§16. Visualization Study of Behavior of Nucleation Bubble in Cooling Channel

Nozawa, M. (National Institute of Technology, Akita College),
Takada, S.

For cooling superconducting magnet using high temperature superconductor (HTS) conductor, liquid nitrogen could apply as a coolant. However, the behavior of small bubbles in complicated channel was not known well. For superconducting magnet, the large bubble may makes hot spots which induce quench. Thus the study of distribution and growth of bubble have been requested. The cooling channels are consisting of complicated many narrow channels. And self-excited vibration may occur in nucleation boiling in narrow channel.

In this year, the small cryostat for liquid nitrogen equipped with three optical windows and two dimensional cooling channel made by the glass plate were prepared. And the demonstration of visualization experiment for liquid nitrogen was conducted with the high speed camera and LED light with collimator lens box shown in Fig.1.

For this demonstration, the rod of Nickel-Chrome foam shown in Fig.2 was used as a heater which induced nucleation boiling. Nickel-Chrome foam has many three dimensional pore which size is close to the order of Laplace diameter as a stable diameter of bubble. The complicated pore may induce unstable boiling coupled with self-excited oscillation. On the other hand, this kind of metal foam is expected to apply to heat exchanger. Thus this kind of sample was selected.

This characteristic heater was set horizontally, and the motions of tiny vapor bubbles were visualized. A typical picture of visualized results is shown in Fig.3. In nucleation state, the vapor bubble never departs to downstream. The bubble which expanded from bottom of the heater rod always flows to the pore of the Nickel-Chrome foam. This characteristic feature never observes around typical cylinder heater or wire heater. The metal foam has the complicated geometry including conversing and expanding passage. Thus heat flux changes dramatically in microscopic view. This may be reason of this characteristic vapor motion.

On the other hand, the heat transfer and pressure oscillation of two phases flow in the narrow coaxial channels of two layers were investigated as a complementation study. In narrow channel, the characteristic vibration of about 150 to 200 Hz was measured. The relation between the characteristic frequency and mass flow rate was understood. Furthermore, the dependency of the channel geometry was planned to investigate. Microscopic visualization is requested to understand these phenomena. Larger micro-lens and higher intensity light should be needed.

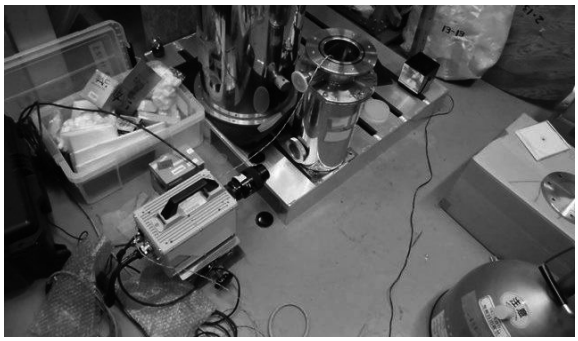

Fig.1 Optical Setup and the small cryostat with glass windows

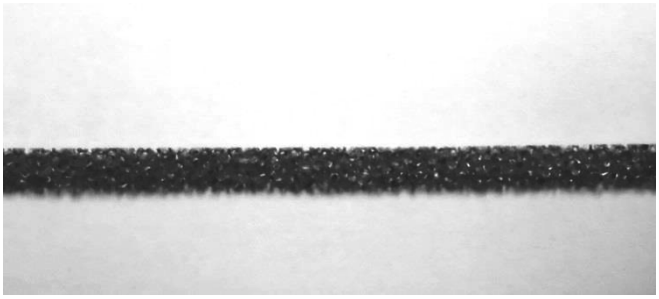

Fig.2 Picture of Nickel-Chrome foam

Fig.3 Typical visualization result of small vapor behavior from Nickel-Chrome foam