THERMAL AND STRUCTURAL ANALYSIS OF THE TPX DIVERTOR*

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The high heat flux on the surfaces of the TPX divertor will require a design in which a carbon-carbon (C-C) tile material is brazed to water cooled copper tubes. Thermal and structural analyses were performed to assist in the design selection of a divertor tile concept and C-C material. The relevancy of finite element analysis (FEA) for evaluating tile design was examined by conducting a literature survey to compare FEA stress results to subsequent brazing and thermal test results. The thermal responses for five tile concepts and four C-C materials were analyzed for a steady-state heat flux of 7.5 MW/m^2. Elastic-plastic stress analyses were performed to calculate the residual stresses due to brazing C-C tiles to soft copper heat sinks for the various tile designs. The monoblock and archblock divertor tile concepts were analyzed for residual stresses in which elevated temperature creep effects were included with the elastic-plastic behavior of the copper heat sink for an assumed braze cooldown cycle. As a result of these 2D studies, the archblock concept with a 3D fine weave C-C was initially found to be a preferred design for the divertor. A 3D elastic-plastic analysis for brazing of the arch block tile was performed to investigate the singularity effects at the C-C to copper interface in the direction of the tube axis. This analysis showed that the large residual stresses at the tube and tile edge intersection would produce cracks in the C-C and possible delamination along the braze interface. These results, coupled with the difficulties experienced in brazing archblocks for the Tore Supra limiter, required that other tile designs be considered. Recent developments at Tore Supra and JET have shown that a robust divertor design can be achieved by a macroblock concept. This concept utilizes a large C-C plate in which multiple coolant tubes are brazed or cast by processes that greatly minimize defects at the C-C/copper interface. Thermal analysis results for a 2D C-C macroblock concept incorporating two coaxial counterflow coolant tubes are presented.

*Work supported by U.S. DOE Contract DE-AC02-76CH03073, Subcontract S03756-K.

ABSTRACT SUBMISSION FORM 16th IEEE/NPSS Symposium on Fusion Engineering

September 30 — October 5, 1995
Champaign, Illinois, USA

Paper Title: **Thermal and Structural Analysis of The TPX Divertor**

Technical Topic Number: **2**

Keywords:
(1)
(2)
(3)

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