

§2. Archival Studies on Devices and Technologies of Plasma Heating

Kuroda, T., Iguchi, H., Namba, C., Matsuoka, K., Obayashi, H., Fujita, J., Ohkubo, K., Watari, T., Fukumasa, O. (Ube National College of Technology)

Plasma heating is the important key for production of high temperature plasma for fusion. In the early days of fusion research, plasma confinement and heating were tackled simultaneously and with equal efforts. As the heating devices have been developed by adopting the new advanced technologies at that time, to analyze and investigate the history of the processes on the heating devices give useful knowledge and suggestions for a course of research and development on future scientific projects.

Objective of research

The main objective of the research is to collect and arrange the documents/materials on the heating devices of fusion research. It is also useful to provide the collections as materials available to researchers who are interested in the history of science as well as the fusion research.

Activities in last fiscal year

In order to collect the materials systematically, we reviewed the researches of plasma heating from the dawn stage of fusion research to 1970 in Japan through the conference proceedings of academic societies, the journals of 'The Physical Society of Japan' and 'The Institute of Electrical Engineers of Japan', the journal of 'Kakuyugokenkyu' and the reports published by the committees related to Fusion Science. We also collected some materials of the heating devices for high temperature plasma experiment, and of the experimental devices for fundamental research of RF heating.

Activities in this fiscal year and conclusions

We have reviewed the researches of heating and the experimental devices from 1970 after breakthrough results from T-3 Tokamak to 1980.

1)1971 ~ 1975:Turbulent heating and electron heating were studied in theta-pinch and some other types of devices. In the devices for high temperature plasma production, Heliotron, JIPP T-II stellarator/tokamak and JFT-2, the research for production of high temperature plasma due to Joule heating was continued by solving the problems of technology such as wall materials. Additional heating was still on the stage of fundamental experiment. More precise experimental studies were carried out developing the diagnostic technology to interpret the experimental data and theory. The behavior of waves in the cold plasma was actively investigated experimentally for excitation, propagation and absorption of various waves and for wave-plasma interaction

in the wide frequency range to electron cyclotron frequency. In small sized experimental devices, the fundamental studies of lower hybrid wave heating (LHH) were done in addition to electron cyclotron heating (ECH) and ion cyclotron heating (ICH). As for the researches of production and heating of plasma by particle injection method, the particle sources by the use of clusters came up to develop as the alternative of the ion source. The researches for beam plasma interaction were enhanced due to the increase of interest in instabilities and heating of plasma. After 1973 when ATC device demonstrated the successful results with the additional heating and the high power additional heating devices begun to develop at the facilities in the world, the test beds to develop additional heating devices were constructed in JAERI and IPPJ and the development of auxiliary heating devices began.

2) 1976~1980:The development of high power additional heating devices, NBI and RF heating progressed and the NBI experiments were successfully initiated at a few hundreds kW level in JFT-2 and JIPP Stellarator in 1978. The fundamental researches on technologies related to the large current ion sources for NBI and RF heating technologies such as antenna and the transmission system were carried out in both universities and institutes. LHH was applied in JFT-2 and JIPP T-II on the basis of the results. Advance of the fundamental experiment and the theoretical studies of wave in the plasma showed that RF power of LH frequency range could be useful for controlling plasma parameters. The demand of millimeter-wave source with high power was increased and the development of prototype gyrotron proceeded in universities, and the ECH experiment was carried out by using the gyrotron. The development of high power gyrotron was followed in the collaboration with the industry. The research and development of high power heating devices and the components were initiated in institutes and universities and the further development was progressed under collaborations between institutes, universities, and industries. On the basis of the results, more powerful reliable heating system was constructed in the industries after engineering studies.

Present status and future plan

In this fiscal year, some documents of the apparatus for fundamental experiment of RF heating, the antenna and the high frequency transmitting system and NBI device including cluster and ion sources have been collected. We are going further to continue reviewing the research of plasma heating in the period from 1981 through 1990 during which heating devices were explored for higher power heating of fusion machine-grade and will collect the materials of the additional heating devices.

This work was conducted under NIFS Collaborative Research Program (NIFS10KVXP003).