

## Heat transfer issues in finite element analysis of PPCS model bounding accidents

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The safety and environmental assessment of conceptual fusion power plants provides insight into physics and technology issues of fusion power generation. Estimation of temperature excursions in structures following worst-case accidents is part of these studies, performed within the European Power Plant Conceptual Study (PPCS). Bounding accidents usually assume total and unmitigated loss of coolant or coolant flow for a prolonged time, with radioactive decay as the source of heat. A new, 3D finite elements (FE) based tool, coupling the different steps of the bounding accident analysis to the same tokamak geometry, has been extensively used to conduct the neutron transport, activation and thermal analyses for all four PPCS conceptual plant models (A, B, C and D).

As power plant passive heat removal depends on conduction and radiation heat transfer, for in-vessel and vessel components, simulation of thermal transients following accidental loss of cooling requires knowledge of the material and component thermal conductivity and emissivity. The heat is ultimately removed by ways of natural convection and radiation, between the coils, vacuum vessel, and the cryostat. The presence of air, which can be stagnant or naturally circulating due to local temperature gradients, may be assumed to fill the space between the vessel/coils and cryostat, but conservative analyses have also been performed with vacuum conditions.

This paper presents results obtained relating to the effects on thermal performance of PPCS plant models during bounding accidents, for the following conditions:

- (a) The effect of radiation heat exchange between the inner surfaces of the tokamak, i.e. the first wall and divertor, is examined. As the divertor sustains high temperatures during an accident, radiation exchange with the surrounding structures is important.
- (b) The effect of stagnant or naturally circulating air, on the heat removal and resulting temperatures is assessed. In general it is demonstrated that the temperature differences of various parts of the structure set in motion a circulation pattern which facilitates heat flow to the surrounding cryostat and eventually the atmosphere.
- (c) The ability of the blanket to remove heat by conduction is partly dependent on the thermal conductivity of the multiplier and tritium generating materials. A general feature of these materials is the degradation of thermal conductivity with exposure to a neutron environment. The effect of different values on the heat transfer capability of the blanket is examined and discussed.