§9. Visualization Study of the Heat Transport in Pressurized Super Fluid Helium

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1. Introduction

In the LHD secondary project, the helical coil will cool down by the pressurized superfluid helium (He II_p). For this purpose, it is necessary for the analysis of the stability of the helical coil to investigate the heat transport in He II_p in the cooling channel. In the present study, the phenomena of the film boiling in He II_p are elucidated qualitatively by the visualization observation. In the second year of the present study, the visualization observation of the film boiling was conducted in more detail by use of the transparent heater.

2. Experimental apparatus

The block diagram of the experimental procedure for measurement and photographing is shown in Fig.1. First, the pulse generator puts out a signal of square wave. The power amplifier amplifies this wave. The transparent heater (25 mm x 25 mm) is heated by the amplified wave. At the same time, the pulse generator sends trigger signals to the high-speed video camera and the digital oscilloscope. And then the video camera is started to record the image of film boiling phenomenon and the oscilloscope is started measuring the pressure and the temperature variations. Therefore, the measurement of the high-speed video camera and the pressure and the temperature variations are synchronized. The transparent heater fixed vertically and the pressure and the temperature sensors are located adjacent to the heater area.

3. Experimental results and discussion

The experimental result of the visualization of the film boiling in He II_p is shown in Fig.2. The He II_p pressure is 26.6 kPa, the He IIp temperature is 1.9 K and the heat flux is 20 W/cm2. Fig.2 – (a) is the schematic illustration of the top view of the vapor film configuration on the transparent heater. And Fig.2 – (b) is the visualization photograph of the vapor film and this photograph corresponds to the upper right portion of Fig.2 – (a), that is shown by a square. From the result of the visualization, the vapor flow on the heater area moved toward the center of the heater from the four edges as indicated by the arrows in Fig.2 – (a). Moreover the striped patterns were observed at the part except the center and the diagonal line of the heater as shown in Fig.2 – (b). It was observed in the visualization photographs that these striped patterns moved toward the center at a speed of about 0.17 m/sec. In this connection, we attempted to calculate the propagation speed of the capillary wave as,

$$v = \sqrt{\frac{\lambda g}{2\pi} + \frac{2\pi\sigma}{\lambda\rho}} \qquad (1)$$

where λ is the wavelength, g is the gravitational acceleration and σ is the surface tension coefficient, respectively. The result of the calculation is 0.15 m/sec. The agreement between the calculation and the visualization result is fairly good. Therefore, this result indicates that the transparent area on the heater is covered with vapor layer that is relatively stable.

4. Summary

The experimental study of the film boiling in He IIp was conducted by use of the pressurized superfluid cryostat and visualization observation. It was indicated that in the highly pressurized state, the film boiling state was relatively quiet and the disturbed area on the heater area was small.

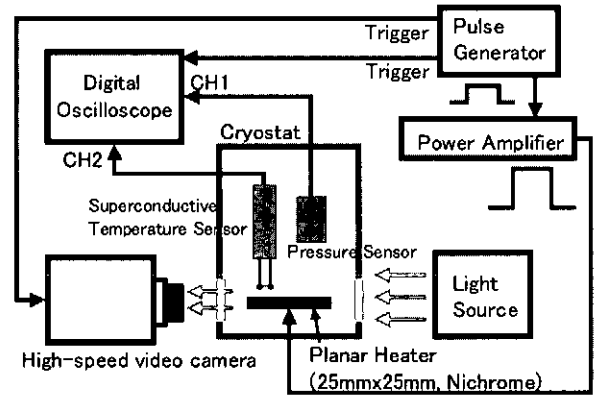

Fig.1 The block diagram of the experimental apparatus.

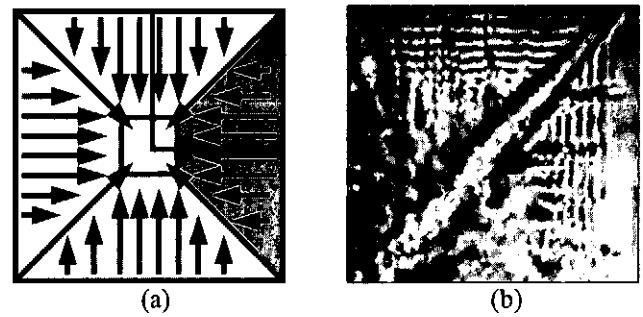

Fig.2 The result of the visualization observation by the transparent heater. P = 26.6 kPa, T = 1.9 K and q = 20 W/cm^2.