X-REPORTS IN THERMAL SCIENCE AND ENGINEERING

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Introduction to X-Reports

In recent years, the thermal science and engineering field has greatly expanded and now overlaps with other branches of science, such as physics, material science, biomedical science, nanotechnology, big data, and artificial intelligence. High-level interdisciplinary research demands closer connections and cooperation among global researchers working on a wide range of subjects. Webcam meetings enable global scholars to easily come together to discuss and cooperate on these crucial topics. The X-Reports aim to invite distinguished professionals from various disciplines and countries to give cutting-edge/breakthrough lectures on an interactive platform to encourage new ideas and promote innovations in thermal science and engineering.

1st X-Report

Prof. Yasuyuki Takata

Kyushu University, Japan

Title: Hydrogen Thermal Problems at High Pressures

Time: 9:00-11:00 am, July 30 (Beijing Time), 2020

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Abstract

Hydrogen is a promising energy carrier for the future carbon-neutral society. In December 2014, Toyota motors started to sell a commercial fuel cell vehicle (FCV) in the Japanese market and has been increasing its production each year. In order to disseminate FCVs throughout the country, hydrogen refueling stations (HRSs) must be placed throughout the country. There are about 130 HRSs in Japan as of June, 2020.

The current typical FCV has 5 kg of hydrogen in a 82 MPa tank. Therefore, the HRS has to handle hydrogen at higher pressures up to 100 MPa to refill the FCVs. The charging time to fill the H_2 tank is expected to be 3 min or shorter. However, such a rapid refueling process will significantly increase the H_2 tank temperature due to adiabatic compression. The temperature limit of the H_2 tank is 85°C because of the melting point of the bonding agent for the carbon fibers of the tank. Thus, to avoid an undesirable temperature rise, recent HRSs have a precooling device that cools the hydrogen to -40°C before it is refueled into the FCV tank.

However, this precooling process causes other problems such as overcharging of the hydrogen tank. Low temperature hydrogen gas is injected into the tank up to the target pressure at the end of the refueling process. The tank pressure then gradually increases due to heat transfer from the surroundings. This pressure rise due to the heat transfer can sometimes exceed the tank limit pressure. The second problem is frost formation around the injection nozzle and the receptacle. Sometimes, the ice freezes the hydrogen nozzle in the receptacle. These thermal problems must be solved for safe operation of the HRS.

Our research effort is devoted to the first problem. To ensure the safety of FCVs during hydrogen refueling, the transient pressure and temperature in the tank must be predicted with sufficient accuracy. The first step is to collect accurate thermophysical property data for hydrogen over a wide range of pressures and temperatures. We have been measuring the thermodynamic and transport properties of hydrogen up to 100 MPa and 500°C to develop a reliable database. This hydrogen thermophysical property database is now being used to develop an HRS dynamic simulation software model to predict the flow rates, temperatures and pressures in the HRS and in the H_2 tank of the FCV. Some typical thermo-technical problems with the hydrogen refueling process are introduced in the presentation.