A Study of Mechanical Sealing Methods Using Graphite Powder for High Pressure Vessel

H. Y. Jeong [a*], J. T. Hong [a], S. H. Ahn [a], C. Y. Joung [a]
[a] *Korea Atomic Energy Research Institute., P.O. Box 366, Yuseong, Daejeon, Korea, 305-600*
[*] *Corresponding author: jhy@kaeri.re.kr*

1. Introduction

The Fuel Test Loop (FTL) is a facility that can conduct fuel irradiation tests at the HANARO (High-flux Advanced Neutron Application Reactor). The FTL simulates commercial NPP operating conditions such as pressure, temperature and neutron flux levels to conduct irradiation and thermo-hydraulic tests [1],[2]. It is composed of an In-Pile test Section (IPS) and an Out-Pile System (OPS).

The OPS contains a pressurizer, cooler, pump, heater and purification system, which are necessary to maintain the proper fluid conditions. In addition, the OPS contains engineered safety systems that can safely shutdown both HANARO and FTL if an accident occurs. The IPS accommodating fuel pins has a loaded IP-1 hole in HANARO, and a double pressure vessel for the design conditions of 350℃, 17.5MPa and is composed of an outer assembly and inner assembly. It has instruments such as a thermocouple, LVDT and SPND to measure the fuel performances during the test [3].

FTL coolant is supplied to the IPS at the core of commercial nuclear power plants at the same temperature, pressure and flow conditions. Sensors are installed on the inside of the IPS to send signal transmission MI-Cables to the outside for instrumentation through the pressure boundary. Therefore, the pressure boundary should be maintained in the sealing performance.

Currently, the sealing of the IPS of the the FTL is maintained through a brazing method. However, A brazing method has disadvantages that can occur owing to thermal deformation or breakage in the instrumentation Mi-cable. IPS inner assembly is a very long design length (approximately 5.29m), so it is difficult to perform in a vacuum chamber. Therefore, an easy and reliable way to assemble the instrumentation Mi-cable mechanical sealing method has been studied [4].

In this study, criteria tests at the pressure boundary were performed using universally applicable graphite powder for the instrumentation MI-cable of various sizes.

2. Graphite sealing

2.1 Graphite powder

In this study, the graphite powder is BD-100PC(Samjungcng) and consist of a 10 mesh screen size for flexible particles. The chemical properties used in the tests are shown in Table 1.

Table 1. Chemical properties of Graphite used in tests.

	Unit	Test basis	Value
Carbon content	% min.	ASTM C 561-91	99.0
Moisture	% max.		0.5
Chloride content	ppm max.	ASTM F 1277-95, D-512	37

2.2 Mechanical Sealing Methods

The inner assembly of the IPS is difficult to brazing. Therefore, mechanical sealing methods were investigated. The graphite powder is used to replace the brazing for sealing at pressure boundary. And, The pressure boundary is formed by compressing its surrounding structures by applying it in a simple and reliable way to maintain the pressure of the pressure vessel.

Fig. 1 using graphite powder shows how to combine the mechanical sealing methods, using graphite powder.

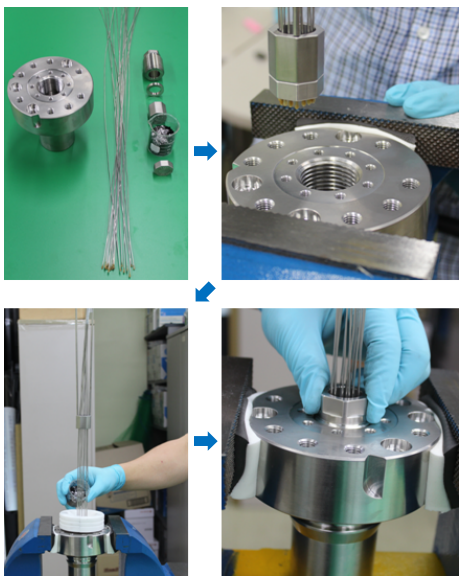

Fig. 1 Mechanical Sealing Method Using Graphite Powder

3. Hydraulic test and Helium leak test

3.1 preformance criteria

The IPS flows coolant of the same commercial nuclear power plants because of the high pressure and temperature of the coolant flow. The IPS design condition pressure is 17.5MPa and temperature is 350 ℃. A hydrostatic test(design pressure 125%) and helium leak test (Leak rate: 5×10^{-9}torr·liter / sec) of the sealing performance criteria were decided by a Sealing Plug. A device for a helium leak test and a hydraulic test was fabricated for graphite sealing of the instrumentation feedthrough to determine the integrity at The pressure boundary of The FTL IPS. Graphite sealing places were performed using a fabricated device.

3.2 Hydraulic test

Hydraulic test were inflicted pressure using a hand pump. It was confirmed at 10 min that a pressure at 22.5MPa (design pressure × 1.25) was maintained, and no water leak was confirmed in the test places. Fig. 2 shows the hydraulic testing device and the test pressure(22.5MPa).

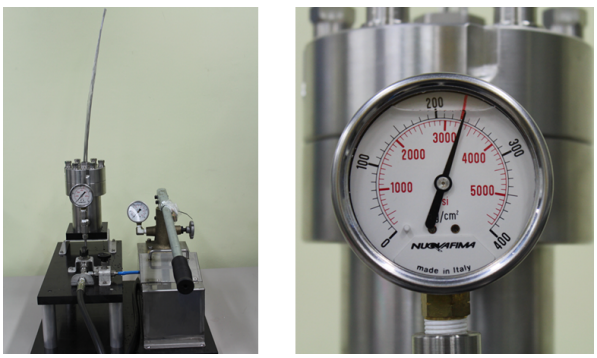

Fig.2 The hydraulic testing device and test pressure (22.5MPa)

3.3 Helium leak test

A helium leak test was performed with a vacuum process using ASM310 models of Alcatel. The results performed on the following criteria were satisfied (Fig.3).

- He leak test : 2.4×10^{-9} torr·liter / sec

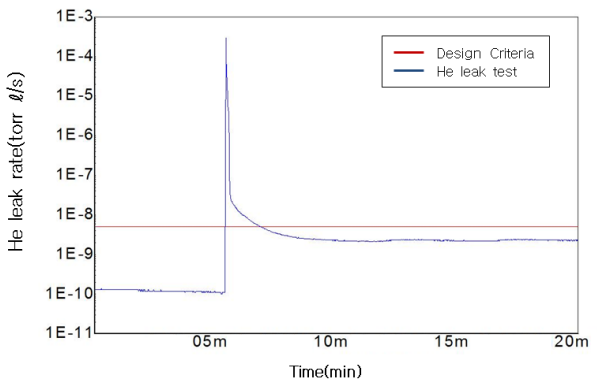

Fig. 3 Result of helium leak test

4. Conclusions

In this study, criteria tests at the pressure boundary were performed using universally applicable graphite powder for an instrumentation MI-cable of various sizes.

The results of performance test for graphite(powder) sealing were satisfying .

- Hydrostatic test : 22.5MPa
- Helium leak test : 2.4×10^{-9} torr·liter/sec

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