MHD Effects on Heat Transfer in a Molten Salt Blanket

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We consider heat transfer in closed channel flows of molten salts under specific reactor conditions as applied to a blanket concept. Either Flibe or Flinabe is used as a coolant and tritium breeder. As an example of such a concept we can refer to a re-circulating blanket [1]. Several dual-coolant blanket options [2] are also currently accessed as possible blanket candidates in the US DEMO plant. Since the electrical conductivity of molten salts is relatively high (~10^2 1/Ohm-m), such flows experience non-negligible MHD interaction, which may result in significant changes in both flow and heat transfer conditions.

In the self-cooled blanket, the molten salt flows first through the cooling FW channels. The magnetic field causes turbulence reduction and heat transfer degradation. This effect depends on the direction of the applied magnetic field with respect to the main flow. The calculations for such flows have been conducted using the "K-epsilon" model of MHD turbulence [3] for two possible channel orientations, poloidal and toroidal. The analyzed conditions address Flibe flows in a 8 m channel, the velocity 5-15 m/s, the magnetic field 0-10 T, and the surface heat flux 1 MW/m^2. Depending on the flow conditions the heat transfer degradation due to the magnetic field effect (in terms of the increase of the film ΔT) can be as high as 30%.

In the blanket itself, the molten salt flows slowly (~0.1 m/s) through a poloidal channel with a typical cross-sectional dimension of 0.5 m absorbing the bulk heat generated by neutrons. The flow regime is laminar due to turbulence suppression by a magnetic field. One of the design requirements is to reduce the amount of heat escaping from the molten salt into the cooling helium channels in the surrounding structure. The calculations were conducted using a 3-D heat transfer model. The velocity profile was calculated with a 2-D MHD code and then used as the input data in the heat transfer analysis. The calculated data show that under the DEMO plant conditions [2] no more than 15% of all heat generated in the Flibe escapes into the helium. Another important conclusion is that the temperature at the interface with the ferritic structure does not exceed the maximum allowable temperature of 550°C.

1. C.Wong *et al*., *Molten salt self-cooled solid first wall and blanket design based on advanced ferritic steel*, to appear in FED.
2. C.Wong *et al*., *Assessement of liquid breeder first wall and blanket option for the DEMO design*, TOFE abstract.
3. S.Smolentsev *et al*., *Application of the K-epsilon model to open channel flows in a magnetic field*, International Journal of Engineering Science, 40, 693-711 (2002).