\$31. Innovative Concepts of Free Surface Cooling System on First Wall of Fusion Reactor

Kunugi, T., Kino, C. (Kyoto Univ.) Sagara, A.

As for the application of the free surface concept to the FFHR (Force-Free Helical Reactor) design conducted by the National Institute for Fusion Science (NIFS) [1], it is necessary to consider the helical configuration, that is, at a certain position the free surface would be at the ceiling. In this case, the liquid might fall down into the plasma. So, we proposed the innovative cooling concept (Kunugi-Sagara free-surface type Free-surface Blanket, KSFB-I) for a magnetic confinement fusion reactor such as the FFHR design [2]. In this concept, if we can make many micro-channels on the first wall as a flow passage, we will expect a capillary force to withstand the gravity force and the wall shear stress. In the case of FFHR, the candidate working liquid is a Flibe. In general, a high Prandtl number (Pr=v/a, here v is viscosity and a is thermal diffusivity) fluid like Flibe (Pr=~30) has relatively lower heat transport capability than that of liquid metal (Pr = ~ 0.03 for Li). However, the surface heat flux at the first wall is about 0.1MW/m2: it is quite low compared to the usual magnetic fusion reactors. Therefore, the Flibe can be used as working fluid of the liquid wall.

Lithium lead (17Li-83Pb) is selected as a working liquid in the present study because LiPb is extremely low Prandtl number (Pr=~0.003). Additionally LiPb eutectic permits the use of moderately enriched or natural Li and has a relatively low cost in comparison with other tritium generating and multiplier materials. Since LiPb has five times higher density than that of Flibe, it might be a problem to keep the fluid in the channel of first wall with reticular girds.

In the present study, the numerical simulation to evaluate its feasibility has been carried out as shown in Fig. 1. For the wall material, a tungsten is chosen as one of candidates because of high temperature resistance and low activation property, and furthermore, a good neutron multiplier to increase tritium breeding ratio (TBR).

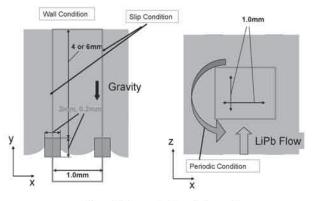


Fig. 1 Computational domain

We performed the numerical simulations in order to evaluate the feasibility of this innovative cooling

concept proposed here. In the case of forminx formin, the numerical results indicate that the LiPb flow is kept stably in the flow passage because of the low-pressure region induced as shown in Fig. 2. Moreover, this concept shows enough heat transport potential as shown in Fig.3. This is because we can find the deformation of the free surface and the circulation flows in the flow passage in the case of 1mmx1mm. It is considered that these circulation flows could enhance the heat transfer for LiPb flows.

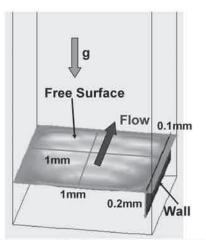


Fig. 2 Free-surface deformation due to shear flow/gravity

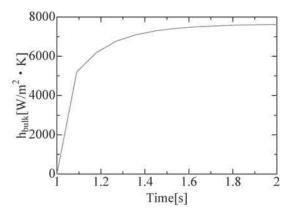


Fig.3 Trend of the bulk heat transfer coefficient (example)

The following results were obtained:

1) LiPb free-surface flow can be kept stably in the grid-typed flow passage if the physical properties are correct. 2) Large secondary flow appear in the grid-typed flow passage. 3) These secondary flows would enhance the heat transfer for LiPb flows. 4) New KSF wall concept might be one of the candidates of liquid wall concept for fusion reactors. However, the results obtained here were very preliminary. Further investigation would be necessary in the future.

Reference

[1] A. Sagara, et al, Proc. of 17th IAEA Fus. Energy Conf., Yokohama, (1998) FTP-3,.

[2] T. Kunugi et al., Fus. Eng. and Des. 65 (2003) 381