ASSESSMENT OF THE TEMPERATURE FIELD of THE ITER inboard BLANKET flexible cartidge in case of THE DESTRUCTION OF THE ELECTRICAL INSULATION COATING [[1]](#footnote-1)\*)

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The shield block of the ITER reactor consists of 440 blanket modules (MB), each of which is mechanically fixed to a vacuum vessel (VV) using four flexible cartridge assemblies, the main element of which is the flexible cartridge. To provide electrical insulation of the assembly from the VV, aluminum oxide is used, which is applied to the nut conical and the insert flat surfaces.

Structural materials of assembly components have different coefficients of thermal expansion, which leads to the occurrence of thermoelastic stresses and to decrease of the central bolt preload. During plasma disruptions, electromagnetic forces are induced in the MB, which can lead to the opening of the joint on the "conical insert-cartridge" interface and to the destruction of insulation with current flow in the ITER reactor cyclic mode of operation.

This work is devoted to the analysis of temperature fields in flexible cartridge assembly in normal and emergency modes. The calculations were performed in the ANSYS Mechanical APDL environment.

The purpose of the thermal analysis is to find temperature fields in the Inductive I mode, which is a sequence of plasma pulse modes and pause modes. To solve the problem, a transient thermal conductivity equation is used taking into account power density. Boundary conditions are temperature setting of 100 oC on interface at the boundary with VV and temperature setting of 130 oC at the boundary with the blanket. Initial condition is uniform temperature setting of 100 oC for all assembly components. The maximum temperature in the cartridge reaches 156 oC, the temperature field in the assembly decreases linearly from MB to VV.

The stress-strain state was analyzed at the following load steps: bolt preload of 600 kN at 20oC, uni-form heating up to 100oC, application of temperature fields corresponding to pause and pulse Inductive I modes, lateral displacement of MB by 1.6 mm and its inclination by 0.085o, axial tensile force of 600 kN. The last 3 steps are caused by the actions of electro-magnetic forces during plasma disruptions at a current of 137 kA. The calculation of the stress-strain state is based on solution of the Duhamel-Neumann equation, continuity equation, Cauchy relations together with boundary conditions.

In the Inductive I mode, the central bolt preload drops to 496 kN, which leads to the opening of the joint with the combined action of an electro-magnetic force of 600 kN and a combination of MB displace-ment and inclination. The opening of the joint can lead to the destruction and electric breakdown of electrical insulation and emergency operation of the blanket when the current goes through the flexible cartridge asssembly.

The purpose of the electrical calculation of the support is to determine the Joule power density field. The calculated power density is superimposed on the assembly in a transient thermal calculation for 300 ms, where the initial temperature field is assumed the field at the end of the pulse Inductive I mode. The maximum temperature in the cartridge will increase by more than 6 times and reaches 966°C. Cooling to the normal operating temperature of the cartridge occurs in 4100 s.

These high temperatures are accompanied by significant thermal stresses, which can lead to the loss of the load bearing capacity of the cartridge, which indicates the need to prevent the opening of the joint. Nevertheless, in Inductive I mode, the assembly and its individual components meet the SDC-IC static and fatigue strength criteria.

1. \*) [abstracts of this report in Russian](http://www.fpl.gpi.ru/Zvenigorod/L/E/ru/IV-Nikulin.docx) [↑](#footnote-ref-1)