

§14. Dependence of Heat Transfer Characteristics in Liquid Helium on Area Fraction of Surface Treatment

Iwamoto, A.

Helical coil in the LHD is pool boiling superconducting magnet. It is well-known that heat transfer characteristics depend on heat transfer surface treatment. To enhance the heat transfer characteristics, surface of the superconductor is treated by oxidation. The treatment may be peeled off in magnet winding. For the stability analysis of the helical coil superconductor, the dependence of the heat transfer characteristics on area fraction of the surface treatment had to be investigated. Experimental results of the heat transfer characteristics were already reported.<sup>1)</sup> In this study, calculated heat transfer characteristics with partially oxidized surface, using heat transfer characteristics of polished and fully oxidized surfaces, are reported compared with experimental results.

Heat transfer surfaces with various surface treatment are shown in Fig.1. Samples (b), (c), (d) and (e) are defined as partially oxidized surface. We approximate the heat transfer curve for samples (a) and (b) as  $h(T)=aT+b$  (Fig. 2), then calculate the total heat transfer for partially oxidized surfaces and a rule of mixtures, Eq. (1):

$$h_{POS}(T) = h_{Oxidized}(T) \cdot x + h_{Polished}(T) \cdot (1 - x), \quad (1)$$

In this expression,  $h_{POS}(T)$ ,  $h_{Oxidized}(T)$ , and  $h_{Polished}(T)$  are the heat fluxes of the partially oxidized, 100% oxidized, and 100% polished Cu surfaces at T K, and x is some area fraction of oxidation. The effect of thermal conductivity are neglected in such calculations.

Figure 3 shows the dependence of the calculated critical and minimum heat fluxes at 90° (vertical) on area fraction of oxidation compared with measured heat fluxes. The critical heat flux is almost constant from 0 % to 60 % of area fraction of oxidation and continuously increases at more than 60 %. On the other hand, the minimum heat flux takes a almost same value at more than 30 %. Calculated heat fluxes approximately agree with measured heat fluxes. It is found that heat transfer characteristics with partially oxidized surfaces are calculated from those with the 100 % oxidized and the 100 % polished Cu surfaces. This method to get heat transfer characteristics with partially oxidized surface is useful for stability analyses of pool boiling superconductors like the helical coil superconductor.

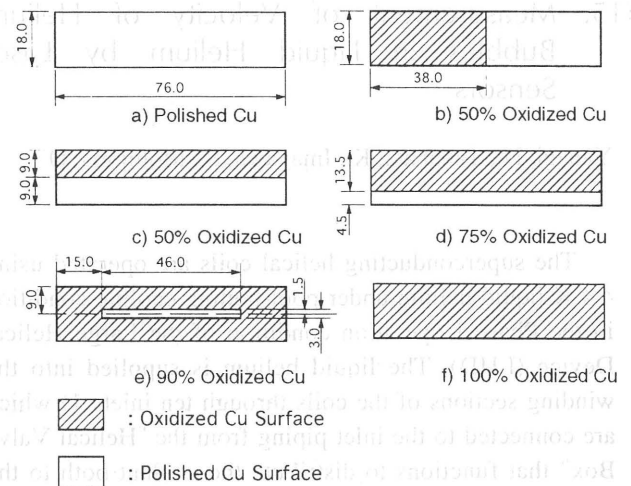


Fig.1. Schematic illustration of heat transfer surface with various area fraction of surface treatment

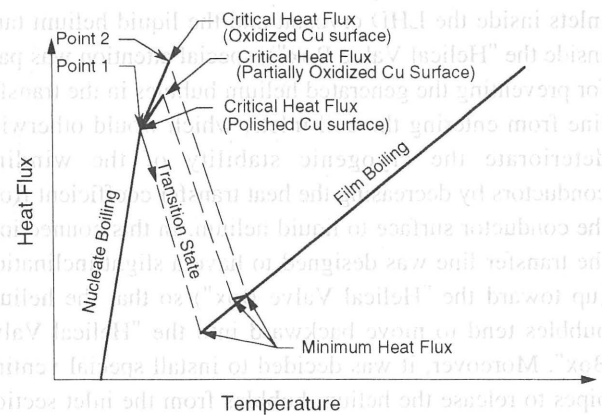


Fig.2. Assumption of heat transfer for calculation

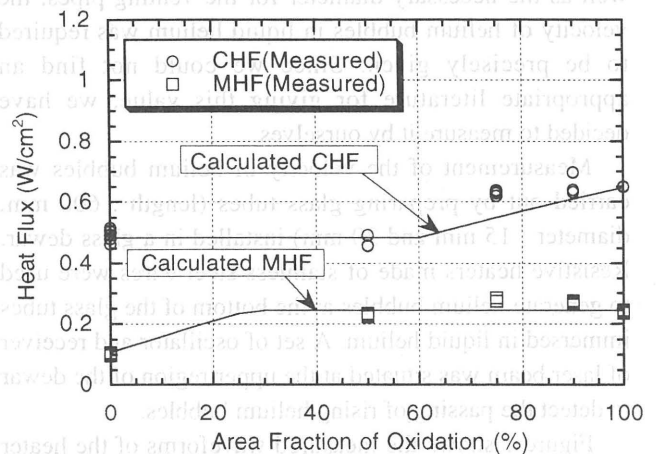


Fig.3. Dependence of the critical and the minimum heat fluxes at 90° on area fraction of surface treatment

References

- 1) Iwamoto, A., et al. : Ann. Rep. NIFS (1994-1995)13.