§14. Present Status of Design Activity of IFMIF HFTM

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In Kyushu University, a series of study on IFMIF test cell installed into high flux test module has been conducted. First, we pointed out the defect of original conceptual design of HFTM test cell in respect of the resultant large non-uniformity of temperature in test piece by comprehensive numerical simulation. Next, we presented new conceptual design and demonstrated its performance experimentally by means of large-scale high pressure gas loop owned by this collaboration. This concept is based on following characteristics.

1. Capsule including many test pieces is laid on its side. This configuration is derived from following expected advantages. Long irradiated unit can realize 2-dimensional temperature distribution, that is temperature uniformity in the test pieces. Furthermore, coolant flow channel can enhance 2-dimensional effect.
2. Rig wall and incidental gap are eliminated. Removal rig wall enhance the cooling performance and uniformity of temperature can be promoted.
3. Test pieces are set in cast-like capsule and gap between capsule and test pieces are filled up by metallic mesh to ensure the local contact of test piece on the capsule inner wall.
4. Thermocouples are inserted in dummy test piece and installed in the capsule. Cast-type capsule realizes accurate measurement of temperature by T.C. and the number of T.C. can be minimized.

Third, stress analysis for container was performed both numerically and experimentally in this FY. In basic design of IFMIF HFTM, the wall thickness of container is set the value of 1 mm. Large pressure difference between vacuum side and high pressure coolant side of container wall and thermal stress caused by nuclear heat of itself may lead catastrophic accident of test module. For experimental study, we demonstrated the large deformation of container wall and early transition of wall material from elastic deformation to plastic deformation by using full-scale container model. For numerical study, 3D stress analysis was performed. Fig.1 shows the change of maximum displacement of container wall without consideration of thermal stress. The point at the edge of discontinued line means the start point of plastic deformation. If the wall thickness is expanded to 2 mm, the plastic deformation will be avoided even at high pressure region. However, when the wall is thicker, the deformation due to thermal stress become serious. (Presentation of calculation results is omitted here) Especially, the heat transfer coefficient of coolant is poor, the region where maximum deformation occurs is completely changed from the isothermal case and the plastic deformation occurs due to only thermal stress. So that, the stress analysis of supported rib wall should be needed in next step.

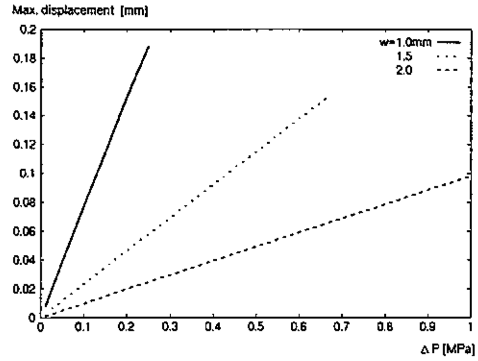

Fig.1 Maximum displacement of container wall

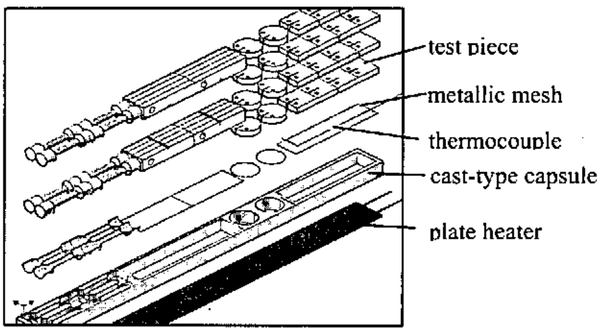

Fig.2 Inside-view of capsule

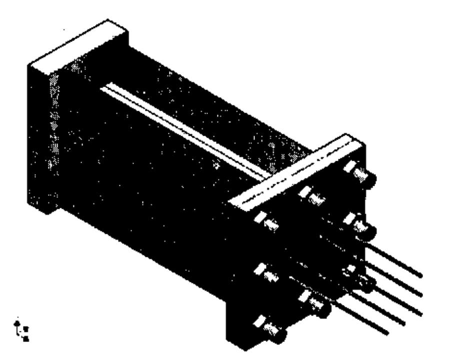

Fig.3 Outside view of HFTM

Finally, test cell based on our concept is designed with taking the maintenance scenario of test cell and test pieces into consideration. Fig.2 depicts the detail of cast-like capsule including test pieces, metallic mesh, thermocouples and heater. Fig.3 shows the test cell module, in which 9 capsules are stored. Four coolant channels are provided and two-dimensional cooling is realized to make the temperature distribution in each test pieces uniform. More details of test cell design with animation of maintenance process can be viewed at website of domestic IFMIF site.

Further considerations are needed for designing the test cell. For example, because metallic mesh cannot guarantee under long-term irradiation, alternative should be considered. Buckling of test module canister should be estimated. Three dimensional distribution of nuclear heat production inside high flux volume needs to be taken into account.