Structure Interaction Due to Thermal Bowing of Shrouds in Steam Generator of Gas-Cooled Reactor

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SUMMARY

The design of the gas-cooled reactor steam generators includes a tube bundle support plate system which restrains and supports the helical tubes in the steam generator. The support system consists of an array of radially oriented, perforated plates through which the helical tube coils are wound. These support plates have tabs on their edges which fit into vertical slots in the inner and outer shrouds. Under normal operating conditions, the plates and tube bundle are exposed to hot helium gas, and the tubes are filled with steam.

When the helical tube bundle and support plates are installed in the steam generator, they most likely cannot fit evenly between the inner and outer shrouds. This imperfection leads to different gaps between two extreme sides of the tube bundle and the shrouds. With different gaps through the tube bundle height, the helium flow experiences different cooling effects from the tube bundle. Hence, the temperature distribution in the shrouds will be non-uniform circumferentially since their surrounding helium flow temperatures are varied. These non-uniform temperatures in the shrouds result in the phenomenon of thermal bowing of shrouds.

This paper is to investigate the interaction among shrouds, support plates and tube bundle resulting from the thermal bowing of shrouds. By using the beam theory the problem of thermal bowing of shrouds is first solved. The obtained result in turn is taken as the prescribed displacement for the tube-plate interaction model. Finally the solutions for bending stress in the tube bundle are solved by simplified method as well as finite element method. Results indicate that a design of support plates without any radial restraints is essential to the reduction of the interaction among shrouds, support plates and tube bundle.

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