th>
<th>Development on High-Power Spallation Neutron Sources with Liquid Metals (Invited)</th>
<th>Masatoshi FUTAKAWA (Japan Atomic Energy Agency, Japan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A01006</td>
<td>Evaluation of Pressure Wave-Induced Cavitation Erosion in Mercury Narrow Channel</td>
<td>Takashi NAOE, Hiroyuki KOGAWA (Japan Atomic Energy Agency, Japan), Nobuatsu TANAKA (Ibaraki University, Japan), Masatoshi FUTAKAWA (Japan Atomic Energy Agency, Japan)</td>
</tr>
<tr>
<td>F05042</td>
<td>Development of Flexible Football Shin Guards using Soft Epoxy Resins and Foams</td>
<td>Takahiko NAKAMOTO, Masahiro HIGUCHI, Yuki NAKAYAMA, Hiroshi TACHIYA (Kanazawa University, Japan)</td>
</tr>
</tbody>
</table>

10:10-11:10

<p>| A07050 | Evaluation of Dynamic Viscoelastic Properties of Hairless Mice                                  | Miho KATSURAGI (Saitama University), Kensuke KAGEYAMA                                                                                                                                  |</p>
<table>
<thead>
<tr>
<th>Session 4C-1</th>
<th>Environmental Science and Engineering</th>
<th>Chair: Toru SAWAI (Kindai University, Japan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F08002</td>
<td>Study on Automatic Soil Sampling by Use of UAV : Control of Falling Speed of the Sampling Device</td>
<td>Syuntaro INOUE, Tomoaki SATOMI, Hiroshi TAKAHASHI (Tohoku University, Japan)</td>
</tr>
<tr>
<td>F08003</td>
<td>Study on Recycling of Unused High Water Content Soils as Banking Materials</td>
<td>Kazuya OGATA, Tomoaki SATOMI, Hiroshi TAKAHASHI (Tohoku University, Japan)</td>
</tr>
<tr>
<td>F08004</td>
<td>Study on Strength Characteristics of Fiber-Cement-Stabilized Soil Mixed with Recycled Granular Material</td>
<td>Kouta MATSUSHIMA, Tomoaki SATOMI, Hiroshi TAKAHASHI (Tohoku University, Japan)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Session 1C-2</th>
<th>Fluid Dynamics VI</th>
<th>Chair: Keh-Chin Chang (National Cheng Kung University, Taiwan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F01142</td>
<td>A Simple Method of Measuring Drag-Coefficient of Any Figured Plate (Invited)</td>
<td>Osamu MOCHIZUKI (Toyo University, Japan)</td>
</tr>
<tr>
<td>F01037</td>
<td>Experimental Investigation of Base Pressure Interference Due to Rear Support in Supersonic and Subsonic Regime</td>
<td>Ting-Tsung CHANG, Hsuan-Wei LIAO (National Chung-Shan Institute of Science and Technology, Taiwan)</td>
</tr>
<tr>
<td>F01051</td>
<td>Revisit Reynolds Decomposition Aspects of Turbulent Flow in Near Wake of a Circular Cylinder</td>
<td>Keh-Chin Chang, Po-Hsiung Huang, Chia-Wei, Shen (National Cheng Kung University, Taiwan)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Session 2C-2</th>
<th>Collision /Impact and other II</th>
<th>Chair: Masatoshi FUTAKAWA (Japan Atomic Energy Agency, Japan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A09120</td>
<td>Transverse Impact on Beams of Different Materials (invited)</td>
<td>Dulal GOLDAR (Delhi College of Engineering, India)</td>
</tr>
<tr>
<td>Session 3C-2  (Room C)</td>
<td>Bioengineering III</td>
<td>Chair: Takenobu SAKAI (Saitama University, Japan)</td>
</tr>
<tr>
<td>------------------------</td>
<td>--------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>A07065</td>
<td>A Dynamic Measuring Method of Length of the Patellar Tendon using Cine Magnetic Resonance Imaging</td>
<td>Tatsuya KONDO, Makoto SAKAMOTO, Koichi KOBAYASHI, Surangika WADUGODAPITIYA (Niigata University, Japan)</td>
</tr>
<tr>
<td>A07103</td>
<td>Adjustment of Pull-Out Force Due to the Slit Configuration in Acetabular Cup of Artificial Hip Joint with a Structure for Preventing Dislocation</td>
<td>Yuki KAWAMURA, Daiki IMAI, Yuki TANIFUJI, Mitsushi OHMASA, Ei YAMAMOTO(Kindai University, Japan)</td>
</tr>
<tr>
<td>A07119</td>
<td>Finite Element Analysis of Change in Shape of Femoral Bone after Total Hip Arthroplasty using Shape Optimisation Method</td>
<td>Takafumi KURAMOTO, Jonas A. PRAMUDITA (Niigata University, Japan), Akimasa KIMURA (Nissan Tamagawa Hospital, Japan), Masaaki MATSUBARA (Nissan Tamagawa Hospital, Japan), Yuji TANABE (Niigata University, Japan)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Session 4C-2  (Room D)</th>
<th>Environmental Science and Engineering II</th>
<th>Chair: Hiroshi TAKAHASHI (Tohoku University, Japan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F08005</td>
<td>Study on Automatic Measurement of Ground Strength by Falling Weight from UAV at Disaster Areas</td>
<td>Naru OZAKI, Tomoaki SATOMI, Hiroshi TAKAHASHI (Tohoku University, Japan)</td>
</tr>
<tr>
<td>F08023</td>
<td>The Relationship between Sound and Rainwater Quality Purification using Waterwheel Rotation</td>
<td>Akira HIRATSUKA, Yugo TOMONAGA(Ryukoku University, Japan), Akitaka IMAMURA(ossa Sangyo University, Japan), Ryoji TSUJINO( Setsunan University, Japan)</td>
</tr>
<tr>
<td>F08091</td>
<td>Wind Tunnel Study of Peak Wind Force Coefficients for Designing Cladding/Components of Gable-Roofed Open-Type Structures</td>
<td>Yuki TAKADATE, Yasushi UEMATSU (Tohoku university, Japan)</td>
</tr>
</tbody>
</table>

11:20-12:20
13:30-18:00 Excursion
City Tour: Fo-Guang Shan Buddha Museum (佛光山佛佗紀念館)

18:00-20:30 Banquet (85 Sky Tower Hotel / 38F Opal Ballroom)

November 2nd, 2018

8:30- Registration (85-Sky Tower Hotel / 38F Opal Ballroom)

9:00-9:50 Keynote Lecture 3 (38F Opal Ballroom)
Title: Study on Particle Motion in Dispersed Two-Phase Flow and its Application
Professor Monji Hideaki
Department of Engineering Mechanics and Energy, University of Tsukuba, Japan

10:10-11:10

<table>
<thead>
<tr>
<th>Session 1D-1 (Room A)</th>
<th>Fluid Dynamics VII</th>
<th>Chair: Yasushi UEMATSU (Tohoku University, Japan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F01059</td>
<td>Numerical Simulation of Flow in Modified Raceway Ponds for Algae Cultivation</td>
<td>Ryunosuke OSAKA, Atsushi KASUBUCHI, Yoshiaki UEDA, Yusuke SAKAI (Setsunan University, Japan)</td>
</tr>
<tr>
<td>F01061</td>
<td>A Study on the Wing Performance and the Passive Separation Control of Two Tandem Arranged NACA0012 Wing using Leading Edge Protuberance in Low</td>
<td>Taito INOUE, Takahiro YASUDA, Hisato MINAGAWA, Ryo KURIMOTO (The University of Shiga Prefecture, Japan)</td>
</tr>
<tr>
<td>F01062</td>
<td>Unsteady Flow Past a VAWT Consisting of Three Quarter Circular-Arc Blades Attached to a Cylindrical Core (Influence of Attachment Angle)</td>
<td>Syunji ARIYOSHI, Yukihiro MARUMOTO, Masaki KOYAMA, Yoshiaki UEDA, Tomoya NAKAJIMA (Setsunan University, Japan)</td>
</tr>
</tbody>
</table>

10:10-11:15

<table>
<thead>
<tr>
<th>Session 2D-1 (Room B)</th>
<th>Materials and Processing</th>
<th>Chair: Tatsuya OHMI (Hokkaido University, Japan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A08036</td>
<td>Structure and Soundness of Multilayer Al-Si Alloy Pipes Produced by Two-Step Centrifugal Casting (Invited)</td>
<td>Tatsuya OHMI, Masaki TADA (Hokkaido University, Japan)</td>
</tr>
<tr>
<td>Session ID</td>
<td>Title</td>
<td>Authors</td>
</tr>
<tr>
<td>------------</td>
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<td>---------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>A08093</td>
<td>Reduction Behavior and Rate of Sintered Iron Oxide Pellets</td>
<td>Kengo KATO, Hirokazu KONISHI, Hirotoshi KAWABATA, Hideki ONO, Yuichiro KOIZUMI (Osaka University)</td>
</tr>
<tr>
<td>A08138</td>
<td>The Influence of Workpiece Subjected to Periodic Forced Vibration on the Dry Hobbing</td>
<td>Shu KARUBE, Daiki GOTOU, Masatoshi SHIMURA (Oita College, Japan)</td>
</tr>
</tbody>
</table>

**10:10-11:10**

**Session 3D-1 (Room C) Bioengineering IV**

Chair: Ei YAMAMOTO (Kindai University, Japan)

<table>
<thead>
<tr>
<th>Session ID</th>
<th>Title</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>F07044</td>
<td>A New In Vivo Method for Three-Dimensional Evaluation of Tooth Axis and Dental Arch using Cone-Beam Computed Tomography</td>
<td>Yuta SAKAGAMI, Makoto SAKAMOTO, Yusuke MORISET, Takashi KAMEDA, Koichi KOBAYASHI, Yuji TANABE (Niigata University, Japan)</td>
</tr>
<tr>
<td>F07041</td>
<td>Adhesion Force Measurement by using Film-Type Sensor: a Pilot Study of Development of Cell Force Monitoring System</td>
<td>Takeshi MORIWAKI, Kazuhiro FUJISAKI, Kazuhiro SASAGAWA (Hiroshima University, Japan)</td>
</tr>
<tr>
<td>A06079</td>
<td>Development of Power Assistance Chair for Aged Person by Motion and Myoelectric Signal Measurement</td>
<td>Koki ARADONO, Yoshifumi OHBUCH, Hitotoshi SAKAMOTO, Ryosuke IZUTSU, Hiroshi HARADA (Kumamoto University, Japan)</td>
</tr>
</tbody>
</table>

**10:10-11:15**

**Session 4D-1 (Room D) Measurement Techniques I**

Chair: Motoharu FUJIGAKI (University of Fukui, Japan)

<table>
<thead>
<tr>
<th>Session ID</th>
<th>Title</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>F11137</td>
<td>Determination of Three-Dimensional Camera Parameters with the Information on Two-Dimensional Plane for 3D Measurement (Invited)</td>
<td>Yasushi NIITSU, Miyu KASUYA (Tokyo Denki University, Japan)</td>
</tr>
<tr>
<td>A10088</td>
<td>Reflection Removal Infrared Thermographic Test using Polarization Theory for Dielectrics</td>
<td>Soshi SUZUKI, Nagahisa OGASAWARA (National Defense Academy, Japan)</td>
</tr>
<tr>
<td>F09082</td>
<td>Interfacial Observation of Composite Rubber with Fiber-Shaped Particles Under Tensile Load by X Ray CT</td>
<td>Masami MATSUBARA, Shinnosuke TERAMOTO, Asahiro NAGATANI, Shozo KAWAMURA, Tomohiko ISE, Nobutaka TSUJIUCHI, Akihito ITO (Toyohashi University of Technology, Japan)</td>
</tr>
</tbody>
</table>

**11:20-12:00**

**Session 1D-2 (Room A) Fluid Dynamics VIII**

Chair: Tatsuro WAKIMOTO (Osaka City University, Japan)
<table>
<thead>
<tr>
<th>Session 2D-2 (Room B)</th>
<th>Materials and Processing</th>
<th>Chair: Tatsuya OHMI (Hokkaido University, Japan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F01066</td>
<td>Experimental Analysis of the Effect of Tread Grooves on a Tire inside a Tire House</td>
<td>Yuki ENDO, Shigeru MURATA, Hiroshi NASHIO, Yohsuke TANAKA (Kyoto Institute of Technology, Japan)</td>
</tr>
<tr>
<td>F01072</td>
<td>Effects of the Arm’s Cross-sectional Shape on the Aeroacoustic Noise of a Straight-Bladed Darrieus Wind Turbine</td>
<td>Kentaro HAMADA, Takaaki KONO, Takahiro KIWATA, Nobuyoshi KOMATSU, Shinnosuke YASUDA (Kanazawa University, Japan)</td>
</tr>
<tr>
<td>11:25-12:25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Session 3D-2 (Room C)</td>
<td>Thermal Engineering I I I</td>
<td>Hiroshi YAMAGUCHI (Doshisha University, Japan)</td>
</tr>
<tr>
<td>A03075</td>
<td>Finite Element Analysis of the Temperature Change during Solar Radiant Heat Reception of a Moss-Greening Ceramic utilizing Waste Silica</td>
<td>Kentaro YASUI, Ayako TANAKA, Kenichi ITO, Minoru FUJISAKI, Toshiaki NAKAMURA, Hiroyuki KINOSHITA (University of Miyazaki, Japan)</td>
</tr>
<tr>
<td>A03078</td>
<td>The Suppression Effect of Temperature Increase by Solar Radiant Heat of a Moss-Greening Ceramic utilizing Waste Silica</td>
<td>Ayako TANAKA, Kentaro YASUI, Kenichi ITO, Minoru FUJISAKI, Toshiaki NAKAMURA, Hiroyuki KINOSHITA (University of Miyazaki, Japan)</td>
</tr>
<tr>
<td>F06099</td>
<td>Silicon Carbide as Seed Particle for Flame Temperature Measurement Based on Emission Spectroscopy</td>
<td>Yuta UCHIDA, Yuichi KATO, Taro HIRASAWA (Chubu University, Japan)</td>
</tr>
<tr>
<td>11:25-12:25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Session 4D-2 (Room D)</td>
<td>Measurement Techniques II</td>
<td>Chair: Yasushi NIITSU (Tokyo Denki University, Japan)</td>
</tr>
<tr>
<td>F05070</td>
<td>Inverse Analysis of the Coefficient of Thermal Expansion of Dissimilar Materials using the Virtual Fields Method</td>
<td>Yohei KANAI, Shuichi ARIKAWA, Satoru YOKONEYAMA, Yasuhisa FUJIMOTO (Aoyama Gakuin University, Japan)</td>
</tr>
</tbody>
</table>

12
<table>
<thead>
<tr>
<th>Session</th>
<th>Topic</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1E-1</td>
<td>Fluid Dynamics IX</td>
<td>Chair: Yi-Chung LIU (National Chungshan Institute of Science and Technology, Taiwan)</td>
</tr>
<tr>
<td>F01090</td>
<td>ILift and Drag of a NACA0012 Airfoil in a Periodic Flow for Changing Angle of Attack</td>
<td>Yu SHIBATA, Yohsuke TANAKA, Yoshitaka ISODA, Shigeru MURATA (Kyoto Institute of Technology, Japan)</td>
</tr>
<tr>
<td>F01113</td>
<td>The Study of Vortex Induced Lift at Finite Span Wings at Critical Mode Reynolds Number</td>
<td>Yi-Chung LIU and Wen-Lih CHEN (National Chungshan Institute of Science and Technology, Taiwan)</td>
</tr>
<tr>
<td>F01152</td>
<td>Reduction of Run-up Height Induced by Tsunami-like Long Wave Using Three Submerged Barriers</td>
<td>Chang Lin, Wei-Ying Wong, Ming-Jer Kao, Hwung-Hweng Hwung, Yun-Ta Wu (National Chung Hsing University, Taiwan)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Session</th>
<th>Topic</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>2E-1</td>
<td>Bubble</td>
<td>Chair: Hideaki Monji (University of Tsukuba, Japan)</td>
</tr>
<tr>
<td>F01116</td>
<td>Sound Emission from a Bubble Generated of an Underwater Nozzle (Influence of the Bubble Size)</td>
<td>Taku KINOSHITA, Yoshiaki UEDA, Tomoya NAKAJIMA (Setsunan University, Japan)</td>
</tr>
<tr>
<td>F01141</td>
<td>A Study on Surface Property of Molten Solder in Oxidative Environment</td>
<td>Tatsuro WAKIMOTO, Kokichi ABE, Kenji KATO, Yoshiaki UEDA, Manabu IGUCHI (Osaka City University, Japan)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Session</th>
<th>Topic</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>3E-1</td>
<td>Adhesion and Friction</td>
<td>Chair: Takashi YOKOYAMA (Okayama University of Science, Japan)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Session Code</th>
<th>Title</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>F05073</td>
<td>Evaluation of Weak Bond in Adhesive Joints of CFRP</td>
<td>Atsushi TAMURA, Kensuke KAGEYAMA, Takenobu SAKAI (Saitama University, Japan)</td>
</tr>
<tr>
<td>F09102</td>
<td>Experimental Study of Stick-Slip Dynamics in Periodically Forced Oscillators with Dry Friction</td>
<td>Shu KARUBE, Takuya NAGAOKA (National Institute of Technology, Oita College, Japan), Takuji KOUSAKA (Chukyo University)</td>
</tr>
</tbody>
</table>

15:15-15:30 Announcement on the next ISEM 2019 - Tsukuba (Japan) and Closing Address (Room D)
<table>
<thead>
<tr>
<th>Poster Presentation (32)</th>
<th>42F</th>
</tr>
</thead>
<tbody>
<tr>
<td>A01021 Optimization of the Swirl Gas Microbubble Generator for a Liquid Mercury Target Vessel</td>
<td>Tsubasa IKEDA, Hiroyuki KOGAWA, Takashi NAOE, Shunsuke KAWAMURA, Nobuatsu TANAKA, Masatoshi FUTAKAWA</td>
</tr>
<tr>
<td>A01054 Fabrication Method of Porous Metal using Ultrasonic Microbubble Generator</td>
<td>Kouyo TAMAKI, Toshinori MAKATA</td>
</tr>
<tr>
<td>A03085 Comfortable Outdoor Space Formation at High Temperature Season by Tree-Planting with Spray-System</td>
<td>Hiroki NAGASHIMA, Sumito SATO, Yuya ISHIDA, Haruhiko IWASAKI, Ayako YANO, Kenji AMAGAI</td>
</tr>
<tr>
<td>A04097 Effect of Dispersed Water Droplet Diameter in Light Oil-Water Emulsion Fuel on Diesel Engine Operating Performance</td>
<td>Takaakun TENTORA, Manabu FUCHIHATA</td>
</tr>
<tr>
<td>A06067 Writing Height Analysis of a Blackboard considering Physical Load to a Teacher and Students’ Vision</td>
<td>Noriyasu HIROKAWA, Shogo NAKATANI, Mitsushi OHMSA</td>
</tr>
<tr>
<td>A07086 Influence on the Standing Burden Exerted by the Seat Surface Trajectory of the Standing Assist Chair</td>
<td>Hiroki TOMYAMA, Noriyasu HIROKAWA, Mitsushi OHMSA, Ichiro KITAYAMA</td>
</tr>
<tr>
<td>A07087 Effect to the Total Hip Prosthesis Metal Back Titanium-Alloy Surface by CNT/PE using the Cyclic Reciprocating Sliding Test</td>
<td>Takako USAWA, Yuya TANAKA, Shigeaki MORIYAMA</td>
</tr>
<tr>
<td>A07114 Mechanical and Histological Evaluation for Skin Tissues Damaged by High Intensity Ultraviolet Irradiation</td>
<td>Daiki IMAI, Yuki KAWAMURA, Yuki TANIFUJI, Kumiko TAKEMORI, Hiroyuki ITO, EI YAMAMOTO</td>
</tr>
<tr>
<td>A08107 Mechanical Properties of Composite Parts Manufactured by Air Cushion Method</td>
<td>Chih-Yuan Chang</td>
</tr>
<tr>
<td>A09008 Observation of Impact Fracture in Ice by Simplified Percussion Test</td>
<td>Hiroyuki YAMADA, Ryo TANAKA, Yuki NAKAO, Hiroyuki FUJWARA, Nagahisa OGASAWARA</td>
</tr>
<tr>
<td>A09043 Shape Processing of Plastic Ankle Foot Orthosis (PAFO) and Their Influence on Stress and Deformation</td>
<td>Miyuki KAWAMURA, Ichiro KITAYAMA, Daiisuke MORIOKA, Takashi YAMANAKA</td>
</tr>
<tr>
<td>A09083 Tensile Behavior on Dried Latewood in Japanese Wood</td>
<td>Shuma YUKI, Akhiro TAKAHASHI, Naoyuki YAMAMOTO, Toshinobu TOYOHISO</td>
</tr>
<tr>
<td>F01020 Visualization of Cavitation Growing and Collapsing Behaviors in Narrow Channel</td>
<td>Shunsuke KAWAMURA, Takashi NAOE, Tsubasa IKEDA, Nobuatsu TANAKA, Masatoshi FUTAKAWA</td>
</tr>
<tr>
<td>F01122 Length of Bubble Dispersion Region in a Cylindrical Bath Subjected to Side Gas Injection through an L-shaped Lance</td>
<td>Yuki FUKUI, Kenji KATOH, Tatsuro WAKIMOTO, Manabu IGUCHI</td>
</tr>
<tr>
<td>F01031 Experimental Study on High Angle of Attack Aerodynamic Flow</td>
<td>Tsai, Ya-Han, Miau, Jiun-Jih, Chou, Hung-Yen</td>
</tr>
<tr>
<td>F01081 Design and Application of Multiple Synthetic Jet Actuators</td>
<td>Chia-Wei, Hsu, Chih-Yuan, Weng</td>
</tr>
<tr>
<td>F02098 Experimental Observations of the Air Cavities Generated by the Impacts of Spheres on Free Water Surface</td>
<td>Chih Huang Chiang, Cheng Chiang Hsu</td>
</tr>
<tr>
<td>F04135 Fluid Flow and Heat Transfer of Natural Convection Induced in Horizontal Circular Slots</td>
<td>Fumiyoshi KIMURA, Nao SHIRAI, Kenzo KITAMURA</td>
</tr>
<tr>
<td>F05104 Methods of Drop Experiments to Simulate Blast Experiments</td>
<td>Hiroyuki FUJWARA, Shotaro FUJWARA, Momentaro NAGAYAMA, Keiji WATANABE</td>
</tr>
<tr>
<td>F06032 Estimation of Irreversibility Fields in Superconducting Pb-Bi Alloy</td>
<td>Yuki MOCHINAGA, Yusei MIYAJI, Ayano SIMIZU, Tsugio HAMADA</td>
</tr>
<tr>
<td>F06127 Fracture Behavior of Aluminum and Silver Alloy Thin Films on Polymer Thin Films</td>
<td>Osphiro KOBAYASHI, Hideaki FURUMOTO, Shigeru NAGASHAWA, Hideyuki KANEMATSU, Ion Cosmin GRUESCU, Mizuki ONO</td>
</tr>
<tr>
<td>F07053 Design of Laminated Flooring Materials with Soft Underfloor Layer to Prevent Femur Fracture</td>
<td>Kaito SHINMURA, Yasumi ITO, Yoshiyuki KAGIYAMA, Ryouchi YAMADA, Tatsuya FUKUOKA, Tomotaka MATSUBARA</td>
</tr>
<tr>
<td>F07057 Dynamic Viscoelasticity Properties Evaluation of Skin and Development of Dummy Skin for Safety Evaluation – Analysis of Deformation Behavior in the Depth Direction of the Skin –</td>
<td>Sota KONDO, Yasumi ITO, Tatsuya FUKUOKA, Kazuya CHIGIRA, Yoshiyuki KAGIYAMA, Ryouichi YAMADA, Tetsuya NEMOTO</td>
</tr>
<tr>
<td>Code</td>
<td>Title</td>
</tr>
<tr>
<td>--------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>F10092</td>
<td>Numerical Study of Elastic Wave Propagation in Flanged Cylindrical Bar</td>
</tr>
<tr>
<td>F11025</td>
<td>Visualization of the Blast Wave Generated by Laser Induced Plasma using Schlieren Method with High Speed Camera</td>
</tr>
<tr>
<td>F11136</td>
<td>Development of High Performance MEMS-Base Accelerometer for Vibration Monitoring</td>
</tr>
<tr>
<td>A16108</td>
<td>Porosities and Strengths of Ceramics utilizing Waste Glass Fiber Reinforced Plastic</td>
</tr>
<tr>
<td>A11124</td>
<td>X-ray Stress Measurement of Carbon Fiber in CFRP</td>
</tr>
<tr>
<td>A11133</td>
<td>X-ray Stress Measurement of the Anodizing Film on Titanium Plate</td>
</tr>
</tbody>
</table>
Evaluation of pressure wave-induced cavitation erosion in mercury narrow channel

Takashi Naoe, Hiroyuki Kogawa, Nobuatsu Tanaka, Masatoshi Futakawa
Japan Atomic Energy Agency
Corresponding: Takashi Naoe, takashi.naoe@j-parc.jp

Abstract: A liquid mercury target system for high-power spallation neutron source has been in operation to provide neutron beams for innovative scientific research at the Japan Proton Accelerator Research Complex (J-PARC). In the mercury target, pressure wave-induced cavitation due to the 3–GeV proton beam injection is a critical issue to achieve stable high-power operation at the goal of 1 MW. A mercury target vessel, which is for embracing liquid mercury and is made of 316L stainless steel, is severely damaged by cavitation erosion and its structural integrity is remarkably degraded. In addition to inject gas microbubbles into flowing mercury for mitigating pressure waves, the double-walled target beam window consisting of the narrow channel structure with the inner and outer wall is adopted to mitigate the cavitation damage by high-speed mercury flow (~4 m/s) and narrow gap boundary (2 mm).

In this study, to quantitatively investigate the effect of the gap width and the flow velocity on pressure-wave induced cavitation damage, cavitation erosion tests conducted by parametrically changing gap with and mercury flow velocity using an electro-Magnetic IMPact Testing Machine (MIMTM). The MIMTM can apply the pressure pulse in mercury for generating cavitation by external force, although the mechanism of pressure wave is different from abrupt thermal expansion by proton beam injection. The results showed that the damage degree expressed as Sa (Arithmetical mean height of the surface) and Sz (Maximum height of the surface) of ISO25178 were decreased by mercury flow. On the other hand, flow velocity dependency was hardly observed in the range between 1.5 m/s and 4.0 m/s. Furthermore, Sa and Sz were seemed increased with increasing with gap width, whereas the opposite trend was observed with the test under stagnant conditions. The mechanism of cavitation damage reduction by narrow channel structure will be discussed.

Keywords: Cavitation erosion, Pressure waves, Narrow gap, Liquid metal, Flow effect
Optimization of the swirl gas microbubble generator for a liquid mercury target vessel

Tsubasa Ikeda, Hiroyuki Kogawa, Takashi Naoe, Shunsuke Kawamura, Nobuatsu Tanaka, Masatoshi Futakawa
Graduate School of Science and Engineering, Ibaraki University
Corresponding: Tsubasa Ikeda, 17tm403g@vc.ibaraki.ac.jp

Abstract: A liquid mercury target for the pulsed spallation neutron source has been in operation at the Japan Proton Accelerator Research Complex (J-PARC). The pressure waves are generated by the rapid thermal expansion of mercury due to the high-intense pulsed-proton beam injection. The pressure waves induce cavitation, and the cavitation forms severe erosion damage on the thin-wall surface of a mercury target vessel which is composed stainless steels for containing mercury. Since the cavitation erosion deteriorates the structural integrity of the target vessel, cavitation is a major issue that has to be overcome for realizing a high-power stable operation for neutron source. Gas microbubbles injection into mercury is one of the effective techniques to suppress the pressure waves that induce cavitation. Microbubbles of less than 100μm in diameter have enough high resonance frequency to suppress the pressure waves in mercury. To generate helium gas microbubbles into the liquid mercury, which has a large surface tension, high-density and bad wettability to the stainless steel, a swirl-flow bubble-generator has been developed.

The swirl-flow bubble-generator consists of vanes to make swirl flow of mercury and Venturi. Gas column generated in the center of the swirl flow is broken into microbubbles due to the shear force and pressure difference at exit of the Venturi. Generated bubble size is correlated with the swirl flow intensity that was depending on the vane angle, reduction rate of Venturi and flow rate. By contrast, the pressure drop of bubble generator is increased with the vane angle, reduction rate of Venturi and the liquid flow rate. In the mercury target, it is necessary to keep the pressure drop at the bubble generator less than 0.2 MPa from the viewpoint of the capacity of an existing mercury circulation pump. Helium gas for injecting bubbles is provided from cover gas in a surge tank of the mercury circulation system by utilizing pressure difference between cover gas and gas injection point of bubble generator. Therefore, decreasing pressure at the gas injection point (aspiration pressure) is related to increasing injecting gas, which results in much reduction of pressure waves. In this study, to optimize the swirl-flow bubble-generator for decreasing the aspiration pressure without increasing pressure drop at the bubble generator, Dependencies of the vane angle and reduction rate of the Venturi were parametrically investigated.

Although the characteristics of bubble-generator are depending on the density of liquid and the surface tension, as a first step, we investigated bubble-generator in transparent water for visualizing the generated gas microbubbles. In the conference, relationship among the aspiration pressure of bubble-generator, the vane angle, and the water flow rate will be discussed.

Keywords: Mercury target, Cavitation erosion, Pressure waves, Microbubbles, Swirl-flow bubble-generator
Fabrication method of porous metal using ultrasonic microbubble generator

Kouyo TAMAKI, Toshinori MAKUTA
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Abstract: The porous metal which has a cell structure, have attracted attention as they have excellent characteristics, such as a higher stiffness to weight ratio and the ability of great impact energy absorbers. The molding method with metal powder metal, the fabrication method with the addition of blowing agent and thickener to a liquid metal are used as conventional methods. However, these conventional methods have the difficulties about the complexity of the fabrication process and the cost of materials, additives. The purpose of study is to develop a novel fabrication method for the porous metal at simple and low cost.

Makuta et.al, [Ultrasonics, 53 (2013), 196–202.] developed a microbubble generator using a hollow cylindrical ultrasonic horn with a path for supplying the gas. In this method, the gas supplied through the path in the horn creates a gas-liquid interface in water and microbubbles of less than 100 µm in diameter are easily generated by irradiating ultrasonic oscillation to the interface. In this study, we developed a novel fabrication method for closed-cell porous metals by generating microbubbles in molten metal by using this microbubble generation technique. Microbubbles generated in the molten metal have low buoyancy, the generated microbubbles stay in the molten metal until solidified by cooling, foams are formed, and closed-cell porous metal is obtained. Observation of the cross section with the optical microscope reveals that the porous metal prepared by using the lead-free solder alloy in this fabrication method is a closed-cell structure containing numerous pores. We determined the porosity of the fabricated closed-cell porous metal is greater than 70%. Moreover, compared with the conventional fabrication method, no thickening agent and foaming agent is necessary in this fabrication method. Therefore, closed-porous metal fabricated by this method is expected to be low cost. We also report differences and effects of melting points to porous metal formation by using several lead-free solder alloys.

Keywords: Microbubbles, Porous Metals, Metal Foams, Gas Injection, Ultrasonic Field
Fabrication method of porous metal using ultrasonic microbubble generator

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Abstract: The porous metal which has a cell structure, have attracted attention as they have excellent characteristics, such as a higher stiffness to weight ratio and the ability of great impact energy absorbers. The molding method with metal powder metal, the fabrication method with the addition of blowing agent and thickener to a liquid metal are used as conventional methods. However, these conventional methods have the difficulties about the complexity of the fabrication process and the cost of materials, additives. The purpose of study is to develop a novel fabrication method for the porous metal at simple and low cost.

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Keywords: Microbubbles, Porous Metals, Metal Foams, Gas Injection, Ultrasonic Field
Relationship Between Vortex Shedding from Rotating Body in Uniform Flow and Fluid Force Acting on the Rotation Axis – On S Shape Blade Vertical Axis Turbine

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Abstract: In this report, the purpose is to investigate the relationship between fluid force acting on S-shaped vertical axis turbine and vortex shedding.

In mechanical engineering, the purpose is to produce products with functionalities, and in the field of fluid engineering in it, it is important to know the mechanism of fluid force generation acting on body in the flow.

When the generation mechanism of the fluid force is clarified, the policy of shape determination in the machine design work is clarified, so that the design engineer can achieve the improvement of the function of the product.

Components of fluid force acting on a body include lift and drag.

In general, circulation generation may be involved in the generation of fluid force, but in particular in the generation of lift force in uniform flow, it generates circulation around the body.

The generation of circulation releases the vortex from the body into the flow field.

Therefore, it is possible to estimate the generation mechanism of fluid force by observing the vortex in the flow field.

The rotation angle of the rotating body in the uniform flow varies with the azimuth angle, and the fluid force acting on the body changes. Therefore, vortex that is a vortex is circulation periodically emitted from the rotating body in response to the change in the circulation bound to body.

Circulation emissions obtained by flow field visualization include not only lift but also circulation emissions related to drag. It is difficult to separate the circulation caused by these. But in the case where the fluid force fluctuates periodically due to the rotation of the body, it is a requirements for generating the large fluid force that the maximum value of the magnitude of fluctuates circulation is large.

In this study, we adopted an S-shaped vertical axis wind turbine as a rotating body.

There are items that observe the circulation in the conventional reports on wind turbines, but there are few reports focusing on the relationship between circulation generation and lift or fluid force.

Particle images obtained by flow visualization experiments were analyzed by PTV to obtain the velocity field.

By subtracting the rotation speed of the turbine from the absolute velocity field, the velocity field relative to the turbine was obtained.

By this treatment, the vortices released from the body became clearer than the absolute velocity field in the relative velocity field.

Using this, observe the vortex shedding. in the flow field from the rotating coordinate system for the turbine.

We investigate the torque obtained from the torque characteristics of the turbine and consider whether there is a relationship between the torque and the vortex shedding from the blade.

Keywords: Wind turbine, Water turbine, Circulation, Flow Visualization, Wind tunnel testing
Combustion characteristics of Biocoke in different apparent density

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Abstract: Biocoke (BIC) is biomass solid fuel which was solidified by simultaneously heating and pressing. BIC is expected by using a melting furnace or a shaft type furnace as alternative fuel of coal coke because BIC has high hardness. Hardness is one of important properties not to break in a furnace during combustion. And the apparent density of BIC is also higher than pellet or briquet. Previous study, it was reported that formation conditions, especially moisture content, of BIC has effect on apparent density. On the other hand, as the formation size becomes large the apparent density was high.

In this study, we focus combustion characteristics based on the apparent density of BIC. We formed BIC using Japanese cedar. As formation conditions of BIC, the initial moisture content was 3wt% and 10wt%. Raw material was put in a reaction cylinder and heated to 443K under pressure 20MPa. The formation diameter of BIC was φ12mm, φ20mm, φ30mm, φ40mm and φ48mm. Their apparent density of 3wt% and 10wt% BIC was 1.23-1.33 and 1.40-1.44 g/cm³ respectively. We clarified quantitatively their combustion characteristics which were combustion rate and flaming and char combustion time. The combustion examination was conducted in a furnace of 973K. Yield of weight of sample in combustion process was measured, and it was input to a computer every one second.

According to the study of Ito (2016), combustion behavior of the high-density biomass briquette, this paper suggested that the average weight loss rate was proportional to surface area during flaming combustion. In this study, we found out 10wt% BIC combustion characteristic has similar behavior. Here, the average weight loss rate was the value which obtained by dividing specific surface area (surface area per unit volume) because the surface area of the sample was different. Furthermore, we also indicated that the average weight loss rate was inversely proportional to apparent density during flaming combustion. This result was the same as the result during char combustion.

Keywords: Biomass, Biocoke, Combustion, Moisture content, Apparent density
Finite element analysis of the temperature change during solar radiant heat reception of a moss-greening ceramic utilizing waste silica

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Abstract: To recycle silica byproducts and to moderate the heat-island phenomenon, a porous ceramic was prepared by mixing waste silica powder with clay and then firing the resultant mixture. By exploiting the high water absorption capacity of the resulting ceramic, a greening material of porous ceramic covered with moss was produced. The moss-covered ceramic is lightweight, and can be attached to rooftops without complicated adhesive processes because the ceramic base can be bonded to the floor. Moss maintenance is straightforward.

This study aims to clarify quantitatively the suppression effect of the temperature increase caused by solar-radiant heat on the moss-covered ceramic. There are a number of studies on the suppression effect of the temperature increase caused by solar-radiant heat on the moss-greening materials. Some of the studies have reported that water included in the sample has a large effect on the temperature reduction. However, their reports generally seem to be phenomenological considerations. It is unknown how much heat from water evaporation and moss transpiration affect the sample temperature reduction. Therefore, it is desired to clarify quantitatively the influence of water content in the sample on the temperature for optimal design.

So, to clarify the influence of heat from water evaporation on the temperature reduction effect of the moss-covered ceramic, we investigated the temperature change of the sample during solar radiant heat reception using the following procedure.

1. The surface temperature change of the water-absorbing moss-covered sample during solar radiant heat reception, and the amount of water that evaporated from the sample were measured simultaneously.
2. The heat of evaporation was estimated from measurements of the rate of water evaporation.
3. To investigate how much the sample temperature was reduced by the heat of water evaporation, the temperature change of the sample when the heat of water evaporation was absorbed from the sample through heat exchange, was simulated by performing FEM analyses.

The summary of the results is as follows.

1. The moss-covered sample did not exhibit much the suppression ability of the temperature increase caused by solar-radiant heat when the sample did not contain sufficient water. The primary factor of the temperature reduction effects on the moss-covered sample was the action of heat from water evaporation.
2. This analytical method proposed in this study enabled us to simulate, with a relatively high accuracy, the temperature change of a water-absorbing sample during solar radiant heat reception. This method enabled us to investigate quantitatively or visibly the influence of water evaporation heat on the sample temperature in addition to the influences of the emissivity of the sample and the apparent specific heat and thermal conductivity changes due to water content in the sample.

Keywords: Waste silica, Porous ceramic, Moss-greening material, Heat of evaporation, FEM analysis
The suppression effect of temperature increase by solar radiant heat of a moss-greening ceramic utilizing waste silica.

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Abstract: Silica is used in various products, including desiccants, toiletries and filtration materials. However, many byproducts are produced during its manufacture, and many of these are discarded as industrial waste. The effective use of waste silica is therefore desirable. On the other hand, countermeasures to the urban heat-island phenomenon have become increasingly important. A rooftop greening of buildings is an effective countermeasure to the urban heat-island phenomenon. However, rooftop greening has not advanced significantly due to various issues such as the installation cost and maintenance of greening-plants.

Considering that situation, to recycle silica byproducts and to moderate the heat-island phenomenon, a porous ceramic was prepared by mixing waste silica powder with clay and then firing the resultant mixture. The high water absorption capacity of the ceramic was used to produce a greening material: a moss-covered porous ceramic. To examine the suppression ability of the temperature increase caused by solar radiant heat on the moss-covered ceramic as well as to clarify the influence of water absorption in the sample on the temperature increase suppression effect, the surface temperature change of a moss-covered sample during solar radiant heat reception and the amount of water evaporated from the sample were measured simultaneously. Furthermore, to verify whether the moss-covered ceramic can reduce the indoor temperature, the heat flux acting between the sample rear surface and the rooftop floor of a testing structure was measured. These measurements were compared with those of mortar and ceramic samples without moss in the non water absorbing and water absorbing states. The heat quantity that was absorbed from the sample due to water evaporation was also estimated from values of the rate of water evaporation measured in the experiments.

The summary of the results is as follows.
(1) The moss-covered sample does not exhibit much ability to suppress the temperature increases caused by solar radiant heat when the sample does not contain sufficient water. It was confirmed that water content in the sample significantly contributed to reducing the sample temperature.
(2) The moss-covered and ceramic samples in the water absorbing state could suppress the temperature increase caused by solar radiant heat, and the moss-covered sample could suppress it for a longer time compared with the ceramic sample. It was also found that the moss-covered sample could mostly reduce the heat flow between the sample rear surface and the rooftop floor caused by solar radiant heat.

It is expected that the moss-covered ceramic could be used as a greening material on building rooftops.

Keywords: Waste silica, Porous ceramic, Moss-greening material, Temperature-increase suppression-effect, heat of evaporation
Comfortable Outdoor Space Formation at High Temperature Season by Tree-planting with Spray-system

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Abstract: Average temperature in Japan became higher compared to the past, and it is thought that global warming and urban heat island are main causes. Particularly in the downtown area of Tokyo, there are many places where the ground is covered with asphalt or concrete, and the influence of the urban heat island is considered to be larger. In summer, a lot of people become heat stroke. Therefore, it is very important to take measures to ease summer heat.

One means effective to relieve summer heat is tree planting. Trees have the blocking effect of direct sunlight by their leaves and the effect of dissipating heat by water evaporation from the leaves. However, It takes long times to grow up from young tree to large tree.

In this study, we carried out the demonstration test against summer heat by planted trees in containers and mist spray in the summer of 2015. We planted 3 to 5 m in height and 2 to 4 m in branch width trees in the container. These trees were able to form enough shade. The place of experiment was the parking lot of Tokyo Big Sight which is one of the major event venues in Japan. We measured the air temperature, WBGT, solar radiation, etc. in four areas, i.e. (1) town-street area, (2) water spray without tree-planting area, (3) tree-planting area, (4) tree-planting with water spray area. Three containers planted trees are placed in each area. Droplet diameter of the spray mist is about 30 um. Air temperature was measured from 11 o'clock to 15 o'clock, and was only reduced by 0.5 to 1 degree Celsius in the tree-planting with water spray area compared with the town-street area. However, the globe temperature could decrease by 3 degrees in the tree-planting area and 7 degrees in the tree-planting with water spray area. Also, based on the WBGT used as a guideline for the risk of heat stroke, the time judged as “danger” decreased from 42.9% to 20.7% of the total time, so it was confirmed that trees and mist have a great effect of preventing heat stroke.

Keywords: Tree-planting, Spray cooling, Temperature measurement, WBGT, Demonstration experiment
A study of mechanical properties of Bio-coke produced from green tea grounds by the addition of bamboo fiber

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Abstract: In this study, the modification of Bio-coke fuels as an alternative to coal coke is investigated by using green tea grounds and bamboo, which is considered to be the second largest resource of forestry in the whole world because of its rapid growth potential. One of the roles of coal coke is to keep the permeability of air and liquid in the blast furnace. Furthermore, a loading pressure of 0.1MPa is loaded on coal coke within the furnace. Hence, coal coke requires hardness. As such Bio-coke requires hardness as well. High-density solid biomass; Bio-coke is produced from the mixture of green tea grounds and bamboo fiber based on the patent (PAT.-No.4088933) as one of the utilization methods of unutilized biomass. Mixed Bio-coke of green tea grounds and bamboo fiber were produced with different content ratio and particle size as variable parameters. The usage of green tea is one way to be able to effectively utilize domestic biomass resources that are being disposed at large and small scale everyday into alternative energy. The compressive strength of each kind of Bio-coke under room temperature and high temperature were measured with a compression test machine. The experimental results showed that the compressive strength of the mixed Bio-coke was related to the mixture content weight and the particle size of the bamboo fiber. The particle size may have an effect on the bonding mechanism of Bio-coke structure. The bonding mechanism that is expected to be the factor of strength difference in this study is still needed further investigation by studying the cross section surface of fractured Bio-coke. The result indicates that if the content weight of bamboo fiber in the mixture increase, the apparent density also increases. Thus, it is observed that the compressive strength is linearly increasing to the apparent density. In conclusion, mixed Bio-coke has great possibility to improve the mechanical properties of Bio-coke.

Keywords: Mixed Bio-coke, Green tea grounds, Bamboo, Particle size, Compressive strength
Influences of material characteristics on mechanical properties

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Abstract: Climate change has increased the awareness to use renewable energy instead of fossil fuel. Excessive usage of fossil fuel since industrial revolution has caused atmospheric concentration of carbon dioxide levels to increase aggressively. Biomass is a promising renewable energy technology with the potential to convert waste streams into chemicals, fuels, and power for the future. Biocoke (BIC) acts as alternative solid fuel for reducing the usage of coal coke in the steel production industry. For that, BIC must have high compressive strength to endure severe conditions in blast furnace and maintain air passage in blast furnace. One of the solutions is to make an improvement on mechanical properties of BIC is mixed BIC. The objective of this research is to investigate the effect of mixing other materials with different characteristics on the mechanical properties of the solid fuel and find the factors that influence the changes on mechanical properties of the biomass solid fuel. Experiment will be divided into two parts. Firstly, BIC is made from green tea leaves, shinoki (Castanopsis tree), and EFB (empty fruit bunches) with initial moisture content of 1%, 3%, 5%, 7%, and 10%. Then the compressive strength under room temperature was measured using compression testing machine (SHIMADZU, AG-300kNX). Next the optimum condition from each material will be selected to make two types of mixed BIC which are EFB+Green tea and EFB+Shinoki. Then compressive strength under room and hot (973K) temperature tests will be conducted. The results of the mechanical properties of mixed BIC show that there is a significant improvement in compressive strength under hot temperature. The result suggested that mixed BIC has a great possibility to make an improvement on mechanical properties of BIC. Also, main components of the materials which are the composition of lignin, cellulose, and hemicellulose and the shape of materials need to be considered in making high mechanical properties of mixed BIC.

Keywords: Biomass, Solid fuel, Renewable energy, Compressive strength, Mechanical properties,
Abstract: In recent years, most of our lifestyle is depending on fossil resources such as oil, coal and natural gas that are expected to deplete in the future. In addition, many of these fossil resources are used as fuel, and carbon dioxide is discharged by combustion behavior, causing global warming. In order to solve this problem, it is essential to create a new renewable energy due to replace fossil resources. Biomass is located renewable energy that can contribute significantly to reducing carbon dioxide emissions. If Biocoke (BIC) can be substituted for coal coke used in the blast furnace, it will be a countermeasure against problems of depletion of fossil resources and global warming. In order to ensure the flow path of the hot air in the furnace, BIC must have equivalent/over strength to coal under high temperature environment. From our previous study, the cold compressive strength of the axial direction has about 100MPa. However, in the molding process, anisotropy happened because it is compressed by adding a load in the axial direction, it is conceivable that the compressive strength of the circumferential direction is low compared with the axial direction. The objective of this research is to examine the anisotropy of compressive strength under a high temperature environment. Firstly, BIC is formed from green tea leaves with initial moisture 3% at outer diameter 12mm. Secondly, The thermal decomposition characteristics of BIC center/outer parts are analyzed by TG/DTA. At that time, Determine if the BIC is thermally uniform. Finally, Compression strength in the cylindrical/circumferential direction of the BIC in a high temperature environment is measured using compression testing machine (SHIMADZU, AG-300kNX). BIC aspect ratio is divided into five patterns (1:0.5, 1:1, 1:1.2, 1:1.5, 1:2) for compression testing. Then, if the compressive strength of both in each condition is different, it can be presumed that there is anisotropy.

Keywords: Biomass, Solid fuel, Renewable energy, Compressive strength, anisotropy
The change in Qualities of Densified Biomass Fuel (Bio-coke) Affected by Alkali Lignin Ratio on Cedar Powder

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Abstract: Efficiency of alternative energy has rapidly increased over the last two decades, in order to counter the environment pollution issue, which is caused by burning fossil fuel. Each alternative energy source has its own unique function, depending on applications and circumstances. Biomass has been used to replace fossil fuel in heat, electricity and fuel application, through conversion technology; biochemical, thermochemical and densification technology. This research focuses on biomass densification technology which is an effective alternative of solid fossil fuels like coal or coal coke used for heat and electricity. Qualities of densified biomass include final moisture content (%), bulk density (kg/m³ or g/cm³), the durability index (%), the percent of fines and the calorific value (MJ/kg). The new densification biomass technology was invented by Kindai university professor, Tamio Ida under patent No. 4088933. The manufacturing process involves low amounts of pressure and temperature in the production process, resulting in high density, calorific value and compressive strength product, called Bio-coke.

The bio-coke product made under variables, about 20 MPa of pressure and near 200 degrees Celsius with various die diameters, particle size and moisture content of raw material. In this study, 53-150 µm particle size of cedar powder and alkali lignin powder produced Tokyo Chemical Industry, were used as initial substances. Amount of alkali lignin in cedar powder is a variable condition of this research which are 0%, 2%, 5%, 8% 10%, 15% and 20%. Biocoke samples were produced by a laboratory scale vertical pressing machine (12 mm mold) under controlled condition of 21.4 MPa loading pressure, 190 ºC of mold temperature, 10% of initial moisture and 3 minutes 45 seconds of retention time. Results of this study were analyzed by using a Fourier transform infrared spectrometer (FTIR) which show the molecular structure of Biocoke, together with two of the densified biomass quality attributes, bulk density and calorific value from the SHIMADZU auto calculation bomb calorimeter of samples.

Keywords: Densified Biomass, Biocoke, Alkali Lignin, FTIR, and Calorific Value
Estimation of energy properties of thermally treated biomass by pyrolysis model

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Abstract: Solid biofuels such as wood chips and pellets are one of the renewable energy resources, but they have several problems to be solved. To upgrade the solid biofuels, intense interest has been shown towards thermal treatments lately. The ISO 17225-8 has just been established in 2016, where the specifications and classification of thermally treated pellets and briquettes are provided. The pyrolysis treatment such as torrefaction or carbonization under inert atmosphere is the promising upgrading methods, and many studies have been conducted so far. In the previous studies, it is shown that torrefied solid biofuels have several good features. Firstly, the pyrolysis temperature range is between 200 and 300 deg. C, and therefore torrefied biomass contains 60-80% of the initial mass and 80-90% of the initial heating value. This means that the energy consumption required for the torrefaction process is not so large and the energy yield contained in solid biofuels is quite high. Secondly, several functions are added such as grindability, water repellency and self-heating. To present the effectiveness of torrefaction in the upgrading of solid biofuels, several detail reviews on torrefaction have already been reported.

In our previous study, the effect of torrefaction on the net energy of solid biofuels was investigated by using the simple energy analysis model. In the analysis model, energy properties such as the mass yield, higher heating value and energy yield of torrefied biofuels are needed, and they are given by the experimental data. The energy properties depend on not only the biomass material but also the torrefaction conditions such as temperature and holding time for pyrolysis. To evaluate the net energy of torrefied biofuels, the energy properties had to be measured experimentally for every biomass material.

In this study, to estimate the energy properties of thermally treated biomass at a given pyrolysis condition, the pyrolysis kinetics is investigated by applying the first-order pyrolysis reaction model to the experimental data obtained in a thermogravimetric reactor. The ranges of temperature and holding time for pyrolysis are 220-300 deg. C and 0-20 h. From the estimated results of the mass yield and higher heating value of thermally treated biomass, it is found that the energy yield can be expressed as a function of the mass yield for various holding time for pyrolysis. The mass yield and energy yield obtained by the pyrolysis model enables us to evaluate the net energy contained in thermally treated solid biofuels. Moreover, the optimum pyrolysis conditions to minimize the heat loss from a furnace is also given, when the thermally treated biomass with the prescribed mass yield is produced.

Keywords: Biomass, Pyrolysis kinetics, Heating value, Energy yield, Mass yield
Abstract: Geothermal energy has been used for electric power generation more than hundred years ago in many countries. However, in the typical geothermal power plant, the only high-temperature geothermal reservoir is suitable to use for commercial production, where hot water or steam, which temperature is higher than 220 °C, is pumped up from the underground reservoir to drive a turbine for electric power generation on the ground. It can be seen that the high rate of energy is required to drive the geothermal fluid in the power plant process. Another factor to consider is the utilization of shallow low-temperature geothermal reservoir for electric power generation.

To utilize the low-temperature geothermal energy from the shallow borehole, the heat pipe (thermosyphon) principle where a working fluid with a low boiling temperature is circulated and extracted heat to generate electric energy in the secondary cycle. The heat pipe achieves a very efficient heat transfer with a vapor (heat) flowing vertically upward and liquid flowing down associated evaporation and condensation effects. To confirm the working principle of the low-temperature geothermal heat pipe, the experiment apparatus has been originally designed and constructed. As the initial design, the primary structure of the vertical heat pipe model is made from aluminum with 1.7 m height. Water has been used as a working fluid to observe the working principle of the heat pipe. At the bottom basin of the pipe, water is filled, while the heater is used to heat water and turns it into steam. High-temperature steam flows upward through the heat exchanger unit at the upper side of the pipe. Particularly, copper tube spiral structure is designed as the heat exchanger, where cooling water is used to cool down and condense steam to water. After condensing, water flows to the bottom basin by the gravitation force to absorb the heat for the next cycle. Thermocouples and mass flow rate are installed to measure at the heat exchanger to measure the heat transfer performance of the heat pipe.

The filling ratio of the working fluid in the heat pipe together with the heat transfer properties from the hot reservoir (heater) to the cold reservoir (heat exchanger) with a driving force generated by a working fluid in the pipe has been investigated for the optimum heat pipe performance. It can be observed that the optimum efficiency of the heat pipe can be achieved at filling ratio of 0.55. Furthermore, the visualization experiment on the steam velocity is observed by associated with the filling ratio. The details of heat pipe experiment and methodology are discussed in this study.

Keywords: geothermal, heat pipe, fulling ratio, flow visualization, steam velocity
Process development and evaluation for upgrading heavy pyrolytic oils from industrial waste into high-valued fuels

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Abstract: Traditional fuels still the main sources of the energy. Non-renewable fuels contribute to greenhouse effects, beside, there are still problems about the limitation. Hydrodeoxygenation is an potential method to transform pyrolytic oils into usable fuels in the future. Catalysts were used in this process. A series of parameters were carried out. Fixed-bed reactor can effectively transform the heavy oils into usable species as the coke formation reduce instead. Hydrogen environment give the solubility through the catalyst to get better results. With a long the reaction time, a better degree of deoxygenation (DOD) (e.g above 90%) will be obtained, also result with low coke formation. When the feed has no enough time to be react, a polymerization at the top of the reactor will be occurred. To get a better quality of usable fuels, parameters should be concerned to for this process. Based on this study, techno-economy has been studied. With a statistic feedrate for a day, the minimum retail prices for the upgrading pyrolytic fuels have been Calculated.

Keywords: Biomass Fast pyrolysis; Pyrolytic oils; Bio-fuels; Hydrotreatment; Hydrodeoxygenation
Effect of Dispersed Water Droplet Diameter in Light Oil-Water Emulsion Fuel on Diesel Engine Operating Performance

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Abstract: In recent years, NOx and soot contained in the exhaust gas of diesel engines become problems. Currently they are elutriated by exhaust gas aftertreatment devices, which make the engine system more complicated. Therefore, we focused on emulsion fuel, which is known as the simultaneous reduction technology of NOx and soot. Although emulsion fuel is generally characterized by its water content, some literatures report that the effect on the diesel engine performance could not be controlled by the water content properly. Therefore, we focused on dispersed water droplet diameter as the other factor. In this study, we prepared emulsion fuels of different water droplet diameters and investigated the exhaust gas and power performance of a diesel engine with these fuels. The emulsion fuels consist of light oil, water and surfactant. We added 2.0 vol% of surfactant whose HLB value was adjusted to 6.0 to light oil. The water content was 10 and 15 vol%. We prepared emulsion fuels of three different mean dispersed water droplet diameters. The diesel engine used in our experiment was of air-cooled, single-cylinder, jerk pump driven direct injection type. The displacement is 320 cc. The test fuel was 6 types of emulsion fuel (3 kinds of dispersed water droplet diameter, water content 10 and 15 vol%) and light oil. The operating condition was the governor position of 7/8 and the engine speed of 2300 rpm. The engine speed was kept constant by load adjustment of a hydraulic dynamometer. At this time, we measured exhaust gas emission (NOx, Soot and CO) and power performance (Output power, Thermal efficiency and Ignition delay). We found a relationship between Sauter Mean Diameter of dispersed water droplet (Ds.m.d.) and each parameter. The smaller Ds.m.d. is, the more the NOx and soot reduced. On the other hand, the bigger Ds.m.d. is, the higher the output and thermal efficiency were.

Keywords: Diesel Engine, Emulsion Fuel, Water Droplet Diameter, Emission, Thermal Efficiency
Development of a 300kgf Bypass Hydrogen Peroxide Hybrid Rocket System

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Abstract: The objective of this research is to establish a 300kgf bypass liquid hydrogen peroxide hybrid rocket system, and the study includes theoretical calculation, bypass liquid hydrogen peroxide (HP) catalyst chamber design and engine design. The purpose of using bypass liquid HP spray is to prevent the heat transfer from combustion chamber which may cause damage and failure to the swirl injector. Hybrid rocket is a good candidate for the upper-stage rocket for the orbital insertion due to the outstanding capability of throttling, restarting, safety, and low-cost. The advantage of using HP as the oxidizer is that HP can react with catalyst to generate high temperature oxygen and steam, leading to auto-ignition in the combustion chamber; and HP is a green propellant causing very minor impact to the environment; and has the highest density-Isp compared with gaseous oxygen (Gox) and N2O. The design of the catalyst chamber is based on the previous experience of long-term studies of the HP mono-propellant thrusters and 30kgf HP hybrid rockets in our laboratory. Based on the results of previous experiments, the platinum-base catalyst is used in the catalyst chamber to decompose high concentration HP up to 95%. The determination of oxidizer flux of catalyst chamber, swirl injector, and length-diameter ratio (L/D) of the propellant are scaled up based on the successful previous results of the 30kgf HP hybrid rocket. In the first part of this research, we use flow visualization and cold gas to simulate the decomposed gas and HP spray inject into the propellant port. In the second part of this research, we use different distance of propellant and inject decomposed gas to measure the ignition distance of spray. Thermocouples are placed at the downstream of the catalyst chamber and in the combustion chamber to measure the temperature rise with time, which is used to verify the catalyst performance and to identify the suitable ignition distance for spray. The last of this research is testing. Experimental test results of the 300kgf hybrid rocket system show that the decomposed gas of HP can extend the spray distance, resulting the longer propellant distance for ignition. The time from initial state to steady state of catalyst is about 0.4s, which is acceptable for igniting the rocket engine. The ignition distance and the designed bypass liquid HP hybrid rocket performance are satisfactory as anticipated.

Keywords: hybrid rocket, bypass catalyst, hydrogen peroxide, spray injection, auto ignition
Co-Combustion Characteristics of Sewage Sludge Mixed with Coal

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Abstract: Co-firing of biomass with coal can be the gateway to reduce CO2 emissions associated to power plants, since biomass can be considered as a carbon neutral fuel, while maintaining stable and secure energy supply for power generation. Because biomass properties are different when compared to coal, it is necessary to comprehend biomass combustion behavior and to ensure that existing furnaces can be used to co-fire coal with biomass fuels. In this study, combustion characteristics of sewage sludge, Australian black coal, and their blends is analyzed by the use of thermogravimetric analysis (TGA) in order to verify their thermal decomposition process and investigate some combustion characteristics parameters such as ignition temperature, burnout temperature, flammability index and combustion characteristics index. Combustion behavior of the fuels and blends was also observed via single pellet combustion experiments. The results of TGA show that sewage sludge combustion takes place in a two-stage thermal degradation and is finished before the temperature reaches to 540 °C which is due to the devolatilization process, volatile reaction and the oxidation of air with complex components. While coal combustion show a typical one-stage thermal degradation. Adding sludge to the mixture decreases their ignition temperature and burnout temperature up to a certain level. Blends with 25 % of sludge exhibits greater values for C and S due to the release and oxidation of the less reactive components. Sludge having more volatile contents than coal are easier to ignite. The single pellet combustion results also show that ignition delay time reduces to a certain extent with the addition of sludge to the blends. Whereas volatile combustion time increases when sludge blending ratio (SBR) reaches 25 %, then decreases for higher sludge content. Total combustion time decreases sharply for blends having higher SBRs. Overall, the co-firing of sludge and coal enhances the combustion reactivity and will help to evaluate the reuse of sludge as energy resources in the future.

Keywords: Sewage sludge, Co-combustion, Thermogravimetric analysis, Combustion characteristics parameters, Single pellet combustion
Design and Ground Tests of a High-Test Peroxide Mono-Propellant Thruster for Satellite Reactive Control

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Abstract: Traditionally, hydrazine is one of the most widely used propellant for the Reactive Control System (RCS) of a satellite. However, with the revised humanity and environmental consideration in the new century, nontoxic and environmental friendly green propellants such as hydrogen peroxide are reconsidered as an important alternative to displace the highly-toxic hydrazine. The objective of this study is to design and develop a high-thrust and high-test mono-propellant thruster that produce a thrust level of 20N to 50N in vacuum (at expansion ratio = 100) with low toxic and environment friendly propellant. 95 wt.% hydrogen peroxide was selected for the propellant of the thruster. Platinum-coated metal meshes were used to construct the catalyst bed for the thruster. The propellant will decompose then generate oxygen and steam gas with heat when flow through the catalyst. The decomposed high pressure and high temperature gas will further pass through the nozzle to generate thrust. The preliminary ground test was in the atmosphere and the nozzle of the prototype thruster has an expansion ratio of 2, which enables the exit pressure of the nozzle to match the atmosphere pressure. The purposes of the test are to examine the general performance of the catalyst bed and thruster design. In the test the measurements include the propellant tank pressure, thruster chamber pressure and temperature, the thrust and the propellant flow rate. By adjusting the propellant tank pressure, different operation pressures of the thruster chamber can be achieved to generate different thrusts and flow rates. The atmospheric performance test results are summarized as follows. The thrust has reached 14N to 37N with different chamber pressure (11bar~26bar), which is very close to theoretical value (16N to 40N, exp. ratio=2, in atmosphere) and the theoretical vacuum thrust (20-50N, exp. ratio =100) under these chamber conditions is 24N to 54N. The injector can suppress up to 20% chamber pressure resonant oscillation with acceptable pressure drop. The Isp is 124s in atmosphere (139s for theoretical value) at a chamber pressure of 26 bar. The chamber temperature is 875°C~885°C, which slightly excesses the adiabatic decomposition temperature (870°C) of 95 wt.% H2O2, it’s due to the inaccuracy of the concentration measurement, thus H2O2 used in the test may be slightly higher than 95 wt..% However, it is still reasonable to believe that the propellant decomposed well in the thruster chamber with good thruster performance.

Keywords: Mono-propellant thruster, Green propellant, Hydrogen Peroxide, Catalytic decomposition, Propulsion
A study of Oxy-fuel Co-Combustion of Palm Empty Fruit Bunch with Australian coal

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Abstract: Fossil fuels, like coal, has been the main energy source for the generation of electricity in the world since the industrial revolution. However, it has also caused high level of carbon dioxide emissions. Oxy-fuel combustion is one of promising technologies for CO2 capture. It replaces air with pure oxygen and flue gas for combustion. Both Indonesia and Malaysia annually produce more than ten million tons of Palm Empty Fruit Bunches (EFB) as oil palm residues, which can be used as biofuel. Co-combustion of coal and EFB can effectively reduce the carbon dioxide emissions and achieve waste utilization. In this study, pyrolysis and combustion behavior of Australian coal, EFB and their blends in air and O2/CO2 atmosphere are investigated by means of thermogravimetric analyser (TGA). TG and DTG signals are then used to explore combustion characteristics (ignition temperature, burnout temperature, combustion performance index(S) and flammability index(C)) under different conditions (21%O2/79%N2, 30%O2/70%CO2, 21%O2/79%CO2, 30%O2/70%CO2 and 40%O2/60%CO2). The species (CO2, CO, H2O and CH4) in the flue gas are analyzed through Fourier-transform infrared (FTIR) spectrometer. The characteristic curves of TGA determined from the combustion profiles show both additive and non-additive behaviors. And a single pellet free-drop furnace is also used to measure fuel ignition delay time, combustion time and flame behavior of the fuels. The investigation focuses on the influence of atmospheric composition on combustion process and especially on the comparison between combustion in the air-like versus O2/CO2. Pyrolysis results show that weight loss profiles are similar up to 700 °C, then char-CO2 gasification reaction starts and more CO is produced. Combustion experimental results show that the ignition temperature and the burnout temperature rise when the fuels are burned in 21%O2/79%CO2. In addition, the char combustion time and total combustion time are prolonged. Replacing N2 in the combustion test by CO2 causes slight delay in the combustion of all samples. Overall comparison of DTG profiles shows that oxygen content in the combustion test is the most effective parameter.

Keywords: Oxy-fuel, Co-combustion, Palm Empty Fruit Bunch, Australian coal, single pellet
Abstract: We have mainly evaluated the skills from the kinematic data obtained from the human movements. Cardiopulmonary resuscitation, commonly known as CPR, is an emergency procedure that combines chest compression often with artificial ventilation in an effort to manually preserve intact brain function until further measures are taken to restore spontaneous blood circulation and breathing in a person who is in cardiac arrest. In this study, we analyzed the skill-building techniques of more experienced practitioner and new practitioner of CPR by using Microsoft Kinect. This study aims at building a quantitative model indicating a motion pattern by a comparatively simple method to evaluate the skill using forms of CPR and developing an exercise support system for new practitioners of CPR and those who want to improve their movement techniques. As the first step in this study, it was investigated whether objective evaluation can be performed by Microsoft Kinect in the same way as that by image-based 3D motion analysis. Results show that the Microsoft Kinect sensor measurement enabled detailed motion information at the installation points to be displayed in a short time. It has become possible to estimate the index which is exactly according to 100 beats-per-minute and contains a memorable repeating drum pattern, but not to extract objective characteristics of the compression depth of more experienced practitioners and new practitioners of CPR. Although it was not possible to confirm the detailed motions of chest compressions of CPR in the Microsoft Kinect sensor measurements as obtained in the 3D motion analysis using motion capture, it is believed that an easily installed Microsoft Kinect sensor can provide motion information as the evaluation index in a short time, and that this method will offer effective means for automatically evaluating by using a computer the techniques of clinical practitioners in the future.

Keywords: Skill Science, Microsoft Kinect Sensor, Cardiopulmonary Resuscitation (CPR), Acceleration Sensor, Dynamic Movement
Abstract: A blackboard is one of commonly used and the most effective equipment in teaching at a school. Its usability such as the loads to a teacher’s body and students’ vision to a blackboard depends on the teacher’s writing position, i.e. writing height, on the blackboard. Therefore, it is important for a teacher to write at an appropriate height on the blackboard to improve the teaching effectiveness. This paper suggests the method to analyze the usability of a blackboard and proposes the appropriate writing height considering the physical load to a teacher and the students’ vision.

The method comprises three experiments: (a) muscle activity measurement of a teacher’s upper body, (b) teacher’s writing speed measurement, and (c) students’ vision analysis. In experiment (a), a subject takes four typical postures corresponding that a teacher is writing at four different heights on a blackboard. Next, EMG of the eight muscles for moving a shoulder, an elbow, and a wrist are measured. The physical load to the subject is evaluated by the total evaluation value calculated as the average of %MVC at the eight measured muscles. Then, the blackboard height is divided into three parts based on the relationships between the writing height and the total evaluation value. In experiment (b), the time for writing a sentence that contains about 70 to 80 characters is measured at three different height parts, i.e. upper, middle, and lower. The results are evaluated by the average time of three trials at each height. In experiment (c), a classroom that contains a blackboard, 40 students’ desks and chairs, and several seated students are modeled in 3D CAD systems. The vision to the upper, middle, and lower part of the blackboard are evaluated by a student sitting at the center or the end of the row of the classroom using a digital mannequin. And the vision for each height is evaluated by the ratio of its visible area and its whole area. Three blackboard heights are scored in each experiment and the results are integrated by averaging the scores for total evaluation.

Six subjects participated in each experiment. The results indicate that in experiment (a), the lower to middle part between 860mm and 1,640mm from the floor is the best for a teacher’s physical load, in experiment (b), the middle part between 1,260mm and 1,660mm from the floor is the best in writing speed, and in experiment (c), the upper part between 1,660mm and 2,060mm from the floor is the best for students’ vision. Therefore, the height between 1,260mm and 1,500mm from the floor is the best for both of a teacher and students.

Keywords: Blackboard, Usability, EMG, Writing Posture, Vision
A Preliminary Study on Scrolling and Selecting Graphic Symbols on Touch-Screen among Individuals with Aphasia

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Abstract: Communication aids (CA) are often used to augment and alternate the communication of individuals with Aphasia. They provide a set of functions for accessing, identifying, and combining graphic symbols to produce sentences and phrases with digitized and synthesized voice output. During the last decade, CA have been actively implemented as applications running on mobile devices such as smartphones and tablet computers. However, it has been suggested that cognitive deficits of individuals with aphasia may interfere their ability to use CA. There are not so many research studies focused on their task performance on mobile devices. This aim of this preliminary study was to investigate their task performance of scrolling and selecting graphic symbols on touch-screen.

We developed the prototype of CA application for a 7-inch android tablet (docomo AQUOS PAD SH-08E). A total of 223 graphic symbols were prepared for this experiment. These symbols were classified into seven top-level categories. Three of them had subcategories. Each category and symbol was represented by a visual image with its caption. The main screen of the prototype consisted of “category pane” and “symbol pane.” The former showed top-level categories as non-scrollable vertical list. The latter showed vertically scrollable collection of all symbols. These symbols were sectioned by top-level categories and subcategories. The user can jump to a corresponding section in the symbol pane by touching one of the top-level categories in the category pane. The user can present the enlarged image with synthesized voice of the caption by touching one of the symbols in the symbol pane. In this experiment, participants were three individuals with moderate Broca’s aphasia and two individuals in the control group. Each participant attempted to present a corresponding symbol representing a task word by using the prototype within 1 minute. There were 16 task words, each word was shown on a printed photo card, for each participant.

The control group presented a greater number of symbols successfully without errors within the time limit (84.4%) compared to the aphasic group (62.5%). The control group corrected 80.0% of the errors by themselves, but the aphasic group could do 61.1%. 50% of the errors in the aphasic group were occurred while selecting top-level categories. In contrast, the control group had no errors while selecting them. However, individuals with aphasia scrolled symbols among different categories and 33.3% of wrong selection of top-level categories were corrected or nearly corrected. Scrolling symbols may increase successful attempts if they had more time.

We focused on successful attempts and analyzed their time efficiency. Individuals in the control group tended to select top-level categories faster than individuals with aphasia. Individuals in the control group had lower coefficient than individuals with aphasia in consequence of a simple linear regression analysis of task completion time subsequent to selecting categories against the number of list items.

These results demonstrate that individuals with aphasia exhibited higher error rates, slower response time to select top-level categories, and slower speed of scrolling to find the task words than individuals in the control group.

Keywords: Aphasia, Communication Aid, Augmentative and Alternative Communication, Touch-Screen, Scrolling
Development of Power Assistance Chair for Aged Person by Motion and Myoelectric Signal Measurement

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Abstract: Recently, rehabilitation and training method are diversified along with advances in technology. There are many kinds of equipment and instruments for these requirements. A chair with the power assistance function was developed by a Japanese company for training and rehabilitation of aged person. Developers aimed to help aged person to stand up easily without other person's support. Another use of this chair is for training of leg muscle by a motion of sitting down and standing up. However, its effect of the function is not yet sufficiently evaluated. To evaluate the power assistance function of the chair, it is effective to measure user's motion and change of muscle power. In this study, the motion of user and moving seat were measured by using motion capture system, and muscle force was evaluated by acquisition of myoelectric signal at the same time. In this experiment, standing up and sitting down motions were repeated under the conditions with and without assistance function of this chair. As the result, motion of user and moving seat of the chair, and muscle force were obtained. By means of simultaneous measurement of motion and myoelectric signal, muscle activity against timing of motion is well understood. However, as additional work, it is necessary to compare the assistance power by changing several parameters, to improve the performance of this chair. In our previous study, the structure of spring mechanism of original chair was not optimum for the power assistance function. Therefore, in order to provide more effective support power, it is necessary to improve the structure and mechanism with spring of the power assistance function of the chair. Firstly, we reproduced the same power assistance function of the chair using commercial parts of frame structure. Next, the function for this support chair is evaluated to investigate the optimum mechanism that provides effective support. The results are useful for understanding of the effect of power assistance function by comparing motion of original assistance chair and the reproduced chair. The more effective assistance is required for aged person, so the chair should be improved of structure, mechanism, assist force, etc.

Keywords: Power assistance, aged person, motion analysis, motion capture, myoelectric signal
Analysis of Relation for Kinetic Load and Knee / Ankle Joint Angle Using PAFO during Stance Phase

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Abstract: According to research in United Nations, world's population of over 60 is expected to increase to 21.5 % in 2050. Aging population is rapidly in the world, our country is no exception at this problem, as of September in 2017, 27.7 % of the total population is over 65. If we decrease strength with age, we could become injured and or diseased. Among the diseases, stroke has high risk of brain damage leading to loss of motor functions such as hemiplegia. Plastic Ankle Foot Orthoses (PAFOs) are usually used to assist ambulatory ability for patients who suffer from hemiplegia. However, the prescription of PAFO is based on the experience and intuition of the doctor that it is necessary to establish a systematic approach.

Therefore, we developed a kinetic load and knee / ankle joint deformed angle measurement system acting on PAFOs during walking. This system has three 6-axis force torque sensors on the PAFO and three 3-axis force sensors two are on the sole of the orthosis and one is on the ankle joint. Also, two flexible goniometers are installed, one is on the ankle joint for PAFO and one is on the knee joint. Using this system, we were able to measure and compare kinetic load (e.g. ground reaction force and calf load) and ankle joint deformation applied to PAFO and subject's knee joint angle during stance phase and swing phase of walking with 2 healthy volunteers (Average Age: 45.0, Average Body Weight: 67.4 kg) and 2 left side hemiplegic patients by stroke sequelae (Average Age: 62.5, Average Body Weight: 64.0 kg).

As a result, we focused on the measurement taken during stance phrase, such as stance phase time, ankle joint deformation angle on the PAFO's ankle joint angle, kinetic load in the anterior-posterior direction for PAFO acting on the calf (Maximum Calf Load) and that range (i.e. maximum minus minimum kinetic load value acting on the calf : Calf Load Range). Stance phase time was about 1.13 s in both groups. Also, for the calf load range, patients were about 2.3 N/kg, volunteers were about 1.8 N/kg. For the Maximum calf load, patients were about 0.14 N/kg, volunteers were about 0.22 N/kg. There was no significant difference in both kinetic load between patients and volunteers. On the other hand, for the dorsiflexion/plantarflexion direction angle, volunteers were about 0.2 degrees, patients were about 0.7 degrees in the PAFO’s ankle joint angle. For the knee joint angle deformation, volunteers were about 45 degrees, patients were about 20 degrees. There was 2.25 times difference between both groups. For future study, we are going to analyze kinetic load to left/right direction on PAFO.

Keywords: PAFO, Hemiplegia, Stance Phase, Goniometer, Ankle Joint
A finite element parametric study of the contact pressure distribution on palm during grasping

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Abstract: Currently, when designing the shape of a product that is comfortable to grasp, gripping comfort evaluation using human subject experiment is commonly conducted. However, this method requires a lot of time and cost to prepare mockups and to perform the experiment. Moreover, it is difficult to quantitatively evaluate the comfort level of grasping. We thought that computer simulation such as finite element analysis can be utilized to perform a huge number of numerical studies (virtual experiments) and to quantitatively evaluate the gripping comfort. In order to conduct a finite element analysis, a hand finite element model should be developed and a grasping simulation method should be established in advance.

In this study, we developed a hand finite element model and a grasping simulation method to simulate the grasping motion of a volunteer and to reproduce the contact pressure distribution on the palm during grasping experiment against a cylindrical object. Furthermore, a parametric study was also conducted to investigate the effect of several factors on the contact pressure distribution.

Firstly, the outer body shape and the skeleton shape of human hand in a grasping posture were created using three dimensional computer graphics software. Then, an element segmentation was performed to obtain a hand finite element model. Material properties of bone and soft tissues obtained from literature were adopted. A damage model was also introduced into the model to avoid error during large deformation. Local coordinate systems were then constructed at each hand joint to allow grasping motion. The joint angles obtained from the experiment was inputted as an imposed angular velocity to the local coordinate systems to simulate the grasping motion. Comparison of the contact pressure distribution between the model and the volunteer showed that contact pressure concentrations on the distal region of the index finger, the proximal region of the middle finger, the thumb, and the distal region of the palm could be reconstructed in the simulation.

Parameter studies were also conducted with respect to the hand size, the dimensions and the material properties of the object, and the friction coefficient. It was found that the contact pressure tends to increase overall with the decrease of the hand size.

This trend was similar to the case, where the contact pressure increases with the increase of the diameter of the cylindrical object. Furthermore, large contact pressure concentration was confirmed when the Young's modulus of the object increased. In addition, the maximum contact pressure in the contact region decreased along with the increase of the coefficient of friction between palm and object.

Keywords: finite element model, gripping comfort, contact-pressure distribution, joint angle, parametric study
Evaluation of Attenuation Properties of Degraded Porcine Cartilage

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Abstract: Knee osteoarthritis (knee OA) is a disease that symptoms such as joint pain occur due to degradation and wear out of cartilage of knee. Early diagnosis of knee OA is important because it is impossible to regenerate worn cartilage of knee. However, it has not been achieved because patients will not go to the hospital until feeling pain or being in pain, therefore, there is no chance to diagnose knee OA. Accordingly, a simple and easy method, which can be used outside of the hospital by yourself, is required, therefore, the knee joint sound is paid attention. In the previous study, the transmitted sound through the knee joint, which sound was inputted by impulse hammer and measured by accelerometer, was measured. As a result, the transmitted sound of OA group had a large attenuation in the high frequency region compared with that of control group. On the other hand, as a result of measurement of sound emitted from knee joint when standing up from the chair, high frequency sound was detected only in OA group. The reason for that differences between the results of OA and control group has not been clarified. These are thought to be affected by attenuation property due to viscoelasticity. The purpose of this study is to understand the differences of the attenuation property due to viscoelasticity of OA and control group. The articular cartilages of porcine femur were adopted as a specimen. To reproduce OA, the degradation of the cartilage by collagenase solution, sanding the cartilage were performed. Evaluation of the attenuation property by viscoelastic measurement by dynamic mechanical analysis (DMA) and ultrasonic testing were carried out. As the results of DMA testing, tan δ that corresponds to energy absorption was slightly increased with the collagenase treatment for 1 hour and kept almost same value after 1 hour treatment. It was suggested that degradation of knee cartilage caused the large attenuation of transmitted sound of OA group. By ultrasonic testing, the thinner specimens had the larger amplitude of transmitted sound. It was suggested that thickness of knee cartilage caused the lower attenuation of knee joint sound of OA group. Consequently, it was revealed that the mechanisms of the attenuation properties of porcine cartilage with or without degradation by considering their viscoelasticity and thickness.

Keywords: Osteoarthritis, Degradation, Porcine cartilage, Viscoelasticity, Ultrasonic wave
Evaluation of dynamic viscoelastic properties of hairless mice

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Abstract: Collagen fibers and elastin fibers are major constructional element in the dermis. The collagen fibers are related to the strength of the dermis, the elastin fibers are crosslinked with collagen fibers and related to elasticity. When the dermis is wounded, it will not regenerate completely, and the wounded dermis will become scar tissue. It has been clarified that the fibers in scar tissue degraded as thinner and less developed than intact tissue, and fibers orientation became irregular. As result of the degradation and the irregular orientation, tensile strength and modulus were decreased. And the quality of skin as tone and firmness also degrades, therefore, to reduce and recover scar tissue are clinical tasks. In previous study, it was reported that the elasticity of wounded dermis of hairless mice was recovered by applying and impregnating the lotion with elastin component from surface of the skin. However, it is not clear about change in viscosity of wounded skin which related to the quality of skin. In this study, DMA (Dynamic Mechanical Analysis) tests were carried out to measure the viscoelasticity of wounded and recovered dermis to know the effect of elastin component on the scar tissue. On the other hand, process of “Pre-conditioning”, which was carried out before the mechanical testing, was often used in biomechanics area to align the fiber direction of dermis to reduce the influences of fiber orientation. In this study, several stress conditions were discussed to determine the pre-conditioning of dermis and loading condition of 60kPa was adopted. For DMA tests, three types of specimens of hairless mice dermis were prepared as intact (control group), wounded (wound group), and UV-irradiated (UV group). Dermis viscoelastic properties were measured by using a DMA apparatus (Rheovibron DDV-25GP, A&D Co., Ltd.) recording E’ as storage modulus, E” as loss modulus, and tanδ as loss tangent. The DMA result showed that the value of E’, E”, tanδ of the control group was statistically larger than that of the UV group. On the other hand, there was no significant difference in these value between wound and control group. The result of DMA is presumed to narrowness of the wounded area against the span length. Consequently, it was revealed that UV damage to dermis influenced viscoelastic properties.

Keywords: DMA, dermis, viscoelasticity, scar tissue, pre-conditioning
**In vivo elastic characteristics of the medial collateral ligament with varying knee flexion angle**

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**Abstract:**

**Background**

The stability of the knee joint is mainly afforded by ligamentous tissues. Medial collateral ligament (MCL) is the primary static stabilizer which resists valgus rotation of the knee joint. MCL is composed of superficial (sMCL) and deep medial collateral ligaments (dMCL). Loading behavior of the collateral ligaments is important in soft tissue balancing during total knee arthroplasty. There are plenty of in vivo studies describing mechanical properties of anterior and posterior cruciate ligaments but a fewer studies available on MCL. In general, elongation of soft tissues like ligaments and tendons exhibit non-linear behavior under loading. Therefore it is important to identify stiffness in different areas along the elongation pathway to estimate the overall mechanical behavior of a soft tissue.

**Objective**

To establish a methodology to assess elastic characteristics such as apparent stiffness of the MCL in varying knee flexion angles using an ultrasound elastography.

**Methods**

Six healthy young adults participated in this study. Ultrasound elastography with an acoustic coupler as the reference material was used to obtain apparent stiffness values of sMCL and dMCL. Strain ratio of the MCL was defined by strain in the ligament to that in the acoustic coupler. Lower strain ratio indicated higher apparent stiffness of the MCL. Strain ratio measurements were obtained at the proximal, middle and distal areas of the sMCL, meniscofemoral and tibiofemoral components of the dMCL while placing the knee in 0, 30, 60, 90 and 120° flexion angles.

**Main findings and Results**

All the proximal, middle and distal areas of the sMCL was shown to have the least strain ratio at 0° and it was almost constant till 30° of knee flexion. From 30° the strain ratio increased gradually and peaked at 120°. Remarkable increase of strain ratio values of all three areas were seen during 60 - 90° knee flexion. However despite of small fluctuations, meniscofemoral and meniscotibial components of the dMCL showed a relatively constant behaviour at 0, 30 and 60° flexion positions and the strain ratio was peaked at 90°. Thereafter it remained in a constant value till 120°. Our results have shown that the apparent stiffness of sMCL was higher at knee extension and it became lower when knee flexion proceeded. Whereas the tightness of the dMCL remained almost same during knee flexion except a laxity after 90° of flexion. This tendency of the elastic behaviour of the MCL over a range of knee flexion angle is in accordance with previously reported data. Ultrasound elastography with the acoustic coupler is a feasible method to assess elastic properties of knee MCL.

**Keywords:** Biomechanics, Ultrasound Elastography, Strain ratio, Medial Collateral Ligament, Apparent stiffness
Abstract: Bone fracture injury frequently occurs in accidents. During an accident, bone may be subjected to a single loading or combination of multiple loadings, e.g., tensile, compression, shear, bending and torsion. It is known that the threshold of rupture of a material commonly changes with the change of the loading conditions. Therefore, in order to establish a measure to prevent bone fracture, the threshold of bone fracture under different loading conditions should be well-understood. In this study, we conducted tensile, compression, shear, and notch bending tests on bone specimens obtained from bovine femur in order to obtain the mechanical properties and the rupture characteristics of cortical bone tissue. Furthermore, by considering the direction of load relative to the femur axis, we also revealed the elastic anisotropy of the bone specimens. Bone specimens were obtained from fresh bovine femur. Haversian bone part of the femur was isolated and was then machined in a normal saline environment to produce four kinds of test specimens used in tensile, compression, shear and notch bending test. Each test specimen was created thus the direction of load becomes parallel or perpendicular to the axis of femur shaft. Tests were conducted using a table-top universal testing machine equipped with appropriate jigs for each test. Pre-loading of 1 to 10 N was applied to the specimens prior to the test. Loading rate was 1 mm/min. Tests were performed in a room temperature. Load was obtained using the load cell of the testing machine. Displacement was obtained by digitizing the deformation image recorded using a video camera. From the test result, load-displacement curves and stress-strain curves could be derived. Variations in the curves were found, however it is quietly common for biological tissue. Furthermore, rupture points of each test and direction could also be determined from the curves. There were notable differences in the elastic moduli and the rupture points. The rupture strength of bone tissue was considered to be dependent on the loading conditions. Moreover, it also has a relationship with the individual characteristic of the component materials of the bone tissue. Collagen fiber was considered to have a strong resistance against tensile loading, whereas hydroxyapatite was considered to have a strong resistance against compression. In addition, the direction of load against bone axis was also found to have an influence on the elastic modulus and the rupture point. The orientation of collagen fibers in the specimens was considered to be the main factor that caused the alteration.

Keywords: bone tissue, rupture, mechanical test, fundamental loading, bovine femur
A dynamic measuring method of length of the patellar tendon using cine magnetic resonance imaging

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Abstract: [Background] Patellar tendon is a tough fiber bundle connecting the tibial tuberosity and the patella. It has a role to increase the torque of quadriceps femoris muscle and moment arm of the knee. Previous in vivo studies of the patellar tendon, using magnetic resonance imaging (MRI) and fluoroscopy, analyzed knee flexion in standing position although fluoroscopy is hardly adequate for assessment of soft tissue. Another previous study using cine MRI analyzed the patellar tendon during knee flexion in prone position however quadriceps femoris muscle was not loaded enough due to the prone position. It is conceivable that the influence of quadriceps femoris muscle is significant for deformation of the patellar tendon in vivo and little attention has been given to the movement of the patellar tendon when it is loaded.

[Objective] The purpose of this study is to propose a measuring method of dynamic characteristics of the quadriceps muscle loaded patellar tendon using cine MRI.

[Methods] Three knees were imaged with 3D T1 – weighted scans at rest and multi-slice 2D cine T1 – weighted scans during knee flexion and extension. Multi-slice 2D cine images were acquired for 2 minutes, about every 1 second during active knee motion. Image registration based on 2D cine images was done with 3D reconstruction images using the transformation matrix from 3D T1-weighted images for the femur, tibia, and patella. Inverse matrix was defined as a transformation matrix which represents the motions of each bone. The patellar tendon insertion sites at the tibial tuberosity and the patella were defined using 3D T1-weighted images. We confirmed that the patellar tendon was in tension in multi-slice 2D cine images and defined the direct distance between each insertion sites as the length of the patellar tendon. We measured the straight length pattern of patellar tendon from insertion sites at the tibial tuberosity and patella during knee flexion angle. In addition, we checked the motion of the knee based on the transformation matrix and 3D bone models reconstructed from 3D T1 weighted images.

[Main findings and Results] The patellar tendon length was increased along with knee extension. Although previous studies on flexion and extension movements during standing and prone positions had a tendency of the patellar tendon to stretch along with knee flexion, the present study showed different results. This difference of length pattern of the patellar tendon was caused by the tensional force of quadriceps muscle.

Keywords: Biomechanics, Patellar tendon, cine MRI, Motion analysis, Knee
Abstract: One of current social backgrounds is the progress of aging and the shortage of people who support them. In our daily life, we spend a lot of time waiting on the chair, and when moving, we need to move up from the chair. The standing motion from the chair is the starting point of the moving motion, and the necessity of the movement also increases according to the frequency of the movement. However, standing motions are difficult for elderly people with weak muscular strength and those with impaired lower limbs, and the risk of falling is high. Therefore, it is important to devise measures so that the standing motion can be easily performed.

In this study, we make two types of standing assist chairs with different rising trajectories of the seating surface in order to reduce the burden on the body when standing up from a chair. Next, we analyze the burden on the body of the user who performs the upright motion by the rising trajectory of the seat surface. In the experiment, we tried comparing and examining in three types of chairs which added ordinary chair to two types of chairs produced. Analysis result of joint torque using Digital Manikin in motion simulation software and measurement of muscle activity amount using EMG, and evaluate the standing load focusing on individual difference of movement characteristics at standing and upright motion.

As a result, the knee joint torque of the standing assist chair was about 50% less than that of the ordinary chair in the situation where the body was heavily loaded during the standing motion. In addition, the amount of activity of each muscle in the scene at the beginning of standing showed the smallest value in the chair in which the trajectory of the seat surface is convex upward with respect to the muscle activity amount of the tibialis anterior muscle. In the spinal erector muscle, vastus medialis muscle, vastus lateralis muscle, it was found that the chair in which seat surface shape is convex downward has the greatest decrease in muscle activity. From this, it was found that the downward convex seating surface trajectory is superior in order to reduce the burden on the knee joint.

Keywords: Standing Assist Chair, joint torque, EMG, motion simulation software, Seat surface trajectory
Abstract: The wear is important for the long-term use of the total hip prosthesis. There is not originally the relative motion between metal back and the liner of the total hip prosthesis, but microscopic wear may occur. Therefore, it is necessary to understand the effect that polyethylene including the carbon nano-tube gives to the metal back titanium surface. The microwear state between back metal and the liner reproduced as giving microscopic cyclic reciprocating sliding movement. The titanium alloy (Ti-6Al-4V) and the polyethylene including the carbon nano-tube were used for the specimens. The specimens were customized in column specimens (a diameter: 15mm), and those end-faces were attached mutually to machine. The upper side specimen was fixed by hydraulic pressure chuck, and the lower driving side specimen was attached by a power lock. The specimen was compressed, then the sinusoidal displacement of constant angular amplitude, was applied by rotating the specimen at the driving side under the control of angular displacement. The cyclic reciprocating relative sliding was generated on the contact surfaces. The static compressive force was applied 1,760N (contact pressure: 10MPa) to driving side specimen. The cyclic reciprocating relative sliding was applied as the sinusoidal torsion in the conditions: amplitude = 1 deg, frequency = 1Hz, number of cycle = 1000cycle, respectively. The tests were performed at room temperature under dry condition. As a result, the amount of wear (weight change before and after the test) was smaller in both specimen than measurement limit. When the titanium alloy surface was observed with an optical microscope, transfer of the resin according to the cyclic reciprocating sliding showed on the surface, but the significant scratch by the carbon nano-tube did not show. It was suggested that it was low-risk that a significant damage is given by carbon nano-tube contained in polyethylene on metal back titanium surface.

Keywords: Biomaterial, Artificial hip joint liner, Carbon nano-tube, Cyclic Reciprocating Sliding Contact, Wear test
Adjustment of pull-out force due to the slit configuration in acetabular cup of artificial hip joint with a structure for preventing dislocation

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Abstract: Although Total hip arthroplasty (THA) has greatly improved the quality of life of patients with hip osteoarthritis, there are still several problems. The joint dislocation is one of the most critical problems in THA. In order to solve this problem, we have newly proposed the artificial hip joint with a preventing structure from the dislocation. Its acetabular cup has a shape with over the half of femoral head. Due to this shape, the joint dislocation does not easily occur in the artificial hip joint. It is important that the pull-out force of the joint is kept within an appropriate range. In the present study, we studied the relationship between the pull-out force and slits in the acetabular cup. To design the optimal artificial hip joint with a structure for preventing dislocation, the effects of slit configuration on the pull-out forces of the artificial hip joint were evaluated using a three dimensional finite element analysis.

The acetabular cup consists of an inner liner made of ultra-high molecular weight polyethylene (UHMWPE) and an outer shell made of titanium alloy (Ti-6Al-4V). The inner liner is contact with the femoral head and is covered with the outer shell. The simple 1/12 model of the artificial hip joint was created using a computer-aided design (CAD) software. The thickness of the inner liner and outer shell was 2 and 1 mm, respectively. The diameter of the artificial femoral head made of titanium alloy was 6 mm. For the mechanical properties, Young’s modulus and Poisson’s ratio of Ti-6Al-4V were set at 113 GPa and 0.33, respectively, and those of UHMWPE were set at 940 MPa and 0.46, respectively. The slit with different depth was made only at the outer shell. We moved the femoral head by 2 mm in the vertical direction and calculated the pull-out force during such movement. For the artificial hip joint with the slit only in the outer shell, we studied the effects of slit length on the pull-out force. A reference position was set as the half sphere line of the femoral head. We located the slit at -0.5, 0, 0.5, 1.0, and 1.5 mm apart from the reference position, and the slit length at each was 2, 1.5, 1.0, 0.5, and 0 mm, respectively.

Analytical results revealed that there was a clear reduction in the force with a decrease in the slit length. The maximum pull-out force in the case of the slit length of 0 and 2 mm was approximately 41 N and 38 N, respectively. That is, the increase in the slit length from 0 to 2 mm was induced the reduction in the pull-out force of 3 N. We concluded that the slit length is an important parameter for the design of the acetabular component to prevent joint dislocation. Clearly, the pull-out force is adjustable within a required range due to the slit configuration of the artificial hip joint with a preventing structure from dislocation.

Keywords: Artificial hip joint, Joint dislocation, Pull-out force, Finite element analysis, Slit configuration.
Mechanical and Histological Evaluation for Skin Tissues Damaged by High Intensity Ultraviolet Irradiation

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Abstract: Skin is the largest organ that covers the outermost layer of the human body. It has many important functions to keep living activities such as body temperature control, water regulation, virus protection, and mechanical sensation. There are 3 layers in the skin: epidermis, dermis and hypodermis. The dermis is an important part to determine the mechanical properties of the bulk organ. It consists 70% of collagen and 5% of elastin, and these fibrous proteins constitute a network structure. It is generally known that the rigidity and extensibility of the dermis are regulated by collagen and elastin, respectively. Therefore, the skin function strongly depends on collagen and elastin. Moreover, their amount is decreased by the exposure of ultraviolet (UV) and aging. However, quantitative relationships between the mechanical properties and protein amount of skin tissues are still unknown. In the present study, we specifically focused on the change in the mechanical and histological properties during healing phase of skin tissues irradiated high intensity ultraviolet. The final goal of our study is to contribute to the development of pharmaceuticals that improve the repair efficacy of damaged skins from a mechanical point of view. We conducted the mechanical and histological evaluation for skins applied elastin ingredient after high intensity ultraviolet irradiation.

Twenty-one hairless mice (male, 18 weeks order) were used for the experiment. They were divided into three groups each for 7 animals: Control, UV, and Elastin groups. Mice in the Control group were used to obtain the data for the normal tissue. The remaining 14 animals were irradiated with ultraviolet for 1 week. The ultraviolet does was set at 1800 mJ/cm². Seven animals treated only with ultraviolet irradiation were used as UV group. Seven animals in the Elastin group were treated with petroleum jelly containing 5% elastin for 4 weeks after the ultraviolet irradiation. After 5 weeks from the start of the ultraviolet irradiation, a skin suction loading test was performed on dorsal skins of each animal. After negative pressure was applied to the skin, the amount of the skin deformation was measured with an infrared probe distance measuring instrument. From the maximum negative pressure and the deformation amount of the skin, we calculated the stiffness expressing the skin rigidity. Moreover, the skin specimens in each group were stained with hematoxylin and eosin (HE stain) for histological observation.

The stiffness of the UV group was significantly higher than that in the Control group. The thickness of dermis in the UV group was significantly higher than that in the Control group. From these results, it is suggested that the network structure of collagen and elastin in the dermis is changed by the irradiation of high intensity ultraviolet. The stiffness and dermis thickness in the Elastin group were lower than those in the UV group. We speculated that the elastin ingredient has an efficacy to enhance the skin repair after severe damage induced by high intensity ultraviolet irradiation.

Keywords: Biomechanics, Skin, Ultraviolet irradiation, Suction test, Histological observation
Residual strength of cortical bone after creep loading at a high stress magnitude

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Abstract: Bone tissues play an important role in the mechanical functions such as the muscle force transmission, body support, and protection of internal organs. Moreover, bone fractures are ultimately a kind of mechanical event, and their healing process is also relevant to mechanical forces applied to the tissues. For these reasons, a quantitative assessment of bone biomechanical performance is essential both biologically and clinically. It is well known that bone tissue is a viscoelastic material which shows time-dependent mechanical manner. In order to know basic insight into the adverse effects of creep loading on bone strength, in the present study, we focused on the mechanical behavior of cortical bone after non-destructive creep loading at high stress magnitude.

Cortical bones of bovine femora were used for the experiment. Cortical bone consists of plexiform and harversian bones. In the present study, we used only plexiform bone because its area was much larger than that of the harversian bone. Then, cylindrical specimens with approximately 4.4 mm in diameter were cored from the plexiform bone using a coring tool. The coring direction was same as the longitudinal axis of the femur (Axial specimen). In preconditioning tests, compressive loads were applied to the specimens using a universal material tester. After the preconditioning, we calculated an initial tangent modulus (E0) of the specimen using obtained load and displacement. Then, we statically applied a compressive stress (σ) normalized the initial tangent modulus of 0.025 (σ/E0=0.025) to the specimens (creep group) for 24 hours. The stress magnitude of 0.025 was so high that the creep failure of cortical specimens was induced by a higher stress than this value. After the creep loading, the specimens were kept at no stress condition for 24 hours. Only preconditioning tests for the specimens without creep loading was conducted to obtain the data on the intact cortical bone (control group). The residual strength of the specimens after applying the creep load was measured by the universal testing machine. The specimens were loaded in compressions until failure at the compression speed of 1 mm/min.

For the compressive strength, the obtained value in the creep and control groups were 138 ± 34 (Mean ± S.D., n =4) and 119 ± 20 MPa, respectively. The tangent modulus was higher in the creep group (8.9 ± 3.8 GPa) than in the control group (4.3 ± 2.0 GPa). Failure strain in the creep group (1.4 ± 0.2%) was lower than that in the control group (2.9 ± 1.0%). These results suggest that bone specimens changed into more brittle material by the application of creep loading at high stress magnitude. Therefore, it is possible that the fracture is easily occur for bone tissues after compressive loading is continuously applied to the tissues.

Keywords: Biomechanics, Cortical bone, Creep, Residual strength, Overloading
Finite Element Analysis of Change in Shape of Femoral Bone after Total Hip Arthroplasty Using Shape Optimisation Method

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Abstract: Introduction
Total hip arthroplasty (THA) is still getting increased because of the increase of number of elderly patients who have suffered from hip osteoarthritis (OA). One of the critical issues of THA is well known as the loosening due to the stress shielding after its operation. In our previous study, remodelling analyses were performed so as to predict the bone mineral density (BMD) of one particular patient after THA through the finite element analysis (FEA), and revealed that the spatial distributions of BMD predicted as a function of time had good accordance with those actually measured. The other aspect of the remodelling associated with THA should be the change in shape of the femur, but few limited works have been done so far. The present study dealt with the prediction of change in shape of the femur as a function of time after THA through FEA in combination with shape optimisation method. The chronological change in shape of the femur of one female patient was calculated and then validated through the comparison with the CT images taken at fourteen years after the surgery.

Methods
A subject was female patient THA-treated at the age of 51. A set of CT data was used to construct the FE model of the whole femur, and the material properties, namely the density and Young’s modulus of each element were determined based on the CT values. The FE model of the femoral stem was constructed from its CAD data as a rigid body. The contact between the area of the stem thermally spray-coated and the femur was considered to be rigidly bonded, while the rest of their contact region was set to be a friction coefficient of 0.2. Maximum loads were applied to the femoral head of the stem and the two points of the muscle attachments, namely abductor and vastus lateralis under the consideration of normal daily walking. The distal end of the femur was fully constrained in all directions. The FE code of ABAQUS instrumented with the shape optimisation tool was used to analyse the change in shape of the femur after THA.

Results and Discussion
The profiles of the cross-sections actually measured before and after surgery (Pre and Post) and those predicted through the FEA (Simulation) at given five cross-sectional planes from proximal to distal end of the femur were depicted in drawing. The cross-sectional areas of Pre, Post and Simulation were also calculated. The cross-sectional profiles of Simulation in the proximal region were easily recognised to be different from those of Pre but to be almost same as those of Post. The cross-sections near the proximal end demonstrated the significant amount of the bone loss or atrophy especially in the anterior and medial side and around lesser trochanter. The Simulation also gave us good prediction of the reduction of cross-sectional areas at all cross-sectional planes. As a result, the Simulation well predicted the change in shape due to THA except the region near the distal end of the femur.

Keywords: Biomechanics, Bone Remodelling, THA, Finite Element Analysis (FEA), Shape Optimisation, Strain Energy Density (SED)
Estimation of long-term stockpiling characteristics based on biocoke

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Abstract: For all of countries, the stockpiling of renewable energy resources is an important issue in planning long-term stable supply. In particular, bioenergy is a weather-independent resource and has steady supplyable characteristics. However, all of biomass has exothermic properties by fermentation. In stacked storage, there is a risk on causing serious disasters that will cause methane fermentation about 20-50 degree-C. In this study, new solid bio-energy; biocoke has extremely high density properties close to true density of biomass. By this high density property, it is expected that does not occurring methane fermentation inside of biocoke. For estimation of long-term period, this study measure extremely small temperature change observed by Thermal Analysis and Calorimetry (TAM) for raw biomass, pellet, and biocoke. Finally, it will suggest for stockpile characteristic and physical behavior for long-term issues.

Keywords: biomass, bio-coke, renewable energy, bio-energy, long term stockpiling
Structure and Soundness of Multilayer Al-Si Alloy Pipes Produced by Two-Step Centrifugal Casting

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Abstract: The solidification structure and soundness of multilayer Al-Si alloy pipes produced by a two-step centrifugal casting process have been investigated. In this process, two kinds of molten metal, i.e., the first melt (Al-12mass%Si or Al-14mass%Si alloy) and the second melt having a higher liquidus temperature (Al-32mass%Si-0.1mass%P alloy) were cast in sequence at a given time interval ($\tau$) into a rotating metal mold of a vertical centrifugal caster. The second melt was cast after the solidified shell of the first melt had grown partway from the contact surface with the mold. When the first melt was Al-12mass%Si alloy, the cast pipe specimens were typically composed of three layers. The outermost layer was the survived part of the solidified shell of the first melt after contact with the second melt cast at a high temperature. The intermediate layer was derived from a molten part of the first melt. The innermost layer had a hypereutectic structure containing fine primary silicon crystals originated in the second melt. At the boundary between the intermediate and innermost layers observed on the transverse cross section of the specimen, two kinds of interface morphologies were observed. One was a turbulent interface with a good bonding state and the other was a macroscopically flat interface accompanied by many crack-like defects. The turbulent interface was dominant when the casting interval was shorter than a critical value, $\tau_{CM} = 16$ s, when the total solidification time of the first melt was about 30 s. Above the critical casting interval, the flat interface increased drastically with $\tau$. The defect fraction, $f_D$, which is a ratio of the cumulative length of the defects to the circumference of the approximate circle of the boundary of the two layers, also showed a similar tendency. The critical casting interval for defects formation, $\tau_{CD}$, was 16 s, which was comparable to $\tau_{CM}$. In the case of the first melt of Al-14mass%Si alloy, however, $\tau_{CD}$ was 4 s, much shorter than in the case of Al-12mass%Si alloy even though $\tau_{CM}$ was comparable. The difference in $\tau_{CD}$ can be attributed to that in solidification behavior of the first melt. In both alloys, another solidified shell started to grow from the free surface of the inner periphery at a certain stage of solidification. In the case of Al-12mass%Si alloy, the inner solidified shell was composed of hypoeutectic structure containing equiaxed $\alpha$-dendrites, which could be readily remelted by contact with the second melt when $\tau < \tau_{CM}$. In the case of Al-14mass%Si alloy, on the other hand, primary silicon crystals accumulated near the inner periphery to form a high-silicon solidified shell, a part of which withstood the temperature rise and remaining surface oxide film interfered the metallurgical bonding with the second melt.

Keywords: Casting Soundness, Multilayer Pipe, Centrifugal Casting, Hypereutectic Aluminum-Silicon Alloy, Primary Silicon
Reduction behavior and rate of sintered iron oxide pellets

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Abstract: Iron industry consumes large amount of energy and accounts for 14% of energy consumption and CO2 emission in Japan. Blast furnace, current process to produce pig iron, emits a large amount of CO2 since it requires coals as energy resource and reducing agents. Therefore, a lots of engineers researched various means to decrease reducing agents at a blast furnace in order to reduce CO2 emissions. For example, injection of waste plastics and carbon neutral materials such as biomass into a blast furnace is better alternative. However, such way to enhance efficiency to decrease reducing agents is reaching the limit and it is important to develop innovative technique to reduce still more CO2 emission.

On the other hand, high reducibility of iron ore sinter is necessary to reduce CO2 emission in blast furnace. However the grade of iron ore becomes lower every year. Especially, Al2O3 content is increases in iron ore. The reducibility of iron ore sinter becomes lower in cohesive zones over 1000 °C in a blast furnace with increasing Al2O3 content in iron ore. It is reported that the initial melt formation temperature is lowered, amount of melt is increased and reducibility of iron oxide agglomerate is decreased with increasing Al2O3 content.

It is expected that the melt formation temperature is lowered with high “FeO” content. Thus, it can be reasonable to decrease “FeO” content by the melt formation temperature and on the initial melt formation stage to decrease amount of melt and enhance the reducibility of iron ore sinter. Therefore, we focused on reduction behavior and rate around initial melt formation temperature such as 1000 to 1250 °C. The experiment of sintered iron oxide pellets were carried out with reducing gas at temperature from 1000 to 1250. The reducing rate were measured as a mass change by using thermos balance. The morphology and porosity were analyzed by SEM and mercury instruction technique.

Keywords: Ironmaking, Blast Furnace, CO2, Reduction, Iron oxide
Mechanical properties of Composite Parts Manufactured by Air Cushion Method

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Abstract: Resin Transfer Molding (RTM) is a cost-effective fabrication process for the manufacture of polymer composites. However, the matched rigid tooling used in RTM is expensive particular for large-scale and complex shaped part. As an alternative process, vacuum infusion (VI) can make high-quality components without the need for expensive tools and equipment since this method merely utilizes a one-sided, rigid mold and a flexible membrane that seals to the mold cavity. One of the major drawbacks in VI is a long resin infusion time since the maximum infusion pressure is low (one atmosphere). A variation on VI process, called air cushion method (ACM), has been devised to reduce resin infusion time by Chang. The method utilizes an innovative vacuum bag, where air cushions adheres to one side of the flexible membrane, instead of single membrane as used in VI. When the cavity is sealed by the innovative vacuum bag and evacuated, the space is present between two air cushions and the membrane, and distribution channels are thus created for flow enhancement during infusion. After enough volume of resin is infused, the binding areas between the membrane and the air cushions are cut. The innovative vacuum bag is turned into a single membrane like VI. Consequently, the vacuum bag fully compacts the preform to the final part thickness. In the previous investigation, the surface roughness of the ACM part was proved to approximate to that of VI part, and significantly reduce infusion time. In this work, the mechanical strength of the ACM part is measured by the tensile test and the microstructure of the test coupon is observed by scanning electron microscope. Experimental results show that the tensile strength of the ACM part is close to that of VI parts in the woven directions. The debonding between the fibers and resin is frequently observed during tension due to poor interfacial adhesion.

Keywords: Air Cushion Method, Vacuum Infusion, Polymer composites, Tensile Strength, Microstructure
Abstract: Gear machining using a hob tool, or hobbing, generates the feed marks on the tooth surface of gears. The feed marks increase the surface roughness on the tooth surface in the tooth trace direction periodically. Generally, the feed marks cause the reduction of surface pressure and the generation of noise because of decreasing the contact area between the teeth of gears. To vanish the feed marks can reduce the vibration and the noise in gear trains.

The purpose of this study is to reduce the feed marks by applying forced vibration to the workpiece while machining gears. We think that it is possible to smooth the convex portion of the feed mark by arising the relative motion between the hob and the workpiece in the hob feed direction like a gear shaper machine. In this paper, we report our developed mechanism for vibrating the workpiece during hobbing, and show that the mechanism is effective for reducing the feed mark.

Our developed work vibration mechanism has a lever, a vibration spacer contacting the lower surface of the workpiece, a motor equipped with an eccentric disk, and some plate springs. The lever connected on the vibration spacer transfers the vibration generated by the rotation of the eccentric disk to the vibration spacer by the principle of leverage. The vibration spacer can vibrate to the vertical direction integrally with the workpiece by plate springs which are arranged in upper and lower positions. The amplitude and frequency of the workpiece are measured with a laser Doppler vibrometer. Our experimental conditions are shown below. The material of workpieces are S45C, the module of gear is 1.75 and the teeth number of gear is 43. The amplitude and frequency of work vibration are about 0.3mm and 10Hz each. Under these conditions, we compare the surface roughness of gears between when the workpiece is vibrated and when it is not, and investigate the effects of reducing the feed mark by the workpiece subjected to periodical forced vibration.

Keywords: Gear, Dry hobbing, Forced vibration, Surface roughness, feed mark
Numerical Modeling for Time and Temperature Dependence on Flexural Strength of Polyimide CFRP

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Abstract: Strain rate and temperature dependence of transverse failure of unidirectional composites are numerically simulated in the present study. By authors’ previous work, it was clarified that the failure mode of transverse tensile in UD-CFRP changes from matrix-failure-dominant mode to interface-failure-dominant mode with an increase of applied strain rate. In other authors’ study, not only strain-rate dependence but also temperature dependence of failure mode are numerically simulated by finite element analyses. The transverse failure governs crack initiation for the ordinary CFRP laminates so that the failure mode transition is very important for a precise estimation of the crack initiation.

The objective in this study is numerical modeling of transverse failure of unidirectional polyimide CFRP at various strain-rate and temperatures.

Commercial finite element method software ABAQUS is used in this study. For the fiber, in-plane isotropic and elastic properties are assumed and temperature dependent elasto-plasticity is applied for the matrix.

In the analyses, interface failure and matrix failure are expressed by cohesive zone modeling and continuum damage mechanics, respectively. Damage initiation of matrix is defined as a function of stress triaxiality, in order to distinguish hydrostatic damage and shear damage. Damage evolution of matrix is defined by temperature- and strain rate-dependent fracture energy.

For the fiber/matrix interface, cohesive element is introduced defined by bi-linear traction separation behavior. Referring authors’ previous work [2], cohesive zone modeling is assumed to be temperature- and time-independent. The cohesive element allows to consider mixed-mode failure.

Time and temperature superposition principle is applied to the relationship between time and temperature in this study. A 2D-unit cell containing 30 fibers is modeled and periodic boundary condition is applied. For the periodic boundary condition, dummy-node method is used in this study. The tensile simulations are performed by various temperatures and strain rates.

At relatively low temperature and / or relatively high strain rate. In this case, the cracks are initiated and propagated by fracture of the interface, and the matrix breaks only between the interfaces around the different fibers. At relatively high temperature and / or relatively low strain rate. In this case, cracks are generated by fracture of the matrix, crack propagates due to failure of the matrix without fracture of the interface.

In this study, time and temperature dependence of transverse tensile behavior of unidirectional CFRP was predicted. When temperature is high and/or strain rate is low, matrix crack occurs very often and the failure mode is matrix-failure-dominant mode. On the other hand, when temperature is low and/or strain rate is high, interface crack significant, i.e. failure mode becomes interface-crack-dominant mode.

Keywords: Composite, Flexural Strength, Numerical Simulation, Micro Mechanics, Time and Temperature Dependence
Abstract: Observation of Impact Fracture in Ice by Simplified Percussion Test
Keywords: Ice, Impact, Fracture, Crack, Percussion
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"Ice" is one of the materials used around us, such as lock ice for drinking and eating and for cold insulator. In the previous study, the deformation and fracture of the ice have been studied, in order to guarantee safety from the disasters such as hail damage. As a method of the ice fracture, it is common to use the sharp objects like ice picks. On the other hand, it is also empirically known that the ice easily fractures when struck at the back of the spoon. However, the mechanisms of these fractures have not been clarified in details. In this study, in order to obtain the knowledge of the mechanism of impact deformation and fracture in ice, we developed the simplified percussion test.

The pure ice was used as the specimen. First of all, we established a method of the surface cutting of the pure ice specimens using microtome. The specimen configuration was cube approximately 20 mm on a side. We developed the simplified percussion test apparatus for pure ice specimen. The accelerometer was installed at the percussion part, and the change of acceleration during percussion was measured. From the time change of the acceleration, the load-time relationship applied to the pure ice specimen under percussion was obtained using the equation of rotational motion. At the same time, the deformation and the fracture states of pure ice specimen was photographed with a high-speed camera (50,000 fps).

The obtained results are shown below. It was clear that the internal crack growth rate of pure ice in was approximately 250 m/s in early stage of deformation. In addition, it was confirmed that pure ice specimen was fractured as a very fine piece by percussion. In the percussion test, the maximum compressive stress of the pure ice specimen was approximately 0.05 MPa. It was suggested that the fracture phenomenon of pure ice in percussion might occur at lower stress in comparison with compression test.

Keywords: Ice, Impact, Fracture, Crack, Percussion
Characterization of triaxial woven carbon fiber reinforced polymeric composites under uniaxial tension by experiments and numerical simulation

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Abstract: In this paper, a simple modeling method for triaxial woven carbon fiber reinforced polymeric (CFRP) composite is presented. In aerospace industry, the material is required the properties of light weight and high stiffness. Triaxial woven fabric CFRP is one of the materials which satisfy these requirements. Triaxial woven fabric CFRP has a structure in which three fiber bundles are braided in Kagome pattern and it has the property of very light weight, thin, isotropic and flexible in the out-of-plane direction. Especially, because of these characteristics, triaxial woven fabric CFRP has been utilized as a structural material for extensible antenna for space satellites. For these application, grasping mechanical response is very important but challenging. The stress-strain relationship of this material is complicated because of its woven structure. A faithful numerical model can aid in grasping the mechanical response of the material. The objective of this study is to verify the validity of numerical simulation model by comparing with the experimental results. In experiments, we conduct the uniaxial tensile test of triaxial woven fabric CFRP. The specimens were consisted of carbon fiber bundle and epoxy resin. It was manufactured by autoclave at 180°C under pressure 0.6 MPa in 2.5 hours. The thickness of this material is 0.07 mm, and the width is 0.9 mm. The uniaxial tensile test was carried out under displacement control at a test speed of 0.5 mm/min to measure tensile load and displacement. In addition, we tried to obtain the strain distribution on the surface of the specimen using the DIC method. In the numerical simulation, Commercial finite element method software ABAQUS2017 is used in this study. The presented numerical analysis is based on periodic unit cell simulation because the triaxial woven CFRP has a periodic structure. In order to make finite elements mesh into a complicated woven structure, contact analysis is utilized in this study. A key degree of freedom method is adopted in periodic boundary conditions so that global uniaxial loading situations, as well as other situations, can be simulated numerically. The bonding of two unit-bundle composites around a crimped part is modeled by surface-based cohesive behavior. A thorough analysis is conducted by ABAQUS without any specially developed user subroutine. This procedure of numerical modeling of woven composite materials is quite simple, but constructing a finite element mesh is of significantly higher fidelity especially before a large nonlinear damage appears. The validity of numerical simulation is examined by comparison with experimental results regarding full-field strain distribution and load-displacement relationships under uniaxial loading.

Keywords: Triaxial woven CFRP, Uniaxial tensile test, strain distribution, finite element method (FEM), Periodic Unit Cell simulation
Shape processing of plastic ankle foot orthosis (PAFO) and their influence on stress and deformation

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Abstract: Many patients suffering from sequela of hemiplegia, due to cerebral vascular accident, are mostly prescribed an ankle-foot orthosis. There are two major types of ankle foot orthoses, one is a plastic ankle foot orthosis (PAFO) and the other is an ankle foot orthosis with a metal joint. Production rates for these devices are 75% for PAFOs and 23% for ankle-foot orthosis with metal joints. In other words, the PAFO is manufactured more than the ankle foot orthosis with the metal joint. The ultimate target of this research is to establish a semi-automated orthosis manufacturing system using 3D scanner, simulation (ANSYS) and 3D printer as an alternative to the conventional manually manufacturing method. We focus on simulation of this design system and verify its accuracy. Using the load data obtained from our previous studies, we perform a static load experiment to apply load to the orthosis and measure the deformation amount of the orthosis. At the same time, we simulate the amount of deformation and the stress when a similar load is applied to the orthosis of 3D data, using finite element method software (ANSYS). After that, we compare difference between the static loading experiment result and the analytical value obtained by the finite element analysis. Besides, as a model of the experiment, TIRR type PAFO which was subjected to processing called hollowing out of heel portion and calf abdomen and corrugation applying type PAFO for weight reduction was targeted for the research.

As a result of applying load in the backward direction against the TIRR type PAFO with 10 mm corrugation, the average difference between the experimental value and the simulation value was about 1.4 mm (experimental value: 16.79 mm, simulation value 18.20 mm). Also, when a load in the forward direction was added, the average difference between the experiment value and the simulation value was about 1.8 mm (experimental value: 16.45 mm, simulation value 18.20 mm). Therefore, the simulation was suggested to have effectiveness for PAFO design from these result. In addition, the tendency of deformation of TIRR type PAFO tended to be larger than that of ordinary PAFO was observed. From this point, PAFO was found to be easier to deform the brace by performing a process of hollowing off the brace.

Keywords: Plastic ankle foot orthosis, TIRR type plastic ankle foot orthosis, Static loading experiment, Finite element analysis, Deformation
Evaluation of Mechanical properties of fiber / matrix interface by micro-bond-test and Molecular dynamics

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Abstract: Interfacial strength is one of the mechanical properties of composite materials and affects the static strength and long-term durability of the entire composite material. It is important to evaluate interfacial strength. In our study, we investigate the relationship between interfacial strength and molecular structure. We attached epoxy (EPON 828) resin droplet including a curing agent (Triethylenetetramine) to a single carbon-fiber and cured it using an electric furnace. For comparison, we prepared vinyl ester/carbon fiber (Ripoxy-804B). In relationship between the load and the time during test, the peak load indicates the moment of debonding of the resin droplet from the carbon fiber. We regard the experimental peak fiber axis load as the boundary condition of the numerical simulation and determine the interfacial strength between the fiber and the resin by comparing experimental data with the FEM analysis. A numerical simulation is performed with ABAQUS using an axisymmetric finite-element model. In the numerical simulation, an accurate value of the thermal residual stress based on the thermo-viscoelasticity and the damage to the resin around the blade-contacting point is considered to simulate the experimental phenomena ideally. In the thermal residual stress analysis, the actual thermal residual stress is calculated by considering the relaxation modulus and the time–temperature superposition principle for the resin. Damage initiation criteria for both dilatational and shear cases, based on continuum damage mechanics, are considered for the resin. Interfacial debonding is simulated using a cohesive zone model, and the interfacial strength is taken as the strength of the cohesive zone element at the simulated fiber maximum stress corresponding to the experimental value. As a result, the interfacial strength of the epoxy resin / carbon fiber was higher than that of the vinyl ester resin / carbon fiber.

We optimized the molecular structure of epoxy molecule (Bisphenol-A diglycidyl ether), curing agent (Triethylenetetramine), vinyl ester molecule (Bisphenol-A), graphene sheet using GAMESS (Molecular orbital calculation software). The charge of those molecules was determined by B3LYP/6-31G. Epoxy model is used as molecules with epoxy molecules attached with curing agents at both ends. For calculation of carbon-fiber/resin model, simulation was performed using MD calculation by GROMACS (MD calculation software). In the system, resin molecules were randomly placed on cells with periodic boundary conditions above and below three graphene sheets. After structural relaxation, MD calculation was performed to create an NPT ensemble at 300 K, 0.1 MPa. The time step was 1 fs. We used the value of interaction energy per unit area as a parameter to evaluate the binding strength of polymers to the graphene surface. As a result, the interfacial energy between epoxy/graphene became larger than the interfacial energy between vinyl ester/graphene. We concluded that there seems to be a correlation between macroscopic interfacial strength and micro interfacial energy.

Keywords: Mechanical properties, fiber / matrix interface, micro-bond-test, Molecular dynamics, interfacial energy
Delamination caused by Internal Gas Pressure for Heat-Resistant CFRP subjected to rapid heating

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Abstract: The carbon fiber reinforced plastic (CFRP) is widely used for thermal protection systems in the aerospace field such as rocket engine nozzle. This material is generally called ablator. The generation of pyrolysis gas by the ablation process may increase internal gas pressure and cause delamination. Delamination of CFRP laminate is one of the fatal damage for CFRP ablator. In this study, we observe delamination of CFRP ablator under rapid heating condition, and we measure the interlaminar strength of CFRP, create numerical analysis code based on it. And we think that it is possible to prevent rising gas pressure and eliminate delamination by using a porous material.

A rapid heating test was conducted on the ablation material using an arc heating wind tunnel. The heating rate can be adjusted by the distance from the nozzle to the sample, the heating rate is 1-16 MW / m². In this study, the CFRP ablator was rapidly heated to observe whether delamination occurred in the ablator after the test. We used 0° laminated ablator (φ 50) as a specimen. In this experiment, ablators with porosities of 0, 10, 20, 30 and 40% are tested and the occurrence of delamination was investigated. Several physical property tests were also conducted. In these tests, the same material as the phenolic CFRP ablator was used as the test piece. In the gas permeability test, measure the gas permeability coefficient of the ablators. The test specimens are circular disks with a diameter of 24 mm and a thickness of 10 mm. The test specimen is placed on specimen holder and the N2 gas is flown until fixed time. This gas which permeates through the specimen and flow to the downstream is retrieved in the measuring cylinder and measured. And TGA test was conducted to derive the unknown constants of the thermal decomposition reaction equation of the phenolic resin component. The temperature range of this study is 300 °C to 1100 °C, and the atmosphere in the furnace maintains an inert condition using argon gas. Curves are obtained at constant linear heating rates of 2.5 °C/min, 10 °C/min, 20 °C/min and 40 °C/min. The change in weight of the specimen when it is heated in the furnace is measured, and the reaction rate is calculated. In addition, the interlaminar strength of CFRP was measured to simulate initiation of the delamination. And this value differs by the charring rate of the material. The specimen is adhered by using two-component epoxy adhesive to loading block, the loading speed is 0.5 mm/min. A tensile test was performed in the laminating direction, and the load applied to the specimen is measured. Finally, simulation was carried out using material properties such as measured gas flow property, pyrolysis reaction property and tensile strength. These results of the simulation have agreement with the rapid heating test results.

Keywords: CFRP, Thermal protection system, Internal gas pressure, Pyrolysis, Delamination
Failure prediction of polyimide resin using non-linear viscoelastic model considering thermodynamic entropy

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Abstract: CFRP (carbon fiber reinforced plastics) are widely used instead of metals in the current aerospace field. However, CFRP has complex structure and the fracture behavior is also complicated. It is required to clarify the material response of the matrix resin in order to predict the failure of CFRP. In recent years, it has been attempted to clarify the damage evolution in solid materials from irreversible thermodynamics (Naderi et al., Proceedings of The Royal Society, 2010). The disorder in the system, which causes deterioration of the characteristics, is raised by the deformation of materials and the entropy increases accordingly. Therefore, irreversible entropy in materials is expected to be a criterion for damage evaluating of materials. This study attempts to construct a new viscoelastic model considering thermodynamic entropy and represent deformation / failure behavior of resin. We conducted tensile tests on polyimide and entropy generation amounts were calculated until failure. Displacement controlled tensile tests using plane specimens of polyimide were carried out. Dimensions of specimen are 100 mm in length, 10 mm in width and 2 mm in thickness. Tensile tests were carried out at various displacement speeds (3.5×10^-4 mm/sec to 3.5 mm/sec). The entropy generation amounts were calculated based on the theory of irreversible thermodynamics and it was calculated about 13.8 kJ/Km³. In addition, creep and recovery tests were conducted to construct a new non-linear viscoelastic model. The specimen was loaded at a rate of 35 N/sec, and the load was hold at 20, 40, 60, 80 MPa for 1 hour. The model which we suggested shows good agreement with results of creep and recovery test, so this model can represent the material behavior of polyimide resin. And we predicted fracture of polyimide in the tensile test by using non-linear viscoelastic model which considered entropy generation amounts as criterion of damage. Comparisons of prediction and results of tensile test show good agreement, so our model can represent the failure of polyimide resin accurately.

Keywords: Viscoelasticity, Thermodynamic Entropy, Failure Prediction, Damage Mechanics, Polyimide
Effects of viscoelastic property of CFRP striker on rebound behavior of spherical object

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Abstract: In this study, effect of the viscoelastic property of CFRP striker on rebound behavior of spherical object is investigated by experiments and numerical simulations. By doing experiments, rebound behavior regarding newly developed CFRP striker in which viscosity is less significant than viscosity of conventional CFRP striker is compared with rebound behavior regarding conventional CFRP striker. Results are showed as follow. Vibration damping ratio of the newly developed striker is larger than that of conventional striker. Static stiffness is the same, but dynamic stiffness of newly developed striker is smaller than that of conventional striker. Rebound speed of spherical object when spherical object collides with a newly developed striker is larger than rebound speed of spherical object when spherical object collides with conventional striker. The aim of this study is to explain the reason why the newly developed striker indicates the above properties. In finite element method (FEM), CFRP striker is expressed as a viscoelastic body in which the spring and the dashpot are connected in series and another spring is connected in parallel. Spherical object is expressed as a rigid body. In the analysis, spherical object collides with CFRP striker and rebound. When spherical object collides with CFRP striker, CFRP striker is displaced. In the analysis, we investigate the damping behavior of CFRP striker and the collision and rebound behavior of spherical object. In the FEM, we assume that the viscosity coefficient of the newly developed striker’s dashpot is smaller than the viscosity coefficient of conventional striker’s dashpot. In case the viscosity coefficient of the new striker’s dashpot is smaller than the viscosity coefficient of conventional striker’s dashpot, analysis results are showed as follow. Vibration damping ratio of the newly developed striker is larger than vibration damping ratio of the conventional striker. New striker's displacement due to collision of spherical object is larger than conventional striker's displacement. Rebound speed of spherical object when spherical object collides with new striker is smaller than rebound speed of spherical object when spherical object collides with conventional striker. Because displacement of new striker is larger than displacement of conventional striker, dynamic stiffness of new striker is smaller than dynamic stiffness of conventional striker. Regarding vibration damping ratio and stiffness, the results of the FEM and experiments qualitatively agree. However, the experimental result on rebound speed of spherical object is different from the result of the FEM. Therefore, in the FEM, we treat spherical object as an elastic body not a rigid body. And we analyze using this property. In case spherical object is treated as an elastic body, sometimes, rebound speed of spherical object when spherical object collides new striker is larger than rebound speed of spherical object when spherical object collides with conventional striker. And the experimental and numerical result qualitatively agree. In case spherical object is treated an elastic body in the FEM, sometimes rebound speed of spherical object increases since spherical object itself vibrates.

Keywords: CFRP, stiffness, damping, rebound, FEM
Tensile Behavior on Dried Latewood in Japanese Wood

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Abstract: It is known that moisture content has an influence on the mechanical property of wood. Correct drying of wood will minimize moisture content changes that might occur after drying when the wood is in service and such changes are undesirable. Wood consists of an earlywood (EW) and a latewood (LW), in this study, tensile property on the dried LW in Japanese wood (Cryptomeria japonica) was investigated. Wood of Japanese cedar from Miyazaki prefecture was used in this study. The wood was over 40 years old, specific gravity of 0.37 and moisture content (MC) of 0 %. The LW with thickness of 0.2 ± 0.05 mm, width of 3.0 ± 0.5 mm and length of 30 mm was cut out by machining. Tensile test in accordance with JIS was carried out at initial loading rate of 1.0 mm/min. In this system, tensile load is measured by one load cell (TCLZ-200NA, Tokyo Sokki Kenkyujo Co.) with capacity of 200 N, and displacement is measured by laser displacement sensor (IL-030, KEYENCE CORP.) and strain gage (FLK-1-11, gage length of 1.0 mm, gage width of 0.7 mm, Heatproof temperature of 393 K (120 °C), Tokyo Sokki Kenkyujo Co.) in pursuit on loading axis to movement. Three tensile specimens were prepared in this study. As a result, it appreciated that deformation behavior on the dried LW could be evaluated with highly accuracy using strain gage. The LW specimens exhibits a linear mechanical response. Elastic modulus, tensile strength and fracture strain on dried LW were 14.4 GPa, 221 MPa and 0.017, respectively. Fracture behavior on dried LW was conducted. Large cracks occurred along the longitudinal direction of the loading axis. After that, the shear fracture took place in between the cracks. The cell-wall in LW consists of four discrete layers where the orientation of the cellulose microfibrils varies from 0 and 90 degree to the longitudinal axis of the fiber. Closer experiments are necessary deformation and fracture of microfibrils and wood structure based on wood fracture theorem.

Keywords: Wood, Mechanical Property, Fracture Behavior, Moisture Content, Strain Gage
Fundamental Study on Repair of CFRTP Laminates from One Side Using Thermal Fusion Bonding

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Abstract: Carbon fiber reinforced thermoplastic (CFRTP) has attracted attention as a material for transportation equipment such as automobiles for the purpose of saving molding time and secondary processing. Since thermoplastic becomes liquid when heat is applied, CFRTP can be joined each other by thermal fusion bonding (TFB). Utilizing this feature, the authors have been studying the repair of delamination within CFRTP laminates by TFB. In the repair of the laminates by TFB, it is necessary to apply pressure in order to contact surfaces of delamination. The authors have used hot press to apply pressure. On the other hand, in a real structure (especially a hollow closed structure), it is impossible to apply pressure from both sides unless a rigid body such as a pressure plate is inserted in the structure. Therefore, this study explored the possibility of repairing the laminates without inserting a rigid body in the structure. The method in this study is as follows (Fig. 1). First, a heated rigid body having spherical surface is pressed against the damaged area in order to close and contact surfaces of delamination. Since the surroundings of heated area do not exceed the melting point of the resin, it is expected that pressure will be applied in the out-of-plane direction just under the rigid body. Then, evacuating air makes the dent smooth. In this method, it is impossible to apply pressure from the out-of-plane surface when smoothing the indentation, but at least it is considered that delamination can be repaired. In this study, delamination area was observed by cross-section observation after pressing and smoothing, and flexural modulus before and after repair was measured to evaluate availability of this method.

Keywords: CFRTP, Repair, Thermal fusion bonding, Delamination, Impact damage
Transverse Impact on Beams of Different Materials

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Abstract: Two types of experiments were carried out. First dynamic photelasticity was carried out to study transverse impact on urethane rubber beam by free fall of a striker from a height of 176.4mm keeping beam-striker weight ratio (2.675) constant. Employing Fastax framing camera (12,000 frames per second) isochromatic fringe photographs were recorded in a light field polariscope for central and non-central impact on simply supported beam with equal overhang for three different types of spans, namely, 90mm, 120mm and 150mm with three different mass of strikers 10.52gm, 14.02gm and 17.53gm respectively. Beam-striker weight ratio (2.675), height of fall, and dimensions of beam were kept constant.

A contact force transducer was fabricated to measure impact force using quartz crystals, charge amplifier and storage oscilloscope. Second set of experiments were conducted on beams made of three different materials, namely, PMMA, Aluminum and PMMA-AL-PMMA with 120 mm beam span. The mass of striker was to 41 gm for central impact only.

Using electrical resistance strain gauges, contact force transducer peak tensile strain and contact force were recorded. A nomogram indicating normalized Hertz’s constant striker-beam weight and peak tensile strain for the beams of different materials were plotted. Peak tensile strains in PMMA beam impacted centrally by different strikers were also recorded. Another nomogram indicating normalized Hertz’s constant, striker-beam weight ratio and peak tensile strain for the PMMA beam under central impact were plotted. Presence of small amplitude ‘precursors’ and small-amplitude higher frequency oscillations in the strain histories recorded and identified.

Keywords: Dynamic Photolasticity, Fastax framing Camera, Contact force Transducer, Electrical resistance strain gauge, Transverse Impact
Mechanical properties of polymer thin films prepared by wet and dry processes

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Abstract: This paper describes an estimation of elastic and plastic properties of Poly(9-vinylcarbazole) (PVK) and 4,4’-Bis(N-carbazolyl)-1,1’-biphenyl (CBP) thin films by using a nano-indentor. PVK and CBP were coated in a thickness of 500 nm on a glass substrate for Organic Light Emitting Diode (OLED) devices by spin coating and vacuum deposition respectively. The measurement of Young’s modulus was carried out by the continuous indentation method. Plastic deformation properties were obtained by a method proposed by Higuchi et al. (2009) and Ogasawara et al. (2007), that is stress-strain curve is estimated in an equation of $\sigma = R \varepsilon^n$. The results have shown that the elastic moduluses of PVK and CBP were 9.3 MPa and 9.5 MPa respectively, which are a little lower than those of Alq3 and $\alpha$-NPD reported in the previous paper. Further, the material constant n are 0.003 and 0.0007 for PVK and CBP respectively, which are much smaller than those of Alq3 and $\alpha$-NPD, suggesting that PVK and CBP have nearly elastic-perfect plastic properties. Therefore, it has been suggested that the reason why PVK and CBP thin films showed higher critical cracking strains more than 7% is resulted from the lower elastic modules and the smaller work hardening rate (n) than those of Alq3 and $\alpha$-NPD whose critical cracking strains are 5.0 % and 3.6% respectively.

Keywords: Elastic modulus, Polymer thin films, PVK, CBP, Nano indentor
Effect of load frequency on cyclic stress measurement method using electrodeposited copper foil

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Abstract: When the electrodeposited copper foil is subjected to a cyclic loading, grain growth occurs in the foil. It has been demonstrated that the grain growth is controlled by the magnitude of maximum shearing stress amplitude and the number of stress cycles. In order to measure the shearing stress amplitude, a calibration test is performed in advance to determine the relationship among shearing stress amplitude, number of cycles and grown grain density. Then, the maximum shearing stress amplitude can be measured based on the grown grain density of the copper foil that adhered to a machine element. Grain growth due to cyclic loading is a phenomenon similar to recrystallization by heating. Therefore, it is related to the movement of dislocations using mechanical or thermal energy. Generally, it is known that there is a strain rate dependence in a phenomenon related to the movement of dislocations such as yielding and fatigue of material. This means that the grain growth occurred in the copper foil is also considered to be affected by the load frequency. From this viewpoint, the effect of load frequency on the grown grain density is investigated in this study. First, the copper foil is obtained by the electroplating. Then the foil is adhered to the surface of a plate-type specimen made from carbon tool steel. Second, cyclic loading tests are conducted at three kinds of load frequencies: 6 Hz, 30 Hz and 60 Hz. Then, the grown grain densities are measured using an optical microscope and image processing software. Finally, the conventional calibration equation is corrected based on experimental results. The experimental results reveal that the strain sensitivity of the grain growth tended to increase slightly with decreasing test frequency. If the difference in the load frequency is about 2 times, the influence of frequency on the grown grain density is small. On the other hand, when the difference reaches about 10 times, a measurement error of about 10% will occur. This means that it is necessary to consider the influence of test frequency in order to measure stress more accurately. The conventional calibration equation for stress measurement based on the grown grain density is corrected to a new expression that takes into consideration the influence of test frequency and it is cleared that measurement error by the new expression is about 1%.

Keywords: Stress-Strain Measurement, Experimental stress analysis, Fatigue, Copper electroplating method, Recrystallization
Reflection Removal Infrared Thermographic Test using Polarization Theory for Dielectrics

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Abstract: Infrared thermographic test is a method of detecting infrared radiation energy and displaying the distribution as an image. This test is effective for non-destructive inspection and condition monitoring because it has some advantages; it is safe, efficient, and easy to be applied. However, the test is often influenced by the environment, which sometimes causes a false detection of defect. Thus the background reflection from sunlight or neighboring structures is a serious problem. In this study, the authors focused on polarization theory for the purpose of solving the problem, in other words, separating quantitatively the background reflection and the defects using the polarization theory for dielectrics. First, the authors focused on the relationship between S polarized infrared energy and P polarized infrared energy obtained by infrared thermographic instrument with the polarizer. This relationship between infrared emission energy and infrared reflection energy was expressed by a two-variable linear equation. By solving the equation, the authors devised an algorithm to quantitatively obtain infrared emission energy and infrared reflection energy. Finally, we created a program to extract emission infrared energy and to inspect the defect from the image. In order to verify the effectiveness of this proposed program, the experiments were conducted in a condition where a background reflection and a defect overlapped on the imaging screen. In the thermal image without polarizer, the reflection energy and the emission energy are still overlapped and it is impossible to judge which is the defect indication. On the other hand, the proposed program can remove the background and obtain the thermal image of only emission energy from the defect part. Based on the above results, the authors could be possible to establish the reflection removal infrared thermographic test using the polarization theory for dielectrics. This test is considered to be effective under conditions susceptible to background reflection, such as nondestructive inspection of civil engineering structures and composite materials except metals.

Keywords: Infrared thermographic test, Background reflection, Polarization Theory, Quantitative evaluation, dielectrics
X-ray Stress Measurement of Carbon Fiber in CFRP

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Abstract: Carbon fiber is used as a composite material such as CFRP (carbon fiber reinforced plastic) by combining with a polymer material. CFRP is a light and strong material with a higher specific strength than metal materials such as iron and aluminum. Therefore, it is widely used in the aerospace and automotive fields. In a fiber reinforced material such as CFRP, a large residual stress occurs in the reinforcing fiber due to the difference in linear expansion coefficient between the fiber and the base material. There is a possibility that this residual stress affects the performance of the material and becomes a problem. Therefore, the purpose of this research is to focus on the carbon fiber material used for CFRP and evaluate its internal stress state.

The residual stress was measured using X-ray stress measurement method capable of noncontact and nondestructive measurement. In this research, we attempted stress measurement with higher precision by using the transmission method instead of the reflection method. In addition, measurement was performed by applying the d-sin^2ψ method. A tensile load was applied to a carbon fiber material by a small tensile testing machine, and the generated stress was measured using two types of characteristic X-rays, MoKα and CuKα. From the experimental results, the relation between the load stress and the stress measured by X-ray was obtained. Next, d-sin^2ψ diagram was prepared and the internal stress state of the carbon fiber material was considered.

As a result, in the X-ray stress measurement method using the transmission method, the high angle side of the diffraction line peak shifted and the asymmetry increased. In this study, it was confirmed that the slope of the d-sin^2ψ diagram due to loading load of carbon fiber was increased by transmission method using characteristic X-ray of MoKα and CuKα.

Keywords: X-ray stress measurement, CFRP, carbon fiber, residual stress
Phase Analysis Method in Fringe Projection with Intensity Distribution for Axial-Direction by Three-Beam Interferometry

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Abstract: In this paper, we study the method for obtaining the phase in the fringe projection using a three-beam interferometry. In the three-beam interferometry, the intensity variations appear to configure the fringe pattern along the axial-direction by superimposing each two-beam interferometry. Therefore, the fringe pattern along the axial-direction enables us to directly obtain the 3D shape and displacement in the out-of-plane direction of an object without the interpolation and the coordinate transform by inclining the camera. Therefore, the positional relationship between the light source and the camera does not affect the measurement accuracy. In other words, an optical system without the alignment of the camera can be realized. If the phase value in the captured fringe is obtained, the 3D shape and displacement of the object can be obtained quantitatively in a similar way as a two-beam interferometry. In order to obtain the phase, the relationship between the shift amount of the phase and the movement amount of the fringe pattern along the axial-direction is evaluated. Then, the phase value is calculated from the phase-shifted fringe images captured by the camera. Further, by measuring the object which has the known height, the accuracy of the system is evaluated. In the future, we will show that our method can achieve the measurement of the displacement in sub-millimeter which is difficult in the conventional method. Our method can be widely applied to the remote and out-of-plane displacement measurement for the test and the maintenance of large constructions.

Keywords: Multi-beam interferometry, Out-of-Plane Displacement Measurement, 3D Shape Measurement, Phase-Shifting Method, Maintenance.
X-ray Thermal Stress Estimation of CFRP Matrix in Low Temperature Condition

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Abstract: The carbon fiber reinforced plastic (CFRP) material is a very important material in industrial fields. Especially, the noteworthy mechanical properties is the light weight and the high strength of the CFRP materials. Therefore, the CFRP materials are used for structural materials on behalf of metal materials in many case. For example, the liquefied natural gas (LNG) tank on a transport ship is the more light the better. The CFRP materials are expected to use to the LNG tank for a long time. However, these requires has not been realized yet, unfortunately. There are still many problems that have to be solved in this dream. Clearly, the one of problems is the thermal residual stresses in the CFRP materials. The manufacturing process of CFRP materials include many thermal alteration processes such as the heat press, the injection molding, and so on. Therefore, the thermal induced residual stresses existed in the CFRP materials in any case. These residual stresses are generated from the thermal expansion mismatch between the fiber and the matrix in the CFRP materials. The mechanical properties of the CFRP materials are influenced by the thermal residual stresses, and it becomes a very important parameter for mechanical designs in industrial fields. In this study, residual stresses in the CFRP materials were measured by the x-ray stress measurement technique. The CFRP materials estimated in this study consists of carbon reinforced fibers and a polyamide matrix, and it was manufactured by a heat press method. The $\sin^2\psi$ method is a most useful method for the x-ray stress measurement. The combination of the $\sin^2\psi$ method with the transmission diffraction method was employed for the x-ray stress measurement of the CFRP materials in this study. In this study, the CFRP samples were cooled in a very low temperature -200K by a cryostat cooling system, it like a situation of the LNG tank. The x-ray beam irradiated to the CFRP sample cooled in a cryogenic condition, and thermal residual stresses are measured by the in-situ x-ray stress measurement technique. From several results of $\sin^2\psi$ diagrams for the x-ray stress measurement technique, regression lines of the $\sin^2\psi$ diagrams showed the good linearity in the case of the polyamide matrix. Therefore, these results can expect to have highly accurate calculations for residual stresses. On the other hand, in the case of the carbon fibres, there are scatters in measurement data, and regression lines of the $\sin^2\psi$ diagrams did not show the linearity. Finally, compressive residual stresses existed in the polyamide matrix and tensile residual stresses existed in the carbon fibres. These stress distribution were generated from the thermal expansion mismatches between the carbon fibres and the polyamide matrix.

Keywords: CFRP, X-ray, stress measurement, very low temperature, in-situ measurement
Residual Stress Estimation of CFRP materials by X-ray Diffraction Method

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Abstract: The carbon fiber reinforced plastic (CFRP) material is one of the functional material and it is expected in many kind of industrial fields because of the excellent properties such as the high specific strength, the corrosion resistance, low manufacturing costs, and so on. In this study, residual stresses in the CFRP materials were measured by the x-ray stress measurement technique. The CFRP materials estimated in this study consists of carbon reinforced fibers and a polyamide matrix, and it was manufactured by a heat press method. Therefore, the thermal induced residual stresses existed in the CFRP materials in any case. These residual stresses are generated form the thermal expansion mismatch between the fiber and the matrix in the CFRP materials. The mechanical properties of the CFRP materials are influenced by the thermal residual stresses, and it becomes a very important parameter for mechanical designs in industrial fields. In the case of polymeric materials, X-ray beam can go thorough deep positions because of very low absorption characteristics of polymer materials. Therefore, the transmission diffraction method with a $\Omega$-diffractometer was employed to estimate the stress distribution of the CFRP materials. The $\sin^2\psi$ method is a most useful method for the x-ray stress measurement. The combination of the $\sin^2\psi$ method with the transmission diffraction method was employed for the x-ray stress measurement of the CFRP materials in this study. Stresses in the CFRP were measured under several applied loads. A small tensile testing machine was mounted on the $\Omega$-diffractometer and several loads were applied by several weights. From results of $\sin^2\psi$ diagram of the x-ray stress measurement technique, regression lines of the $\sin^2\psi$ diagram showed the good linearity in each applied load. Therefore, these results can expect to have highly accurate calculations for residual stresses. On the other hand, the gradient of the regression lines increased with the load rising. These phenomena indicate that the crystalline phase of the polyamide matrix changed with the external forces. From these results, the stress measurement method by the x-ray diffraction is possible to estimate of the residual stresses in the CFRP materials.

Keywords: Stress measurement, X-ray, CFRP, composite material, $\sin^2\psi$ method
**X-ray Stress Measurement of The Anodizing Film on Titanium Plate**

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**Abstract:** Titanium is used in various industrial fields. It was performed various coloration processes to improve added values of titanium. Anodizing films on the titanium surface are generated by the anodic oxidation method. Anodic oxidation method is the mainstream of coloration processing. Film thicknesses change by the voltage at the time of the formation in the anodic oxidation method. A refractive index changes and colors change. However, the stress conditions in the anodizing materials has not been clear enough yet. In this study, residual stresses in various anodizing films are measured by the X-ray diffraction method. Polished titanium thin plates are flowed in phosphating solution and be a current of 16V. Diffraction profiles from the anodizing sample and the titanium substrate was compared. From these experimental results, both of diffraction profiles matched exactly, and there was no diffraction peaks from the anodized film on the titanium surface. On the other hands, results of the stress measurement from titanium substrates showed good linearities for 2θ-sin^2ψ diagrams. From these results, residual stresses reduced after anodized treatment. The reasons for these results are considered as follows; An anodized film is formed in the surface of the polished titanium thin plate, and the thin surface layer was changed to the anodized film form the titanium substrate. The compressive residual stresses generated by the emery polishing were replaced with an anodic oxide film. Therefore, compressive residual stress is estimated to decrease comparing before released conditions. Furthermore, the anodized film thicknesses were measured in this study. The film thicknesses were measured with a surface roughness meter. However, the film thicknesses could not be measured in exactly. There are two reasons for this result. First, the film thickness is lower than 1μm which is the accuracy of the surface roughness tester. The second, the anodized film is formed into the thickness direction of the titanium substrate. Therefore there is no level differences in the boundary between the anodized film and the titanium substrate.

**Keywords:** titanium, anodizing film, X-ray stress measurement, anodic oxidation method, color
Crack Width Measurement Method of Brittle Materials by Moiré Method

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Abstract: It is very important to measure the deformation of the structural parts of the large constructions for the health monitoring or damage evaluation of the constructions. The Moiré methods are measurement methods for the deformation of the materials and structures using moiré phenomena which can be observed when two grids were overlapped. There are a lot of cracks initiate and propagate in the brittle materials such as the concrete structures. However, it is very difficult to find and measure the cracks and crack width.

In this study, a novel moiré method to measure the crack width of the brittle materials by Moiré method. The concrete specimens and mortal specimens with model grid was prepared. The splitting tensile tests of the concrete and mortal specimens were carried out to observe the Moiré fringes of the specimen. These tests were carried out by the mechanical testing machine (Load capacity:100kN). The 1.5mm square grid was sealed on the side surface of the concrete and mortal specimens. The Moiré fringe was observed during the splitting tensile test of concrete specimen and the other side of the specimen (without any grid) was also observed. When the crack was observed on the other side of the specimen, the offset of Moiré fringe can be observed along the crack. The spacing of the Moiré fringe and offset of the Moiré fringe was measured near the crack. From the offset of the Moiré fringe and the spacing of the model grid, the width of the crack at the center of the specimen was calculated by using these data. Minimum value of the crack width with 1.5mm grid was about 0.3mm. These result show the Moiré method can be applied to measure the width of the cracks of the brittle materials.

Keywords: Moiré method, Crack Width Measurement, Brittle materials, Miss-alignment of Two Grids, Offset of Moiré Fringe
Porosities and strengths of Ceramics utilizing Waste Glass Fiber Reinforced Plastic

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Abstract: Glass fiber-reinforced plastic (GFRP) is plastic to which glass fiber has been added as a reinforcement material to improve its specific stiffness, strength, and incombustibility. GFRP is used in products such as automobile parts and small vehicles. However, most waste GFRP is buried underground like other industrial waste. Fine glass fiber dust and leachates from this process may cause serious health and environmental damage, and landfill sites may also become unavailable in the future because of space constraints. To save resources and reduce environmental load, the development of an effective technique for the disposal of waste GFRP without polluting the environment is strongly desired. To recycle discarded GFRP, we have developed a process that produces porous glass fiber-reinforced ceramics by mixing crushed waste GFRP with clay before firing the resultant mixture. This process is not selective about the type of GFRP, and it can also minimize fine glass fiber dust generation by sintering clay and glass fiber, or sintering between glass fibers. In the ceramic manufacturing process that we have proposed, clay-based ceramics with an extremely high porosity can be produced because the ceramic clay matrix is reinforced with glass fibers. Some ceramics possess a high water absorption and permeability with high strength. Therefore, application of the ceramics to high-value-added products such as retentive pavement and permeable pavement blocks can be expected. There are various type of GFRPs. The GFRPs contain glass fiber of 60% (mass%) at most. The type of glass fiber is mostly E glass. It is important to clarify how much the ceramics made from the GFRP and clay possess the porosity and specific strength, when we think about the applications of the ceramics in the future. So, various specimens were made by adjusting the mixing ratio of clay and crushed GFRP, the particle size of the GFRP, and the firing temperature using GFRPs containing 30%–60% glass fiber. The porosities, water absorption and permeability on the ceramic samples were then investigated. Their values were also compared with those of porous ceramics made by mixing plastic without glass fiber with clay before firing. Furthermore, bending strength tests were then carried out on the samples. The summary of the results is as follows.

(1) The porous ceramics made by mixing plastic without glass fiber with clay had porosities of approximately 50% and 40% at most, respectively when the mixtures were fired at 1000 and 1100 °C. In contrast, the ceramics made by mixing GFRP with clay had porosities of approximately 60% and 50% at most because clay matrix by glass fiber was reinforced.

(2) When using GFRP containing 40% or more glass fiber, the strength of ceramics significantly increased compared with that of porous ceramics made using plastic without glass fiber. Part of ceramics had higher specific strength than that of ceramic made from clay alone.

Keywords: Waste GFRP, Recycling, Ceramic, Porosity, Strength
Quantitative evaluation by shape measurement for production technology legend and reproduction of Transitional Folding Fan

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Abstract: Japanese folding fans were born during the Heian period (794 to 1185) and had been used in every situation. Many of the fans in the Edo era (1603-1868) have been successfully blended with the processing technology of "natural materials" and its application to "artistic originality". For the technological legend and the reproduction, it is important that the investigation and the consideration from viewpoint of description which arises by folding configuration of "Folding Fan". Therefore, the 3-D measurement was carried out for the quantitative evaluation.

The investigation total numbers of the "Folding Fan" and the “Ougi-E” (folding fan picture) and the Senmen-ga (flat picture)” for research targeted becomes 500 more. Here, the “Senmen-ga” is drawn on a fan-shaped paper, but it is just drawn on a two-dimensional plane as similar to a general painting. On the other hand, "Folding fan picture" is tailored to make "Fan", so painters are required to predict the 3-dimensional morph.

In this study, the investigation items of the "Folding Fan" are 1) Fan's closing and opening configurations, 2) Painter's data, 3) Fan's detail dimensions , 4) Bamboo bone's, 5) "Kaname" (joint pin of bamboo bone) , and so on. These data were measured and recorded by photograph. The forming mechanism of the “Folding Fan is clarified based on these quantitative measurement data. Furthermore, Moreover, the difference between the "Ougi-E" (three dimension image which has the fold structure and the opening and closing function) and the "Senmen-ga" (two dimension appreciation image) is clarified, and the visual illusion effect of the “Ougi-E" by concavexo-concave effect are shown . In this study, the re-verification and the revaluation overlooked by a past research of "Folding Fan" become possible.

Keywords: quantitative valuation, fording fan, traditional technique, reproduction, convexo-concave effect
Observation of Particle Behaviors in Extrusion Flow of Concentrated Particle Suspensions

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Abstract: Mixtures of water and thick concentration of potato starch are representative dilatant fluids. The dilatant fluid is one of concentrated particle suspensions, which shows the phase transition from solid to liquid or vice versa according to the magnitude of deformation occurring within a fluid during a flow. Since the phase transition of suspension is an interesting phenomenon from the view point of rheology, there are many reports aiming to clarify the details, until now. In many reports, however, although the dilatant effects due to the phase transition have been examined by the measurement of flow resistance, there are few reports describing the details from particle behaviors. Especially, the phase transition is considered to be closely related to the interaction among particles, and complicated phenomenon like particle aggregation should occur during the transition process. Therefore, we focused on the particle behavior in suspension flow and tried to clarify the mechanism of the occurrence of dilatancy. For test fluids, we used two kinds of mixtures of acrylic spherical particles and glycerin. The particle size was the order of submillimeter, and the volume fraction of particles of the test fluids were 40% and 48%. With regards to the flow pattern of the particle suspensions, we selected the 2D extrusion flow with a contraction part in order to facilitate the observation of particle behavior. In the measurements of the shear viscosity of the test fluids using a rotational rheometer of bob and cup type, the dilatant effect meaning the abrupt increment of viscosity could not be observed for each fluid. However, in the flow visualization in the extrusion channel at almost the same shear rate as the measurements with the rheometer, the particle aggregation appeared in the neighborhood of a contraction part at a startup of flow. Although this local particle aggregation was temporary and thereafter flowed out to the downstream part together with a main flow, the particles repeated the aggregation and collapse at the contraction part. These results suggested that strong interaction among the particles was necessary for the occurrence of dilatancy. Furthermore, we consider that the relationship between the surface property of the particle and fluid property like surface tension has an important role in the occurrence of dilatancy.

Keywords: Particle suspension/ Extrusion flow/ Dilatancy/ Particle aggregation/ Rheology
Wind Loads on Offshore Floating Photovoltaic Panels
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Abstract: Renewable energy sources are rapidly becoming an integral part of worldwide measures to combat the effects of climate change. In 2016, it is approximately 375 TWh of energy generated from photovoltaic (PV) systems. However, the installation of solar PV has the burden of intense land requirement (ground mounted or rooftop systems). Since oceans cover approximately 71% of Earth surface, the development of PV systems in offshore environments, which floats directly on the waterline, is proposed in recent years. A PV system consists of tilted panels in row and is prone to extreme wind loads, e.g. hurricanes or typhoons. Previous studies showed that the first row of solar panels is subject to the greatest uplift force. To ensure proper functions of a system, the effect of wind and tidal wave should be addressed.

This study determines wind loads on offshore floating solar panels. Experiments were conducted in two wind tunnels for pressure and force measurements. A single solar panel or a solar array (6 solar panels) was installed to determine the length-to-width effect. The tilt angle, $\alpha$, and wind incidence angle, $\theta$, are $10^\circ$ to $60^\circ$ and $0^\circ$ to $180^\circ$, respectively. Pressure taps on the upper and the lower surface of the tilted solar panels were used for mean and fluctuating surface pressure measurements. Normal force coefficient is computed by integrating the differential mean surface pressure distributions. A force model was also fabricated and a six-component force balance was used to determine the uplift force coefficient. For $\theta = 0^\circ$, the uplift force coefficient varies linearly when the tilt angle is relatively small. The value of $\theta$ has an effect and the maximum uplift coefficient is observed at $15^\circ$ to $30^\circ$.

Keywords: floating PV; offshore; inclined solar panel; wind incidence; wind load
Aerodynamic Characteristics of inclined Solar Arrays in a Low-Rise Building

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Abstract: Renewable energy sources are sustainable. In 2016, it is approximately 375 TWh of energy generated from photovoltaic systems. A PV or thermal system consists of tilted panels and is prone to extreme wind loads, such as hurricanes or typhoons. To ensure proper functions for the system, it is important to determine its aerodynamic characteristics. Experiments were conducted in a boundary-layer wind tunnel at the Architecture and Building Research Institute. The closed-loop tunnel has a honeycomb and three screens. The tilted solar arrays (6 rows 10 solar panels, tilt angle = 25°) were installed facing into the direction of the wind on the flat roof of a low-rise building. The building code in Taiwan requires that the maximum height of a PV system must be less than 3 m above the top of a flat roof. To determine the effect of roof clearance on wind loads for solar arrays, the total height of the solar arrays was set at 1, 2 and 3 m. In addition, a 1/20 scale model was fabricated. Fifty-two pressure taps on the upper and the lower surface of each solar array were used for surface pressure measurements. A total of 312 pressure taps were installed on the upper and the lower surfaces of the tilted solar arrays. Mean and fluctuating pressure distributions are obtained to compute normal force coefficient by integrating the differential mean surface pressure distributions. The uplift force from the second to the sixth solar arrays is reduced because of sheltering effect. However, an increase in roof clearance results in greater uplift force for inclined solar panels, particularly on the first solar array facing into the direction of the wind. Peak pressure fluctuations are observed on the second solar array. This corresponds to vortex shedding by the first solar array. Wind-induced vibrations require caution.

Keywords: PV; inclined solar arrays; low-rise building; roof clearance; sheltering effect
Couette Flow between Cylindrical Surfaces

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Abstract: The modeling of the Couette flow in a circular gap between coaxial surfaces formed by rotating cylinder and semicylindrical outer surface is considered. The geometric dimensions of the experimental facility were determined taking into account the minimum deviation of the velocity profile in the gap from the linear one in the case of laminar flow regime, and also to prevent the formation of Taylor-Görtler vortices at some flow parameters. The internal volume of the facility was sealed to make it possible measurements in a wide range of pressure and Reynolds and Knudsen numbers. The possible range of flow velocities on the surface of rotating cylinder is up to 100 m/s, including the lowest gas pressure of 5 torr corresponded to large Knudsen numbers and small Reynolds numbers.

The velocity profiles has been obtained with the hot-wire in three several position along the channel. The possibility of using this flow to study the law of heat transfer between the heated wire and the flow to determine the hot-wire sensitivity coefficients is demonstrated. The influence of the Knudsen number on the heat transfer of the hot-wire is shown.

The difference between measured profiles in annular channel and classical profiles in plane Couette flow (Schlichting H. Boundary-Layer Theory. New York: McGraw-Hill, 1979) is presented in a dimensionless form. As it is shown the velocity profile in the annular channel does not have a central symmetry with respect to the channel axis. The reasons for this velocity distortion can be the effect of centrifugal forces acting on the flow due to the curvature of the channel, and the possible action of the Görtler vortices, which also arise due to the curvature of the channel. Confirmation of forming the Görtler vortices at some regimes were obtained with the help of oil visualization. However their joint influence is not excluded also.

Keywords: Couette Flow, Rotating Cylinder, Hot-Wire, Velocity Profile, Görtler vortices
Investigation of Aerodynamic Coefficients of a Rocket Model with Rotation Rate in Tri-sonic Wind Tunnel

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Abstract: Wind tunnel test provides the confidential experimental verifications of flow properties and corresponding aerodynamic characteristics. In conceptual design phase, experimental data is an important evidence for engineers to determine whether the aerodynamic characteristics of designed model are correct. This test is carried out in the 4ft × 4ft tri-sonic wind tunnel in Aeronautical Systems Research Division, National Chung-Shan Institute of Science and Technology (ASRD-NCSIST) in Taiwan, applying a new-designed rocket test model. The aerodynamic loads of body are measured by a six-component internal force balance in body, and two three-component internal force balances are installed to measure aerodynamic loads of fin, at angles of attack (AOA) varying from -5 to 25 degrees, roll angle varying from 0 to 90 degrees, and Mach number from 0.4 to 2.5. The blockage ratio of model at zero angle of attack is 0.1%. Beside the aerodynamic loads, the total and static pressure of wind tunnel, and base pressure of rocket model were also measured. In this research, there are two modes of roll angle variation while AOA was fixed. For mode one, the fins and forward part of model are rotated to the assigned angle, while mode two rotates the whole model in full 360 degrees. While the model rotates, the aerodynamic loads of body and fins are measured simultaneously, so we can compare the data and do further calculation. The results show that the distribution of normal force coefficient varies for different Mach numbers, AOAs, and roll angles. Furthermore, the position of body pressure center moves more rear as long as Mach number increase. With the rotation rate, the position of fin pressure center shows different phenomenon. When the rotation angle range is 0~180 degrees, the data of two modes show good consistency. However, the position of pressure center moves more after at rotation angle range between 180~360 degrees.

Keywords: Tri-sonic wind tunnel, Roll angle, Normal force coefficient, Pressure center, Rotation rate
The velocity measurement of the detonation wave induced by combustion of the air-acetylene mixture by ion probes

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Abstract: A Pulsed Detonation Engine (PDE) utilizes repetitive detonation to obtain the thrust and the work. PDE boasts high thermal efficiency as compared with the conventional internal combustion engines and has the potential to achieve light weight and low cost simultaneously with its simple structure. Because of its apparent advantages, PDE has come to the attention widely from the several fields of science and engineering. Thus various research results have been reported. However, generation mechanism and stable control method of detonation are still unclear, and PDE has not been put to practical use. Therefore, accumulation of knowledge about detonation phenomena are essential.

One of the detonation initiation methods is known as Deflagration to Detonation Transition (DDT) where the combustion mode of gas changes from deflagration to detonation. DDT is proper method for PDE because stronger ignition devices with high energy are unnecessary. For shortening the length of burner, decreasing the weight and simplifying the structure, it is essential to initiate DDT in short time and short distance. It is well known that the DDT distance can be shortened by installing the obstacles such as Shellkin spiral in the burner, because the transition to turbulent flow of the combustion gas is promoted.

Acetylene is one of the candidates can transit to detonation without strong ignition devise among the hydrocarbon based fuels, and is easy to obtain at low cost.

In this study, we have performed the velocity measurement of the combustion wave propagating in the detonation tube (length: 1235mm, diameter: 29.5mm). The mixture of air and acetylene (equivalence ratio 2) was filled in the detonation tube. Mixture was ignited by a spark plug settled at the front of detonation tube. Propagation velocity is measured by 10 ion probes settled along the detonation tube axis at regular 100 mm intervals, which are made from spark plugs. Additionally, experiments in case of installation of Shellkin spiral (line diameter: 3.2mm, pitch 10mm, inner diameter: 18mm) with its length as a parameter (30%,35%,40%,45%,50%,60%,80% for tube length) was performed and compared with in case of non-installation.

As a result, since maximum propagation velocity without spiral and with 30% tube length spiral were obtained as 635 m/s and 659.7 m/s respectively, which were less than C-J velocity 1088 m/s at this experimental condition calculated by using STANJAN, it is thought that the detonation had not occurred at these spiral condition.

On the other hand, maximum propagation velocity with 35 to 80% tube length spiral were faster than C-J velocity (35 to 60%: about 2000m/s, 80%: about 1700 m/s), and the velocity with 45% length was the fastest (2333 m/s). Consequently, it is attributed to the fact that the detonation limit condition of spiral length exists in the range of 30 to 35 % length and the spiral length which promotes DDT exceedingly is in the range of 40 to 50% at this experimental condition.

Keywords: Shock wave, Gas combustion, Ion probe, Flame velocity measurement, Detonation tube
Abstract: Aerodynamic flow around a blunt body is featured with flow separation taking place on its contoured surface where the adverse pressure gradient is in effect. For such a flow, the aerodynamic drag is dominated by the form drag which is basically determined by the extent of the flow separation region. In the sub-critical range, which can be described in terms of Reynolds number based on the characteristic length of the blunt body and the incoming freestream velocity, the drag coefficient of the blunt body stays almost constant. This signifies that the phenomenon of flow separation, or the extent of the flow separation region noted, is not sensitive to the Reynolds number. Nevertheless, as the Reynolds number is further increased and falls in the critical regime, a drastic reduction in drag coefficient is discerned. This pronounced transition in drag is known as the drag crisis. Physically, this phenomenon is involved with the development of laminar separation bubbles on the contoured surface, followed by turbulent reattachment, then turbulent separation further downstream. As a result, the extent of the flow separation region is much reduced. Meanwhile, flow in the critical regime is characterized as highly unsteady, even non-stationary, which is intimately linked with the development of the laminar separation bubbles.

This paper provides new experimental data with regard to two blunt models, aiming to explore the unsteady nature of flows in the critical transition regime. Both models are of two-dimensional configurations, one of which is a circular cylinder and the other is in a teardrop shape. The flow parameters considered include the Reynolds number, the freestream turbulence intensity, the surface roughness of the model and the wind-tunnel blockage ratio.

On the blunt model of a two-dimensional circular cylinder, experiments were actually made in two wind tunnels of different sizes in test section. Thus, the cases of which the circular cylinder was subjected to different geometric blockage ratios, freestream turbulence intensities and surface roughness were considered. For each of the cases, analysis on the instantaneous pressure signals obtained on the model surface was carried out with emphasis on unveiling the characteristics of intermittent switching of flow states.

On the experiment of flow over a teardrop shaped model, a method of oil-film flow visualization was first applied to reveal the development of laminar separation bubble at Reynolds numbers in the critical transition range. Subsequently, instantaneous pressure measurements were made at 22 locations on the model surface simultaneously. The unsteady characteristics of the separation bubble were confirmed and further analyzed.

Keywords: drag, blunt body, critical transition, wind tunnel, pressure measurement
Accreditation of a Cup Anemometer Calibration System

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Abstract: The wind data reflects the characterization of the wind that is important to infrastructure safety, wind power generation, meteorology, etc. Therefore, the accuracy of the wind speed measurement is essential. The offshore wind installation will increase rapidly in Taiwan in the coming years. There are many options that can be exercised to quantify wind resources at a given wind farm site but the traditional meteorological mast equipped with anemometers, thermometers and other sensors are still the most accurate way to obtain such data. To obtain a reliable estimate of the amount of electrical power that could be produced, say annually, at a specific location requires accurate instrument. To make such an assessment there is a specific procedure that must be followed according to the IEC 61400-12 standard.

A cup anemometer is a standard instrument that is used industry wide to measure wind speed for wind energy application and is required to be calibrated regularly to maintain its quality. The necessary of establishing a cup anemometer calibration system in Taiwan is in high demand in the near future. Calibration of a cup anemometer shall be made according to the procedure of Annex F in IEC-61400-12-1. The calibration procedure will perform in a renovated low-speed wind tunnel in National Cheng Kung University. The application of TAF (Taiwan Accreditation Foundation) accreditation for the anemometer calibration system will be submitted later.

Keywords: cup anemometer, calibration, IEC-61400-12-1, TAF accreditation, wind tunnel,
Visualization of cavitation growing and collapsing behaviors in narrow channel

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Abstract: A pulsed spallation neutron source whose target materials are liquid mercury has been in operation at the Japan Proton Accelerator Research Complex (J-PARC). When the high-intense proton beam of 3 GeV hits the mercury in order to produce spallation neutrons, pressure waves are generated due to the abrupt heat deposition of mercury. Mercury enclosure vessel made of stainless steel with a thin wall thickness of 3 mm is severely damaged by pressure wave-induced cavitation erosion. It is required for high-power operation of neutron source to mitigate the cavitation damage. For the purpose, an idea of double-walled structure with narrow gap channel at the front part of the target vessel has been proposed. The previous studies showed that the cavitation damage was dramatically reduced by the double-walled structure. However, we do not understand why the cavitation damage is mitigated by the double-wall structure.

In this study, we observed experimentally the growth and collapse behavior of water cavitation bubbles, which were produced by spark discharge, in narrow channel using a high-speed video camera. Projection radius and aspect ratio of cavitation bubble, and collapsing pressure were investigated with respect to the parameters of flow velocity, gap width and distance from wall. As a results, when the flow velocity was changed, the projection radius of the bubble tended to decrease as the flow velocity became faster.

In the meeting, relationship between the gap width and collapsing pressure under stagnant condition will be discussed. The results to unravel the phenomenon getting from the experiment will be reported. In particular, I will introduce the trend of projection radius of the cavitation bubble owing to the difference of flow velocity and distance from walls.

Keywords: Cavitation erosion, Narrow gap, High speed flow, Pressure wave, Spark discharge
Unsteady Upstream Flow Effects on Vehicle Aerodynamics

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Abstract: In this paper, we describe an experimental research using a wind tunnel to determine the aerodynamic characteristics of a vehicle driving in conditions of atmospheric fluctuation. Historically, wind tunnel experiments have usually been conducted with constant wind speed. However, in on-road tests under natural wind conditions, the obtained results are deficient in reproducibility. Instead, we used an advanced wind tunnel that was able to generate fluctuating wind speeds in a programmable way. Furthermore, the environmental changes during a vehicle driving were simulated as a sinusoidally fluctuating wind, which the vehicle received from the front. In the wind tunnel, a pulsating airflow was generated by superimposing a sinusoidal wind with a comparatively large amplitude to a steady wind with a constant speed. We used an Ahmed-type model with slant angles of 0 to 40 degrees as testing vehicle, which had been employed in many previous studies under steady wind conditions. The experiments were performed under pulsating wind conditions, with a time-averaged airflow speed of 13 m/s, fluctuating amplitude of approximately 2.6 m/s, and periods of 1.5, 3.0, and 5.0 s. In the experiments, the drag and lift forces acting on the vehicle were measured using a three-component load cell, and the pressure distribution on the centerline of the vehicles was obtained by pressure transducers. The time-dependent variations in the obtained forces and pressures were compared with those under a steady wind having the same velocity as the time-averaged speed of the pulsating wind. Moreover, we examined the influences of the Ahmed model’s rear slant angle on the forces and pressure distributions.

The results show that the fluctuation of the wind speed has a greater than predicted effect on the aerodynamic forces. The amplitude of the drag force under a pulsating wind becomes larger on a vehicle with a shape that receives a large drag force under a steady wind. Under pulsating wind conditions, the ratio of amplitude to time-average of the drag force is about two times the ratio of wind speeds, regardless of the rear slant angle. Furthermore, the drag force varies with a phase lead from the fluctuation of the wind speed, with the time-averaged value being 3 to 5% higher than that under steady wind conditions. The lift force for a model with the slant angle of 0 degree, with symmetric upper and lower halves, changes in opposite phase of the fluctuating wind. In addition, under fluctuating wind, there exists a critical slant angle of 30 degree, at which the vehicle experiences either of the high or low fluid forces.

Keywords: Vehicles, Unsteady Flow, Aerodynamic Force, Ahmed Body, Wind Tunnel Test
Experimental study on High Angle of Attack Aerodynamic Flow

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Abstract: For flow over a delta wing, massive flow separation occurs at high angles of attack. In such a case, the aerodynamic characteristics are evidently dominated by the separated flows. One of the most significant characteristics of the separated flows is the unsteadiness, which is accompanied with the development of large-scale vortical flows. Moreover, the vortices generated at the leading edges may interfere each other, therefore the physical phenomenon of the entire flow field appears to be very complicated.

The present experiment was carried out in a recirculating-type water channel. The characteristics of the vortex flow developed above a delta wing model were first studied by means of flow visualization. Subsequently, a particle image velocimetry (PIV) was employed to acquire the velocity distribution of the flow field above a delta wing model chosen. Flow visualization was made for a delta wing model at the angles of attack (α) and yaw (β), in a range of 5° ≤ α ≤ 30° and 0° ≤ β ≤ 30°, respectively. Experiments were made to study the characteristics of the vortical flows developed from the leading edges of the delta wing under different flow conditions. The independent flow parameters varied in this study include α, β, and the sweep angle of the model called Λ. Particular attention was paid to the flow conditions under which the event of vortex breakdown took place. The corresponding limiting-streamline patterns appeared on the surface of the delta wing model were of interest to study. The velocity measurements were then performed above the delta wing model selected, which unveiled the differences in the flow structures due to the flow parameters.

Further experiment will be carried out with a NASA TP-1803 model. Including the dye injection method and the surface dot paint method for studying the delta wing models mentioned above will be employed to observe the vortex structure and the location of vortex breakdown associated with this model. The experimental observations will be further evaluated with the PIV measurement data obtained, which can provide the quantitative information regarding the velocity field around the model. The resultant findings will be presented in terms of velocity vector, velocity profile, and vorticity distribution plots. Thus, the information regarding the size and the location of each of the vortical structures developed from the model surface as well as the flow characteristics near and downstream of vortex breakdown can be obtained. Consequently, discussion of the experimental findings with respect to the flow parameters of α and β will be carried out. The impact due to the interaction between the vortices developed above this model will be addressed.

Keywords: High Angle of Attack, Delta Wing, Vortex Breakdown, Flow Visualization, Particle Image Velocimetry (PIV)
Effects of a Wind Concentrator on the Performance of a Cross Flow Wind Turbine

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Abstract: We developed a wind concentrator for a cross-flow wind turbine consisting of an arc-shaped wind-shield and a diffuser with a flange. By conducting wind tunnel experiments (WTE) and computational fluid dynamics (CFD) simulations, we investigated the effects of this wind concentrator on the performance of the cross-flow wind turbine. In this study, we investigated the effect of the semi-open angle $\phi$ of the diffuser, when $h = 0.625D$ and $0.875D$, in WTE and CFD. In addition, we investigated the effect of the covering angle $\theta$ of the arc-shaped wind-shield and of the incline angle $\Theta$ of the wind concentrator itself in CFD. The experiment was conducted using a closed-circuit wind tunnel with an open test section. The size of the cross section of the wind tunnel outlet was $1250 \text{ mm} \times 1250 \text{ mm}$. The wind turbine has an outer diameter of $D = 80 \text{ mm}$, an inner diameter of $65 \text{ mm}$, and a lateral length of $400 \text{ mm}$. When we investigated the effect of $\phi$, the flange height $h$ was fixed to $0.625D$ or $0.875D$ and $\phi$ was set at $0^\circ$, $30^\circ$, or $40^\circ$ which gets higher output in previous CFD simulations. The wind speed at the outlet of the wind tunnel, which was $600 \text{ mm}$ upwind from the center of the turbine, was $7 \text{ m/s}$. Two-dimensional CFD simulations of the flow around the wind turbine and wind concentrator were performed using the commercial CFD software ANSYS Fluent 17.0. A sliding mesh technique was used to couple the rotational grid and stationary grid. The governing equations were the Reynolds-averaged continuity equation and the Reynolds-averaged Navier-Stokes equations. The Reynolds stresses were computed using the k-\omega SST turbulence model. At the inlet boundary, which was $600 \text{ mm}$ upwind from the center of the wind turbine, a uniform velocity of $7 \text{ m/s}$ was implemented. When we investigated the effect of $\phi$, $h$ was fixed to $0.625D$ or $0.875D$, and $\phi$ was set at $0^\circ$, $10^\circ$, $20^\circ$, $30^\circ$, $40^\circ$, or $50^\circ$. When we investigated the effect of $\theta$, $h$ was fixed to $0.625D$, $\phi$ was fixed to $40^\circ$ and $\theta$ was set at $0^\circ$, $5^\circ$, $10^\circ$, $15^\circ$, or $20^\circ$. When we investigated the effect of $\Theta$, $h$ was fixed to $0.625D$, $\phi$ was fixed to $40^\circ$, and $\Theta$ was set at $0^\circ$, $\pm3^\circ$, $\pm5^\circ$, $\pm10^\circ$, $\pm15^\circ$. With an increase in $\phi$, power coefficient $CP$ generally increased from $\phi = 0^\circ$ to $40^\circ$. When $h = 0.875D$ and $\phi = 40^\circ$, maximum power coefficient $CP_{\text{max}}$ was the highest value 0.37 in WTE, which was three times as higher as wind turbine only. In addition, with an increase in $\theta$, $CP$ generally increased from $\theta = 0^\circ$ to $15^\circ$. However, $CP$ didn’t significantly increase from $\theta = 15^\circ$ to $20^\circ$. Furthermore, with a decrease in $\Theta$, $CP$ generally decreased from $\Theta = 0^\circ$ to $-5^\circ$. Conversely, with an increase in $\Theta$, $CP$ generally increased from $\Theta = 0^\circ$ to $+10^\circ$. However, $CP$ didn’t significantly increase from $\Theta = +10^\circ$ to $+15^\circ$.

Keywords: renewable energy, wind energy, cross flow wind turbine, wind tunnel experiment, CFD
Experimental Investigation of Base Pressure Interference due to Rear Support in Supersonic and Subsonic Regime

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Abstract: This research is aimed to investigate the rear support interference during the wind tunnel experiment. The importance of the subject is that the incorrect base pressure correction leads to the wrong fore drag coefficient of the any aviation vehicles for example, an airplane or the missile. Many have indicated that the appropriate space should be employed between model and the support cape in order to ensure that the measured base pressure coefficient is correct. However, in some case, this space cannot be achieved. In this way, the base pressure is interfered due to the rear support. The model employed is a simple body of revolution whose length ratio, L/D, is 24; non boat-tailing projectile. The gap between the bottom of the model and the support cape is 0.9 diameter of the projectile. In addition, the ratio of the support diameter to the model is 0.67. The experimental conditions studied are of three kinds, one of which is in the supersonic regime where ranges from 2.0 to 3.5; another is transonic regime where ranges from 0.8 to 1.5; the last is the subsonic regime in which the flow is below Mach 0.8. Figure 1 presents the base pressure coefficient with the Mach number, noted that the angle of attack is at 0 degree. As shown in the figure, the base pressure coefficient is severely interfered, the base pressure coefficient should be positive in our definition. In general, the interference is considerably large around Mach 1.0, while at higher Mach number the interference seems lighter. Indeed, the level of the interference is related to the wake structure downstream at different Mach number and in this discussion we try to correct the drag coefficient by comparing the non-interfered case. As the Figure 2 shown, the influence of angle of attack will be considered as well.

Keywords: Supersonic base pressure coefficient, Rear support interference, Wind Tunnel Experiment, base drag correction, Projectile base pressure
Revisit Reynolds decomposition aspects of turbulent flow in near wake of a circular cylinder

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Abstract: The vortex formation and shedding process in the near wake region of a long (2-D) circular cylinder has been investigated by means of particle image velocimetry (PIV) together with proper orthogonal decomposition (POD) to characterize the large-scale organized (coherent) motion that is associated with the wake vortex shedding process. Due to the large-scale organized motion in the flow field, the time-dependent velocity in the wake includes a coherent (quasi-periodic) and a chaotic (random) part. The instantaneous velocity data are analyzed in terms of the triple decomposition [1] as

\[ U_i(x,t) = \bar{U}_i(x) + \tilde{U}_i(x,t) + u_i'(x,t) \] (1)

where \( \bar{U}_i(x) \) is the time-independent mean velocity component, \( \tilde{U}_i(x,t) \) is the quasi-periodic component with zero mean due to the large-scale organized motion, and \( u_i'(x,t) \) is the turbulent fluctuation. The sum of the first and second terms is called the phase averaged velocity, which is defined by

\[ \langle U_i(x,t) \rangle = \bar{U}_i(x) + \tilde{U}_i(x,t) = \lim_{N \to \infty} \frac{1}{N} \sum_{n=0}^{N-1} U_i(x,t+n\tau) \] (2)

where \( \tau \) is the quasi-period of the coherent motion. The quasi-periodic and random fluctuations are uncorrelated each other. In order to remove the quasi-periodic component from Eq. (1), a period-time averaging is made for each instantaneous data as

\[ [U_i(x,t)] = \frac{1}{\tau} \int_t^{t+\tau} U_i(x,t^*) dt^* \] (3)

Since integration of the quasi-periodic component over a time period is equal to zero, the period-time averaged Eq. (1) becomes

\[ [U_i(x,t)] = \bar{U}_i(x) + u_i''(x,t) \] (4)

Comparison between the turbulence statistics made either with Eq. (1) or with Eq. (4) will be performed and discussed. The quasi-periodic component in Eq. (1) is determined from the first two POD modes, which are considered to represent the orthogonal components of the basic harmonic of the quasi-periodic component, in the study.

Reference

Keywords: Reynolds decomposition, ensemble averaging, wake, PIV, orthogonal decomposition
Numerical simulation of flow in modified raceway ponds for algae cultivation

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Abstract: An open channel raceway pond is widely used to cultivate algae. The aim of this paper aims to investigate suitable geometry of raceway pond for algae cultivation with the use of Computational Fluid Dynamics (CFD). In a usual raceway pond the stream can be stagnant when turning at the corner. To decrease such a dead zone, this study seeks to the optimized layout of deflectors and wing baffles set around the corner. Results for the velocity and vorticity fields and the pressure field. In addition, the friction loss in the open-channel raceway ponds can be estimated.

Keywords: raceway pond, algae cultivation, Computational Fluid Dynamics, open channel flow, deflector
A study on the wing performance and the passive separation control of two tandem arranged NACA0012 wing using leading edge protuberance in low Reynolds number

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Abstract: In many previous studies, it was found that the wing performance in low Reynolds number region was improved by the passive separation control technique using the leading edge protuberance (LEP). However, in almost all of these studies, the characteristics of the wing performance for a single wing in a uniform flow was only investigated. Therefore, these results are difficult to directory apply to the design of the fluid machine with multiple wings, e.g., wind turbine, hydraulic turbine and drone, which are affected by a velocity defect and a turbulence occur from other wings. Thus to design such fluid machines, it is required to investigate the effect of the non-uniform velocity distribution and the turbulence occur from the other wing on the wing performance.

In this study, we focused on the two tandem arranged NACA0012 airfoils in the uniform flow and investigated the effect of a velocity defect and a turbulence occur from the forward wing on the performance of backward wing. Furthermore, to investigate the effectiveness of the separation control using leading edge protuberance (LEP) for tandem arranged wing, we compared the wing performance of two types of backward wings, a backward wing with linear leading edge and one with LEP.

At first, to know the velocity profile and the turbulence characteristics occurred by the forward wing, we set a NACA0012 airfoil with linear leading edge as the forward wing and measured the velocity distribution and the velocity fluctuation behind the forward wing by using hot wire anemometer equipment for three attack angles of $\alpha = 0\text{deg}, 10\text{deg}, 20\text{deg}$. As a results, we found that the dead water region and turbulence region behind the forward wing expands as increase in the attack angle due to the flow separation.

Then we measured the fluid dynamic forces (CL, CD) acting on the backward wing with two types of leading edge located at the unit cord length downstream from the forward wing. From the comparison of the wing performance between a single wing and the backward wing of the two tandem arranged wings, we found that at the attack angle of forward wing of $\alpha=10\text{deg}$, the stall region of the backward wing was reduced due to the disturbed flow occurred from forward wing, however, the separation control effect was not appeared at the attack angle of forward wing of $\alpha=0\text{deg}$ and $\alpha=20\text{deg}$. From the comparison of the wing performance between a backward wing with linear leading edge and one with LEP, we found that at the attack angle of forward wing is $\alpha=0\text{deg}$, the improvement of the wing performance by using LEP was observed depending on the attack angle of the backward wing, whereas, in other forward wing attack angles, the effectiveness of LEP wing was not found.

Keywords: Passive Separation control, Tandem arranged wing, Leading edge protuberance, Low Reynolds number, NACA0012
Unsteady flow past a VAWT consisting of three quarter circular-arc blades attached to a cylindrical core (Influence of attachment angle)

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Abstract: This study aims to investigate influence of attachment angle for a drag type vertical-Axis wind turbine (VAWT) consisting of three quarter circular-arc blades attached to a cylindrical core. The drag type VAWT is known to produce a high torque although the power characteristic is poor. This high torque performance of the drag type VAWT can start up the rotor even in weak wind condition. In this study, three values of the attachment angle of the circular-arc blades are selected as alpha=20, 45 and 75 degrees. The flow visualization around the rotor can be carried out with both the experimental PIV and the computational fluid dynamics based on a vortex method.

Keywords: Vertical-Axis Wind Turbine, Drag-Type Turbine, Flow Visualization, Particle Image Velocimetry, Vortex method
Experimental Analysis of the Effect of Tread Grooves on a Tire inside a Tire House

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Abstract: In recent years, energy saving is required from the viewpoint of global warming and energy resource issue, and energy saving in an automobile has been done so far. The total air resistance in an automobile is said to consist of 45% for body shape, 30% for tire rotation and 25% for underfloor flow. In order to grasp the flow field around a car, an approach from the viewpoints of both numerical analysis and experimental measurement is necessary, and a lot of researches have been done. However, the flow field around a tire has been mainly studied by numerical analysis because of the complexity of the flow field. The purpose of this study is to understand three-dimensional flows around a tire inside a tire house by experimental analysis. We aim to understand the effect of tread grooves on a tire inside a tire house on the flows by experimental analysis. In addition, we aim to observe the flow field inside a tire house by flow visualization. In this study, we use a circular disk (50 mm in diameter, 17 mm in thickness) and a half-open casing which are the model of the tire and the tire house, respectively in experiment. Three different types of disks are used. Two disks have tread groove patterns, another one without a tread groove pattern. Experiments are carried out with the circular disk with tread grooves and the half-open casing located at the center of the test section of a circulating water tank. Velocity vectors around the disk are measured by using particle image velocimetry (PIV). The uniform flow velocity is 250 mm/sec and the Reynolds number based on the disk diameter is $1.25 \times 10^4$. Three-dimensional vector fields are reconstructed by overlapping two different sets of two-dimensional velocity vector slices on x-y and x-z planes. We will present the change of the flow structure depending on the tread grooves to show the effect of tread grooves on the vortex structure behind a tire. Furthermore, from the observation results for the flow field inside the tire house, it will be also shown the inside flow is related to the vortex structure outside the tire house.

Keywords: Flow measurements, Rotating tire, Tread grooves, Tire house, PIV
Effects of the Arm's Cross-sectional Shape on the Aeroacoustic Noise of a Straight-bladed Darrieus Wind Turbine

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Abstract: Using a microphone array, a wind tunnel experiment for a straight-bladed darrieus wind turbine (SDWT) was carried out to investigate the effects of the arm’s cross-sectional shape on the aeroacoustic noise. Three kinds of arm’s cross-sectional shapes were used: airfoil (NACA0021), ellipse, and rectangular. In addition, the aeroacoustic feature of each arm’s cross-sectional shape in the uniform flow was investigated by computational aeroacoustic simulations to understand the difference from the case where the arms were attached to the rotating SDWT. The experiment was conducted using a closed circuit wind tunnel with an open section. The size of the cross section of the wind tunnel outlet was 1.15 m × 1.15 m. The SDWT had three blades with an airfoil shape of NACA0021, with a span length of H = 0.8 m and with a chord length of c = 0.15 m. The diameter of the SDWT was D = 0.88 m. The microphone array was composed of 4 × 4 microphones. The distance between each microphone in the streamwise and lateral directions was 0.3 m. The measurement surface was at a height of 0.53 m from the upper end of the blades, and was higher than the upper wall of the wind tunnel outlet. The sound pressure was measured for 60 seconds, and 1/12 octave band analysis was carried out at the same time. The computational aeroacoustic simulations were performed for an airfoil, ellipse and rectangular cylinder in a uniform flow by using computational fluid dynamics software ANSYS Fluent 17.2. Then, the Ffowcs Williams-Hawking equation was used for the computational aeroacoustic simulation. At the inlet boundary of the computational domain, a uniform streamwise velocity of U = 15.4 m/s was implemented. As a result, the values of the overall A-weighted SPL in the case of using the ellipse arms are slightly larger than those of using the rectangular arms and is significantly smaller than those of using the airfoil arms. The values of the overall A-weighted SPL in the case of using the ellipse arms are slightly larger than those of using the rectangular arms and is significantly smaller than those of using the airfoil arms. Except for 1000-4000 Hz, the values of A-weighted SPL in all cases were not different conspicuously. At the 1000-400 Hz, the values of A-weighted SPL in the case of using the airfoil arms were the largest, and the values of A-weighted SPL in the case of using the ellipse arms were almost the same with the case of using the rectangular arms.

Keywords: Straight-bladed Darrieus Wind Turbine, aeroacoustic, noise, experiment, numerical simulation
Abstract: The applied research of Indigenous Built Airplane Policy. Its purpose is to study the application delayed stall phenomenon of multiple synthetic jet actuator in the asymmetric airfoil experimental study. There have been many studies about the flow control with SJA, especially for separated flow control, virtual shaping, and mixing enhance, etc. One of the advantages of SJA is the easy implement, which can realize the active flow control in actual applications. The design and basic properties of SJA were studied extensively, but there is still no actual applications reported. The criteria of its implements is also absent. The purpose of this proposal is to realize the dynamic measurement of the flow field of the asymmetric airfoil and to simulate the dynamic analysis of the flow field after excitation by multiple SJA. Suitable elements and driver circuits of SJA will be developed. The criteria about its implements will be obtained with the aid of wind tunnel testing.

Keywords: Synthetic jet, asymmetric airfoil, flow control
Lift and drag of a NACA0012 airfoil in a periodic flow for changing angle of attack

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Abstract: In Japan, coastal structures such as quay and pier of harbors built during the period of high economic growth (1950’s ~ 1970’s) are required to be inspected, especially underwater parts due to aged deterioration. Although these inspections are mainly done by divers, diving work is dangerous. Unmanned remotely operated vehicles (ROVs) are useful for underwater inspection, but their cables can be entangled around complicated structures. Autonomous underwater vehicle (AUV) is expected to be utilized without these problems. However, it is necessary to dive stably in underwater with a standing wave at harbor. In order to improve the stability of AUVs in the wave, it is useful to research the force on AUVs and the surrounding flow field.

As a first step, we model AUV as a NACA0012 airfoil and the standing wave at harbor as a periodic flow with a sinusoidal velocity profile in the streamwise direction. We investigate the changes in lift and drag for changing angle of attack in the range of 0 degrees to 70 degrees, each 5 degrees. This periodic flow in water tunnel is generated by two pumps controlled by the function generator connected to the inverter. The chord length of a NACA0012 airfoil is 100 mm, and the Reynolds number is 3675. We measure the two-dimensional velocity field around a NACA0012 airfoil and forces acting on it. The two-dimensional velocity field is measured by particle image velocimetry (PIV). Lift and drag are measured by an experimental device with strain gauges. These measurements of the velocity field and force are performed synchronously and simultaneously. For comparison, a similar experiment is carried out in a steady flow, for which the average mainstream velocity is the same as that for a periodic flow condition.

We compare the experimental results in a periodic and a steady flow. As a result of PIV measurement, as the angle of attack increases, the structures of large scale vortex shed from the leading and trailing edges of the wing are remarkably developed. Comparing the lift-to-drag ratio in the case of a periodic flow with that of a steady flow, significant difference is confirmed. It is found that the ratio has the maximum value when the angle of attack is 10 degrees in both cases, whereas the value is about 2.4 times larger in a periodic flow than in a steady flow.

Keywords: Lift-to-drag ratio, PIV measurement, Periodic flow, NACA0012 airfoil, AUV
The Study of Vortex Induced Lift at Finite Span Wings at Critical Mode Reynolds Number

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Abstract: Hysteresis phenomenon at aerodynamic transition plays an important role on the fixed wing unmanned aerial vehicle (UAV) design at critical Reynolds numbers (Re). The paper uses the experimental results of rectangular finite wing with NACA 633-018 airfoil section to construct the numerical simulation methods on the study of aerodynamic transition and corresponding flow structures. The experimental of aerodynamic properties including the lift and drag coefficients, wing root chord line pressure distribution, vortex shedding spectral analysis and corresponding velocity profiles. And the numerical simulation method is used the program of Star CCM+ and corresponding modeling to construct the capability of flow analysis. The present results indicate that the nonlinear of lift curve, the “jump” and “drop” of lift distribution and clockwise hysteresis loop are existence at the critical Re regions between $8 \times 10^4$ and $1.1 \times 10^5$, and the mean velocity profiles and vortex shedding spectral analysis at near wake region indicate the coherent structure of laminar flow separation and flow reattached at upstream of the wing. The strouhal number analysis indicates the constant value near the 0.29 at laminar flow separation without flow reattachment but increased with Re after transition, and two different values show the flow structures under the hysteresis loop at the same AOA with difference of flow structure. Finally, the methods of numerical simulation modeling can provide well documented techniques on the aerodynamic transition issues and initial analysis processes on UAV design at critical Re.

Keywords: Hysteresis phenomenon, Unmanned aerial vehicle, Critical Reynolds numbers, Laminar flow separation, Flow reattachment
Sound emission from a bubble generated of an underwater nozzle (Influence of the bubble size)

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Abstract: Air bubble emits an acoustic sound from single-hole nozzle to underwater. An air bubble is formed from a nozzle, and such a generated of bubbles makes an acoustic sound within the order of microseconds. This study aims to investigate the acoustic sounds from bubbles having several values in its volume. To do so, the resulting acoustic signal is measured with the hydrophone with ten microseconds of the sampling period, and the situation is simultaneously taken with a high-speed camera. Then, the mechanism of the sound emission from a bubble of a nozzle could be discussed.

Keywords: Bubble detachment, Acoustic, Sound emission, Single-hole nozzle, hydrophone
Investigation of the characteristics of the flow round the circular cylinder in the critical regime

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Abstract: This study aims to investigate the flow around a circular cylinder at high Reynolds numbers in a range of $3.0 \times 10^5$ to $4.0 \times 10^5$. A reference parameter $R_{\text{coef}}$, which is defined as the ratio of the summation of the pressure coefficients at $\pm 90^\circ$ and the base pressure coefficient, is used to characterize the flow states in the critical regime for the Reynolds numbers in the range of $10^5$. For the cases without the turbulence generator, in the sub-critical regime, the reference parameter $R_{\text{coef}}$ is found near 2 with a small variation. In the pre-critical regime, $R_{\text{coef}}$ stays around 2 but varying in a magnitude substantially larger than that in the sub-critical regime. In the transition from the sub-critical to one-bubble states, $R_{\text{coef}}$ fluctuates very significantly between 2–8, which indicates that the time-averaged values of the pressure coefficients around the circular cylinder vary with time. The significant non-stationariness can be observed in the transition regime. In the steady one-bubble regime, $R_{\text{coef}}$ is around 5–6 with relatively small variations. The value of $R_{\text{coef}}$ in the two-bubble regime lies in a range of 10–12, which is significantly higher than that in previous flow states, with relatively smaller fluctuations in comparison with that in the transition regime.

For the cases with the turbulence generator, in the sub-critical regime, $R_{\text{coef}}$ stays near 2 with small fluctuations which characteristics are similar to that in the case without turbulence generator. In the transition from the sub-critical to one-bubble regimes, the variations of $R_{\text{coef}}$ are noted significantly large. In the one-bubble regime the variations of $R_{\text{coef}}$ are quite remarkable and gets even larger as Reynolds number increases. This is distinctly different from that seen in the cases without turbulence generator. In the two-bubble regime, the $R_{\text{coef}}$ values obtained for the cases with and without the turbulence generator are noted with some discrepancies.

Keywords: flow over a circular cylinder, critical regime, pressure coefficient, high Reynolds number, transition
Length of Bubble Dispersion Region in a Cylindrical Bath Subjected to Side Gas Injection through an L-shaped Lance

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Abstract: Dissolved oxygen in liquids plays an important role in a variety of fields such as civil and materials engineering, medical and physiological sciences, fish and shrimp farming. For example, the dissolution rate of oxygen into a molten metal bath is responsible for the efficiency of decarburization in the steelmaking industry. Oxygen is commonly introduced into the bath using many kinds of injection devices. The dynamic behavior of oxygen bubbles thus generated in the bath mainly governs the oxygen dissolution rate. Model experiments were carried out in a previous study to understand the oxygen bubble behavior and dissolution rate for basic three (bottom, side, and top) gas injection systems. Water and air were chosen for the models of molten metal and oxygen, respectively. The side gas injection was found to be most effective for oxygen dissolution under the experimental conditions considered. This is probably because the oxygen dissolution rate is closely associated with the length of bubble dispersion region in the bath. In this study air was injected horizontally into a cylindrical water bath through an immersed L-shaped top lance. The dispersion pattern of bubbles and related bath surface oscillations were observed with a high-speed video camera and a steel camera. An empirical equation was proposed for the length of bubble dispersion region, LBS, based on the data on LBS measured in this study.

Keywords: Steelmaking, Decarburization, Oxygen dissolution, Side injection, Bubble dispersion
A Study on Surface Property of Molten Solder in Oxidative Environment

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Abstract: Surface tension of liquid metal varies in oxidative environment for a short time since it is sensitive to surface oxidation. Although the variation of surface tension requires a certain time, the time is not fully understood. It is expected that the temporary change of surface tension (dynamic surface tension) has great influence on various processes relating to liquid metal such as metallurgy, solder joint and metal particle production processes. In our previous study, we proposed a novel method for measuring the dynamic surface tension of liquid metal based on the trajectory of a horizontally ejected capillary jet. We derived a theoretical model to predict the jet trajectory and determined the dynamic surface tension from the condition that the theoretical and experimental trajectories agree with each other. This method has great advantages of simple operation, low cost and high accuracy. Actual measurements for Wood’s alloy (Bi:48.8%, Pb:26.3%, Sn:14.6%, Cd:10.3%, Melting point 70ºC), which is a kind of low-melting alloy, demonstrated the feasibility of the capillary jet method. In this study, we used eutectic solder (Sn:63%, Pb 37%, Melting point 183ºC) as more easily-oxidizable and more practically-utilized liquid metal, and investigated the influence of oxidative environment on the surface properties of the molten solder. We prepared controlled environment in a glove box, and maintained the temperature of the solder at 200 ºC. Argon gas was introduced into the glove box, and oxygen concentration Doxg was adjusted within the range of 0 - 20.6%. In the environment, we determined static surface tension in equilibrium state by conventional pendant drop method, and measured dynamic surface tension by capillary jet method. Experimental results showed that static surface tension increased with increasing oxygen concentration in Doxg > 0.025%, while it decreased in Doxg < 0.025% owing to adsorption of oxygen to liquid surface. Under the high oxygen concentration of Doxg > 0.025%, measured static surface tension also increased strangely as drop diameter increased, and the capillary jet became unstable because of frequent break up. It is conjectured that the strange behavior is due to the forming of oxidized membrane on the solder surface. The measurement of the dynamic surface tension in the small oxygen concentrations of Doxg < 0.025% demonstrated that surface tension decreases from initial surface tension to static one in about 3 ms, which is very shorter than the time scale of 15ms for Wood’s alloy. The formation of oxidized membrane and the shot time scale of dynamic surface tension are characteristic surface properties of the solder in comparison with those of Wood’s alloy.

Keywords: Dynamic surface tension, Liquid metal, Oxidization, Capillary jet, Surface property
A simple method of measuring drag-coefficient of any figured plate

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Abstract: The purpose of this study is to obtain drag coefficient of any figured plate like as polygons, star polygons, a circular plate with holes, etc. The drag coefficient of the plate is obtained experimentally by using the following method. I developed a simple method to measure a drag coefficient of any figured plate based on its equation of motion describing the force balance acting on the plate falling in water. The analytical solution of the equation is presented by the speed of the plate changing by a hyperbolic tangent. The drag coefficients and added mass can be obtained by means of adjusting the hyperbolic tangent curve to measured data. Our experiment is very simple. The test plate is falling in water according to the equation of motion. The change in speed of the plate is measured by a high-speed CCD camera. Comparing with the drag coefficient of a circular plate as well as a sphere obtained by the other previous studies, our results obtained by our way in the both case of a circular plate and sphere are reasonable. This paper shows the comparison with the drag coefficients of normal circular plate and any figured plate, and we discuss about these differences.

Keywords: Drag coefficient, Measurement, Plate, Equation of motion, Added mass
3D PIV experiment on the wake past rounded square cylinders with a ground effect

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Abstract: The vortex wake of rounded square cylinders with a ground effect has been investigated by using tomographic particle image velocimetry. The rounded cylinder is placed perpendicular to the bottom of a water channel with a span length half of the water depth of the channel flow and the cross flow Reynolds number is 500. The main interest of study is the effect of the roundness of the square cylinder corners on the 3D vortex wake that is generated from the side walls and the top end of the finite-length cylinder. More prominent downwash effect of the vortex wake is discernible in the case of non-rounded square cylinder. The flow model in this work is briefly depicted and typical tomographic PIV velocity maps are provided.

Keywords: 3D wake, Bluff body, Square Cylinder, Ground effect, Tomographic PIV
Abstract: Chronic disease such as diabetes mellitus makes wound healing more difficult. It delays the normal phases of wound recovery that the injured sites are easily infected and take longer time to heal. Therefore, how to accelerate wound healing is an important issue. Atmospheric-pressure plasma jet (APPJ) is known for abundant generation of RONS. The applications of sterilization, surface cleaning and modification in biological field have increased tremendously. In this study, we will apply the argon atmospheric-pressure plasma jet (APPJ) on acute and chronic wound model of rats and investigate its effectiveness. In this research, Sprague Dawley rats were used for acute and chronic wound model. The streptozotocin (STZ) injection at 60 and 30 mg/kg dose with normal and high-fat chow were used to induce type 1 and type 2 diabetes in rats, respectively. Two full-thickness circular wounds were created on the dorsum of each rat. The results show that application of the APPJ is effective in the early to middle stage of the wound healing process in both cases. More details will be provided in the conference.

Keywords: atmospheric-pressure plasma jet, acute wound, chronic wound, diabetes
Reduction of Run-up Height Induced by Tsunami-like Long Wave Using Three Submerged Barriers

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Abstract: To reduce the inundation zone along coastal lines, it has become an important issue that the development of an effective measure for trapping and dissipating most of the tsunami-like long wave energy by way of large-scale vortex formations between any two neighboring submerged structures deployed in ocean environments. The innovative experiments were carried in a glass-walled and glass-bottomed wave flume. A wave maker mounted at one end of the wave flume can follow the wave-plate trajectory to generate perfect solitary wave. The sloping beach was made of acrylic sheet with a slope of 1:20. The incident wave-height to water-depth ratios, H0/h0, are varied from 0.10 to 0.40. Three barrier models were made of acrylic plate having a thickness of 2.0 cm but with different heights over the sloping beach. The mounting locations for the central points of the first, second and third barriers are positioned at x/h0 = 4.5, 6.0 and 7.5, respectively, with x = 0 being the toe section of the sloping beach. The maximum run-up heights R (without barrier) and R’ (with barriers) that represent the maximum flooding extent or inundation heights, were measured by using two high-speed cameras. A high-speed particle image velocimetry (PIV) system was utilized to measure the instantaneous velocity fields and calculate the maximum magnitudes of vorticity (as one of the indicators for trapping wave energy). Variation of the relative reduction of run-up height, (R - R’)/R, with the incident wave condition and the maximum magnitude of vorticity are discussed.

Keywords: Tsunami-like long wave, coastal inundation, run-up height, particle image velocimetry
Experimental study on gas-liquid Taylor flow in rectangular microchannels

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Abstract: Gas-liquid two-phase flows appear in microdevices such as fuel cells, micro-total analysis systems. Prediction models for the pressure drop and void fraction are of great use for the design and development of the microdevices. The characteristics of two-phase flows are affected by sectional shape of channels and microchannels in several microdevices have rectangular cross-sectional shapes. It is well-known that Taylor flow is dominant flow in microchannels. Hence, we measured the pressure gradient and the void fraction of gas-liquid Taylor flows in rectangular microchannels. We used microchannel plates with rectangular microchannels with width of 300 and 500 micro meter. The aspect ratio of the height to the width of the rectangular microchannels were 0.5, 0.75 and 1.0. The exit side of the microchannels were at the atmospheric condition. Experiments were carried out at room temperature and atmospheric pressure. The temperature of the liquid was kept at 298 + 1 K. We used Deionized water or glycerol-water solutions as the liquid phase, and nitrogen gas as the gas phase. The glycerol-waters solutions were made of deionized water and glycerol and the kinematic viscosities are 52 and 64 wt% respectively, five and ten times that of water. The liquid and gas phases were mixed at a Tee junction in the microchannel plate. The mixed liquid and gas phases flowed toward the outlet in the microchannel as Taylor flow. Pressure after the Tee junction was measured using a pressure gauge and the pressure gradient could be calculated by the measured pressure and the atmospheric pressure. Taylor flows were taken using a high-speed video camera to measure bubble velocities, liquid and bubble lengths. Gas volumetric flux at the visualization point was calculated by the Boyle’s law. The void fraction was calculated by the bubble velocity, the gas volumetric flux and the pressure.

Before the experiment of Taylor flow, the pressure gradient in liquid single phase flows was measured for the validation of the experimental setup and the measurement method. The measured pressure gradient agreed with the theoretical value in the liquid single phase flows. In Taylor flow, we confirmed that the measured pressure gradient and void fraction were affected by the liquid properties and the aspect ratio of the microchannel. We will consider the effects of them on the pressure gradient and the void fraction for developing accurate prediction models.

Keywords: Taylor flow; rectangular microchannel; void fraction; pressure drop; experiments
Experimental observations of the air cavities generated by the impacts of spheres on free water surface

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Abstract: The impact on and entry into water of a solid body is observed in many natural phenomena and industrial applications. The fishing of sea birds and the running over water of lizards are both related to the dynamic interaction between the solid body, water, and air. The impact process and corresponding loads on the solid body should be concerned for the periodic slam of boat on waves and the landing of a spacecraft on water surface. In defense applications, the ability to attack underwater targets is undoubtedly related to the drag and stability of the projectile during water entry. In this study, the water-entry process of solid spheres were observed using a high-speed camera. The influence of Weber number on the evolution of air cavity was investigated. The spheres were dropped freely or pushed by an air-soft gun. A detecting device composed of transmissive optical sensors was used to monitor the speed. The moving speed of the sphere were also evaluated according to the high-speed imaging results. Spheres of various diameters, 4 to 12 mm, were tested. The Bond number based on the diameter ranges from 2.1 to 19. The Weber number ranges from 100 to 100,000. Different modes of air cavity were observed. At lower speeds, the cavity is pinched off in the middle, which is classified as the deep seal mode. The location and time of pinch-off depend on the values of Weber number. When the sphere impact the water surface at higher speed, the surface seal mode was observed. Although the cavity seals at the water surface, the occurring time varies with Weber number. After the air cavity seals at the top, the pinch-off may occur in the middle of the cavity at later time. At much higher impact speed, the value of Weber number is close to 100,000, the air cavity may collapse and becomes tiny bubbles before the occurrence of pinch-off.

Keywords: sphere, free-surface impact, air entraining, cavity formation, supercavitation
Verification of Simulator for Designing Stone Heat Storage Tank

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Abstract: Solar energy is absorbed by a black body and converted into heat including radiation. Concentrated solar power plant (CSP) uses the receiver which is designed specially to absorb a concentrated sun rays and convert into heat. In the receiver, some fluids such as air, oil, molten salt etc. are flowed for using pipes fixed inside of the receiver to transfer the heat into a thermal fluid, which can generate a steam for power generation all day using a heat storage system. The major problem of CSP is the changing in the concentration degree (thermal power change) of the cosine-effect variation depending on the season and latitude. In the winter season, the cosine-effect becomes lower, and the summer season, higher. For the latitude problem, the higher, the cosine effect decreases the lower. We, Tokyo Tech, newly proposed an innovative solar concentration system of CL-CSP (Cross Liner-CSP). With this concentration system, we can store the heat at 600°C in every season and at a higher latitude such as North Africa, Mongolia, north district in China. An economical and technical solution in the heat storage is a key point for reduction of power generation cost of the CSP plants. Zanganeh et al. have been developing a TES (thermal energy storage) system which uses the air as HTF (heat transfer fluid) and a packed bed of stone as the storage material. This heat storage system needs 600°C air fluid, therefore the hybrid system of CL-CSP and the stone heat storage system (SHSS) is a promising process lowering the cost of heat storage system. This paper describes the experimental and CFD study on a TES system with packed-bed of stone using high-temperature air as HTF to be hybridized with CL-CSP. The numerical simulation is performed using commercial CFD software ANSYS Fluent and the validation is performed using a pilot-scale TES model. The influencing factors which affect the thermal stratification, such as the tank height-to-diameter ratio, the different stone size and the mass flow rate, are taken into the consideration. As the result, the CFD simulation and experimental investigation show good agreement, and an optimized section of the TES parameters is presented, to be guidelines for the future TES design and operation.

Keywords: Solar energy, Heat storage, Packed bed of stone, CSP, CL-CSP
A Theory of Dropwise Condensation Heat Transfer with Contact Angle Hysteresis.

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Abstract: Phase change heat transfer has many important engineering applications, including electronic cooling devices, heat exchangers, solar energy collectors, flow boiling and flow condensation, etc. Also, this work focuses on the phase change heat transfer of flow condensation. In the past two decades, Le Fevre, Rose, Mousa and Kim present the model of dropwise condensation heat transfer. D.J. Huang uses Mousa's model to estimated the heat transfer of superhydrophilic / superhydrophobic hybrid surface. His result shows the hybrid surface could be better than superhydrophobic surface, the estimated heat flux of Mousa's model is close to the experimental data. However, this model ignores the contact angle hysteresis of droplet on the superhydrophobic surface. Therefore, this study presents the model with the phenomenon of contact angle hysteresis, and investigates the effect of contact angle hysteresis on heat transfer.

Keywords: contact angle hysteresis, superhydrophilic, superhydrophobic, phase change heat transfer, flow condensation
Abstract: A regenerative burner system allows high-efficient recovery of exhaust heat, leading to the high thermal efficiency of the industrial furnace, especially for high temperature furnaces including heating furnaces for rolling, forging furnaces, heat treatment furnaces, melting furnaces, baking furnaces, and deodorizing furnaces. The increase in the efficiency is owing to transferring heat from the exhaust gas to the heat reservoir and preheating the air by the heat reservoir. Therefore, in order to further increase the thermal efficiency of the regenerative burner, optimization of the heat reservoir is important. Conventionally, heat reservoir bodies are ball type or honeycomb structure, and alumina and cordierite are the material mainly used. Recently, it is demonstrated in industrial furnace that thermal efficiency is improved by using other material of ball type heat reservoir, but the mechanism has not been elucidated. Therefore, the present study experimentally and numerically investigates how thermal conductivity and emissivity of the heat reservoir influences the transient heat transfer between the high and low temperature spherical heat reservoirs. This study focus on the simplified system, that is, identical spherical heat reservoirs with large temperature difference in the initial conditions, in order to understand the major factor in the transient heat transfer in heat reservoirs. Heat is transferred between them by thermal radiation and heat transfer through the gas between them. Thermal radiation was shown to become dominant at high temperature. Thermal conductivity of spherical heat reservoirs also affects this transient heat transfer. Therefore, the scale effect of spherical heat reservoir on heat transfer is also investigated for the scale modeling in the future study. The obtained results explained the increase in thermal efficiency by the material of heat reservoir with different thermal conductivity and emissivity, which leads to further improvement of thermal efficiency of regenerative burner systems.

Keywords: Regenerative burner, Thermal radiation, Heat reservoir, Scale effect, Scale modeling
Fluid Flow and Heat Transfer of Natural Convection Induced in Horizontal Circular Slots

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Abstract: Natural convective flows induced in the horizontal slot of finite gaps are encountered in many situations of electronics cooling. For instance, the printed-circuit-boards are often placed horizontally in electronic devices and cooled by the natural convection in the slot is indispensable. Thus, some experimental and analytical studies have been carried out to investigate their flow and heat transfer characteristics. However, most of them have dealt with the slot having a rectangular cross-section, yet very little information has been available for the natural convection induced in the slots of the other cross-sections. The one of such slots is the circular slot formed by two circular disks placed co-axially. The configuration is seen in the reactors making chemical-vapor-deposition onto the silicon wafers. These motivate the present experimental investigation.

The present experiments were carried out with the circular slots confined with circular disks of equal diameter, where the lower disk is heated with uniform temperature and the upper disk is insulated. The outer periphery of the circular slot is opened to the surrounding fluid. Water at room temperature was adopted as a working fluid. The diameter D and the gaps H between two disks were varied systematically as, D = 50, 100, 150 and 250 mm, and H = 10, 20, 30, 50 mm, ∞ (without upper disk). The Rayleigh numbers based on the disk diameter were ranged as; $3 \times 10^6 < \text{RaD} < 3 \times 10^9$.

The flow fields induced in the circular slots were first visualized with dye. The visual results depicted that the following flows appear in the circular slots. A laminar boundary layer develops over the lower disk near the outer periphery of the slot. Then, the boundary layer separates three-dimensionally from the surface of the lower disk, and the streaky flow appears downstream the separation, and a turbulent flow is attained near the center of the slot. It was also found that the onset of the separation over the heated disk shifts to the outer periphery of the slot with decreasing the gap H, and that the radial-pitches of the separation are decreased significantly.

The overall Nusselt numbers of the heated lower disk were subsequently measured. The results showed that the Nusselt numbers remain identical as those without the upper disk when the gaps H are large enough. However, the numbers decreases significantly with decreasing the gaps H, in particular, when the diameter of the slot is large.

Keywords: Heat Transfer, Natural Convection, Horizontal Circular Slots, Flow visualization, Interaction
Development of flexible football shin guards using soft epoxy resins and foams

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Abstract: In this study, we develop a flexible football shin guard having good wearability and high impact absorption by using soft epoxy resins and foams. Usually, sports protectors are composed of a hard outer shell for dispersing an impact force and a soft inner foam for absorbing impact. To construct the flexible football shin guard, soft epoxy resins were used as an outer shell for dispersing an impact force without arising local deformation only under impact loadings. For the purpose, the relaxation modulus of epoxy resin was controlled by changing the compound ratio of the main and curing agents which affects the crosslinking density of the resin. In addition, soft epoxy foams of which matrices are above mentioned soft epoxy resins were used as an inner foam for the reduction of an impact force. The fabricated soft epoxy foams showed remarkable strain rate effect on compressive properties due to the viscoelastic property of its matrix. The fabricated shin guards were confirmed to be sufficiently flexible in wearing. In addition, the impact tests revealed that the proposed shin guards have high impact absorption over commercially available shin guards.

Keywords: Impact, Foam, Epoxy Resin, Football, Protector
Influence of Graze Layer on Bending Fracture Strength of Clay Roof Tile Specimen

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Abstract: Clay roof tiles are widely used for the roof of houses in Japan. In recent years, the weight saving of the roof tile has been requested due to gradual exhaustion of high quality clay. Thinning of the roof tile is a common way to reduce the weight, however, it also induces reduction of the bending strength. On the other hand, since a glaze layer applied to the surface of roof tile is vitreous, it is expected to contribute to the improvement of the bending strength. The purpose of this study is to clarify influences of the glaze layer on the bending fracture strength of the clay roof tiles.

The roof tile clay was molded to a rectangular shape with a width of about 46 mm and a thickness of about 9 mm. Three types of specimens were prepared; one has no glaze layer on its surface, one has glaze layer on the surface, and one has glaze layers on the surface and also on the restricted area of the back face. The area of glaze layer on the back face was restricted to a fixed length from the symmetry axis of the specimen. Those specimens are air dried and baked at about 1460 K. Then, the specimens were applied to three-point bending and four-point bending tests. In addition, the finite element analyses of the bending tests were conducted to examine the stress conditions around the glaze layers. The analysis model was a quarter of the specimen considering its symmetry, and the clay part was divided by larger elements while the glaze layer was divided by smaller elements.

The experimental results revealed that the glaze layer clearly improved the bending fracture strength of clay tile specimens. The glaze layer on the back side was effective to improve further the bending strength. It was found that the bending fracture strength became the maximum with the specific length of the glaze layer on the back face with respect to the span. The results of finite element analyses pointed out that the influence of glaze layer on the back face was owing to that the onset of fracture was not on the outer surface of the glaze layer but on the clay beneath the glaze layer. Those findings are expected to be useful for the development of lightweight roof tiles with sufficient bending fracture strength.

Keywords: Roof tile, Bending fracture strength, Glaze layer, Bending test, Finite element analysis
Experimental Study on Mechanical Property Control in Local Area of AZ31 Magnesium Alloy Thin-Walled Circular Tube

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Abstract: Magnesium alloys are the lightest among structural metallic materials and are expected to be used in various engineering products. However, it should be noticed that the magnesium alloy has less strength and inferior ductility compared to other metals. In addition, the plastic anisotropy easily develops in manufacturing processes due to hexagonal close packed crystal structure.

In recent years, the development of coronary stents made of magnesium alloy was pushed forward. The coronary stent generally consists of link struts and cell struts. The cell strut works to support the blood vessel in radial direction, while the link strut provides bending flexibility to suit the curved blood vessel. Thus, the different mechanical characteristics are required in cell struts and link struts and for that, the localized control of mechanical properties is required.

Based on those background, we have started the trial to control the local mechanical characteristics of the magnesium alloy circular tube. In this study, we focus on the extension twinning that is activated during plastic deformation. If the twin is activated in the selected area, the yield stress in that area is also changed. At first, the bulging process was performed on the selected area of AZ31 magnesium alloy thin-walled circular tube. Next, the additional process was applied to the bulged area to restore the original profile. Finally, the work hardening due to processing was removed by the annealing process. In order to realize those processes, the special tools were newly designed and incorporated to the press machine. The activation of extension twinning during the bulging and restoring processes was confirmed by an electro-back scattering diffraction analysis. The work hardening was almost diminished by annealing at 473 K for 20 min without recrystallization. In order to check the changes of mechanical properties in the processed area, the specimens were cut out from the area and the uniaxial tensile tests were performed. As a result, it was found that the processed area exhibited larger flow stress and superior ductility compared with the non-processed area. Vickers hardness test was also conducted and it was revealed that the processed area became harder than the non-processed area. Those results imply the possibility to control the mechanical properties of the selected area of AZ31 magnesium alloy tube by the processes utilized in this study.

Keywords: AZ31 magnesium alloy, Mechanical properties, Circular tube, Mechanical twin, Local bulging
Abstract: In recent years, composite materials are increasingly replacing conventional metallic materials in aerospace, civil, marine and automotive industries, because of their higher specific strength and stiffness, higher fatigue properties and corrosion resistance. Composite structures in service conditions are often subjected to dynamic loading and temperature changes. It is, therefore, required to characterize the dynamic mechanical behavior at elevated temperatures of composite materials. Their impact compressive, tensile and shear stress-strain properties were accurately determined using the classic or modified split Hopkinson pressure bar (SHPB). However, loading direction and temperature dependence of the impact stress–strain behavior of composite materials has not been well investigated.

The purpose of the present paper is to investigate the high strain-rate compressive characteristics of a cross-ply carbon/epoxy laminated composite in the three principal material directions or fiber (1-), in-plane transverse (2-) and through-thickness (3-) directions on the conventional SHPB over a range of temperatures between 20 and 80 °C. A nearly 10 mm thick cross-ply carbon/epoxy composite laminate fabricated using vacuum assisted resin transfer molding (VaRTM) was tested. Cylindrical specimens with a slenderness ratio (= length/diameter) of 0.5 are used in high strain-rate tests, and those with the slenderness ratios of 1.0 and 1.5 are used in low and intermediate strain-rate tests. The uniaxial compressive stress-strain curves up to failure at quasi-static and intermediate strain rates are measured on an Instron testing machine at elevated temperatures. A pair of steel rings are attached to both ends of the cylindrical specimens to prevent premature end crushing in the 1- and 2-direction tests on the Instron testing machine. It is shown that the ultimate compressive strength (or failure stress) exhibits positive strain-rate effects and negative temperature ones over a strain-rate range of 0.001 to 1000/s and a temperature range of 20 to 80 °C in the three principal material directions.

Keywords: Carbon/epoxy laminated composites, Compressive property, Loading direction, Strain rate, Temperature
Inverse Analysis of the Coefficient of Thermal Expansion of Dissimilar Materials Using the Virtual Fields Method

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Abstract: Electronic circuit boards are a mechanical component of electronics used in railway vehicles, automobiles, elevator control devices, etc. They are made of various materials having different mechanical properties, such as the coefficient of thermal expansion. A difference in the coefficient of thermal expansion of the materials can lead to large thermal stress and strain from device heat generation and changes in ambient temperature, leading to device failure. In order to design an appropriate lifetime, it is necessary to know the exact coefficient of thermal expansion of each material in the circuit board structure. Modern circuit board structures are becoming finer and more dense, making it more difficult to measure the coefficient of thermal expansion by a test of a conventional bulk specimen. Therefore, this paper proposes a method for identifying the coefficient of thermal expansion of dissimilar materials that are simulating electronic packaging by measuring displacement. Displacement data used for inverse analysis is obtained by a digital image correlation method which can measure full field of view without contact. In this study, a coefficient of thermal expansion mismatch in a substrate structure is simulated using dissimilar materials with silver solder composed two kinds of metal. The displacement distribution under a uniform thermal load is applied to this specimen is measured and the coefficient of thermal expansion is calculated by performing inverse problem analysis using the measured displacement result as an input. The virtual fields method based on the principle of virtual work is employed as the method for the inverse analysis. Each coefficient of thermal expansion that is an unknown parameter is determined by preparing the virtual displacements of as many as the number of materials in the structure. The validity of the inverse analysis method is verified by identifying the experimental coefficient of thermal expansion and confirming that it close to the reference value.

Keywords: Inverse analysis, Virtual fields method, CTE, DIC, Electronic circuit
Evaluation of Weak Bond in Adhesive Joints of CFRP

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Abstract: Conventionally, the assembly of Carbon Fiber Reinforced Plastics (CFRP) structures carried out by mainly using bolts. However, the assembly techniques have changed recently, not just using the bolts but also by using the adhesives. This is because adhesive bonding has several advantages which are less stress concentration and lighter-weight than mechanical bonds. However, there is a serious problem as all defects occurred in bond line are not detected by non-destructive testing (NDT), and it has made difficult to evaluate reliability of CFRP adhesive joints. Defects like porosity, delamination or debonding are detectable by NDT, however, weak bonds are not able to be detected by NDT. It is because weak bonds have no or little strength, and adhesive and adherent are in intimate contact. Also, if there were some weak bonds in bond line, the strength of adhesive parts was ~20% lower than the healthy adhesive parts, however, the Young’s modulus showed almost same value. Therefore, it is important to understand the mechanism of weak bonds to detect weak bond by NDT. The purpose of this paper is to understand the mechanism of weak bonds on adhesive joints of CFRP by reproducing the weak bonds experimentally and analytically.

In this study, two types of single-lap joint specimens were prepared to understand the effect of weak bonds in bond line. One was normal type (NOR) and the other was weak bond type (WB). Weak bond type was reproduced by placing the release agent in bond line. Firstly, NDTs of adhesive joints was carried out by ultrasonic inspection system and soft X-ray inspection system to confirm whether defects can be detected or not. As a result, defects were undetected by both NDTs. Secondly, single-lap shear test was carried out by using tensile testing machine to evaluate the mechanical properties. The strength of RA was about 30% lower than NOR, but Young’s modulus’s value was almost same. It was suggested that weak bonds were reproduced by NDTs and single-lap shear test. On the other hand, molecular dynamics simulation (MD) was carried out to understand the reason of differences between two types of models, their MD models were prepared. One was “Without defect model” which simulated “adhesive bonding”. This model was thermally fused after two cross-linked epoxy resin models were placed close to one another. The other was “defect model” which simulated “weak bonds” and has the rectangular defect with or without H2O as contamination at the interfaces of fused area. Then, tensile analysis was carried out to evaluate the effect of defect size on stress-strain behavior. As the result of tensile analysis, it was revealed that the intermolecular force does not work when the contamination existed in bond line. Also, as the defect size of model became small, the Young’s modulus and strength were respectively close to those gained from single-lap shear test. Therefore, it was suggested that weak bonds were likely to be the very small defect. Consequently, weak bonds were reproduced and the mechanism of weak bonds were revealed by MD.

Keywords: weak bonds, CFRP, Non-destructive testing, single-lap shear test, molecular dynamics simulation
Representation of CFRP Anisotropic Characteristics by Simple Lamination Model for New Product Design

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Abstract: Existing product developments tend to separate product design from product planning. After planning of shape and style of product by designer, its strength is evaluated by engineering analysis, and then the product will be finally designed. However there are many design products which has difficulty to commercialize by conventional method and technique from a restriction of strength and weight even if it has wonderful shape and function. Recently, composite material has been widely used for various products. Composite material typified by CFRP (Carbon Fiber Reinforced Plastics) has high strength and modulus regardless of its light weight. It becomes possible to produce complex form products by using composite material. For example, aircraft, car structure members, sport goods, blade of wind power generation and so on. However, it is more difficult to use composite material for product and structural design compared with using isotropic material. A suitable material design is necessary, since composite material generally has anisotropy and laminate structure. However, the development process and design method of isotropic material are occasionally used for anisotropic composite material, because development process and design method of composite material have not been completely established.

We proposed a simplified CAD model of CFRP laminated structure which has high anisotropy, and it can well represent the material characteristics in CAE analysis. The representation of CFRP was applied to the basic shape and characteristic and behavior of lamination structure were examined. And we confirmed the behavior caused by anisotropy of CFRP can be represented on simulation using proposed model. Based on this result, we will examine the method which uses CFRP effectively for new product design. By using this modeling method, the behavior of CFRP structure with various complex shape proposed by product designer can be well represented, and we can estimate its strength and stiffness of CFRP structure by simulation. Therefore, the product designer can get its material characteristics and structural behavior before styling, and will be able to pursue the optimum structure design and styling effectively by considering the characteristics and behavior of original shapes he designed.

Keywords: CFRP, anisotropy, laminated structure, elastic modulus, product design
Mechanism of repairing of delamination via thermal fusion bonding in CF/PA6 Laminates

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Abstract: Carbon fiber reinforced plastics (CFRP) has excellent specific strength and rigidity. CFRP is used as structure of transport equipment for energy saving. On the other hand, CFRP has a weak point that internal damage, such as delamination, transverse crack and fiber brakeage, is caused by out-of-plane impact. Especially, the delamination is a major factor which is decrease the in-plane compressive strength. That is why the strength of compression-after-impact (CAI) is regarded as one of the important criterion on damage-tolerant design of composite material structures. There are several methods for improving and recovering the CAI strength. Authors focused on repairing of delamination by means of thermal fusion bonding (TFB) in carbon fiber reinforced thermoplastic (CFRTP) laminates, especially on the effect of repairing condition such as temperature and duration on the residual shear strength of the interlaminar repaired by TFB. In this study, authors evaluated the relationship between the shear strength at repaired delamination by TFB in CFRTP laminates and the repair conditions; temperature, duration and cooling. Delamination was introduced in specimen by out-of-plane impact test. Interlaminar shear strength at repaired region was measured through double-notch shear test. As a result, the interlaminar shear strength increased as the repairing temperature raised. The shear strength of repaired specimen at 498 [K] was 84% of that of intact specimen. On the fractured surface, it was confirmed that the resin was not molten under the temperature condition lower than the melting point. On the other hand, at above the melting point, granular materials considered to be crystals of polyamide 6 were partially confirmed especially on the very surface of fractured interlaminar. From this result, partial melting can occur at the fractured surface prior to melting of inside material, and this phenomenon can cause bonding between two fractured surfaces. Further discussion on the mechanism of TFB will be conducted in our following testing and observations.

Keywords: carbon fiber reinforced thermoplastics (CFRTP), Impact damage, Repair, Thermal fusion bonding, Interlaminar shear strength
Experimental study of meso fracture mechanism in carbon fiber/epoxy cross-ply laminates based on digital image correlation method

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Abstract: Since the failure propagates being mixed with each other, it is significantly difficult to predict the failure propagation behavior in the carbon fiber reinforced plastic (CFRP) laminates. Among the failures, the microscopic interfacial debonding between fibers and matrices is one of the very initial failures which finally lead macroscopic failure of the laminate.

In this study, we focused on the initiation and propagation behavior of the interfacial debonding in the 90o layers in cross-ply CFRP laminates under tensile loading. We adopted two kinds of approaches; one is in-situ mesoscopic observation, and the other is the digital image correlation (DIC) method based on the in-situ observation results. From the former, failure propagation behavior was traced on the side edge of laminates by using a microscope. The latter method was used to visualize the strain distribution and to detect the failure location in the 90o layers. Although some literatures used the DIC method with nanoscale particle as the random marker to detect the microscopic failure in 90o layer, it is difficult to follow meso- or macroscopic failures behavior occurring randomly and widely in the laminates. Therefore in our approach, the fiber cross-sections were used as the mesoscale random markers in the macroscopic observation range in the DIC method.

We compared the in-situ failure propagation observation results and the local strain distribution results obtained by the DIC method in order to validate the applicability of the DIC method for evaluation of barely visible initial failures without observer’s subjective decision. Under approximately 0.54% nominal strain, the location indicating higher strain in the DIC showed good agreement with the location where initial debonding was recognized in the in-situ observation. In addition, higher strain distribution was confirmed in the DIC results before the crack recognized on the in-situ observation.

Thus, it is expected that the detection and prediction of damages can be realized by the measurement of mesoscopic strain distribution by the DIC method based on the fiber cross-sections as random markers proposed in this study.

Keywords: Crack propagation behavior, cross-ply laminates, In-situ observation, Digital image correlation, Interfacial strength
Methods of drop experiments to simulate blast experiments

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Abstract: The shock due to a blast causes a large acceleration on an object in very short time. In order to obtain such a blast load, it is necessary to perform an explosion experiment. However, there are several problems in performing a blast experiment, as follows. Large facilities and preparation time for blast experiments are necessary. Since it is difficult to adjust the explosive, a relatively large error occurs in the measurement results of blast experiments. Sensors around the explosive may be damaged by blast pressure. Because of these problems, a simple method of applying a blast load to an object instead of a blast experiment is desired.

The purpose of this research is to reproduce the large acceleration of a blast by collision of the ground due to falling instead of a blast experiment. The impact acceleration of the blast acting on the object is very short and large. The time of the blast is generally about 0.1ms - 10 ms and its peak is about 500 G - 3000 G. First, the acceleration of a steel block acting on a blast load was measured. The acceleration form was a pulsed waveform, time interval was 0.1ms, and the peak acceleration was 2000 G. Next, the same steel block was dropped from a certain height, and the acceleration of collision with the ground was measured. We calculated the impulse obtained from the acceleration at collision with ground and decided the drop height so as to attain an impulse equal to that of the explosion. We set blocks of three types of top shapes (plane, hemisphere, and sharp) and three types of materials (steel, aluminum, and brass) on the ground. We searched for shapes and materials of blocks to be similar to the acceleration wave form of the blast load. As a result, a sharp steel block was found suitable for obtaining the acceleration as a substitute for blast experiments.

Keywords: blast load, drop experiment, impact acceleration, collision, pulsed waveform
Experimental Evaluation of Mode II Interlaminar Fracture on Asymmetric Interlaminar in CFRP Laminates

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Abstract: Although carbon fiber reinforced plastics (CFRPs) have high specific strength and stiffness, the out-of-plane low-velocity impact easily causes complex internal damages, such as delamination and transverse cracking, which are hardly detected from outside. Since especially the delamination drastically degrades the strength of compression after impact (CAI), the interlaminar fracture toughness is one of the most important parameters for evaluation and estimation of the performance of impact resistance of CFRP laminates. The interlaminar fracture toughness of composite laminates has been evaluated mainly for unidirectional or cross-ply laminates. However, it is difficult to estimate the realistic interlaminar fracture toughness and failure process for quasi-isotropic or angle-ply CFRP laminates composed of fiber layers having different orientation angles. In this study, we focused on the effects of fiber orientation angle on the interlaminar fracture toughness and the failure mechanism in CFRP laminates having asymmetric interlaminar. The static Mode II interlaminar fracture toughness was measured for three types of CFRP laminates in which interlaminar orientations consisted of 0°/45°, ±22.5°, and 0°/0° layers, respectively. Prior to the experimental evaluations, the fracture mode distribution at the crack tip was calculated by the finite element analysis owing to ensure that the dominant fracture mode was the Mode II. Both the 0°/45° laminates and the ±22.5° laminates showed almost the same energy release rate as the unidirectional laminate. However the typical hackle-like failures were observed on the fracture surfaces in all laminates, the difference was revealed in the fracture mechanism between the 0°/45° and ±22.5° laminate. The morphology of the delamination propagation between the 0°- and 45°-oriented layers resembled the fan-shaped pattern induced by the out-of-plane impact in quasi-isotropic laminates. Therefore, the evaluation methods proposed in this study enable the the interlaminar fracture toughness evaluation based on the mechanisms of impact damage occurrence and fracture propagation peculiar to the quasi-isotropic laminates.

Keywords: Mode II interlaminar fracture, Fracture mechanism, Asymmetric interlaminar, Fiber orientation angle, CFRP
Effect on Fundamental Property of EFB Biocoke based on Additional Pectin

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Abstract: Previous biomass energy has problems which are loads on the global environment by new farmland and deforestation because biomass as raw materials is often specified. However, Biocoke does not depend on raw biomass materials if the materials derive from photosynthesis. Thus, we can use discarded biomass such as food residue, factory waste. We can also use unutilized biomass at each region all over the world. It is possible to realize biomass energy based society of self-sufficiency in not only Japan but the world. Although Biocoke has above properties, there are some differences in specific gravity and compressive strength in accordance with raw materials. In previous verification tests and practical applications, Biocoke has the satisfactory ability to be able to use in a cupola furnace while conventional biomass solid fuels do not have the usable ability in the furnace. The cold compressive strength of Biocoke exceeds the compressive strength of the biomass solid fuels, even in comparison with coal coke. However, further research is needed about the compressive strength under the temperature of about 973K because the hot compressive strength of Biocoke is approximately one-tenth of coal coke. It is known that Biocoke produced from apple and orange belonging to fruit-tree plants has high hot compressive strength. The fruit-tree plants contain a lot of pectin. In this study, we focus on the effect by adding pectin to EFB fiber. Even though the EFB fiber is mixed with the pectin, we can produce Biocoke and contribute to improved functionality. As a result, it was found that the EFB Biocoke mixed with pectin greatly changed the compressive strength properties by the contents of initial moisture and pectin for the raw materials. Furthermore, we use lemon grounds disposed as one of the waste products since we assume actual production of Biocoke. We will consider about the contribution to improved functionality as well as additional pectin by mixing lemon containing a lot of pectin into EFB fiber.

Keywords: Biocoke, Pectin, Biomass, EFB Fiber, Compressive Strength
Possibility of Compressive Strength Increase of Biocoke by Japanese Cedar Lignin

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Abstract: Recently, lignin resource has been focused as a usable material for industrial products. A plant cell wall has the three main components such as cellulose, hemicellulose and lignin. Among them, lignin especially possesses the property of formation of impregnable walls, namely, to harden entire anatomy and structure of biomass. Although lignin is a functional material, its effective utilization is difficult owing to a wide variety of lignin structures elaborated by G, S and H monolignols in nature. The lignin structures in softwood, hardwood and herbaceous plant are different. The softwood includes G monolignols. The hardwood includes G and S monolignols. The herbaceous plant includes G, S and H monolignols. Kindai University developed Biocoke as one of the biomass solid fuels. Biocoke is produced from biomass carrying on photosynthesis through a process of adding load and heat. Biocoke has mechanical characteristics such as high compressive strength at room and high temperature. It is considered that this compressive strength is caused by lignin and hemicellulose, especially, the lignin affects the compressive strength at high temperature.

In this study, we focus on Japanese cedar as a material of Biocoke. Japanese cedar has relatively more lignin than other biomass. Also, the Japanese cedar lignin is homogeneously consisted of G monolignols. However, to derive lignin from Japanese cedar is more difficult than to derive lignin from hardwood. If we can successfully use Japanese cedar lignin, we have possibility to produce a biomass solid fuel with a homogeneous formation characteristic. We set the particle size of material and diameter of Japanese cedar Biocoke as formation parameters. We chose the particle size to investigate the effect of bulk density on Biocoke by the change of filled state of material and the diameter to establish molded homogeneity by the difference of heat transfer into the center of Biocoke. After producing each size of Biocoke with each particle size of material, we measured the compressive strength at room and high temperature. Thus, we showed the possibility that the cold and hot compressive strength was affected the bulk density and heat transfer during the production process.

Keywords: Japanese cedar lignin, Biomass solid fuel, Bulk density, Homogeneous formation state, Compressive strength
Development on high-power spallation neutron sources with liquid metals

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Abstract: The developments of the high power proton accelerators get to be a worldwide interest to provide various applications. The J-PARC (Japan Proton Accelerator Research Complex) which is consisting of the high power proton accelerators and 3 facilities; hadoron, neutrino, MLF (Materials and Life science experimental Facility), and the planned facility relating to the transmutation technology for nuclear wastes, is to provide high intensity proton beams for various research fields to create the discovery of new physics, to explore materials and life science, to investigate technology on the transmutation of nuclear wastes, etc. The accelerator technology on the stable and high intense proton beam supplying is being developed. In these science filed, targets effectively converting from primary beam to secondary beams are essential to survive the intensive MW class proton beam power supplied by the accelerators. As for the high power primary proton beams with a few MW, targets have to withstand the intensive heat deposition that comes along with the passage of such primary beams. Although the liquid metal targets are promising to accept the high intense beam, there exist technical issues to realize the target concepts. In the past years, we have been exploring to find each solution. In the paper, the relevant innovative technologies developed through experimental and numerical approaches will be reviewed.

Keywords: Liquid metals, Giga-cycle fatigue, Irradiation embrittlement, Thermal shock, Shock waves
Estimation of Irreversibility Fields in Superconducting Pb-Bi Alloy

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Abstract: Superconducting properties are roughly dominated by temperature, magnetic field, and electric current. The critical temperature is higher than that of metal superconductors, and liquid nitrogen can be used as the refrigerant. The upper critical fields in high-temperature superconductors have been estimated as over 50T at 0K. This is enough to apply for industrial equipment, e.g., a MRI equipment (Magnetic Resonance Imaging). However, the critical current density defined as a balance of between the Lorentz and pinning forces is not enough for the power applications. The critical current density of high temperature superconductors suddenly decreases with increasing temperature or magnetic field. Such a poor property of critical current density is attributed mainly to weak pinning strength against large thermal agitation at high temperatures. Therefore, it is desired to improve the critical current property of high temperature superconductors by improving the pinning strength. The structure in high temperature superconductors is not simple in comparison with that of the metal superconductors. That is, high temperature superconductors have many uncertainties which affect to the characterization. Therefore, the estimation of superconducting property using a metal superconductor on that of the high temperature superconductors have been studied in this paper. The reason why the superconducting Pb-Bi alloy has been used for the research. The upper critical field is so lower than that of Nb-Ti superconductors. For the purpose, the mechanism that determines the critical property is required to be clarified. The poor critical current property in high temperature superconductors is reflected to the low irreversibility line on the flux pinning. However, it is difficult to control the pinning force in high temperature superconductors. In this paper, superconducting Pb-Bi alloy specimens are used, since the pinning strength can be controlled by changing Bi quantities. The experimental results will be compared with the flux creep theory. Superconducting Pb-Bi alloy specimens were prepared as follows: Lead and Bismuth with the purity of 99.99% were mixed in the desired composition and melt at 673K for 96 hours in a vacuum of 10^-4 Torr. In general, the superconducting Pb-Bi alloy consists of the superconducting epsilon phase and the normal Bismuth-rich phase. We prepared two samples and the atomic ratio of bismuth was selected as 28% and 56% so as to obtain the volume fraction of normal precipitated of 0% and 20%, respectively. Magnetic property was measured by a SQUID magnetometer. The upper critical fields, Bc2, was obtained from the DC susceptibility measurement. The critical current density, Jc, and the irreversibility field, Bi, were estimated from the DC magnetization measurement. The Bean model was used for the calculation of Jc. The irreversibility fields in superconducting Pb-Bi alloy specimens can be observed in several temperatures. The reversible region of the magnetization curve in a weakly pinned specimen is remarkable in comparison with that of the strongly pinned specimen. The details about its contents will be presented in my presentation.

Keywords: Irreversibility Fields, Pb-Bi Superconductor, Pinning Strength, Flux Creep Theory, WHH Theory
Flame Synthesis by Clustered Microflames on Six Fuel jets and One Air Jet with Silicon Dioxide Particles

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Abstract: Nanoparticles are particles with a diameter of the order of nanometer and their specific surface area is extremely large. They exhibit characteristic physical properties different from solid materials of general size, such as the quantum size effect (quantum dot), various functions are expected for the material in nanosize. Thus, research and utilization of nanoparticles have been conducted in a wide range of fields. The present study was conducted to produce nanoparticles by flame synthesis based on the fine control of flame structure by clustered diffusion microflames. The burner used in this study has the six fuel micro-nozzles around one air micro-nozzle. The flame structure can be greatly changed by changing distance between the nozzles in addition to jet velocities. The established clustered methane microflames has characteristics such as reaching ultra high temperature of 1900 K. In addition, depending on the flame structure, merged microflames have a reduction zone between inverted diffusion flame and diffusion flame. As a result, fine particle synthesis by reduction reaction can be expected, but at the same time it is necessary to control the flame structure in accordance with the selection of the particles to be synthesized.

Silicon dioxide microparticles were carried into clustered microflames by the air jet and nanoparticle was successfully synthesized. The size of collected particles were measured by a scanning electron microscope (SEM) and the crystal structure of the particles were analyzed by X-ray diffraction (XRD). In the manufacture of metal grade silicon, similar to aluminum, a large amount of electric power is required for reduction from the metal oxide. The success of metal grade silicon by flame synthesis will lead to save significant electric power and its cost.

Keywords: nanoparticle, flame synthesis, diffusion microflame, X-ray diffraction, Silicon
Experimental verification of effect of microscopic impregnation behavior between fibers and resin on permeability

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Abstract: Vacuum assisted resin transfer molding (VARTM) is one of the various molding methods for fiber reinforced plastics (FRP). It has an advantage in the cost especially for necessary equipments, however, there is possibility to include resin pockets or voids, which can degrade mechanical properties of FRP. Thus, prior to the molding of large FRP structures, for instance wind turbines or marine vessels, a numerical simulation is conducted with permeability as one of the parameters. Although the permeability is defined by the Darcy’s law, it is led by the macroscopic resin flow status, and the visible resin flow does not normally coincide with that inside reinforcement fabrics. The difference between macroscopic and microscopic resin flow statuses can cause misreading of the permeability itself or formation of voids inside or between fiber bundles.

This study focused on the capillary number, which represents the balance between the viscous force and the surface tension force, because these two forces predominate the resin impregnation status inside and between fiber bundles.

Our aim of this study is verification of the effect of the capillary number on the permeability. Especially, in the case that the capillary number is identical, that is, the microscopic resin flow status is thought to be also identical, the variation of permeabilities of reinforcement fabrics with various surface treatments are measured against various resins.

Contact angle was measured for evaluation of wettability between glass and epoxy resin. Slide glasses were heated to unify their surface condition and then modified their surface with silane coupling agent. Heated slide glasses and modified ones were used for contact angle measurement.

Glass cloths treated as same conditions as slide glass were used for the evaluation of permeability. Glass cloths were impregnated with resin in a vacuum state, and the permeability was measured.

The capillary number was derived from contact angle, surface tension and viscosity. The correlation between the capillary number and the permeability was evaluated by comparing them. Although the experimental results showed that silane coupling agent improved wettability and apparent permeability, it helps to occur the clogging intra fiber bundles.

It is considered that the change in the apparent permeability and capillary number is due to clogging of the fiber bundle, which makes it easier for impregnation between fiber bundles. In addition, when resin impregnation under the condition that the capillary number is unified, the permeabilities were almost identical among glass cloths with different surface treatments against epoxy resin. Thus, the capillary number can represent one of the dominant parameters for the permeability. However, for confirmation of our current results, it is necessary to continue investigation on the permeability in the capillary number with different resins.

Keywords: FRP, VARTM, capillary number, permeability, contact angle
Fracture behavior of aluminum and silver alloy thin films on polymer thin films

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Abstract: Critical cracking strains of transparent conductive polymer thin films, aluminum and silver alloy thin films on polymer thin films prepared on a flexible polyethylene naphthalate (PEN) substrate were investigated by applying tensile strain to the specimens with monitoring the electric resistance of the thin films. The final target of the present research is the improvement of flexibility of organic devices, flexible displays and flexible organic light emitting diodes (OLEDs). With regard to PEDOT:PSS shows increase of electrical resistance with increasing the tensile strain up to more than 20%. The experimental result is consistent well with theoretical resistance by 10%. Then the empirical electrical resistance value shows higher than theoretical values probably due to the increase of the distance among each PEDOT molecular or cluster. The electrical resistances start increasing at around 3.25-4.25 % and 3.25-4.85 % for the specimens with Alq3 under layer (Al/Alq3/PEN) and with CBP under layer respectively, then they reach a resistance level of 7.5-70 kΩ and 1-4 kΩ respectively at an applied strain of 10 %. It is observed that the direction of cracks is perpendicular to the tensile direction. However the cracks do not pass through completely, that is aluminum film still has network circuit to conduct current, which is the reason why the electrical circuit has conductivity without causing rupture. The increase of the electrical resistance means the increase of the length of pass due to the increase of cracks. The other hand, in the case of MgAg, the drastic increase of electric resistance was not observed, especially MgAg/CBP/PEN specimen does not show any increase of electrical resistance even at a strain of 20 % or more. Regarding Al/Alq3/PEN structure, although the increase in electrical resistance was observed from an applied strain of 8-10 %, the electrical resistance was only 40 Ω, that is around 0.003 % of Al. Consequently, it was found that MgAl films shows much higher electric conductivity than that of Al thin films.

Keywords: Critical cracking strain, Polymer thin films, Metal electrode, Electric conductivity, Flexible OLED
Graphite size dependency of hydrogen storage capability and its effect on the tensile properties of ferritic ductile cast iron

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Abstract: Hydrogen embrittlement, degradation of strength properties of metallic material by hydrogen penetration, is a problem for safety of hydrogen equipments. At present, high-cost materials such as austenitic stainless steel and aluminum alloy are used for hydrogen equipments because these materials are less susceptible to hydrogen. In order to establish a hydrogen society, the range of available material for hydrogen equipments should be extended to include common and low-cost material.

Ductile cast iron (DCI) is one of the prospective materials used for the hydrogen equipments because of low-cost, good workability and formability. The mechanical properties of DCI are tailored to the component’s needs by changing its microstructural factors such as graphite size, volume fraction of graphite, matrix structure and so on. Therefore, an optimal microstructural condition that is less susceptible to hydrogen embrittlement should be found out for safety use of DCI in hydrogen environment. In this study, the effects of graphite size on the hydrogen storage capability and the hydrogen-induced ductility loss of ferritic DCI were investigated.

Tensile tests using ferritic DCIs with a different graphite diameter of about 10 µm - 30 µm were conducted in air at room temperature. The hydrogen content of a tensile specimen was measured by a thermal desorption analyzer (TDA). To perform hydrogen charging, specimens were soaked in thiocyanate ammonium solution prior to the tensile test. The fracture surface was observed by a scanning electron microscope (SEM).

It was clarified that the amount of hydrogen stored in DCI was dependent on the graphite size, and there was the critical graphite diameter that significantly increased the hydrogen content. When the graphite diameter was smaller than the critical value, the amount of hydrogen was about a few mass ppm. On the other hands, when the graphite diameter was larger than the critical value, the amount of hydrogen was about 50 - 60 mass ppm and then it was almost constant irrespective of graphite diameter. The ductility was decreased by hydrogen, and the hydrogen-induced ductility loss was dependent on the hydrogen content. As a consequence, the hydrogen embrittlement of DCI with larger graphite nodules became more pronounced owing to a large amount of hydrogen.

Keywords: Hydrogen embrittlement, Ferritic ductile cast iron, Tensile test, Graphite size, Hydrogen content
Finite Element Study on Effect of Cross-Sectional Shape of Stent Strut on Internal Deformation of Coronary Artery

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Abstract: As a treatment method for coronary artery diseases, balloon expandable vascular stents have been used to widen narrowed blood vessels and secure blood flow. However, since the stent has higher rigidity than the blood vessel, the risk has been pointed out that the stent deployment may induce mechanical stimulus to the blood vessel and cause the restenosis. In order to reduce the risk, it is important to clarify the influences of the stent deployment and the stent strut shapes upon the physical response of the coronary artery. In this study, therefore, the mechanical response occurring in the coronary artery during the stent deployment was investigated using a finite element analysis.

First, the tensile properties of three layers constituting the coronary artery; the intima, the media, and the adventitia were obtained from the literature. Next, the property of each layer was approximated by James-Green-Simpson function, which was adaptable to the nonlinear elastic finite element analysis. The coronary artery was modeled as an axisymmetric long tube with an inner diameter of 3 mm, while the various kinds of cross sectional shapes of stent struts were modeled as rigid bodies. Using those models, axisymmetric finite element analysis was performed to investigate the deformation and stress conditions of the coronary artery that was expanded by the stent to a predetermined diameter.

The results of the analyses revealed that the large stress was generated in the intima during expansion of the stent. It is because the intima has higher rigidity than the media and the adventitia in the coronary artery. It was found that the stent was not embedded in the intima and protruded into the blood vessel. Such protrusion is considered to be inappropriate because it interferes the blood flow in the coronary artery. Besides, the reaction force from the coronary artery after the stent deployment was almost constant regardless of the different cross sectional shapes of stent strut. This result implies that the stent cross sectional shapes have only a small influence on the force required to widen the artery. By considering the results obtained, the optimum cross sectional shape of the stent strut to reduce the mechanical irritation to the coronary artery was discussed.

Keywords: Stent, Coronary artery, Finite element analysis, Deformation, Physical properties
Adhesion force measurement by using film-type sensor: a pilot study of development of cell force monitoring system

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Abstract: In cell culture process, adhesion force acts between cell-to-cell and/or cell-to-culture dish, control of these adhesion force is a key factor of formation of cell spheroid. These adhesion forces are thought to vary depending on the cell activity and the surrounding environment (e.g. dish, medium). Monitoring of the actual adhesion and shear forces on bottom of the culture dish can be useful for the reproducible cultivation and the detection of defective product. We have developed a thin and flexible sensor for understanding the force between contact interfaces. This sensor was simply composed by electrodes and pressure-sensitive layer and can measure 3-dimensional stress and/or force distribution. In previous study, this sensor was applied to the field of biomechanics such as 3-axial stress measurement at sole, pressure distribution at narrow joint space of biological tissues, and analyzing the fingertip force in the process of blood collection. Since conventional our sensor was made by merely stacking and packing of two electrodes with pressure-sensitive layer, accuracy and repeatability in the low contact pressure region were poor, and adhesion force could not be measured since the electrode were separated. Recently, however, we can fabricate the no-separate film sensor by using printing or bonding technology of conductive materials. In this study, we examined the possibility of measuring adhesion force by the film sensor, as a first step of development of cell force monitoring system.

A single point force sensor was prepared, and compression / tensile (adhesion) force was applied by a universal testing machine. Two electrodes were fabricated from a flexible copper-polyimide laminated film, through photolithography and wet-etching process. A conductive polymer was used as the pressure sensitive layer. Two electrode and conductive polymer were bonded by silver paste. The fabricated force sensor was fixed to the universal testing machine. As a result, when the compression force was applied, the electric resistance of the sensor decreased according with the applied force as before. When the tensile force was applied, the electric resistance of the sensor increased according with the applied force. Tensile force could be detected as a change in electric resistance with less than sub-kilo pascal resolution. The force of tensile direction could be measured by the no-separate film sensor. It is considered that the 3-dimentional force acting on the cell culture dish can be detected by controlling the electrode arrangement and sensitivity.

Keywords: Adhesion force, Film sensor, Pressure-sensitive material, Sensor design, Cell adhesion
A new in vivo method for three-dimensional evaluation of tooth axis and dental arch using cone-beam computed tomography

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Abstract: Background
Although the tooth axis is the basic morphological reference axis of a tooth, method of its determination is a conceptual definition. When a three-dimensional (3D) tooth axis is defined and at the same time a unique 3D dental arch also can be established. This can be widely used as an effective method in the field of orthodontics and prosthodontics. The current method for evaluating the dental arch was an intraoral model which was first produced by casting and then, characteristic point of a tooth was contacted using a 3D measuring device, “stylus” or 3D laser measuring instrument. However, these in vitro methods do not give an objective evaluation of the dental arch.

Objective
In this study, we developed a 3D global coordinate system from three feature points of the upper and lower jaws using in vivo cone-beam computed tomographic (CBCT) images, and proposed a new method to calculate the tooth axis and dental arch of the maxillary and mandibular teeth automatically.

Methods
We used in vivo CBCT images from two adults to produce 3D models of the maxilla and mandible. Then a 3D global coordinate system was determined using three feature points comprising the bilateral mental foramina in the mandible and the incisive canal in the maxilla. We also produced 3D models of the maxillary and mandibular teeth, and used a 3D principal component analysis to calculate the tooth axis (PC-A) as the principal component of the long axis direction of these teeth. The center of gravity (COG) was automatically calculated from 3D models and the dental arch represented as mathematical regression curves for the COG.

Main findings and Results
The tooth axis and the dental arch from COG of the mandibular teeth were projected on the X-Y (horizontal) plane, X-Z (coronal) plane and Y-Z (sagittal) plane in the 3D global coordinate system. The COG appears as a dental arc in the X-Y plane, PC-A is almost symmetrical about the Y-axis in the X-Y plane, and about the Z-axis in the X-Z plane. Furthermore, the dental arch in each plane can be expressed by an appropriate mathematical functions. The same tendency was confirmed for maxillary teeth as well. In this method, since the feature points of the upper and lower jaw were used to determine the 3D global coordinate system, there is an advantage that the absolute 3D position of the maxillary and mandibular teeth can be expressed. In comparison, our new method which calculates the tooth axis and arch from COG of the 3D tooth shape, gives the advantage of using unambiguous target points derived from the unique 3D shape of each tooth.

Keywords: Bioengineering, Tooth axis, Dental arch, Three-dimensional evaluations, Cone-beam computed tomography
Design of Laminated Flooring Materials with Soft Underfloor Layer to Prevent Femur Fracture

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Abstract: Prevention of femur fractures in elderly people due to falls has become urgent task in the super-aging society of Japan, since the fractures cause the long-term nursing care. In order to solve this problem, development of flooring materials with high buffering properties and slip resistant by surface processing has been addressed. In the conventional safety assessment method of flooring materials, acceleration has been used as an evaluation parameter, and head (brain) damage at the time of falling is assumed. However, it is not suitable for evaluating femoral fracture risk.

Therefore, we have proposed a method to evaluate the safety (femur fracture risk) of flooring materials. In order to estimate the load that penetrates soft tissue at the time of falling and acts on the femur, impact tests, which drops a weight fixed with the flooring material to the dummy skin on the load cell, have been performed. As a result of evaluating the existing flooring materials using the method, it have been suggested that buffering properties is improved by combining general flooring materials with soft underfloor layer.

In this study, we newly investigated the design of flooring materials that reduce the risk of fracture by combining the flooring materials with soft underlayer to prevent the fracture of the femur due to falls. In the experiments, we investigated compressive properties and buffering properties of the commercially available flooring materials with hard surface layer and different softness underfloor layer by static compression tests and impact tests. As a result, we have confirmed that the laminated flooring material composed of hard surface layer and soft underfloor layer have high buffering performance. This was thought to be caused by absorption of the impact with wider surface of the soft underfloor layer and the hardness of the surface layer. Also, due to the difference in compressive properties in static compression tests of soft underfloor layer, buffering performances of the laminated flooring materials differed. Since it has been predicted that the impact area of soft underfloor layer would fluctuate due to the rigidity of hard surface layer, it has been thought to be necessary to select the soft underfloor layer suitable for various hard surface layer. Therefore, we formulated mathematical expressions to estimate the buffering properties of laminated flooring materials by using the shape and material properties of each of the hard surface layer and the soft underfloor layer. We proposed to estimate the optimum combinations of hard surface layer and soft underfloor layer using mathematical expressions.

Keywords: Flooring material, Fracture risk, Femur, Fracture prevention, Buffering property
Dynamic Viscoelasticity Properties Evaluation of Skin and Development of Dummy Skin for Safety Evaluation ~ Analysis of Deformation Behavior in the Depth Direction of the Skin ~

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Abstract: Quantitative mechanical evaluation of human injury is important in the field of care, welfare and medical care in super aged society. Especially, in measures against pressure ulcers and safety evaluation of power assist robots, in order to evaluate skin irritation mechanism due to mechanical load, mechanical properties such as viscoelasticity and hardness of soft tissue include skin and muscle are required. In general, the mechanical properties of the human body often use numerical values measured in vitro. However, because soft tissue of the skin is heterogeneous, nonlinear and has anisotropy and frequency dependency, a complicated hierarchical structure, it is necessary to measure mechanical properties considering these. From this, it is desirable to use the mechanical properties measured in vivo. The data measured in vivo is very little, and in addition, the values obtained for each measurement are largely different. Therefore, the exact value of the mechanical properties of the skin is not clear.

We have been measuring the dynamic viscoelasticity of human skin in vivo using a rheometer. Also we created a dummy skin that reproduces the dynamic viscoelasticity of human skin from the measured values obtained. As a result, it became clear that the influence of age and gender on dynamic viscoelastic properties is much larger than individual differences among males in their twenties. Also, by simulating the material properties and the tensile state of the epidermis, it was possible to create a dummy skin which closely resembles human skin of male in his twenties in terms of hardness and dynamic viscoelastic characteristics in the direction of displacement.

In this study, in order to develop dummy skin considering the layered structure of human skin and individual difference such as age, gender and physique for dynamic mechanical properties, dynamic viscoelasticity was measured using rheometer on human skin and dummy skin made with laminated structure. The deformation behavior in the depth direction and the influence on the viscoelastic properties were investigated by measuring while changing the pressing pressure. As a result of measurement against human skin, the elastic component showed a tendency to measure with the entire skin as homogeneous material. In addition, the viscous component suggested that the measurement range in the depth direction is changed by changing the pressing pressure. As a result of measuring viscoelasticity of dummy skin laminated with different hardness and thickness, it became clear that individual differences such as age, gender and physique can be reproduced.

Keywords: Viscoelasticity, Human skin, Rheometer, Dummy skin, Deformation behavior in the depth direction
Abstract: In Japan, recently, natural disasters such as landslide due to earthquakes and typhoons and pyroclastic flow due to volcanic eruptions occur. In the site of landslide or a pyroclastic flow, obtaining the information of disaster sites is important for recovery. Specifically, information obtained by sampling soil is important to predict second disaster. However, on-site inspection by human will be dangerous, because there is likely to be exposed to toxic volcanic gas or sudden landslides. 
In this study, we focused on the use of UAV (Unmanned Aerial Vehicle) at the disaster site survey. UAV is also referred to as Drone, the moving speed is faster, the operator can operate from safe place, it is possible to access to the site sky regardless of the situation on the ground. By using UAV, we can safely obtain situation of disaster areas. Technology to get the 3D data of the terrain by a camera or a laser scanner equipped UAV has already been put to practical use. In addition to 3D data, collecting soil sample will make inspection more detailed. For this purpose, we have already developed automatic soil sampling device mounted to UAV. This device can sample soil by dropping from 2 m height and penetrating to the ground. However, the speed control when dropping the device from higher altitude was unknown. In the actual operation of this equipment, it is required to be dropped from an altitude of 10 to 20 m which is a flight altitude of the UAV. In this case, as the device will break by penetrating to the ground at excessive speed, it is necessary to control falling speed of the device. 
Based on the background, the purpose of this study is to investigate control of the falling speed of the device. Specifically, to give a braking force to the device by a wire that connects it to the UAV, a motor equipped to wind up the device was used as a generator, and the generated electric energy was released as heat from resistance. Optimal falling speed to soil sampling and the parameters of motor and resistance to achieve the speed were investigated.

Keywords: Disaster site inspection, Disaster recovery, On-site inspection, Soil sampling, Unmanned aerial vehicle
Study on Recycling of Unused High Water Content Soils as Banking Materials

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Abstract: On March 11, 2011, Great East Japan Earthquake and the gigantic tsunami caused serious damages to coastal areas of Tohoku region. From this disaster, many banks near a river and seashore were destroyed and need to reinforce it. Furthermore, the project of building new banks is now desired in many places. However, the huge problem in a bank construction is how to prepare large amount of soils and high transportation cost. The high water content soils usually doesn’t use as banking materials because of its minus properties, but if various kinds of high water content soils can use as bank materials then a bank construction will be more efficient. From the previous study, the potential as banking materials of fiber-cement-stabilized soil method modified tsunami sludge was discovered. Fiber-Cement-Stabilized Soil method is a recycling method for high water content soil by adding fragment of old paper and solidification material. The modified soils have several features such as large failure strength, large failure strain, and high durability in wetting and drying condition. In this study, we focused on the recycle of various kinds of unused high water content soils using fiber-cement-stabilized soil method. The properties of modified soil of artificial sludge and unused natural sludge were experimentally investigated. In order to recycle various kinds of soils using fiber-cement stabilized soil method, the tendency of artificial modified soil strength property was investigated first. The artificial sludge was made by mixing various kinds of soil which is commercially available. The strength properties of modified soil were measured by conducting unconfined compression test. As a result, the strength properties of modified artificial soil depend on the particle size of each soil when the additive amount of paper debris and cement are certain. From this result, the flowchart to modify various kinds of soil was proposed. Also, the unused natural high water content soils modified by the flowchart have enough strength properties as banking materials. The possibility of using high water content modified soils as bank materials was shown.

Keywords: Fiber-cement-stabilized soil, Soil improvement, Application of banking materials, Unconfined compression test, Unused natural soil
Study on Strength Characteristics of Fiber-Cement-Stabilized Soil Mixed with Recycled Granular Material

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Abstract: “Fiber-Cement Stabilized Soil Method” is known as recycling method for high water content sludge. The modified soil is made by adding paper debris and cement based solidifying material into sludge. Paper debris has two roles, which are to absorb pore water of sludge and to attach soil particles each other. This modified soil has some features: high failure strength, high failure strain and high durability in wetting and drying condition. However, recently, as the price of old paper is increasing, development of new material which can absorb pore water instead of paper debris is desired. To reduce the additive amount of paper debris, we focused on using granular materials recycled from construction waste because they absorb pore water of sludge. We have confirmed that the additive amount of paper debris reduces when making the modified soil through unconfined compression test of the modified soil using one kind of granular material. However, actually, there are various particle sizes of granular materials, the compressive strength characteristics of the modified soil with granular materials of different particle sizes are not well understood.
In this study, to grasp the compressive strength characteristics of the modified soil with various granular materials, granular materials with three different kinds of particle size characteristics were used. In addition, to investigate the effects of soil property of sludge on the modified soil, sandy soil and silty soil were prepared as artificial sludge. Then, unconfined compression test of the modified soil was carried out, and failure strength and failure strain were measured. Based on the measurement results, it was confirmed that the modified soil has high failure strength when the particle size distribution by combination of sludge with granular materials is the widest. Moreover, to obtain sufficient failure strain of the modified soil, it was found that the modified soil made of sandy sludge needs more additive amount of paper debris compared with that made of silty sludge. However, as the failure strength of the modified soil made of sandy sludge was too large, it is necessary to reduce the additive amount of cement when increasing the additive amount of granular material.

Keywords: Recycled granular material, paper debris, Fiber-cement-stabilized soil method, Unconfined compression test, Recycling
Abstract: Japan has been badly affected by natural disasters such as landslide due to volcanic eruption, heavy rainfall and earthquake. After natural disasters occur, it is very important to introduce construction machinery such as excavator rapidly for life-saving and recovery work. In general, trafficability is used as judgmental standard for introducing construction machinery to the disaster area. The trafficability means the capacity of soil to bear construction machinery. The trafficability is expressed as cone index, which is measured by using a cone penetrometer. To measure the cone index at landslide area, the measurement by human power or land running machine is required. However, the work is very dangerous because of possibility of secondary disaster.

We focused on a new technology which means investigating ground from the sky by unmanned aerial vehicle (UAV). The measurement from the sky has two large advantages that geographical features and obstacles do not affect the measurement and a wide range measurement of disaster area can be investigated in a short time. We have been produced a device for measuring impact acceleration by dropping to ground and developed a method for estimating the cone index from the impact acceleration. However, the method has a cable sensor for measuring the impact acceleration. The purposes of the method are to develop wireless measuring device and to expand the possibility of application at the disaster site.

Firstly, we developed new device using Arduino. Then, we carried out free-fall test by using silica sand with different water contents. Furthermore, we carried out cone penetration test to measure the ground strength. The size of new device used for the experiment is a hemisphere weight on 12 cm in diameter. The experimental conditions are the dry density is 1.2 g/cm³, the water content is 6 conditions from 5% to 30% with increments of 5%.

As a result, it was obtained that between the maximum impact acceleration and the cone index have positive correlation. However, it was confirmed that the results using wireless device are larger variation than the results using the device with a cable sensor. For that, we will investigate the cause of the variation and improve the wireless device. After that, we carried out free-fall test to expand the range of application of new device.

Keywords: Unmanned Aerial Vehicle, Trafficability, Impact acceleration, Disaster site, Arduino
The Relationship between Sound and Rainwater Quality Purification using Waterwheel Rotation

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Abstract: Sustainable water resource conservation is now essential to secure sustained, sound, and high-quality water in the world. In this paper, a rainwater quality purification using a waterwheel rotation was first considered through the experiment. Next, the relationship between the sound wave and the rainwater quality purification using the device is stated. Finally, a consideration regarding sustainable environmental management and a water resource purification has been described in the paper.

Keywords: Emergency Drinking Water, Rainwater Quality Purification, Sound, Waterwheel Rotation, One's Life
Wind tunnel study of peak wind force coefficients for designing cladding/components of gable-roofed open-type structures

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Abstract: The present paper discusses the peak wind force coefficients for designing the cladding and its immediately supporting structures of open and semi-open type membrane structures with gable roof, based on a wind tunnel experiment. Note that the semi-open type structure has only one gable wall, while the open type structure has no gable wall. Enclosed type structure was also tested for a comparative purpose. The geometry of the structure is determined based on a survey of practical framed membrane structure used for temporary building and sports facilities, which have been constructed in Japan. The geometric scale of the wind tunnel model is 1/200. Experiments were carried out in two kinds of turbulent boundary layers corresponding to open-country and urban terrains. The wind pressures were simultaneously measured at many points on the external and internal surfaces of the wind tunnel model. The wind force acting on the structure per unit area is defined by the pressure difference between the external and internal pressures. The internal pressures for the enclosed type structure are assumed to be zero.

First, the mean wind force coefficients are investigated in order to understand the characteristics of the wind forces, focusing on the effects of gable wall configuration. Then, the maximum and minimum peak wind force coefficients irrespective of wind direction in two kinds of the turbulent boundary layers are examined. These peak values are generally used in practical design. Based on the experimental results, an estimation method of the peak wind force coefficients for open and semi-open type structures are investigated. The magnitudes of external peak pressure coefficients for the enclosed and open-type structures are compared with each other in order to understand the effect of gable-end configuration on the external peak pressure coefficients. Then, the virtual internal pressure coefficients which obtained from the difference between the peak wind force coefficients for open or semi-open type structures and the external peak pressure coefficients on the enclosed type structure are calculated, which are combined with the external peak pressure coefficients on the corresponding enclosed type structures for estimating the net wind forces on the structure. Finally, we propose models of the internal pressure coefficients for open and semi-open type structures. The proposed models can be applied to open and semi-open structures with various roof shapes, because the range of roof shape is limited in practical design and the roof shape does not affect the internal pressure coefficients significantly.

Keywords: Peak wind force coefficients, Wind tunnel experiment, Gable-roofed open-type structure, Internal pressures, Cladding/components
Coupled mode analysis of surface vibration and far-field sound of snare drum with extend Proper Orthogonal Decomposition

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Abstract: In this study, coupled mode analysis of surface vibration and far-field sound of the snare drum with extended Proper Orthogonal Decomposition (hereinafter referred to as POD) was experimentally performed to investigate the characteristics of the generated sound caused by the difference of the degree of proficiency of players. First, vibrational accelerations of the surface of the drum and generated far-field sounds were measured at multiple points simultaneously by means of light and small acceleration sensors and microphones in an open space where the sound reflection could be almost neglected with two different players. One had been playing the drum more than 7 years and the other had a little experience of playing.

The diameter and height of the drum were 360 mm and 150 mm, respectively. The natural frequency of the drum was about 140 Hz. Ten acceleration sensors (PCB Inc., 352C41) were set on its surface with an interval of 30 mm on the straight line passing through the center of it. They were connected to the DC power supplier (PCB Inc., 482C05) and its output signals were saved on the hard disk of a personal computer through the analog-digital converter and data logging equipment (Keyence Inc., NR500 & NR-HA08). Three microphones were set around the left, front, and right side of the drum with the distance of 2.0 m from its center. They were connected to the amplifier (Keyence Inc., NR-CA04) and its output signals were save on the hard disk with the same data logging equipment. The sampling frequency of the measurement was 5 kHz and beating sound was measured more than 20 times for each player. The force of the beating by means of a wooden stick of the players was almost the same.

Experimental results showed that the 1st mode of the surface vibrational acceleration caused the biggest sound in both player cases. However, the decay speed of the 1st mode sound by experienced player was faster than that by inexperienced one because the experienced one did not beat the just center of the drum and beat it relatively short time. Further, the radiated sounds of the 2nd and 3rd mode of the surface vibrational acceleration by the experienced player was smaller than those of inexperienced player. Therefore, it can be concluded that the experienced player does not make big sound except for 1st mode one and it decays faster by devising the way to beat it originally.

Keywords: Mode Analysis, Dynamic Mode Decomposition, Proper Orthogonal Decomposition, Snare Drum, Proficiency of the player
On the active vibration control of a flat plate with a self-made PVDF actuator

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Abstract: In this study, the effect of the active vibration control by means of a self-made actuator made of Poly Vinylidene DiFluoride (hereinafter referred to as PVDF) was experimentally investigated. An actuator was composed of two acrylic films, two film electrodes, and a PVDF. A PVDF was installed between two acrylic films and film electrode was glued both sides of the PVDF. The thickness and electrostatic capacity of PVDF were 28 μm and 11 nF, respectively. The length, width, thickness, and weight of the whole actuator were 171 mm, 22 mm, 40 μm, and 3 g, respectively. The electrodes of the actuator were connected to the AC power supply with voltage amplifier and AC power in the range from 100 to 2,000 Hz was supplied. The actuator was set on the center of a flat plate that could be excited by acoustic wave emitted from a speaker (FOSTEX Inc., FE208Σ). The diameter and resonance frequency of the speaker were 230 mm and 42 Hz, respectively. The size and mass of the flat plate were 400 mm × 400 mm × 3.0 mm and 0.6 kg, respectively. In this experimental setup, the resonance frequency of the plate was 97 Hz. The active vibration control was realized by a feedback control with LMS algorithm referring to the vibrational acceleration of the flat plate measured by the vibrational acceleration sensor on the center of the flat plate. In the preliminary experiments, it was found that the amplitude of the vibration of the actuator had dependency on its frequency. Present actuator had a maximum and minimum amplitude at 800 Hz and 2,000 Hz for the same AC power, respectively. Results of the active vibration control show that the vibrational acceleration of the flat plate in the range from 2 m/s^2 to 12 m/s^2 could be decreased up to 50 % by the actuator in the vibration control of one point and one frequency. Further, it could be decreased up to 40 % in the case of one point and two frequencies. Therefore, it can be concluded that a self-made PVDF actuator that is a simple structure and lightweight has a possibility to be effectively used in the active vibration control of a lightweight vibrating bodies.

Keywords: Active vibration control, PVDF, Actuator, Feedback control, Smart material
Interfacial observation of composite rubber with fiber-shaped particles under tensile load by X-ray CT

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Abstract: In recent years, miniaturization and weight reduction of mechanical structures have been advanced, however since the vibration sensitivity of the machine increases and the space for arranging the vibration damping material also decreases, vibration enough to hinder the original function is excited a problem arises. Therefore, it is considered that the development of vibration damping materials that small amounts and exhibit high vibration damping properties is useful. It is known that damping characteristics are improved by composing fine particles in a viscoelastic material, however its mechanism is unknown. From the previous research, we obtained knowledge that the loss factor, which is one of the damping characteristics, changes depending on fiber direction for composite natural rubber with fiber-shaped PET particles. From this, it is conceivable that the interface state of the filler / matrix and the strain distribution of the test piece change depending on the fiber direction. Therefore, in this research, to investigate the filler / matrix interface, an X-ray CT image was obtained with a tensile load applied to the test piece, and the interface state was observed from the image processing. A viscoelastic material in which fiber-shaped PET particles were compounded at a ratio of 5% by weight with respect to NR was manufactured as a viscoelastic material. In addition, X-ray CT images were acquired in Japan's large synchrotron radiation facility Spring-8. As a result, it was confirmed that voids were generated or grown at the fiber ends when the fiber direction coincided with the tensile direction. When the fiber direction was orthogonal, it was impossible to confirm the generation and growth of voids. Thus, it can be seen that separation and interfacial sliding occur between filler / matrix at viscoelastic material whose tensile direction is consistent with fiber direction in which the dependence of damping characteristics on strain amplitude is high. From the above results, it was found that separation and interfacial slippage in the fiber end and these phenomena largely influenced the strain amplitude dependence of the attenuation characteristic at composite rubber with fiber-shaped particles.

Keywords: Composite material, Polymer, Vibration characteristic, Interfacial slippage, X-ray computer tomography
Experimental study of stick-slip dynamics in periodically forced oscillators with dry friction

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Abstract: Stick-slip phenomena occur in vibration systems with dry friction. For example, they occur in sliding parts of machine tools, between tools and chips during cutting process, on wiper blades or brake pads, and so on. They often produce chatter sounds, and adversely affect machines or processing surfaces. Especially, a change of the stick-slip phenomena when subjected to forced vibration is an important problem in the mechanical system, because of the forced vibration often occurred by a motor, an engine and so on.

In recent years, many researchers have studied the influence of forced external forces on the stick-slip phenomena, and they have clarified the existence of bifurcations and conditions of occurrence of chaotic vibration. However, many of those studies are numerical studies and there are few experimental studies.

In this report, we develop an experimental device that gives forced external force to a frictional vibration system with dry friction, and experimentally consider the effect of forced external force on the stick-slip phenomena. Our experimental device is a one degree of freedom system which is the most fundamental friction vibration system. It has a weight, which is connected on a spring and an eccentric motor for generating periodic external force, on a belt conveyor. A stainless sheet is stuck on the contact surface of the weight and the belt to make contact surfaces between the stainless steel sheets. We measure the displacement and velocity of the weight by a laser displacement sensor and laser Doppler vibrometer, and analyze by using the waveform, phase plane and power spectrum method.

By this experimental setup, we investigated the effects on the stick-slip phenomena by changing amplitude or waveform of forced external force. This knowledge is useful for reducing chatter sounds due to stick-slip phenomena, or increasing the accuracy of the machined surface by controlling the stick-slip between tools and chips.

Keywords: Friction vibration, Forced vibration, Stick-slip, Nonlinear vibration, Response
Numerical study of elastic wave propagation in flanged cylindrical bar

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Abstract: The Split Hopkinson bar (SHB) method is known as one of the most reliable impact testing methods of material. However, for low impedance materials, the accuracy may deteriorate due to a small signal of a transmitted wave observed from an output bar. Therefore, a flanged SHB method, which has a larger contact area than a cross-sectional area of bars in order to increase the mechanical impedance ($A\rho c$) of specimen, has been proposed. In this study, for the purpose of developing the flanged SHB testing apparatus, finite element analyses of the effect of circular flanges on the propagation of elastic waves in cylindrical input and output bar were performed using the LS-Dyna code. The finite element models of an input and output bars with flanges were constructed. The material properties of the flanges were the same as those of the input and output bar. An incident elastic wave generated at the end of the input bar propagates into the output bar through the flanges. A pair of compression and tensile pulse were generated at the contact surface and observed in the input bar as reflected waves. According to the relationship between the velocity of the elastic wave in the input bar and the gauge position, it is considered that the compressive reflected pulse corresponds to the rising time of the elastic wave and the following tensile reflected pulse corresponds to the falling time, respectively. The amplitude of the reflected pulses increased with the increase in the flange diameter. Thus, it is considered that these pulses were attributed to the mismatch of mechanical impedance between the bars and flanges. Furthermore, it was founded that the stress at the contact surface has a distribution in the radial direction due to a three-dimensional propagation like a spherical wave in the flanges. The effect of the three-dimensional effect becomes larger as the flange diameter becomes larger and as the flange thickness becomes thicker.

Keywords: FEM, SHB method, Wave propagation, Impact testing, low impedance material
Visualization of the blast wave generated by laser induced plasma using schlieren method with high speed camera

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Abstract: The blast wave phenomenon is assumed primarily as pressure wave process with finite amplitude induced by rapid rapid of the energy.
In our previous study, we had performed the schlieren visualization of the blast wave, propagating in two dimensional stepped structure model, generated by laser induced plasma, which is obtained from the CO₂ pulsed laser focusing. Consequently, the complex interaction of the primary and the reflected shock wave can be clearly observed comparatively. However, it was difficult to obtain the clearer schlieren photograph with higher time resolution, and to find the appropriate light source, especially in case of digital still camera with flash light. Additionally, the position of the shock wave was obtained from the average of a lot of schlieren photograph which was taken at the same delay time in our previous blast wave measurements. Thus, improvement of the experimental efficiency is essential.
Recently, the continuous schlieren photograph with higher time resolution can be easily obtained from small amount of experiments especially in case of using high speed camera. In addition, super luminosity LED becomes highly noticed as the point light source because of easily obtainable, simpleness of the lighted circuit and so on. In our previous study, the lighted circuit for LED was constructed. Consequently, it was shown that LED used as the light source is very convenient and promising device. Thus, replacement to the high speed camera and the point light source for schlieren system are most effective way for improvement of the experimental efficiency with higher time resolution.
In this study, we have performed the schlieren visualization of the blast wave by using the high speed camera and the super luminosity LED as the point light source. The blast wave is generated by laser induced plasma as mentioned above. As a consequence, the continuous schlieren photograph with higher time resolution can be easily obtained, and the primary shock wave immediately after disappearance of plasma can be clearly observed by applying the high speed camera and the super luminosity LED. Additionally, the time resolution of the continuous schlieren photograph can be modified with improving the experimental efficiency in this study.

Keywords: blast wave, schlieren method, laser induced plasma, CO₂ pulsed laser, high speed camera
Visualization of paint film formation process on spray coating

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Abstract: Volatile organic compounds (VOC) generated from the paint is one reason to cause air pollution and human sickness. When coating large area; i.e. body surface of vehicles and buildings, spray coating method is often used. However, spray consumes a large amount of paint, and generated VOC diffuses into the air. It is important to enhance the coating efficiency to reduce excessive paint. It is required that investigate relationship between spray characteristics and coated surface quality, but there are few investigations about this research.

In this study, droplet adhesion behavior of spray coating to a wall surface was investigated experimentally. Characteristics of paint film formation by the spray droplets were visualized. And paint film thickness was measured using fluorescence method to investigate the smoothing mechanism. In order to evaluate the roughness of coated surface, spatial frequency analysis was performed using fast Fourier transform of fluorescence image.

Image of coated surface observed by digital microscope was binarized to measure the ratio of coated area. At the start of coating process, the ratio of coating area increased linearly but then the increasing rate of the coated area became decrease. Coating was completed sooner when use higher injection pressure. From the data of coated area, overlapping ratio of paint droplet on the adhered droplets was also calculated. Overlapping ratio can be used as an indication of the excessive paint, and is become 350% at maximum injection pressure condition. The effect of droplet size during the coating process was also evaluated. From the data of the fluorescence measurement, the smoothing mechanism of the paint film was also discussed. Fluorescence intensity of paint film increase with the lapse of time. Simultaneously, dispersion of fluorescence intensity distribution decrease. From these results, it is confirmed that the thickness of paint film was increase and smoothed with time lapse.

Keywords: Spray coating, Visualization, Coating process, Fluorescence method, Smoothing mechanism
Three-Dimensional PTV Robust to Rotation Based on Conservation Law of Mass

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Abstract: PIV is a well-known method for extracting the instantaneous velocity information of a flow field from particle images obtained by flow visualization, and many reports on the measurement of two-dimensional flow fields have been made. Actual fluids often show three-dimensional behavior, and the importance of measuring the three-dimensional velocity distribution of the flow field is increasing. In this study, we focus on Particle Tracking Velocimetry (PTV), which identifies each particle on the visualization images captured at time intervals with the information of three-dimensional particle positions, and have developed a new method for particle tracking based on the physical law. In this paper, we evaluate the basic performance of the method by numerical simulation and show that the method can be accurately used for three-dimensional velocity measurement.

The developed method is a particle tracking method using the fact that the volume of a tetrahedron composed of four particles adjacent to each other is invariant regardless of temporal change and it is based on mass conservation in incompressible fluid. For example, if a certain particle is focused on the visualization image at the first time, three nearby particles around it are selected. Then, the volume of the tetrahedron consisting of the four particles obtained is the evaluation index in particle identification. The procedure described above is repeated on the image at the second time, and the particles the evaluation to particles with the evaluation index nearest to each other are identified as the same one.

We apply the method in three-dimensional rotational and shear flows. It is confirmed that particle tracking can be done at high correct rate without depending on the rotational angle of particle patterns in rotational flow. In shear flow field, if the shear rate exceeds a certain level, the correct tracking rate decreases, but if it does not exceed it, it is found that the correct tracking rate keeps high. We also investigate the influence of various parameters of flow field model and particle tracking algorithm on the performance of particle tracking, and show the feasibility of this method in flow measurement.

Keywords: PTV, Flow measurements, Rotational flow, Shear flow, Taylor-Green vortex
Development of High Performance MEMS-Base Accelerometer for Vibration Monitoring

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Abstract: We developed a high precision MEMS triaxial accelerometer for vibration monitoring. The accelerometer was developed to monitor the vibration of the building. The accelerometer internally has a 1GB flash memory, USB interface and a real-time clock, and by turning on the power, the accelerometer starts measuring the 3 axis acceleration under the conditions set by the internal MPU. The noise level was less than ± 0.2 cm / s² at 100 Hz sampling and 32 Hz low pass filter. This noise level corresponds to 1/5000 G, and corresponds to an inclination of 0.01 degree. Continuous measurement is possible for about 21 days at a sampling rate of 100 Hz. Continuous measurement for more than one year is also possible by limiting storage conditions. The measured acceleration data is managed and stored in seconds. The origin of seconds is 0:00:00 on January 1, 2016, and the number of elapsed seconds since it is recorded as 32-bit data. The structure of the acceleration data of each second is composed of a header (6 bytes) of "elapsed seconds (4 bytes) + temperature (1 byte) + measurement condition (1 byte)" and subsequent acceleration data array. Multiple accelerometers can be operated synchronously. The synchronous measurement of acceleration is realized by the slave machine receiving the synchronization pulse generated by the master machine.

This accelerometer is installed in several buildings and constantly monitoring those vibration in Japan. Overseas, it is set up in temples in Nepal and Parthenon palace in Greece for the research of the structural responses at the earthquake.

Keywords: Measurement, Vibration Monitoring, MEMS Accelerometer, Low Noise, Earthquake Response
Determination of Three-Dimensional Camera Parameters with the Information on Two-Dimensional Plane for 3D Measurement

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Abstract: In the stereo image measurement for determining the three-dimensional coordinates, the determination of the camera parameters is the most important calibration work. Linear Camera-parameter is composed of eleven constants representing the state of the camera. Those are necessary for calculating the real space coordinate \((x, y, z)\) from screen coordinate \((X, Y)\) on the camera image. The decision of eleven camera parameters needs the information of more than six points of the coordinates in space \((x, y, z)\) and the corresponding camera screen projection coordinate \((X, Y)\). The set of those six points must include three-dimensional structural information (six points must not on same plane).

In this research, a theoretical method to determine eleven camera parameters from four points of information in the plane and focal length of the camera lens is developed. Specifically, the eight parameters among of the eleven parameters are determined from the information of four points on a two-dimensional plane. Next, the orthogonal condition of the camera screen coordinates and camera focal length are used to determine the remaining three parameters. For two types of camera setting conditions, the camera parameters determined from the two-dimensional information and the focal length were compared with the camera parameters determined from three-dimensional information. Both are almost the same, and the camera parameters from the two-dimensional information and the focal length have been proved to be determined.

We compared the measurement results of three dimensional coordinates using the camera parameters obtained by three-dimensional information with the measurement results of three-dimensional coordinates using the camera parameters obtained from the two-dimensional information proposed in this report. As a result, the two agree well, and it was confirmed that the method of finding the camera parameters from the proposed two-dimensional information is effective.

Keywords: Image-Based Measurement, Camera Parameters, 3D Measurement, Image Processing, Perspective Transformation
Kaohsiung Travel Information