§11. Mechanical and Stability Analysis of Large Scale Cable by Numerical Simulation

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The convection of liquid helium in the superconducting magnet was analyzed by means of lattice Boltzmann method to study the cryogenic stability of the superconducting magnet. Since the cooling capability is thought to depend on the convection of liquid helium, the cryogenic stability of the superconducting magnet is ought to be discussed considering the effects. For example, the cooling capability in the cooling channel, where the liquid helium flow is restricted, is thought to be different from those in open area. Because the propagation of the normal state zone is controlled by the cooling conditions, the characteristics of the normal state zone in the cooling channel are different from those in open area.

In this work, the cooling capability and the stability of the superconducting magnet were studied by analyzing the convection of liquid helium in the superconducting magnet. In the calculation, we applied the lattice Boltzmann method which is suitable for the analysis of the complex flows and the heat transfer. By calculating both the convection of liquid helium and the heat transfer, the propagation of the normal state zone was studied to evaluate the stability of the superconducting magnet.

Lattice Boltzmann method is the numerical computation method in which the fluid is treated as the cluster of particles The particles are thought to collide each other or transfer and results in the fluid flow occur. However the particles in this model do not correspond to atoms or molecules but the bulky pseudo-particles representing the continuous fluid. Therefore lattice Boltzmann method is the numerical computation method introducing the Boltzmann equation t the continuous flow analysis such as Navier-Stoke equations.

We employ the two fluid model to calculate th temperature and convection. In the model two types o particles are considered that is the one (blue) has large mass and lower temperature and the other (red) has lowe mass and higher temperature. The temperature is calculate by the ratio between the number of blue and red particles The difference of the density between the two particle induces the convection. We set up the two dimension hexagonal lattice for the system and make the velocity of particles discrete. Consequently the fluid density is described by the distribution function of the velocity and each particle moves towards one of six directions or stops at the lattice point. When the BGK model is applied to the collision rules, the distribution functions is derived as equation (1),

$$f'(t,r) = f(t,r) - \frac{1}{\phi}\left[f(t,r) - f^{(0)}(t,r)\right] \qquad (1)$$

where f(t,r) is the distribution function of the fluid density before collision, f'(t,r) is that after collision, φ is the relaxation time, $f^{(0)}(t,r)$ is the equilibrium distribution based on the Maxwell-Boltzmann distribution. By using eq. (1), we can get the distribution function of the fluid density with time and then we can calculate the local density, velocity and temperature with time.

Fig. 1 shows the change of the temperature distribution in the system having a normal state zone. The effect of a plate disturbing the convection is studied. Though the normal state zone shrinks in both cases, in the with-plate system the normal state zone needs longer time to disappear than in without-plate system. We note that the difference is brought the flat plate by reducing the heat flux and hence the temperature at the front of the plate becomes higher.

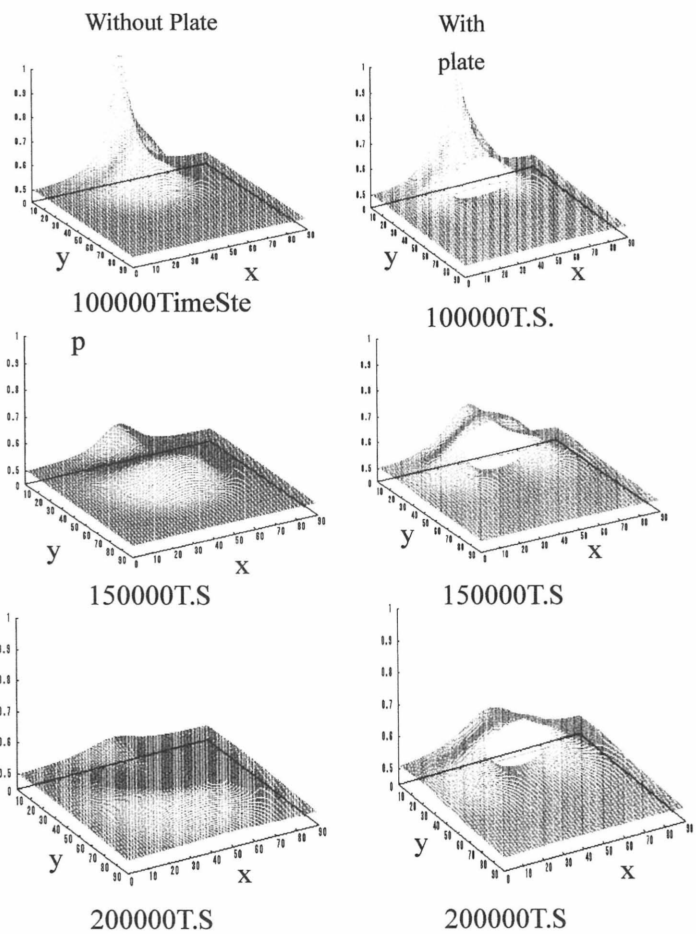

Fig.1 Temperature Distribution