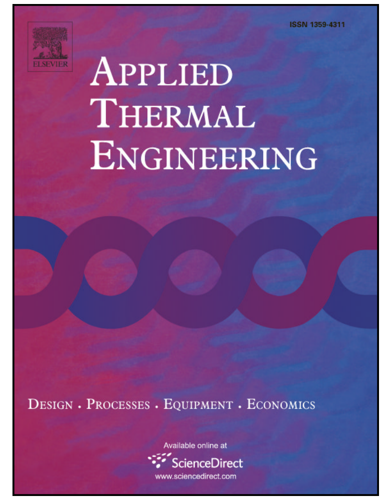

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ABSTRACT

Throughout the testing program at a large scale thermal hydraulic test facility, strong influences of ambient conditions were observed in the experimental data when baseline tests were repeated under identical test procedures. Significant analysis efforts were conducted to gain understanding of these influences, and quantify the system response of the test facility. An empirical model was developed based on theoretical considerations and using experimental data to correlate zero-power system flow rates with ambient meteorological conditions, including wind and temperatures. Coefficients in the model were determined based on best fitting of the experimental data set. The predictive capability of the empirical model was demonstrated by applying it to new sets of experimental data. After implementing the empirical model in both system-level thermal fluids and computational fluid dynamics modeling of the facility, simulations from both approaches resulted in accurate predictions in system natural circulation flow rates.

Key words: ambient condition effects; natural circulation; decay heat removal

INTRODUCTION

One of the key safety features of advanced nuclear reactor designs is the use of passive heat removal systems that remove decay heat by natural convection. Such designs include advanced liquid-metal reactor (ALMR) concepts, high-temperature gas-cooled reactor (HTGR), and advanced light water reactor (LWR) designs. The Reactor Cavity Cooling System (RCCS) is one passive safety concept under consideration for the overall safety strategy of HTGRs. One such variant, the air-cooled RCCS, uses natural convection to drive the flow of ambient air from outside the reactor building to remove decay heat during accident scenarios. The reactor vessel auxiliary cooling system (RVACS) is another variant of RCCS considered in ALMR designs for passive decay heat removal. Both RCCS and RVACS remove decay heat by radiation and natural convection of air in the gap between the reactor vessel and ducts surrounding the reactor vessel. The reactor heat is released to the atmosphere through multiple stacks, without the need for pumps, diesel generators, or human intervention during accident conditions.

The design philosophy for passive decay heat removal systems is centered on natural circulation driven flow to successfully remove decay heat. The inherent sensitivity of these buoyancy driven systems, augmented by multiple parallel flow paths, introduces certain complexities that are often difficult to predict with computational models alone. The onset of flow instabilities may be triggered by minor perturbations and result in undesirable behavior or reduced performance. Thus, there is value in experimental validation, which the Natural