MATHEMATICAL MODELING OF THE COOLING FIRST WALL OF A TOKAMAK-REACTOR

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For the past two decades, projects of the next generation of tokamak neutron sources [1] and demonstration reactors [2] have been developed in several countries. During design of such installations, the list of new technical and scientific problems updates with new issues that did not exist on the installations of the previous and current generations. One of the important issues from this list is a creation of design of the first wall of the reactor, capable of withstanding the heat flux from fusion reaction for the whole duration of fusion impulse. Preliminary estimates show that such a wall cannot be made without additional cooling of first wall.

In this work, a numerical analysis of the currently accepted design of the first wall of the designed reactor DEMO-FNS [2] is carried out. The wall under consideration consists of a composite layer of PFM (Plasma-Facing Material) and carrier tubes for a cooling agent. Layer of PFM is a set of cells made of a refractory material. The wall has a finite thickness, its inner side receives heat flow from the plasma, the outer side touches the blanket.

The authors have developed a new two-dimensional mean model of heat balance, which allows to take into account the peculiarities of wall construction. The model includes heat transfer equations for two types (coolant in different kind of tubes flows in opposite directions), and heat conduction equations for the PFM layer. When considering the stationary mode of operation of the reactor at the inner boundary of the wall the boundary condition of the second kind is set (due to a constant heat flux coming from the plasma), and at the outer boundary of the wall the condition of heat exchange with the blanket of the reactor is set.

References

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