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Heat Transfer Simulation on HTGR Pebble Bed Using ATHLET Code

High temperature reactors are helium-cooled reactors which consist largely of graphite, both fuel elements (pebbles) and the main structure material. It uses a special fuel element made of graphite in which the uranium dioxide in three-fold coated particles is homogeneously dispersed in a graphite matrix. The coatings especially the silicon carbide layer create an effective barrier against fission product diffusion. The HTGR Pebble bed, in modular design, is laid out that the maximum allowable fuel temperature of 1620 C is never exceeded in any possible accident without actuation of active components and it can solely shutdown the reactor via negative temperature feedback effects.

The thermal-hydraulic fluid dynamic programme ATHLET applies the porous medium approach for flow in packed beds according to Ergun (dominance of friction). This approach uses a quasi-steady state formulation for the momentum equation while time dependent formulations are employed for mass conservation, and energy conservation for both, the solid and gaseous phase. For spatial discretisation of the conservation equations, the finite volume method is used. For material properties, gas densities, heat transfer etc. a set of constitutive equations completes the set of differential equations. Time integration in ATHLET is realised applying modified Newton Raphson method which linearizes and subsequently solves the set of equations.

This study describes the modelling of a HTGR Pebble Bed using ATHLET code and outlines further HTGR-specific development perspectives of ATHLET. The objectives of this work is to simulate and compare the ATHLET results with the measurements of HTGR Pebble Bed steady state temperature distribution in the initial full-power operation. Calculation results by ATHLET for the measuring points in the reactor internals show good agreement with the experimental values. For next study, the development of an effective thermal conductivity heat transfer model for pebbles bed Reactor on ATHLET is needed.

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