Out pile test of a disassembly tool for the intermediate examination of nuclear fuel rods

Jintae Hong [a*], Chang-Young Joung [a], Sung-Ho Ahn [a], Tae-Ho Yang [a], Seo-Yoon Jang [a], Seung-Jae Park [a]
[a]*Department of HANARO Utilization and Research, KAERI, 111 Daedeokdaero 989beon-gil Yuseong-gu Daejeon, 34057*
[*]*Corresponding author: jthong@kaeri.re.kr*

1. Introduction

When a long term irradiation test is carried out, it is necessary to check the status of nuclear fuel pellets, and structural soundness of the clad periodically. Therefore, a test rig which enables intermediate examination can satisfy the safety concern. However, because the irradiated fuel rod emits radioactive rays, operators can not treat it with hand in the air. The irradiated fuel rod should be treated in the reactor pool, and it needs a special tool to disassemble fuel rod in the reactor pool and to transfer to the hot cell.

Hong et. al developed a test rig whose fuel rod assembly can be disassembled from the main test rig[1-2]. In the design, the test rig is classified into two parts, an instrumented fuel rod assembly and a non-instrumented fuel rod assembly. The two fuel rod assemblies are assembled with a bayonet coupler, and the non-instrumented fuel rod assembly can be disassembled for intermediate examination. A tool to disassemble the non-instrumented fuel rod assembly from the test rig was developed, and steel wires are connected to the tool to operate release function. However, because wire of the tool frequently interfered with the test rig, design of the bayonet coupler and of the tool needs to be modified.

In this study, an assembly plug with a quick plug typed bayonet coupler and the accompanying disassembly tool was designed to prevent the interference problem. A test rig mockup was fabricated, and performance test was carried out in the laboratory. And, the out pile test was also carried out in the single channel test loop established in the KAERI.

2. Development of disassembly mechanism of the fuel rod assembly

2.1 Design modification of a coupler

As shown in Fig. 1, the current test rig and wire of the disassembly tool are easy to be interfered or tangled during transferring the test rig. The wire is necessary to operate release pins, which release locking buttons in the bayonet coupler. Therefore, design of bayonet coupler is modified to add quick plug structure instead of locking buttons not to use wire in the disassembly tool. In addition, the quick plug structure at the non-instrumented fuel rod assembly is designed to be the same with that of irradiation test capsule used in HANARO reactor. Therefore, the same tool can be used in transferring the non-instrumented fuel rod assembly and the irradiation test capsule.

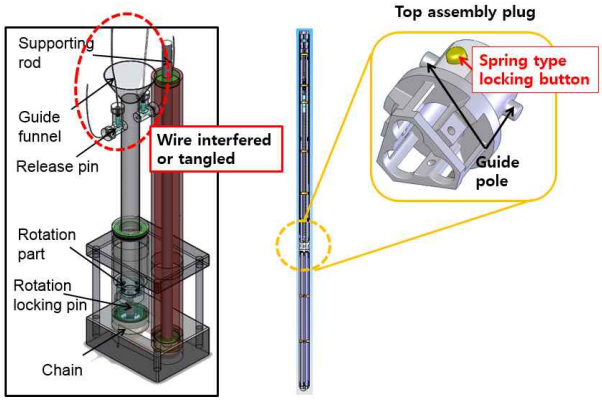

Fig. 1. The current design of a test rig and a disassembly tool

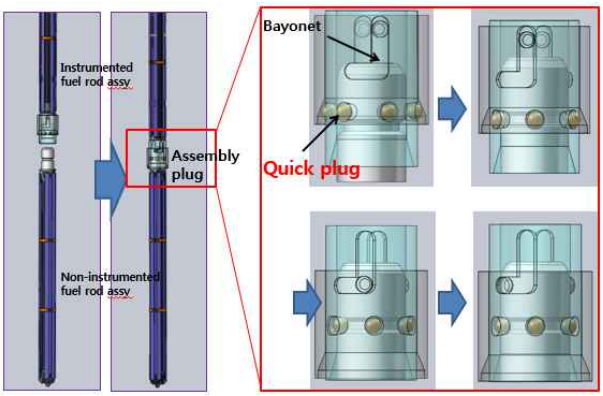

Fig. 2. Quick plug type bayonet coupler and its test rig

2.2 Design of the disassembly tool

Because design of the coupler was changed, a new disassembly tool was designed to enable the disassembly process. The disassembly tool consists of insertion guide, drum pad, fuel rod assembly supporter, extraction paddle, and supporting rod. In particular, drum pad is designed to handle the quick plug type bayonet coupler. As shown in Fig. 3, the drum pad induces compressive stress to the radial direction owing to the compression spring and internal structure of the disassembly tool. Therefore, when the test rig is inserted through the insertion guide, the drum pad grabs the quick plug type bayonet coupler, and it enables the disassembly process by a simple movement of the test rig. Fig. 4 shows the process of disassembling the non-instrumented fuel rod assembly from the test rig.

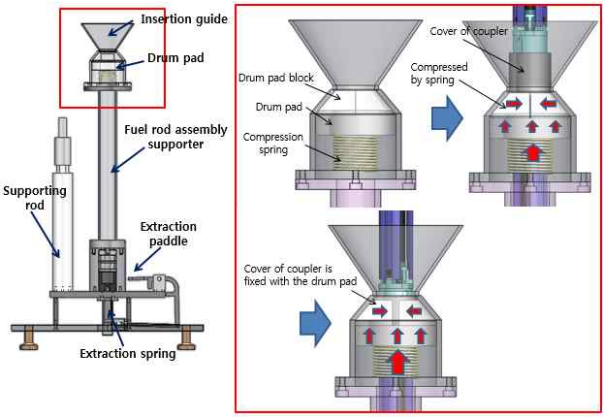

Fig. 3. A modified design of the disassembly tool

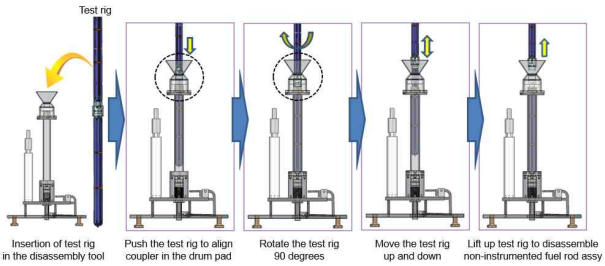

Fig. 4. Disassembly process of the non-instrumented fuel rod assembly from the test rig

Disassembly process consists of five steps as below:
(a) Insert the test rig in the disassembly tool
(b) Push the test rig to align coupler in the drum pad
(c) Rotate the test rig 90 degrees clockwise
(d) Move the test rig up and down
(e) Lift up test rig to disassemble non-instrumented fuel rod assembly

2.3 Performance test and out pile test

To verify the performance and reliability of the developed design, a test rig mock up and a disassembly tool was fabricated. Core components of the disassembly tool are made of STS 304 to prevent deformation or malfunction owing to corrosion. Fig. 5 shows the performance test of the disassembly tool and the quick plug type bayonet coupler. As shown in the picture, all process was carried out without interference or malfunction.

Then, out pile test was carried out in the single channel test loop in the KAERI. The single channel test loop is filled with five meters depth of demi-water. The disassembly tool was set on the bottom of the single channel test loop, and the test rig mockup was transferred by the crane installed in the facility. All the process was carried out according to the standard wok procedure, and Fig. 6 shows the disassembly process of the non-instrumented fuel rod assembly in the single channel test loop. In the out pile test, three processes, such as the disassembly of the non-instrumented fuel rod assembly, the extraction of the non-instrumented fuel rod assembly from the disassembly tool, and the re-assembly of the non-instrumented fuel rod assembly with the instrumented fuel rod assembly of the test rig, were tested and verified that all processes act well in the water. In addition, its reliability was also verified by more than ten times of repeat test.

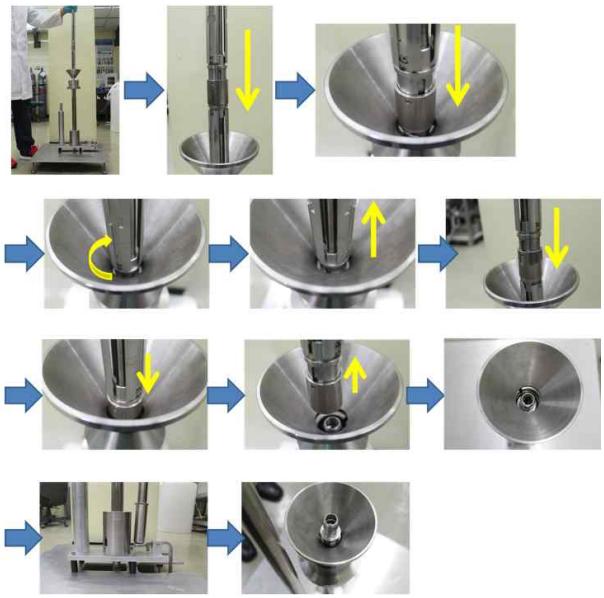

Fig. 5. Performance test of the developed disassembly tool

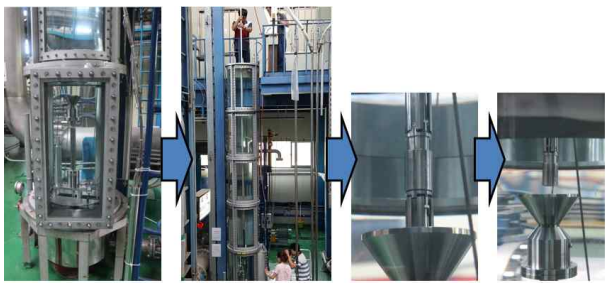

Fig. 6. Out pile test of the developed disassembly tool

3. Conclusions

In this study, a modified coupler design to disassemble the non-instrumented fuel rod assembly from the test rig for the intermediate examination was suggested to solve interference problem of previous design. The performance of the modified design was verified by test mockup fabricated with the modified coupler design and accompanied disassembly tool design. Finally, out pile test was carried out in the single channel test loop in the KAERI, and the test rig and the disassembly tool showed good performance and reliability. The developed technique will be useful to the periodic intermediate examination of nuclear fuel rods.

ACKNOWLEDGEMENTS

This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIP) (2012M2A8A5010535).

REFERENCES

[1] J. T. Hong, S. H. Heo, K. H. Kim, S. J. Park, and C. Y. Joung, Development of Disassembly Tool for Intermediate Examination of Nuclear Fuel Rods, Trans. Korean Soc. Mech. Eng. A, Vol. 38, No. 4, pp. 443-449, 2014.
[2] J. T. Hong, S. H. Ahn, K. H. Kim, C. Y. Joung, Development of Tools for Treating an Irradiated Fuel Rod Assembly in the Pool of HANARO, Proc. of IGORR 2013, 2013.