Brazing of Sealing for Instrumentation Feedthrough of high Pressure Vessel

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

1. Introduction

Fuel Test Loop(FTL) is a facility which could conduct a fuel irradiation test at HANARO(High-flux Advanced Neutron Application Reactor). FTL simulates commercial NPP's operating conditions such as the pressure, temperature and neutron flux levels to conduct the 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 could safely shutdown both HANARO and FTL if an accident occurs. The IPS accommodating fuel pins has loaded IP-1 hole in HANARO has a double pressure vessel for the design conditions of 350℃, 17.5MPa and is composed of 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 and the same temperature, pressure and flow conditions. Sensors installed on the inside of IPS to send a signal transmission MI-Cables to the outside for instrumentation is through the pressure boundary. Therefore, pressure boundary should be maintained in the sealing performance.

Brazing is typically lower than the melting point of material without melting the material almost would be like welding when it is necessary to use. It is commonly used to use BAg(ASME II SFA-5.8 UNS-P07563) filler metal, but corrosion occurs containing a large quantity of copper in Bag, and when contact with the coolant, the coolant water quality is influenced. Therefore, using BNi-2(ASME II SFA-5.8 UNS-N99620) filler metal is considered. Brazing at the Sealing Plug in the top of IPS was considered for Mi-cable's integrity and to maintain the pressure boundary.

After brazing is performed, brazing the Mi-cable integrity and pressure boundary sealing performance was tested.

2. Brazing of Instrumentation Feedthrough

2.1 preformance criteria of Brazing Sealing Plug

The IPS flows the coolant of the same commercial nuclear power plants because of the high pressure and temperature of the coolant flow, IPS design condition pressure is 17.5MPa and temperature is 350 ℃. Brazing sealing Plug design conditions pressure is 17.5MPa and temperature is 350 ℃. 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 Sealing Plug, mi-cable to the integrity was measured the insulation resistance .

2.2 MI-Cable

In this study, the MI cable of C-type thermocouples, LVDT and SPND are used. MI-cable is composed of signal lines insulated with alumina as the metal sheath, and its property used in the tests are shown in Table 1.

Table 1. Property of MI-cable used in tests.

T.C.	Material (diameter)		
	Sheath	Insulator	Wires
C-type	AISL 316L (OD : 1.0±0.01mm) (ID : ≒0.82mm)	Al_2O_3	Alloy 405[+] / Alloy 426[-] (0.18mm)

2.3 Filler metal

According to ASME code(ASME II SFA-5.8 UNS - N99620), nickel based Filler metal(BNi-2) was selected. BNi-2 was used to paste type(NickelbrazeTMHTN2).

2.4 Brazing

IPS inner assembly is a very long Design length (approximately 5.29m) so it is difficult to perform in a vacuum chamber. Thus, as shown in Fig 1, Brazing was carried out using coil of High frequency induction heating to heat Induction Brazing methods. In addition, Furnace Brazing was carried out to compare the Brazing performance.

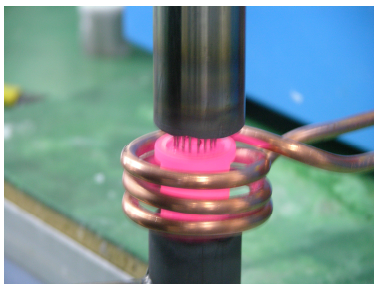

Fig. 1 induction brazing

3. Result of a performance test

3.1 Measurements of insulation resistance

Before and after brazing the Mi-cable to determine whether the damage TOADKK's Ultra Megohm meter SM-8220 was measured using the insulation resistance. In Fig 1, insulation resistance was measured at Before Brazing and after brazing.

(A) + of the internal signal line and sheath,
(B) - of the internal signal line and sheath,
(C) + and - of the internal signal line

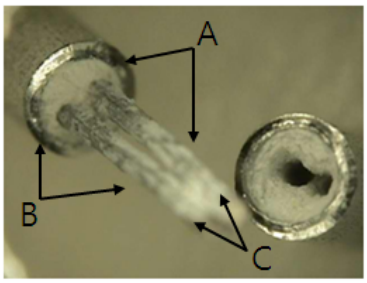

Fig. 2 Measurements part of insulation resistance

Results were shown in Table 2. The result of insulation resistance measurements at after brazing was $1.00 \times 10^{11}\Omega$.

Table 2. The result of insulation resistance measurements (unit : $10^{11}\Omega$)

No.	Brazing before			Brazing after		
	A	B	C	A	B	C
1	1.17	0.99	0.97	6.00	6.85	6.98
2	1.10	1.00	0.89	2.10	1.23	1.23
3	1.06	1.04	0.93	3.02	3.52	2.75
4	1.14	1.12	0.67	6.08	5.77	3.74
5	1.47	1.03	1.00	7.10	5.70	5.60
6	1.23	1.06	0.77	3.10	2.55	2.00
7	1.21	1.08	0.74	5.82	5.80	3.94
8	1.05	1.02	1.04	4.58	4.14	5.47
9	1.25	1.17	0.50	4.51	4.24	2.97
10	1.09	1.00	0.67	5.24	4.36	4.67
11	1.31	0.97	0.83	3.07	2.42	4.12
12	2.33	1.65	1.42	2.67	5.39	6.79
13	1.15	1.10	0.75	5.62	4.62	4.14
14	0.16	0.11	0.14	1.97	1.55	1.60
15	10.3	2.28	3.19	4.19	4.62	2.87
16	1.28	1.04	1.05	2.62	2.27	3.27

3.2 Hydraulic test and Helium leak test

The device for a Helium leak test and a hydraulic test was fabricated for brazing of Instrumentation Feedthrough in order to determine the integrity at Pressure boundary of FTL IPS. The next places were performed using Fabricated the device.

- Top Flange and Head connecting place
- Top Flange and Sealing Plug connecting place
- brazing area of Sealing Plug and Mi-cable (16 holes)

3.2.1 Hydraulic test

Hydrostatic were Inflict pressure using a hand pump. It was confirmed at 10 min that pressure 24.5MPa higher than the test pressure 22.5MPa (design pressure × 1.25) is maintained, no water leak were confirmed in the test places.

3.2.2 Helium leak test

Helium leak test was performed with the vacuum process using ASM310 models of the Alcatel. Results performed on the following criteria were satisfied.

- Furnace brazing : 2.0×10^{-9} torr·liter / sec
- Induction brazing : 2.3×10^{-9} torr·liter / sec

3. Conclusions

In this study, brazing materials and FTL coolant consider suitability, and the brazing of using BNi-2 was performed in two methods.

- Furnace brazing (Vacuum)
- Induction brazing (Ar)

Results of performance test for brazing sealing plug were satisfying .

- Insulation resistance : more than $1.00 \times 10^{11}\Omega$
- Hydrostatic test : 22.5MPa
- Helium leak test : 5×10^{-9} torr·liter/sec

REFERENCES

[1] S. H. Ahn., et. al., "Operation of fuel test loop for irradiation test of PWR fuels in HANARO," *Proc. of the 3rd International Symposium on Material Testing Reactors*, Czech Republic, 2010

[2] S. H. Ahn., et. al., "Fuel test loop in HANARO," *Proc. of the 2008 Water Reactor Fuel Performance Meeting*, Seoul, Korea, 2008

[3] J. M. Lee., et. Al., "In-Pile Section(IPS) Inner Assembly Manufacturing Report," *KAERI/TR-3973/2009* KAERI, 2009