§18. Study of Heat Transfer Across the Interface of Phase Transition (He II/He I)

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For fusion reactors, the superconducting magnet systems of high stability and high performance have been strictly required. Thus the high performance coolant loop is also required for this purpose. The cooling system using superfluid helium is one of candidates for the superconducting magnet system of high stability. Superfluid helium has extremely high ability of heat transport. However, its low viscosity causes the difficulty to be used in a commercial cooling system so that there is no available circulation pump for superfluid helium[1]. In other words, the study of development of a circulation pump for He II cooling system is an important issue for fusion.

In 1980's and 1990's, many researchers try to apply the thermo-mechanical effect in He II to circulation pump using porous plug called fountain effect pump (FEP) [1)-4)]. The circulation system is shown schematically in Fig.1. FEP is based on the thermo-mechanical effect in He II. The thermo-mechanical effect is expressed by London's formula,

$$\Delta p = \rho s \Delta T \quad \text{(Eq.1)}$$

, where ΔT is the difference of temperature across porous plug. However the pressure difference between FEP has not high and the efficiency is not sufficient though the ability of heat transportation is very large. Therefore the cooling loops using FEP were not conventional choice for magnet cooling yet. Prof. H. Kobayashi in Nihon Univ. suggested another concept that the cooling loop is used forced flow of normal liquid helium through the sub-cooler with saturated He II exchanger as shown in Fig.1[5]. This kind of circulation requires heat exchanger with high efficiency in saturated He II. Thus the studies of heat transfer of He II-He I interface and understanding of boiling and condensation in the sub-cooler. Especially the role of pressure difference between the liquid-vapor interfaces should be investigated.

In this study the hydrodynamic pressure on the heater were varied to investigate the role to critical heat flux of saturated He II using glass Dewar shown in Fig.2. And these experiment results were compared with microgravity experiment[6].

The critical heat flux on several pressure head is shown in Fig.3. The critical heat flux depends on pressure head proportionally including the data under microgravity experiment. And from this tendency, offset pressure head about few ten Pa can be seen. This offset pressure is assumed van der Waals pressure. Calculated van der Waals pressure has good agreement with the experimental results.

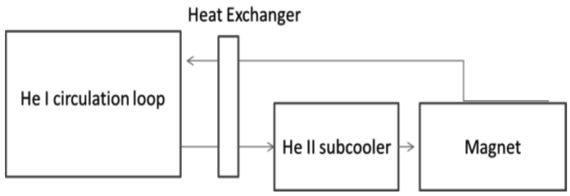

Fig. 1. Flow Diagram of He II forced flow loop with He I loop

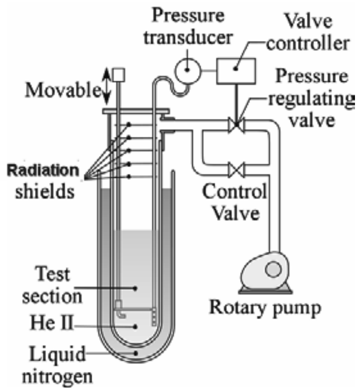

Fig.2 Sketch of glass Dewar experiment setup

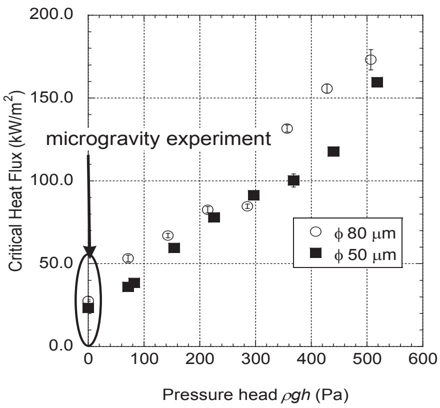

Fig.3 Dependence of critical heat flux on hydrostatic pressure at 1.9K

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