Development of the underwater robot for environmental research and protection in the coastal sea area of Okinawa prefecture, Japan

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Status: Professor
Keywords: Underwater robotics, Field robotics
Technical Support Skills: • Robotics
• Mechatronics
• Control engineering

Research Contents

We have been developing the underwater robot for coral reefs research and protection in the coastal sea area of Okinawa, Japan.

1. Development of the underwater robot for crown-thorns starfish control

Crown-of-thorns starfish die by injecting the acetic acid. We succeeded to inject the acetic acid into crown-of-thorns starfish by Remotely Operated underwater Vehicle (ROV).

2. Image-based position measurement of underwater objects

Visual recognition of distant underwater objects is possible in the water with high transparency, for example, in the coastal sea area of Okinawa, Japan. So, we have been researching the image-based position measurement system of underwater objects using a low-cost maritime mobile robot with a monocular camera.

Fig. 1 Prototype of the developed underwater robot
Fig. 2 Position measurement of an underwater object
Visualization of 3D Crystallographic Defects using SEM/EBSD technique

Crystallographic grains and defects play an important role in many fundamental processes, such as grain growth and recrystallization, damage, and plastic deformation. Due to the importance of these processes, there is considerable interest in characterizing the crystallographic orientation and grain boundary distribution of crystalline materials. In this study, an experimental investigation of the crystallographic defects, such as dislocation arrays, grain boundaries and its orientations, using electron backscatter diffraction (EBSD) mapping with a scanning electron microscope (SEM) have been performed in a commercial polycrystalline metals.
Theoretical Study of Evaporation Heat Transfer in Horizontal Microfin Tubes

Name
Osamu Makishi

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Status
Professor

Affiliations
The Japan Society of Mechanical Engineers (JSME), The Heat Transfer Society of Japan (HTSJ), Japan Society of Refrigerating and Air Conditioning Engineers (JSRaE)

Keywords
phase change heat transfer, heat transfer enhancement

Technical Support Skills
- design of the heat exchanger
- numerical analysis of heat transfer and fluid flow

Research Contents
A stratified flow model and an annular flow model of evaporation heat transfer in horizontal microfin tubes have been proposed. In the stratified flow model, the contributions of thin film evaporation and nucleate boiling in the groove above a stratified liquid were predicted by a previously reported numerical analysis and a newly developed correlation, respectively. The contributions of nucleate boiling and forced convection in the stratified liquid region were predicted by the new correlation and the Carnavos equation, respectively. In the annular flow model, the contributions of nucleate boiling and forced convection were predicted by the new correlation and the Carnavos equation in which the equivalent Reynolds number was introduced, respectively. A flow pattern transition criterion proposed by Kattan et al. was incorporated to predict the circumferential average heat transfer coefficient in the intermediate region by use of the two models. The predictions of the heat transfer coefficient compared well with available experimental data for ten tubes and four refrigerants.

Fig.1 Physical model
Fig.2 Comparison of measured and Predicted $\alpha$ value

Available Facilities and Equipment

<table>
<thead>
<tr>
<th>Thermal Video System • TVS-8500 (NIPON Avionics)</th>
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<tbody>
<tr>
<td>Thermal Constants Analyser • TPS2500 (Kyoto Electronics)</td>
</tr>
<tr>
<td>Surface Tensionmeter • DY-7000 (Kyowa Interface Science)</td>
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</table>
Studies of Surface Modification of Metals

Name: MAKISHI Takashi  
E-mail: tmakishi@okinawa-ct.ac.jp
Status: Professor
Affiliations: Japan Society of Mechanical Engineers
Keywords: Surface modification, Heat treatment, Corrosion, Special needs education
Technical Support Skills:  
- Surface modification of Metals by using Plasma Nitriding  
- Making and Improvement of teaching materials for special needs education

Research Contents

My research field is surface modification of metals by means of plasma nitriding process. Characteristics of nitrided materials, fatigue properties and corrosion behavior are investigated in my studies. Making and improvement of teaching materials for special needs education are also carried out in our laboratory.

Available Facilities and Equipment

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<th>Machine work</th>
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<td>Scanning electron microscope</td>
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<tr>
<td>X-ray diffraction analysis</td>
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<tr>
<td>Fatigue test</td>
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<td>Atmospheric corrosion test</td>
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Advancement of mechanical system

<table>
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<tr>
<th>Name</th>
<th>Ken Shimojima</th>
<th>E-mail</th>
<th><a href="mailto:k_shimo@okinawa-ct.ac.jp">k_shimo@okinawa-ct.ac.jp</a></th>
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<tr>
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<td>Keywords</td>
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<td>Support Skills</td>
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Research Contents

① Estimation of geometric deviation method by artifact at five axis control machining center
Estimation of geometrical deviation by measurement.

② Development of food processing machine by underwater shock wave
Food processing technology by underwater shock wave. It is possible on non-heating milling flour, sterilization, softening, and the extraction. Design and manufacturing of disintegrator and carrier machine to demanded food.

③ Development of underwater fixed point camera with maintenance free
The camera is fixed at the bottom of the sea, and the ocean weather-ship observation of one month is possible.

④ Study of cutting and junction property of composite materials (FRP)
Evaluation of various processing properties of composite materials

Available Facilities and Equipment

<table>
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<th>CMM-Mitsutoyo</th>
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<td>5MC-Mazak</td>
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KOSEN National Institute of Technology
Solid-state welding of dissimilar metals by using frictional heating, like as Friction Stir Welding (FSW; as shown in Fig. 1), Friction Stir Spot Welding (FSSW; as shown in Fig. 2) are investigated in my studies.

Example of dissimilar metal joining:
- Pure copper to pure nickel by FSW (as shown in Fig. 3).
- Non-combustible magnesium alloy to galvanized steel sheets by FSSW (as shown in Fig. 4).

Fig. 1 Schematic illustration of FSW method and definition of offset value for offset-FSW.

Fig. 3 Appearance of pure copper to pure nickel butt joint by offset-FSW.

Fig. 2 Process parameters of FSSW method.

Fig. 4 Comparison of tensile shear strength of FSSW joints for non-combustible magnesium alloy and various galvanized steel sheets.

Available Facilities and Equipment

- Arc and Laser welding apparatus
- Optical microscope
- Scanning electron microscope
- Energy dispersive elemental analyzer
Manufacturing Systems Analysis with Discrete Event Simulation

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<tr>
<th>Name</th>
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<tr>
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<td>IEEE, ACM, IPSJ (Information Processing Society of Japan), and JSME (Japan Society of Mechanical Engineers)</td>
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<td>Keywords</td>
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<td>Technical Support Skills</td>
<td>performance evaluation of discrete systems with systems simulation, analysis of discrete manufacturing systems, production scheduling algorithms</td>
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Research Contents

The objectives of this research include undergraduate education and training in manufacturing systems engineering. Our research interest focuses on risk management in manufacturing systems through the use of virtual factories. We provide several research themes for undergraduate students who are interested in discrete mechanical systems such as robots or inspection instruments. We guide students to implement virtual factories by using commercially available discrete event systems simulators, and to develop several manufacturing systems based on their ideas or their inspirations and their experimental results.

Students of our undergraduate course finally learn to manage the risks by themselves in introducing their original manufacturing system developed in virtual factory, by thinking rationality from stand points of quality and reliability or maintainability.

Figure 1 shows process flows of two contest robot, these process flows are implemented into the virtual factory under several scenarios of manufacturing systems developed for two contest robots production. Figure 2 depicts probability distributions of lead time obtained from experimental results. The results show the effectiveness of their manufacturing systems developed for.

Figure 1. Process flows of Contest Robot Prototype

Figure 2. Two Prototype Lead Time Distributions

Available Facilities and Equipment

- systems simulator Arena 14.7 (Rockwell Software)
- 3D graphics simulator Auto Mod 12.3 (Applied Materials)
**Evaluation of Fracture Mechanics of Material**

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<tr>
<th>Name</th>
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<tr>
<td>Status</td>
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</table>

**Affiliations**
- The Japan Society of Mechanical Engineers
- The Society of Materials Science, Japan
- The Japan Institute of Light Metals

**Keywords**
- Material Strength, Fatigue, Surface modification, X-ray Computing Tomography

**Technical Support Skills**
- Investigation of fatigue property
- Evaluation of material strength
- Investigation of fracture mechanism

**Research Contents**

- **Investigation of fatigue property**
  Conduct of the fatigue test
  (Axial fatigue, Plane bending fatigue, Rotating bending fatigue, Torsion fatigue)
  Obtain of the S-N diagram

- **Evaluation of material strength**
  Obtain of the tensile strength, Hardness, Stress strain curve
  Detection of internal defects of material with X-ray CT

- **Investigation of fracture mechanism**
  Find out the cause of fracture by fractography with SEM

**Available Facilities and Equipment**

<table>
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<tr>
<th>Plane bending fatigue testing machine</th>
<th>PBF-30X, 60X</th>
<th>Hydraulic servo fatigue testing machine</th>
<th>EHF-EM 100kNI</th>
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<tr>
<td>Rotating bending fatigue testing machine</td>
<td>ORB-10</td>
<td>High speed axial fatigue testing machine</td>
<td>PBF4-10</td>
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<td>Cantilever type fatigue testing machine</td>
<td>CRB-MS-1</td>
<td>Industrial X-ray CT</td>
<td>TOSCANER 32300uhd</td>
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<td>Autograph AG-IS 10kN</td>
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<td>Micro scope (SEM, OM, SM, etc.)</td>
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<td>Universal testing machine</td>
<td>UH-F500kNI</td>
<td>Hardness tester, X-ray diffraction analyzer etc.</td>
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</tbody>
</table>
Studies on design and development of control systems

Name: Kentaro Asato  
E-mail: k_asato@okinawa-ct.ac.jp

Status: Lecturer

Affiliations: IEEJ, ISCIE, SICE

Keywords: Control engineering, Control theory, Soft computing

Technical Support Skills:
- Design and development of control system based on control theory
- Design and development of control system based on soft computing
- Development of educational material for science and technology
- Study on order reduction of controllers and models

Research Contents: Design and development based on control theory and soft computing

(1) Development of nursing care devices
Because of declining birthrate and aging population, there is the critical labor shortage for nursing care in Japan. Furthermore, in order to prevent the long-term care, support apparatus for health maintenance is required. In this study, we are developing useful nursing care devices.

(2) Development of educational materials for learning science and technology
It is essential to acquire logical thinking based on mathematics in education of science and technology. In this study, we are developing a balancing robot, magnetic levitation system, and ball & beam apparatus as the educational materials, which are suitable to obtain the logical thinking.

(3) Development of magnetic levitation system
Applications of magnetic levitation (maglev) control provide many benefits. However, construction of maglev systems require a high-cost in most cases. In this study, we are developing a Hall element displacement sensor with neural network in order to achieve lower-cost maglev system.

(4) System-order reduction
From the perspectives of system maintenance, implementation cost, and so on, it is a consequential problem to reduce the high order of system. In this study, we are trying to devise novel system-order reduction methods by using generalized Gramians and LMIs.

(5) Development of a Pumped-Storage Generation System using Batteryless Photovoltaics
In this study, we have been developing a micro-waterwheel generator. The micro-waterwheel generator is applied to the pumped-storage generation system using batteryless photovoltaics.

Available Facilities and Equipment

| Programmable Logic Controller (Mitsubishi Electric) | Active suspension system (Quanser) |
| Matlab (Mathworks) | 3DOF helicopter (Quanser) |
| Scilab (Scilab enterprises) | Magnetic levitation system (Original system) |
| Inverted pendulum (Servotechno) | Motor control experiment system (Original system) |
| Inverted pendulum with high fidelity linear cart (Quanser) |