THERMAL ANALYSIS OF SPENT NUCLEAR FUEL SHIPPING CASK

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ABSTRACT

In this study, a computational fluid dynamics (CFD) thermal analysis was performed for the TN-24P cask. For the analysis, ANSYS Fluent as a CFD tool was selected since it has the proper finite volume methods to realistically simulate the thermal behavior of shipping casks.

For the analysis, spent fuels discharged from pressurized water reactors (PWRs) were modeled. In the model, there are 24 PWR spent fuel assemblies loaded in the TN-24P cask. The fuel design is assumed to be similar to standard Westinghouse 15x15 rod design. Total heat (decay) generated in the cask was estimated to be 20.6 kW. To input the axial power profile required to calculate the heat flux, a User Defined Function was generated. Fuel storage space (canister) is filled with Helium gas to cool spent nuclear fuel. In the cask, heat transfer occurs through the heat conduction by helium and basket, natural circulation driven by gravity, and thermal radiation in the complex geometry. In the canister region, laminar flow model with Boussinesq approximation is used to simulate the natural circulation. The helium domain was assumed symmetric in the model. For thermal radiation, the Discrete Ordinates (DO) model was chosen in the presented study due to its accuracy and capability of parallel processing. In typical vertical TN-24P dry storage cask system consist of two nested cask. Between inner and outer cask is in the air. Air inlet section is at the bottom side of cask and outlet ventilation is at top of cask. At this region, turbulence regime occurs and turbulence is modeled by using k-epsilon model.

The analysis include small scaled and full scaled model. In small scale model, geometry is defined rectangular to make mesh generation easy and to validate the analysis tools using the experimental data. In the full-scale simulation, the results of analysis and experimental data for peak clad temperature (PCT) were compared.

Key Words: TN-24P dry storage cask, CFD, thermal analysis, PCT, air blockage.

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