Improvement on the End Plug for an Instrumented Nuclear Fuel Rod for the Irradiation Test at HANARO

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1. Introduction

An instrumented capsule for a nuclear fuel irradiation test (hereinafter referred to as "instrumented fuel capsule") has been developed to measure the fuel characteristics, such as the centerline and surface temperatures of nuclear fuels during an irradiation test at HANARO(High-flux Advanced Neutron Application Reactor) [1,2]. A C-type thermocouple was used to measure the centerline temperature of the nuclear fuels, a K-type thermocouple was used to measure the surface temperature [3]. An instrumented fuel capsule contains three instrumented nuclear fuel rods. An instrumented fuel rod for measuring the temperature consists of a cladding, a seal tube, a thermocouple, a nut and an end plug body. A seal tube has been used to fix a thermocouple to the end plug body and to seal the fuel rod. A thermocouple has been fixed at the end of a seal tube by laser or EB welding, and a seal tube was fitted at an end plug body by a nut. Fig. 1 shows the schematic view of a seal tube.

But sometimes the helium leakages were detected at the fitting surface between a seal tube and an end plug body. Therefore we are in need of improvement on the end plug of an instrumented fuel rod.

In this paper, we designed and fabricated a new end plug for an instrumented nuclear fuel rod using VCR(Vacuum Coupling for the Radlab, Swagelok). And we performed the out-pile tests for the new end plugs.

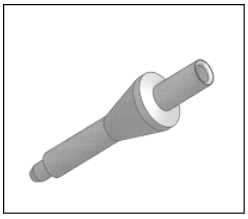

Fig. 1. Schematic View of a Seal Tube

2. Improvement on the End Plug using VCR for an instrumented fuel rod

2.1 The Concept of VCR

The typical VCR assembly consists of a female nut, a grand, a gasket and a body as shown in Fig. 2. The female nut and grand were made of stainless steel, gasket was made of stainless steel, nickel or copper.

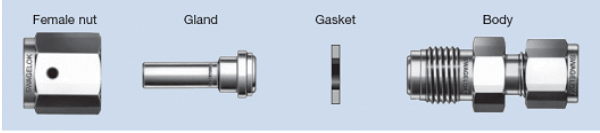

Fig. 2. A Typical VCR Assembly

2.2 Design and Fabrication of the End Plug using VCR

We designed a new end plug using VCR for an instrumented fuel rod. A female nut, a grand and a gasket were made of STS-316L and a end plug body was made of Zircaloy-4 or STS-316L. We drilled out a center hole(Ø1 mm) through the grand to insert a thermocouple. Fig. 3 shows the parts and assembly of the end plug using VCR.

Fig. 3. The End Plug using VCR (before and after assembling)

3. The out-pile tests of the end plug using VCR

The major function of the end plug of an instrumented fuel rod is the sealing of helium gas. Therefore a helium leak test is necessary to the assembly of an instrumented fuel rod. Therefore we fabricated a jig for helium leak test of the new end plug using VCR as shown in Fig. 4.

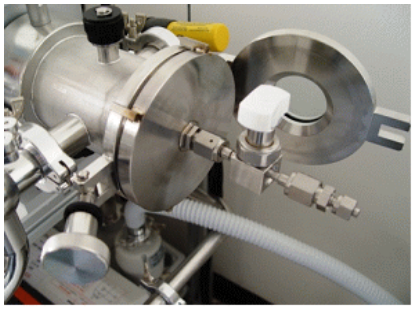

Fig. 4. A Jig for Helium Leak Test of the End Plug using VCR

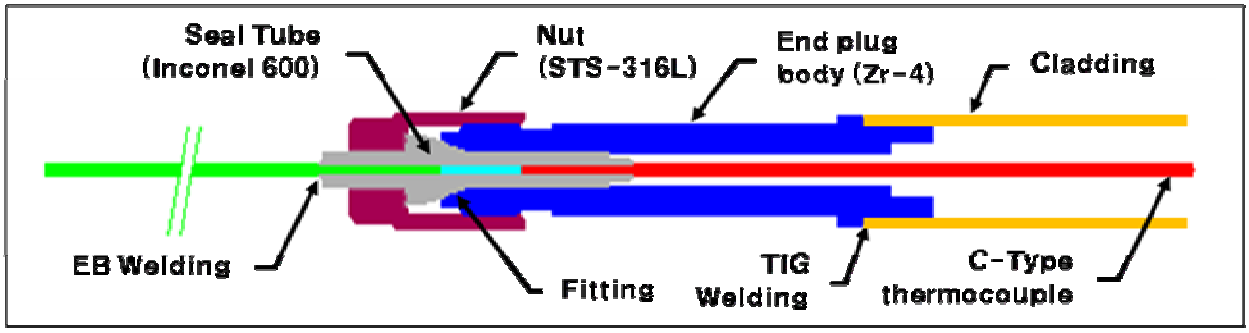

Fig. 5. The End Plug of a Instrumented Fuel Rod using a Seal Tube (old-type)

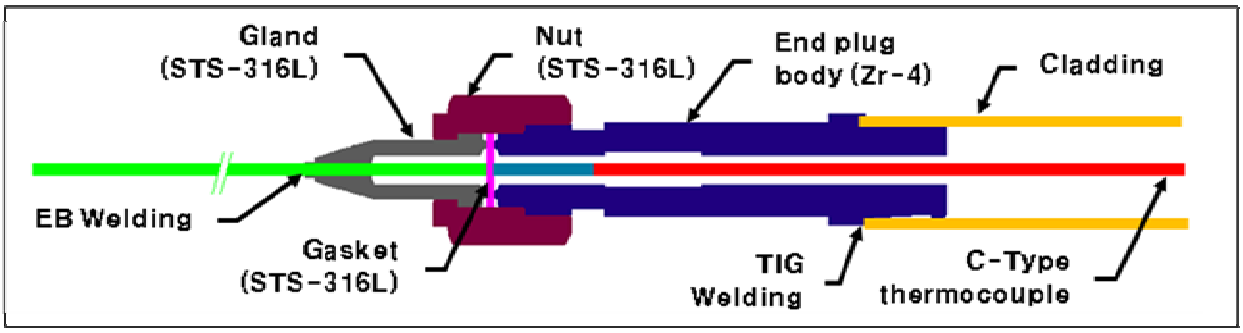

Fig. 6. The End Plug of a Instrumented Fuel Rod using a VCR (new-type)

Fig. 5 shows the structure of an old-type end plug using a seal tube and Fig. 6 shows a new end plug using VCR.

The fuel rod mockups with a new end plug were filled with helium gas of a gauge length of 3.0 kg/cm^2 or 22.5 kg/cm^2 using the jig. The helium leak tests were performed at the room temperature, 70℃ and 300℃. Fig. 7 shows a result of helium leak tests, the helium leak tests were performed repeatedly from room temperature to 300℃. And all the tests were performed after maintaining each temperature during 5 hours. In the helium leak tests of the new end plugs, a leakage of helium gas was not detected.

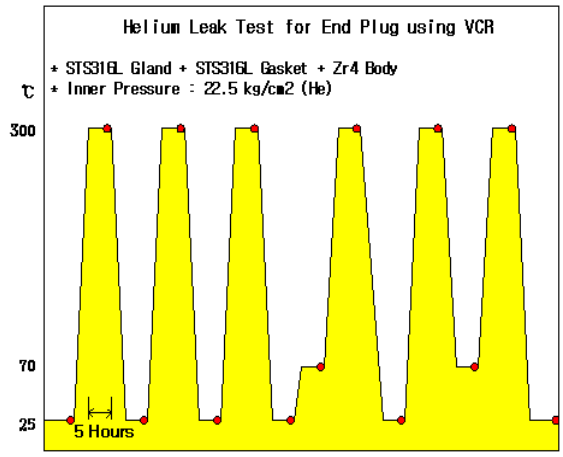

Fig. 7. The Helium Leak Test of a New End Plug using VCR

4. Conclusion

The new end plug using VCR has been designed successfully. And the results of the helium leak tests showed a good performance. The new end plug using VCR will be used at the instrumented fuel rods for the irradiation tests of the nuclear fuels.

The in-pile tests of the new end plug will be carried out in an experimental hole of HANARO in 2010.

Acknowledgement

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