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.

4th X-Report

Prof. Wenquan Tao

Xi'an Jiaotong University, China

Title: Application of Similarity Theory in Study of Complicated Heat/Mass Transport Problems Even with Chemical Reaction

Time: 9:00-11:00 am, October 24 (Beijing Time), 2020

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Abstract

Similarity theory is widely used in fluid flow and heat transfer fields. Although it has been proposed more than one hundred years, it is expected to play more and more important roles in the study of today's much more complicated transport processes. In this lecture its applications in two complicated engineering problems are presented.

The 1st problem is related to the experimental study on the pollutant transport in urban region. To conduct wind tunnel test, Reynolds number of the prototype must equal Re of the wind tunnel test, which is absolutely unmanageable in an atmosphere boundary layer (ABL) wind tunnel. Actually for flows in ABL once Re is larger than a certain value, the flows will be approximately similar if geometries are similar. The question is: how high must the Reynolds number be to be high enough? We proposed the concept of numerical wind tunnel and a criterion to determine the specific value of this Reynolds number. Numerical results give strong support to the proposals, thus solving the problem that has not been successfully solved for the past 60 years.

The 2nd problem is about the multiple reactive transport processes in proton exchange membrane fuel cell (PEMFC). First two examples will be presented for studying the characteristics of its two components using the similarity theory: cross flow under the rib of bipolar plate and performance prediction of the catalyst layer by the agglomerate model. Then discussion on dimensionless polarization curve is presented in detail. Polarization curve is the most important integrated performance of PEMFC, which is affected by several dozens of dimensional parameters and is so far obtained only dimensionally for individual group of parameters. Similarity analysis is adopted for a 3-D single-phase isothermal model of PEMFC to derive similarity criteria. Seven kinds of input criteria are obtained and dimensionless voltage and dimensionless current density are defined as two output criteria. Numerical verifications show that if the seven input criteria keep their individual values even with their components vary in a wide range, the dimensionless polarization curves keep the same with a maximum deviation of only about 0.01%, showing the validity and feasibility of the present analysis.