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Derivation of a Condensation Heat Transfer Model for Light Water Reactor Applications using Machine Learning Techniques

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In this study we develop a model that can predict the condensation heat transfer coefficient (HTC) during free-fall condensation on vertical tube surfaces in the presence of non-condensable gases (NCG). The aim is to compile a comprehensive database that includes a wide range of geometric values and operating conditions. The study is specifically motivated by the need to establish a generalized model/correlations that can predict the condensation heat transfer performance of the passive containment cooling system used in nuclear power plants. This passive cooling system eliminates heat from the containment vessel in case of an accident by condensing water vapor with gravity-driven force. To develop the model, we used MATLAB's neural network toolbox to build an artificial neural network model, specifically a multi-layer perceptron network. The model predicts the HTC during the condensation process of two types of NCG (air and nitrogen) as well as pure steam. The inclusion of pure steam data aims to improve the accuracy of predictions under conditions where light gases are present. The dataset used for the model was constructed from 1,613 data points obtained from various experimental sources. The input layer receives various parameters, including P_tot,ΔT_sub,W_nc,L,D_h. The output data is the condensation HTC. The input data was normalized by scaling each feature between the range of 0 to 1, whereas the output data was subjected to a transformation using the natural logarithm. The resulting machine learning model exhibited outstanding performance when predicting the condensation HTC. The findings of this study will represent a significant advancement in the analysis of large amounts of data from experiments and simulations, enabling the identification of complex patterns and relationships. Findings from the present study would serve as tools for the nuclear industry for designing and modelling Design Basis Accident (DBA) and Design Extension Conditions (DEC) scenarios.

Speaker Bio

Primary authors: A. ALBDOUR, Samah (Department of Mechanical Engineering, School of Engineering, Khalifa University, Abu Dhabi. Emirates Nuclear Technology Center (ENTC), Khalifa University of Science and Technology, Abu Dhabi); Dr ADDAD, Yacine (Department of Nuclear Engineering, School of Engineering, Khalifa University of Science and Technology, Abu Dhabi. Emirates Nuclear Technology Center (ENTC), Khalifa University of Science and Technology, Abu Dhabi); Dr AFGAN, Imran (Department of Mechanical Engineering, School of Engineering, Khalifa University, Abu Dhabi. Emirates Nuclear Technology Center (ENTC), Khalifa University of Science and Technology, Abu Dhabi. Department of Fluids and Environment, School of Engineering, University of Manchester, Manchester, UK)

Presenter: A. ALBDOUR, Samah (Department of Mechanical Engineering, School of Engineering, Khalifa University, Abu Dhabi. Emirates Nuclear Technology Center (ENTC), Khalifa University of Science and Technology, Abu Dhabi)

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