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LIQUID METAL BREEDER-COOLANT BLANKET CONCEPT*

by

D. K. Sze, Y. S. Cha, Y. Gohar S. Majumdar
P. Picologlou, and D. L. Smith
Argonne National Laboratory
Argonne, IL 60439

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D. K. Sze, Y. S. Cha, Y. Gohar, S. Majumdar, B. Picologlou, and D. L. Smith
Argonne National Laboratory, Argonne, IL

This paper discusses the results and conclusions of a self-cooled, liquid-metal design for a D-T fusion reactor, which is part of the Blanket Comparison and Selection Study (BCSS). The effort reported in this paper emphasizes the inboard blanket of a tokamak since the problem is most severe in this region. The work on a self-cooled TMR is also reported.

The conceptual design of the blanket for tokamak is shown in Fig. 1. It is composed of slightly slanted poloidal manifolds and relatively small toroidal channels. Each manifold supplies 48 toroidal channels. The coolant velocity can be kept high along the toroidal direction to improve heat transfer on the first wall. A large poloidal manifold is to provide for coolant distribution and to reduce coolant velocity perpendicular to the magnetic field so that pressure drop can be minimized. This design decouples the first wall cooling (heat transfer) problem from the pressure drop (MHD) problem.

Neutronic calculations have been performed for different blanket composition. Candidate structural materials are PCA, HT-9 and V-15Cr-5Ti. The breeding materials considered are Li and ^{17}Li -83Pb. Adequate tritium breeding is not a limiting factor in the liquid metal blanket design. Therefore, the objective of neutronics is blanket optimization, i.e., to obtain enough breeding with maximum energy multiplication at minimum thickness of blanket and shield. Tritium recovery is feasible from either Li or ^{17}Li -83Pb system with

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acceptable tritium inventory. Tritium containment will be a more difficult problem for ^{17}Li - ^{83}Pb system due to the relatively high tritium partial pressure.

Integrated analysis of self-cooled Li and ^{17}Li - ^{83}Pb blankets from the standpoints of stress, MHD effects, thermal-hydraulics and power conversion were performed to determine whether a "design window" of allowable parameter space exists for these concepts. A typical result of one set of calculations is shown in Fig. 2. The area enclosed by limitations imposed by power cycle, stress and structural temperature is the area available for system optimization. Results indicate that, for the conditions assumed by the BCSS (surface heat flux = 0.5 MW/m^2), a design window exists only for lithium and if vanadium alloy is used as the structural material. No design window exists for either stainless steel or ferritic steel for this design case.

Various design variations have been considered to alleviate the MHD problems. A possible solution is to use an insulated wall to reduce the MHD pressure drop. An alternative is to design the inboard blanket as a nonbreeding blanket and rely on the outboard blanket to provide enough breeding. A concept with a gas cooled inboard region has been evaluated.

A blanket design for tandem mirror reactor is also completed. The MHD and heat transfer problems are less severe here. Therefore, the work performed for TMR is toward optimization of the design. A similar analysis to that for the tokamak is also performed.

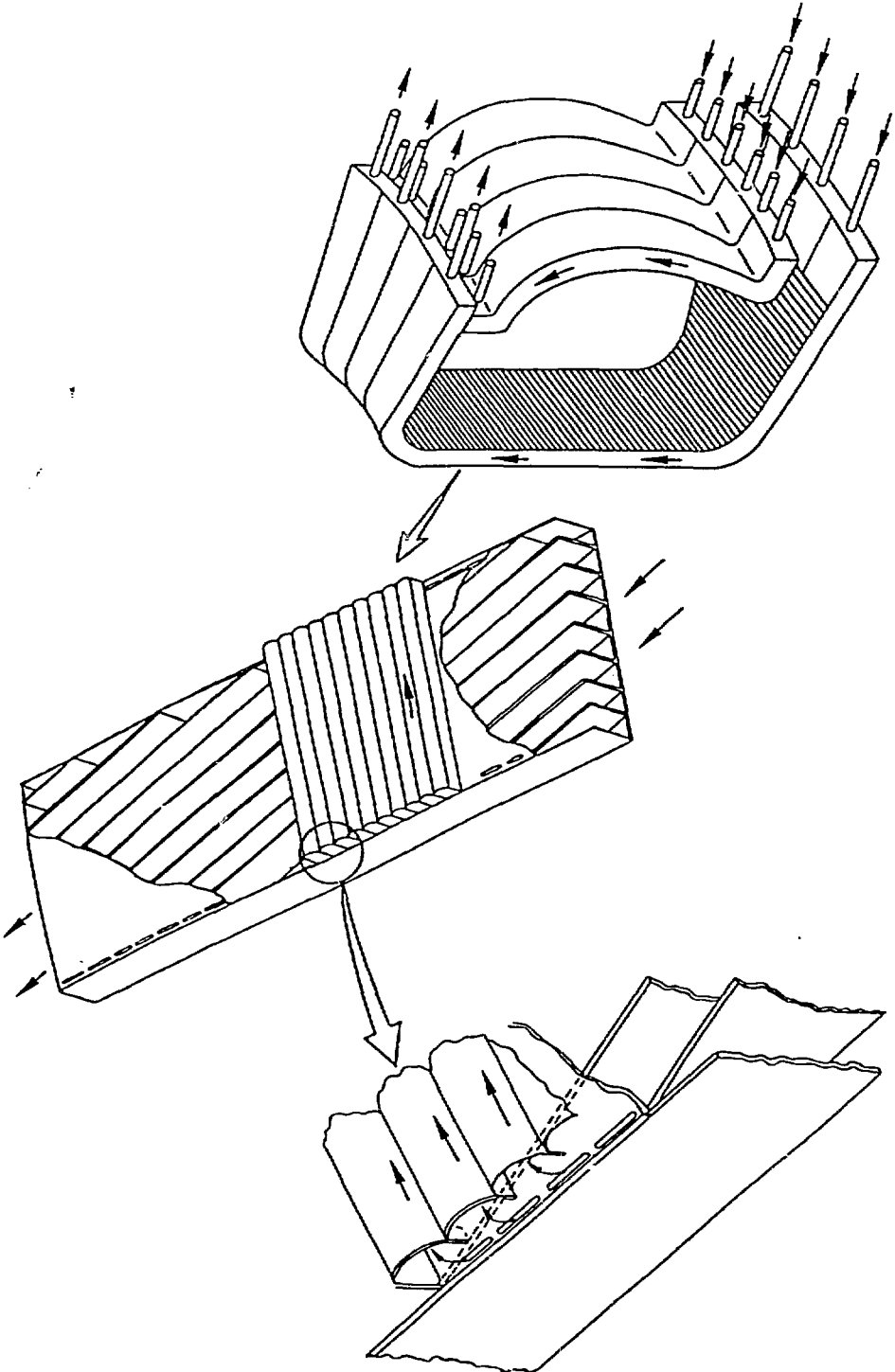


Figure 1. Liquid metal flow concept (poloidal/toroidal flow).

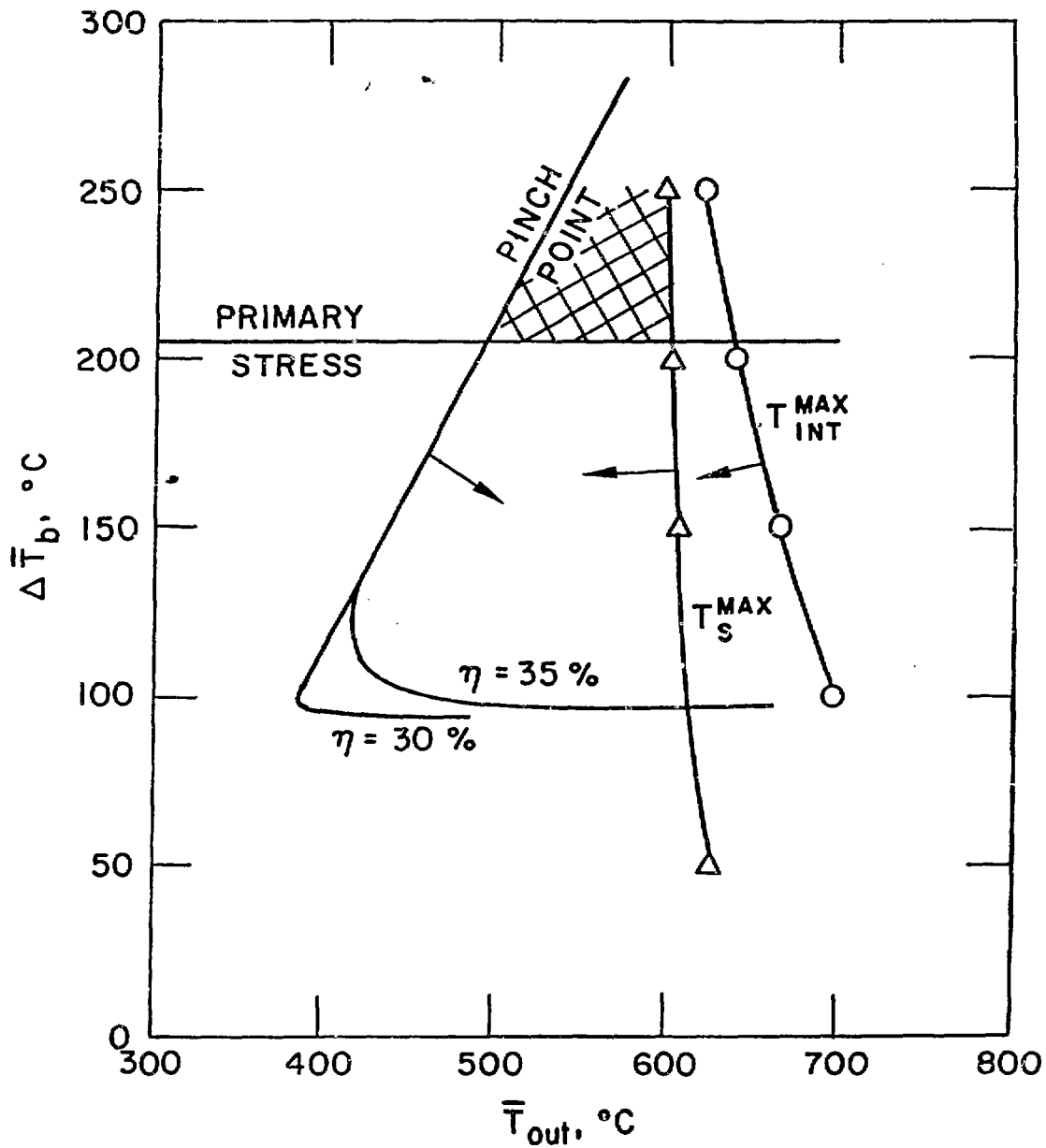


Figure 2. Design window for a vanadium structure, Li cooled blanket.