Development of Solid Breeder Blanket at JAERI

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Japan Atomic Energy Research Institute (JAERI) has been assigned as a leading institute for developing the solid breeder blanket in the long-term research program of fusion blankets in Japan, which was approved by the Fusion Council of Japan in 1999. In accordance with the long term research program, element technology development of solid blanket has been performed at JAERI and showed significant progress. Based on the achievement of the element technology development, the development phase is now stepping further to the engineering development phase. This paper presents the major achievements of the element technology development of solid breeder blanket in JAERI.

According to the reactor designs of a fusion power demonstration plant in JAERI, the blanket is required to withstand the neutron wall loading of up to 5 MW/m^2, and the surface heat flux of up to 1 MW/m^2. Target availability of operation is 75%. In the fusion power demonstration plant, it is required to show the feasibility of tritium breeding ratio to be more than 1.05 and thermal efficiency of power plant system to be comparable or higher than 35%. As a near term blanket option, reduced activation ferritic steel, F82H, and high pressure water (15 or 25 MPa) were selected as the candidate structural material and coolant. To realize the selected solid breeder blanket design, the element technology development consists of the development of module fabrication technology, the development of irradiation technology for in-pile mockup irradiation test, the development of fabrication technology for breeder and multiplier pebbles, irradiation tests of breeder and multiplier pebble beds, neutronics studies on a blanket module mockup and the development of tritium recovery system.

As for the blanket box fabrication technology, treatment conditions of a Hot Isostatic Pressing (HIP) joining were studied. It was made clear that the coarse grained microstructure after conventional HIP process was refined by the post HIP normalizing process at the temperature below 1313 K. This result implies the thermal hysteresis effects could be canceled by an appropriate heat treatment. As for the evaluation of thermal and mechanical characteristics of the pebble beds, new measurement apparatus was established and the data on the effect of compressive strain on the pebble bed thermal conductivity was measured in good accuracy. This apparatus is expected to clarify effective thermal conductivity of pebble beds under creep conditions and cyclic stress conditions.

Based on the achievements of above stated element technologies, the R&D program is now stepping to the engineering testing phase, in which scalable mockup tests will be performed for obtaining engineering data unique to the specific structure of the components, with the objective to define the fabrication specification of test blanket modules for ITER.