Study of an induction brazing process for the instrumentation feed through part

Jintae Hong [a*], Sung-Ho Ahn [a], Chang-Young Joung [a], Ka-Hye Kim [a], Sung-Ho Heo [a]
[a] *Neutron Utilization Technology Division, KAERI, Daedeok-daero 989-111, Yuseong-gu Daejeon*
[*] *Corresponding author: jthong@kaeri.re.kr*

1. Introduction

A loop is a facility to carry out irradiation test for nuclear fuels and materials in a research reactor by measuring the irradiation behavior of them in a timely manner. Because flow condition of coolant in a loop should be the same with that of NPPs', highly pressurized (15.5 MPa) and highly heated (300℃) coolant is circulated through the loop. Therefore, sealing of the pressure boundary is one of the most important processes in fabricating the in-pile test section (IPS).

In particular, sensors such as thermocouples, LVDTs and SPNDs are attached in a test rig and deliver signals to the measuring device at the outside of the reactor pool through instrumentation cables, which pass through the pressure boundary of the test rig. Therefore, it needs to seal out the instrumentation feed through part to not leak the coolant.

In general, brazing is used to seal out the feed through part of thin wires, and several studies in nuclear fields used brazing as a sealing method [1-3]. However, previous techniques using a manual torch or an induction brazing by blowing Ar gas as a shield gas cannot avoid soot, which is difficult to remove. In addition, because their brazing quality is not uniform, instrumentation cables cannot deliver signals due to damage of excessive heat.

In this study, an automatically controlled induction brazing system has been developed including a vacuum chamber to prevent generation of soot.

2. Development of an induction brazing system

Fig. 1 shows the modeling of the IPS and marked area is the sealing area. According to the assembly process, the marked area is assembled after most of components are assembled. Therefore, it needs to lift the assembly upside down to carry out brazing at the marked sealing area. Because the radioactive coolant touches the brazed part during irradiation test, BNi-2 needs to be used as a filler metal based on the ASME section II SFA-5.8 to not pollute the coolant in the test loop. In addition, because a test rig is 5.29 meters long and it is difficult to make vacuum state during brazing process, old studies used Ar as a shield gas. In this study, a special chamber on which a long vessel can be connected is developed to carry out the induction brazing in the vacuum state. To eliminate most of oxygen in the chamber, the chamber has inlet system of helium gas in addition to the evacuating system.

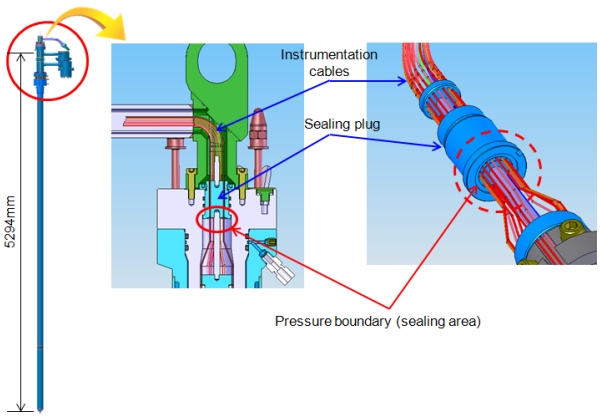

Fig. 1. Sealing area of the instrumentation cables in the IPS

Fig. 2 shows the developed induction brazing system. The induction heater is controlled with a frequency of 25 KHz ± 5 KHz, and the brazing component can be heated up to 1250℃. The induction coil is designed as a brass tube and water is circulated through the tube to cool down the surface temperature of the coil. A K-type thermocouple can be installed on the brazing component to measure its temperature and deliver the signal to the controller. The controller controls the induction heater by comparing the measured temperature and programmed temperature of the brazing component.

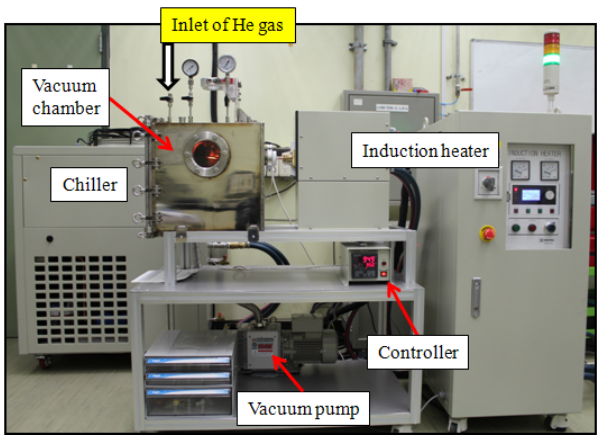

Fig. 2. Vacuum induction brazing system

In this study, because paste-type BNi-2 (melt temperature 970℃ ~ 1040℃) is used as a filler metal,

brazing temperature is controlled 1000℃. The sequence of brazing the sealing plug is as follows:

(1) Acid pickling for the MI cables and a sealing plug using HNO_3.
(2) Assemble the MI cables and the sealing plug by passing through the holes in the sealing plug.
(3) Spread paste on the MI cables and let the paste sit on the groove of the sealing plug by adjusting the sealing plug. Then, dry the paste in the air for 24 hours.
(4) Put the sealing plug assembly in the protection module and install it on the chamber.
(5) Install K-type thermocouple on the sealing plug and close the chamber.
(6) Evacuate the chamber up to 2.5 x 10^{-4} Torr. Then, fill the helium gas with 1.5 atm. Repeat it 2 times.
(7) Evacuate the chamber up to 2.5 x 10^{-4} Torr.
(8) Program the controller to heat the sealing pug up to 1000 ℃ within 5 minutes and maintain 30 seconds.
(9) After the sealing plug assembly is cooled down below 120℃, relieve vacuum state in the vacuum chamber. Then, open the chamber and take out the assembly.

3. Result of experiment and conclusion

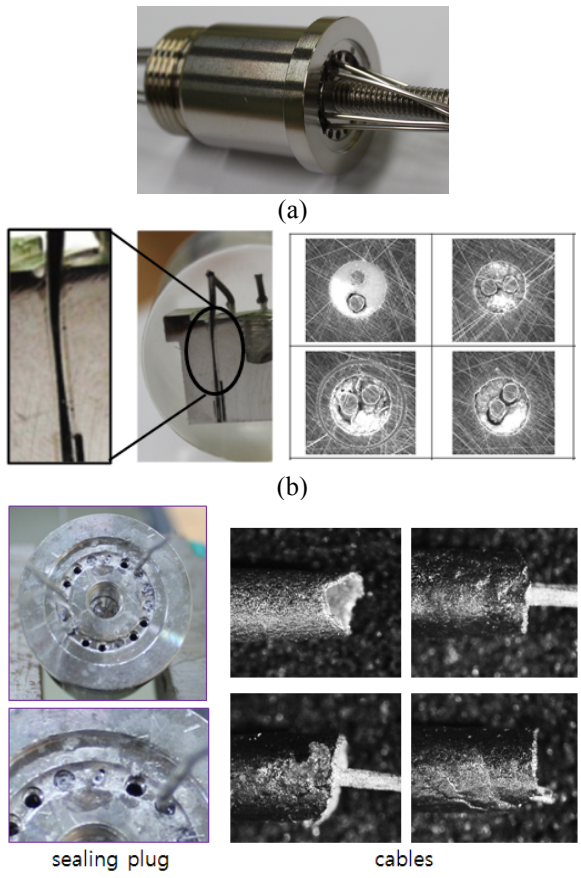

Fig. 3. Result of induction brazing on the sealing plug (a) Brazed sealing plug (b) Sectional view of brazing area (c) Tensile test of brazed MI cables

Fig. 3 shows the result of the induction brazing for the sealing plug assembly. The sealing plug assembly is well brazed without soot and filler metal wets well around the MI cables. As shown in Fig. 3(b), BNi-2 is well infiltrated through the brazing gap. According to Fig. 3(c) which shows the result of tensile test of the brazed MI cables, MI cables are not damaged so much because it shows ductile fracture.

To check the sealing performance, a hydraulic pressure test and a helium leak test were carried out according to the ASME section III. According to the ASME code, because design pressure of the IPS is 17.5 MPa, the criterion for the hydraulic pressure test is 21.9 MPa. The test result was that there was no leakage of water and pressure drop under 22.5 MPa of hydraulic pressure. And, the criterion for the helium leak test is 5x10^{-9} Torr·liter/sec. Accoding to the test result, the helium leak rate is 2.3 x 10^{-9} Torr·liter/sec and it satisfies the criterion.

From the above test results, it was verified that the developed brazing system has a good performance in sealing out the instrumentation feed through part with uniform quality.

Acknowledgement

This research has been carried out as a part of the nuclear R&D program funded by the Ministry of Science, ICT and Future Planning in Korea.

REFERENCES

[1] Y. H. Hwang, J. Y. Kim, H. K. Lee, J. H. Koh, and S. Y. Oh, A study on the Comparison of Brazed Joint of Zircaloy-4 with PVD-Be and Zr-Be Amorphous alloys as Filler Metals, Journal of Korea Academia-Industrial cooperation Society, Vol. 7, No.2, pp. 113-119, 2006.
[2] K. T. Shim, M. S. Cho, and K. N. Choo, A study on the Brazing using Inconel 600 and STS 310 Materials, Journal of the Korean Society of Mechanical Technology, Vol. 13, No.2, pp. 145-153, 2011.
[3] H. Y. Jeong, J. T. Hong, S. H. Ahn, C. Y. Joung, J. M. Lee, and C. Y. Lee, Development of Sealing Technology for Instrumentation Feedthrough of High Pressure Vessel, Journal of the Korean Society of Mechanical Technology, Vol. 13, No.2, pp. 137-143, 2011.