TERMINATION OF THE POROUS WALL CONCEPT

To: APEX GROUP
From: Anter El-Azab (anter@seas.ucla.edu)

Re: POROUS WALL CONCEPT

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Dear Colleagues,

One of the concepts which was suggested for APEX during the first meeting, October 97, was based on using a porous first wall which was infiltrated by liquid lithium. The idea was as follows. Conduction of heat through the solid wall results in thermal stress. The induced stress increases as the material modulus increases, the thermal conductivity decreases. So, a porous material would have a lower modulus. Also, infiltration with a liquid lithium with higher thermal conductivity (~ 55 w/mK) would result in a composite wall with higher thermal conductivity. However, being porous, the wall would have a reduced strength.

I have evaluated two wall materials : SiC-SiC and V-alloy. The results of the analyses showed that the present idea will NOT work.

It turned out in case of SiC the effects of increasing effective conductivity and reducing the modulus prevail over the reduction in strength of the material, the NWL is not limited by thermal stress. For a 50% porosity, 3mm thick wall, stress-based NWL limits of 7.5 Mw/m2 and 10 Mw/m2 (1.5 Mw/m2 and 2Mw/m2 surface heat loads) are achievable. However, keeping in mind that the temperature limit in this case can not exceed 600 degree C, determined by the compatibility of SiC and liquid lithium, the NWL limit turned out to be severely limited. Recall that, for a solid SiC-SiC wall, the NWL limit was limited by thermal stress since the temperature limit was considered to be 1000 degree C. Based on these results, a porous SiC wall infiltrated with Lithium will can not work and this concept should be terminated.

For the case of vanadium alloy, the strength reduction due to including porosity prevails over the increase in thermal conductivity and reduction in modulus. Calculations were conducted for the 5 mm thick porous V-alloy wall infiltrated with liquid lithium. While the temperature limit-based NWL was higher than that for the solid wall, the stress-limited NWL was significantly lower (NWL ~ 4 Mw/m2) than that for the solid wall. The results suggest that idea of a porous wall will not work in the case of vanadium alloy as well.

I have not tried to do any calculations for refractory materials since solid walls of these materials already withstand neutron-wall loads that are significantly higher the 7.5-10 Mw/m2 range for APEX.

CONLUSION:

The idea of a porous wall infiltrated with liquid lithium does not seem to meet the APEX NWL limit criteria, and work on this concept should be terminated.

Best Regards,

Anter