3 Nuclear Fusion Research and Development

For Practical Use of Fusion Energy

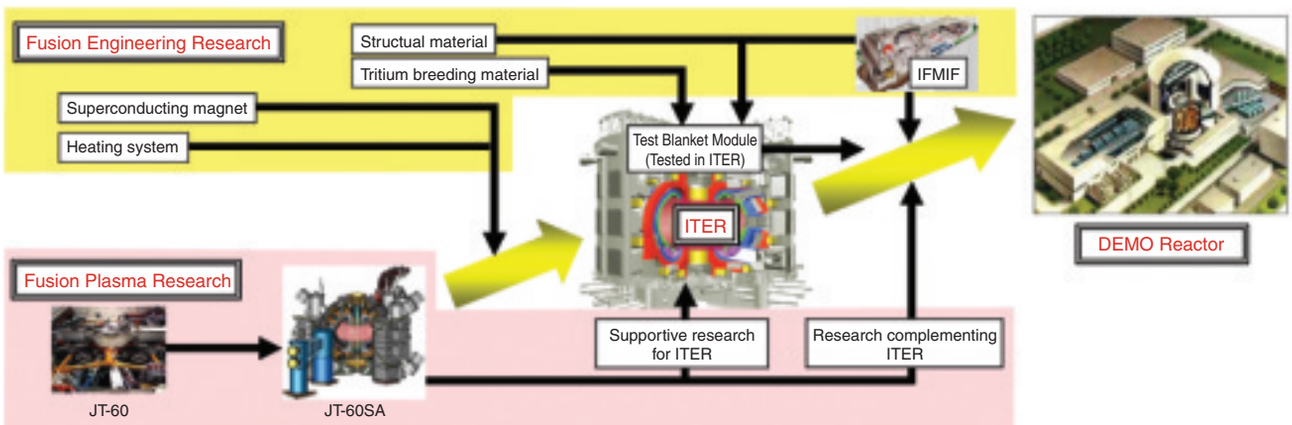

Fig.3-1 Development of the Fusion DEMO Reactor

In the fusion research and development field, R&D into three fields that are keys to the fusion development needed for the practical use of fusion energy are being pursued:the ITER project, the fusion plasma research, and the fusion engineering research. We are intensively engaged in international cooperation not only in the ITER project, but also in R&D over a broader area pursued by Japan and EU (Broader Approach Activity) etc (Fig.3-1).

ITER (International Thermonuclear Experimental Reactor) Project

The ITER project is an international cooperative project to demonstrate the scientific and technical feasibility of fusion energy through construction and operation of an experimental reactor. The participants are Japan, EU, US, Russia, China, Korea, and India, more than half of the world population. The experimental reactor, "ITER", is scheduled to be constructed in Cadarache in France. The international agreement on the construction and operation of "ITER" was signed by seven participating parties in Paris in November 2006. We are to become the domestic agency of the ITER project in Japan and will play an important role in the project.

Fusion Plasma Research

Studies for the JT-60SA plan (upgrade of JT-60 to a superconducting machine) to support the ITER project and to seek the advanced performance of a core plasma for the DEMO reactor were begun as one of the broader approach activities through the cooperation of Japan and EU. Topic 3-1, "Accomplishment of the Conceptual Design of JT-60SA Through Collaboration of Japan and Europe" concerns this upgrade, making a wide range of experiments possible by using existing equipment of JT-60 to the maximum, and adopting advanced technologies.

The critical requirement for the DEMO reactor is to attain a high level of economical efficiency, namely, to sustain a high fusion power in a reactor core of compact size. It is necessary to improve the plasma pressure (temperature $\times$ density) for that. Topic 3-2, "The Search for the Plasma Rotation Needed for High Pressure Plasma", is the first research in the world that experimentally showed that a high plasma pressure can be maintained stably using JT-60. Moreover, major progress was achieved in theoretical research in parallel with the experiment. Topic 3-3, "Sharpening Plasma Shape Improves Pressure Limit", clarified theoretical guidelines to achieve high plasma pressure, and Topic 3-4, "Suppression Mechanism of Turbulent Electron Heat Transport", verified that the heat insulating layer discovered by experiment is a self-organization phenomenon, the same as the formation of a jet in a planet atmosphere, by first-principle simulation of electron turbulent flow. In the future, great progress in fusion plasma research through the combination of experiment and theory is expected.

Fusion Engineering Research

The fuel of fusion energy is deuterium and tritium. A large quantity of deuterium exists in seawater. The tritium hardly exists naturally at all, but it can be produced from lithium, which is also contained plentifully in seawater. In the fusion reactor, the energy of the neutrons resulting from fusion reactions is extracted with the device "Blanket", and here tritium is also produced. Topic 3-5 and Topic 3-6, "Development of Full Scale First Wall of Fusion Blanket" and "Developing a Method for Suppressing Irradiation Hardening of F82H by Heat Treatment Utilizing the Difference in the Hardening of Weld Joints" are research results needed for the development of a manufacturing method of Blanket and a method of controlling the stiffening caused by neutron irradiation, using ferritic steel (F82H) which is a low activation material developed by us. On the other hand, the development of a breeding material and the accurate evaluation of the tritium production rate are necessary for the development of Blanket so that it can efficiently produce tritium. The research into tritium breeding by Blanket has progressed steadily due to the results of Topic 3-7 and Topic 3-8, "Measurement of Tritium Production Rate in Blanket with High Accuracy" and "Material Allowing Stable Fuel Supply to Fusion Reactor". Moreover, the development of materials other than those for Blanket were also advanced as shown in Topic 3-9 and Topic 3-10, "Research on Interaction between Tritium and Metal" and "Neutron Shielding Resin can be used in the High Temperature Environment of a Fusion Device".

Thus, we aim at the utilization of fusion energy in the middle of the 21st century, through a comprehensive approach to the necessary research, including fusion plasma and fusion engineering technologies centering on the ITER project.