Pre-operation Tests for the Development of the Capsule Assembly Machine

Young-Hwan Kang, Jong-Kiun Kim, Ki-Un Youm, Ki-Byeong Yoon, Myung-Hwan Choi, Bong-Goo Kim
Korea Atomic Energy Research Institute, P.O. Box 105, Yusong, Daejon, 305-600, yhkang2@kaeri.re.kr

1. Introduction

Initial stage of the capsule development program was concentrated on developing the material capsules and the related facility such as a cutting device for 3 years from 1992. After an additional one year of field testing of the I&C system and the upgrades of the software for the material irradiation test, the capsule and related-devices have been installed and operated since 1997. For the material irradiation tests, 67 capsules (54 non-instrumented and 13 instrumented capsules) have been designed, fabricated and successfully irradiated in HANARO since 1995[1]. Based on the considerable experiences of the material irradiation tests and the 3 years of development of the fuel capsule technology, a non-instrumented capsule with a total length of 960mm and an outside diameter of 56mm has been developed and is now being used.The capsule has been optimized and used for the irradiation test of new fuels such as the high burnup fuel, DUPIC, and the high performance metallic fuel since 1999[2]. Although fruitful experiences were obtained from various in-pile tests for about ten years, it is necessary for us to have leading-edge technology to satisfy the specific test requirements of the recent R&D activities such as the high-fluence-and high-burnup-related tests. To meet the demands for the high burnup test at HANARO, new capsule assembling technology and re-instrumentation technology are required in the HANARO reactor. In 2003, mockup of the capsule assembly machine was designed and fabricated[3]. The stress intensity and displacement of the external tube of the capsule mainbody was obtained using the finite element analysis program, ANSYS[4].

2. Methods and Results

The manufactured mockup as shown in Figure 1 consists of a base plate, a capsule stand, a capsule guide pipe and a clamping device. Dimensions of the mockup are 1m in outer diameter, 1.8m in height and 136kg in weight. The assembly procedure consists of three steps. First, orient the capsule mainbody vertically inside the guide pipe. Second, turn the clamping screw with the special tool until the jaw meets the capsule mainbody to be properly clamped. Third, after clamping the capsule main body, insert the protection tube with holes into the guide pin, which is located at the top end of the capsule main body, and fasten them together with bolts. In this assembly procedure, the potential parameters that affect the safety or environmental effects associated with its use can be addressed as a source of concern. This situation requires additional care in the design and operation of the machine. Then, a series of the pre-operation tests are needed and required for a better understanding and design optimization of the machine.

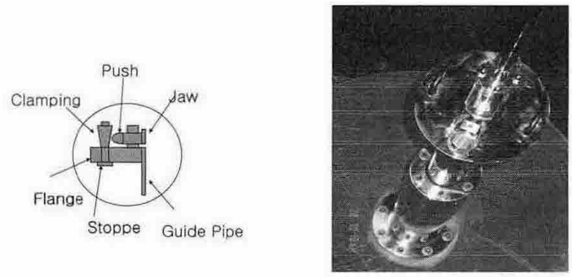

Figure 1. Detail of the clamping device and the capsule assembly machine mockup.

2.1 Optimum Clamping Torque for Assembling the Capsule Parts

The method for determining the desirable clamping force, that is acceptable for assembling the capsule parts, is based on the fact that although the accuracy and consistency of the clamping loads are not reliable, the clamping force achieved depends on the tightening torque selected with the torque wrench. The test data shows that the optimum clamping force is 350kgf·cm for preventing a rotation or shaking of the capsule main body during an assembly of the capsule main body and the protection tube. In order to strongly increase the accuracy of the readings, we also used the calibrated torque wrench (model: Kanon-230QLK).

2.2 Clamping Torque for Preventing a Capsule Tube Deformation

Clamping torque test for preventing a deformation of the capsule tube was also carried out to ensure a long operational life and optimal performance. The measurement of the diameter change of the capsule mainbody was done by increasing the applied load to the claming screw. This test data shows that the applicable load due to the total mass of the tool and an operator during an assembly of the parts should be smaller than 700kgf.cm as shown in the Figure 2.

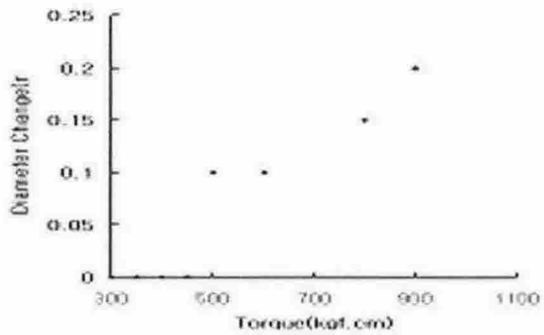

Figure 2. Diameter change of the capsule tube with an applied load.

2.3 Torque Test for Preventing the Damage of Locking Bolts

Locking bolts provide enough safety and have many variables associated with them. They should be made from a strong and durable materiel. Stainless steel is the preferred material primarily because it is much stronger than lower grade steels. Although a special design concept was taken into account to provide a maximum safety, the applied loads could destroy the bolts as shown in Figure 3. The threshold value was obtained from the visual examination results by increasing the applied load to the claming screw. From the test, it shows that the maximum allowable load should not be bigger than 750kgf.cm to prevent any damage to the locking bolts.

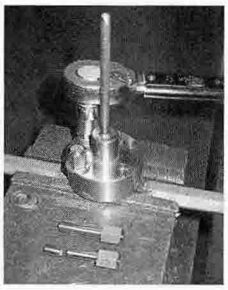

Figure 3. Damaged locking bolts and the torque meter used.

2.4 Preliminary Structural Analysis for the Design Optimization

The preliminary structural analysis for the design optimization of the capsule assembly machine was performed using the FE analysis program, ANSYS[4]. The stress intensity and displacement of the capsule external tube by the applied force is 92.8 MPa and 0.0926 mm, respectively. Figure 4 shows the stress distribution of the external tube. In order to estimate the structural integrity of the tools, the critical buckling load, the shear stress and twisting angle are to be reviewed soon.

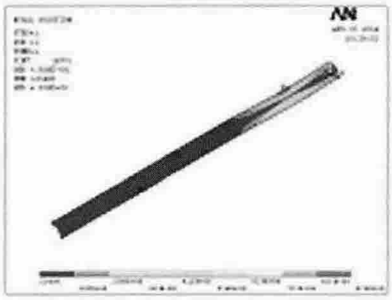

Figure 4. Stress intensity of the external tube of the capsule by the horizontal force

3. Conclusion

In order to optimize the design of the capsule assembly machine, the pre-operation test and FEM analysis of the mockup machine were performed. Major findings from this study are delineated below.

1. The capsule assembly machine is to be used in the remote assembly of capsule components for the long-time irradiation tests in HANARO.
2. Test data prepared by this study are to be directly used for the design and fabrication of the HANARO capsule assembly machine
3. Analysis results show that the critical buckling load, the shear stress and twisting angle of the tools need to be reviewed soon.

ACKNOWLEDGEMENTS

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