**2023传热学暑期国际培训课程-通知**

时间：2023年7月21日-23日

地点：天津大学北洋园校区34教A123

**课程简介**

为推动和深化教学的国际化改革，提高传热学方向的创新能力，培训青年学术骨干，天津大学动力工程及工程热物理学科拟定于2023年7月21日-23日期间，在天津大学北洋园校区线下举办传热学暑期国际培训课程。特邀请3位国际知名学者高田保之（Takata Yasuyuki）、花村克悟（Hanamura Katsunori）和小宮敦樹（Komiya Atsuki）进行授课。

本期课程以双碳（碳达峰、碳中和）目标为背景，介绍传热学领域的最新发展方向。内容包括相变传热、高压条件下氢气热物性、零排放汽车排气后处理技术、微纳米尺度热流体测量技术等诸多传热学及相关领域前沿热点问题。本课程采用全英文形式授课，面向国内能源动力类专业研究生、青年教师和工程技术人员免费开放。

课程组织：天津大学动力工程及工程热物理学科，先进内燃动力全国重点实验室，中低温热能高效利用教育部重点实验室

课程负责人：宇高义郎，陈志豪

**课程安排**

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| 7月21日  10:00-12:00  14:00:16:00 | 主讲人：高田 保之 Takata Yasuyuki  （九州大学碳中和能源国际研究所、爱丁堡大学，教授；第58届日本传热学会会长） |
| Effect of Surface Properties on Phase Change Heat Transfer and Thermal Problems of Hydrogen at High Pressures | |
| 7月22日  10:00-12:00  14:00:16:00 | 主讲人：花村 克悟 Hanamura Katsunori  （东京工业大学，教授；第59届日本传热学会会长） |
| Fundamentals of After-Treatment of Exhaust Gases from Internal Combustion Engines and Nano-Technologies for Zero-Emission Vehicles | |
| 7月23日  10:00-12:00  14:00:16:00 | 主讲人：小宮 敦樹 Komiya Atsuki  （東北大学，教授） |
| Sensing and control of micro-nano scale thermo-fluid flows | |

**课程主讲人及内容简介**

**(1) Effect of Surface Properties on Phase Change Heat Transfer and Thermal Problems of Hydrogen at High Pressures**

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| **Takata Yasuyuki**  Professor  International Institute for Carbon Neutral Energy Research (WPI-I2CNER), Kyushu University, Japan  School of Engineering, Institute for Multiscale Thermofluids, University of Edinburgh, UK |

**Abstract:** The present lecture consists of two parts.

**Part I: Effect of Surface Properties on Phase Change Heat Transfer**

Pool boiling and evaporation of liquid droplets are significantly influenced by properties of heat transfer surfaces. These properties are wettability, macro/microscale roughness, oxide layers formed on it at higher temperatures. In case of wettability, hydrophilic surface elevates critical heat flux (CHF) by almost two times compared with ordinary copper surface, whereas onset of nucleate boiling (ONB) delays. On the contrary, hydrophobic surface enhances ONB at lower surface superheating and nucleate boiling heat transfer, whereas CHF occurs at significantly low superheating. The combination of hydrophilicity and hydrophobicity can be an ideal boiling surface. The lecture introduces some such characteristics based on a series of experimental studies.

The other topic on phase change phenomenon is a spray cooling. Spray cooling is often used in various industrial processes such as in water cooling of hot slabs in iron-and-steel making industries. During the cooling process of the steel surface initially at a high temperature, the cooling mode of sprayed water changes from film boiling regime to nucleate boiling via “quenching point” where rapid cooling occurs by the direct contact between liquid and hot surface. It is of great importance predict the quenching point. The lecture explains at what condition the quenching occurs based on our recent experimental studies.

**Part II: Thermal Problems of Hydrogen at High Pressures**

Hydrogen is a promising energy career in the future carbon-neutral society. In December 2014, Toyota motors has started to sell a commercial fuel cell vehicle (FCV) into Japanese market and has been increasing its production year by year. The current FCV has 5kg of hydrogen at 70MPa in tank pressure and the hydrogen refueling station (HRS) has to handle hydrogen with higher pressure up to 100MPa to refill it to FCVs. To ensure the safety of FCVs during refueling hydrogen, transient pressure and temperature in tank should be predicted with sufficient accuracy. The first step is to collect accurate thermophysical property data for hydrogen in a wide range of pressures and temperatures. We have been measuring thermodynamic and transport properties of hydrogen up to 100MPa and 500°C to develop a reliable database. Based on this hydrogen thermophysical property database, we have been developing a useful software for dynamic simulation of HRS which predicts flow rate, temperatures and pressures of HRS and H2 tank of FCV. Some typical thermo-technical problems with hydrogen refueling process are introduced in the presentation.

**(2) Fundamentals of After-Treatment of Exhaust Gases from Internal Combustion Engines and Nano-Technologies for Zero-Emission Vehicles**

**Hanamura Katsunori**

Professor

School of Engineering,

Tokyo Institute of Technology, Japan

**Abstract:**

According to a scenario of CO2 net-zero emission by 2050, the direct consumption of fossil fuels should be reduced up to 1 or 2 % among the total energy consumption: others are renewable energies, produced hydrogen and ammonia (sometimes accompanied with carbon capture storage (CCS)) and nuclear energy. Then, development of electric vehicles (EVs) is accelerated drastically accompanied with research and development of electric batteries for achievement of carbon neutrality. However, it takes long time to develop a sustainable society using carbon free power trains. During the modal shift process, there are some choices to decrease the emission of pollutants including CO2. The one of important issues is an increase in thermal efficiency of all energy conversion systems including internal combustion power trains. The other is a choice of carbon free fuels such as hydrogen, ammonia and synthesized fuels. It is still very challenging to develop those from a balance between the output power and the emission control and from how to produce from the primary energy source. The higher the thermal efficiency is, the lower the exhaust gas temperature: as a result, it is not easy to complete the zero-emission of pollutants using the conventional after-treatment systems under a low temperature condition. On the other hand, depending on the kind of carbon-free fuels, the amount of chemical species compound emitted from power trains will be changed: as a result, we have to prepare many kinds of catalyst converters to achieve zero emission of pollutants. Moreover, even if we can use a perfect carbon-free fuel, particulate matters including soot and ash will be emitted because of oxidation of lubricant oils and wear at any contact sliding portions in the internal combustion power trains especially for vehicles. Consequently, a new concept of after-treatment system should be needed to develop zero-emission technologies accompanied with development of high thermal efficiency power trains. In this lecture, the fundamentals of after-treatment of exhaust gases emitted from gasoline and diesel engines will be summarized with picking up the significant issues, then a new concept of filters with a high filtration efficiency, a low pressure drop and a high purification performance will be proposed from a time-lapse electron microscopic visualization results: it is a membrane filter made of spherical catalyst particles with a mean diameter of 1 – 2 microns agglomerated from Three-Way Catalyst (TWC) nano-sized particulates.

**(3) Sensing and Control Of Micro-Nano Scale Thermo-Fluid Flows**

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|  | **Komiya Atsuki**  Professor  Institute of Fluid Science  Tohoku University |

**Abstract:**

This lecture is about micro and nano scale thermo-fluid measurement and consists of following two parts.

1. **Visualization and measurement method**

A deep understanding of mass transport phenomena is one of the essential key factors in engineering and industrial fields. Especially, the understanding of micro and nano scale heat and mass transfer will contribute an accurate heat and mass transfer control system, which will be a feature of new technological development for industrial applications. To clearly understand the phenomena, a rapid yet accurate measurement method is required. This lecture focuses on the precise visualization and measurement of heat and mass diffusion by using an optical system and novel image processing technique. Experimentally the transient heat and mass diffusion fields were visualized, and the accuracy of the proposed system was evaluated.

One good example is the visualization of protein hindered mass diffusion process in sub-milli scale. It has generally technical difficulties because the event of protein transport takes on slow and small phenomenon. There is a great lack of reliable experimental data due to the measurement difficulties encountered when measuring a process as slow as transport phenomena. The technique proposed in this study solves this problem and a series of clear visualized images of concentration profiles of hindered diffusion field was obtained. From the results, the capability and technique for precise control of protein mass transfer are discussed.

1. **Micro- and nano-scale heat and fluid flow phenomena**

Phase-shifting ellipsometer, which can precisely visualize two-dimensional thin film thickness at the edge of small droplet has been developed in our laboratory. Experimental investigation in the vicinity of boundary area of three phases, solid-liquid-gas interface namely “contact line” is important for understanding of the phase change phenomena, such as boiling, condensation, and surface events such as wetting and drying phenomena. Theoretically, de Gennes has proposed a formula for a thickness of precursor film under the assumption that the wetting process obeys a viscous flow driven by disjoining pressure. This theoretical approach shows a formation of precursor film, however it is difficult to achieve precise measurement of nanoscale thickness of the film. In this lecture, a visualization system for the measurement of two-dimensional thickness distribution of the precursor film by using a phase-shifting technique is introduces. The proposed system can measure the transient thickness distribution. At the initial stage of droplet formation, the thickness of the edge region got thicker compared with that of inner region. However, its thickness difference decreases with the droplet spreading. From the visualization results of two-dimensional image, the relation between circumferential shape of precursor film and surrounding condition was also discussed.

**课程报名**

本课程不收取任何费用，面向国内能源动力类专业研究生、青年教师和工程技术人员免费开放。学员交通费、食宿费等自理。

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