§26. Aspect Ratio Effect of He II-Channels on Heat Transport Characteristics

Kobayashi, H. (Nihon Univ. Sci. & Tech.)
Kabashima, S., Okamura, T. (Tokyo Inst. Tech. Univ.)
Satoh, S.

The critical heat flux q_λ (W / wetted surface area) at which superfluidity is broken at the center of the channel length with a heat source distributed along the inner wall (see Fig.1) has been observed to be smaller than the estimated value if the channel has short and wide aspect. This geometry effect can be explained by the fact that the temperature difference between T_2' and T_2 is built across the channel gap (Fig.2). At q_λ the temperature T_3 near the heater side reaches the λ-point while T_2 in the liquid on the opposite side is yet lower. This aspect ratio effect should be taken in for the estimation of stability margin of superconducting coils cooled with He II because a large aspect ratio d/L occurs rather in the coils.

The heat transport characteristics with distributed heat source have been investigated in the framework of the Gorter-Mellink theory. A modification is required since the deviation of q_λ from the calculated value becomes noticable as the aspect ratio increases. Because the heat flux q(x) (W /channel cross-sectional area) in the channel next to the heated surface depends on the distance x along the surface q(x) becomes $Q \cdot x / (A_c \cdot L)$ where Q(W) is the total heat and A_c the cross-sectional area of the channel. By integrating the Gorter-Mellink heat conduction $dT/dx = -f(T)\,q(x)^3$ from T_b to the λ-point, q_λ is given by q_λ (Calc.) $= \{(L^{4/3}/4d)^3\}^{-1/3} \cdot Z(T_b)$, where $Z(T_b)$ is the integrated heat conductivity function. A factor $\gamma = q_\lambda(\text{Exp.})/\ q_\lambda(\text{Calc.})$ was observed for channels with relatively short length L compared to their width d. Assuming a linear relation with constants a and b, q_λ(Exp.) becomes $q_\lambda(\text{Calc.}) \cdot \{a - b(d/L)\}$ Thus, q_λ is not proportional to the channel gap width d. As seen in Fig.3, the equivalent aspect ratio $(d/L)_{eq}$ as a function of d/L indicates how many portion of the actual channel size contributes to the heat transport.

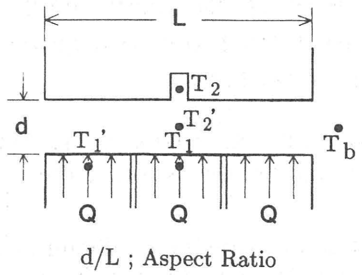

Fig.1. Channel arragment and the positions of thermometers.

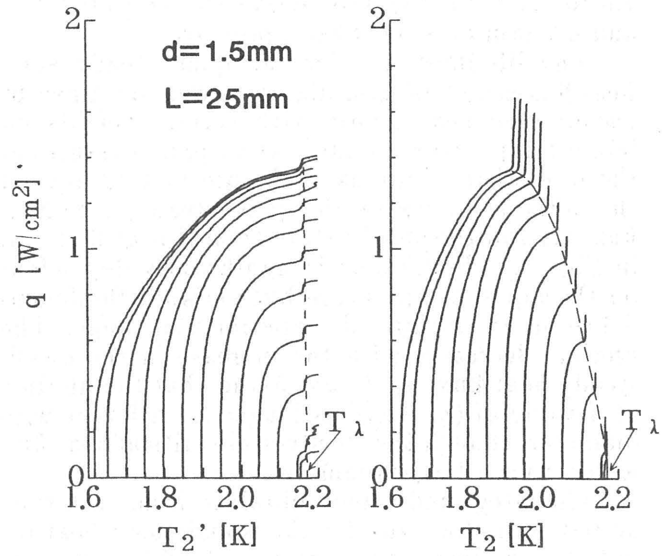

Fig.2. Temperature changes at T2' and T2 as a function of heat flux.

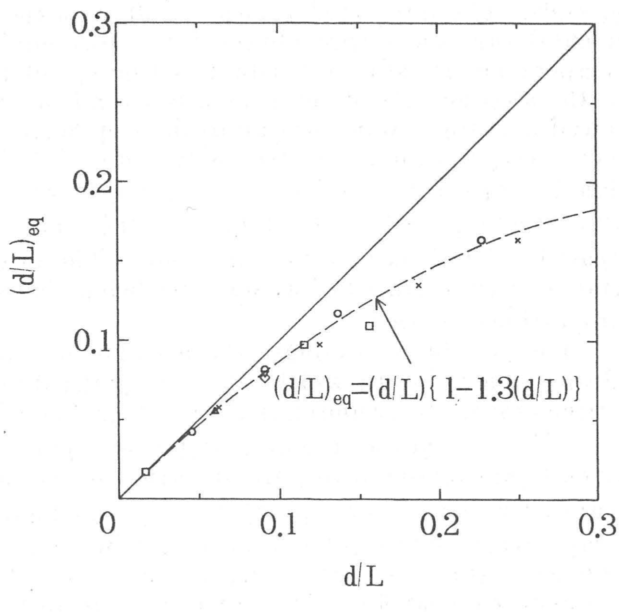

Fig.3. Equivalent aspect ratio (d/L)eq.