Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, October 25-26, 2012

The Moisture-Proof Connection of Signal Cables on Test Rig Instrumentation

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1. Introduction

The rod inner pressure, centerline temperature, coolant temperature, and neutron flux resulting from the irradiation properties of nuclear fuel are an important factor for evaluating nuclear fuel properties in pile. In addition instrumentation and measurement techniques for nuclear fuel are necessary to measure the exact data. Special sensors such as a TC (thermocouple), LVDT (linear variable differential transformer) and SPND (self-powered neutron detector) are instrumented in and out of the fuel rod to measure the various irradiation characteristics of the nuclear fuel [1]. These sensors are made up of the sensor itself and a signal cable. In the instrumentation, an MI (Mineral Insulated) cable used as the signal cable has such properties as high electrical insulation, heat resistance, and mechanical strength [3]. However, it is difficult to handle and treat with care owing to the extremely hard composition, which is made up of weak signal wires and alumina powder in a stainless tube. The sealing of the end tip of the MI cable and extension cable is very important in terms of the insulation resistance to seal the insulator inside the MI cable tube from moisture [3]. To maintain the insulation of sensors and signal cables, the insulation resistance must be checked in accordance with each process throughout the instrumentation and fabrication period. To safely mount the signal cables drawn from a fuel test rig on the terminal block of a junction panel, the MI and extension cables should be easy to connect. Therefore, it is necessary to develop instrumentation technologies of a moisture-proof connection process for a fuel test rig.

This paper will provide an overview of the work done with moisture-proof connection procedures to connect the MI and extension cables to extend the MI cables jointed with the sensor.

2. Methods and Results

2.1 The joint of signal wires

The MI cables over the fuel test rig assembly coming from the seniors mounted around a fuel rod must be joined with the extension cables for easy instrumentation handling and to extend the signal cable from the MI cable of sensors. Therefore, the joint experiments for the signal wires of the MI cable and the extension cable were fulfilled by silver brazing. The photographs before and after the silver brazing of the signal wires are shown in Fig. 1. In the metal joints, silver brazing is the most general process and uses a silver alloy. The material used in this test is BAG-7 paste mixed with a silver alloy (Ag56%+Cu22%+ Zn17%+Sn5%) and flux (FB3-C). It has low a melting point (872℃), high penetrability, good ductility and corrosion resistance property**.**

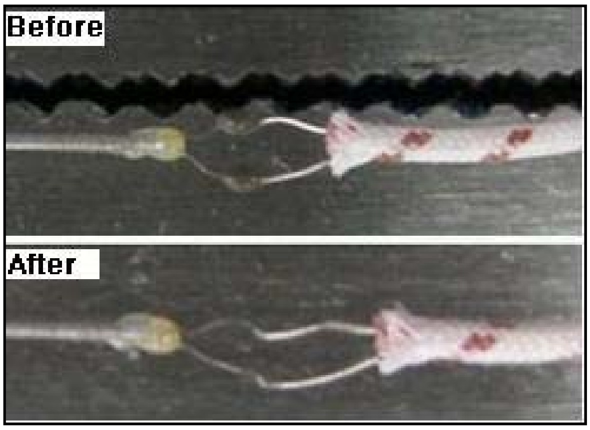

Fig. 1 Photographs before and after the silver brazing of the signal wires

2.2 Moisture-proof connection

The joint component used for the moisture-proof connection is Araldite 2020 (XW 396/XW 397). Araldite 2020 has a two-component, room temperature cured, low-viscosity adhesive specifically designed for glass bonding. It is also suitable for bonding a wide variety of metals, ceramics rubbers, rigid plastics and most other materials in common use. Resin (Araldite 2020/A) and a hardener (Araldite 2020B) were branded in scale cup. The mixed composition ratio for the resin and hardener was 100 to 30 by weight or 100 to 35 by volume. The mixed compound was stirred for about 10 minutes until it formed a homogeneous mixture. It was completely cured for 16 hours at 23℃. The moisture-proof connection process of the MI and extension cables was as follows: First, a thermal contractile tube 80mm in length and 8mm in diameter is placed around the joint part between the MI cable and the extension to connect the two cables, and the joint point of MI and extension cables must be confirmed to have no contact between the wire conductors. Second, the signal wire conductors of the MI and extension cables should be clean. The joint part of the signal wires is uniformly covered with silver paste, and then heated by a torch. After the silver brazing is completed, the thermal contractile tube placed previously around the signal cable is moved to the center of the joint part, and the lower end of thermal contractile tube is heated by a torch until it shrinks. Third, an Araldite mixture through the upper end of the thermal contractile tube is filled to about 5mm from the thermal contractile tube top by an injector. Finally, the upper end of the thermal contractile tube is heated by a touch.

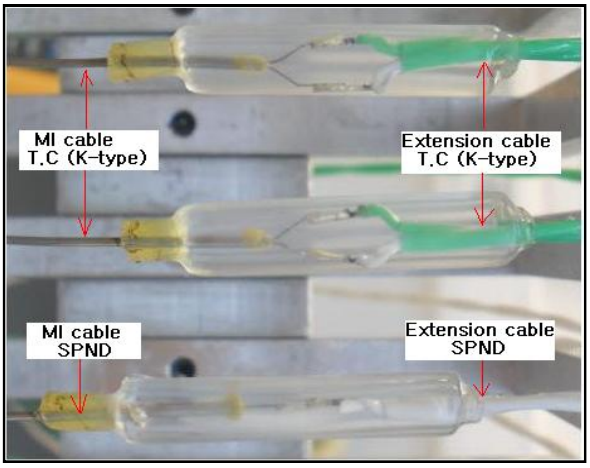

Fig. 2 Photograph of the specimens connected by the moisture-proof connection process

The photograph of the MI cable/extension cable specimens connected using the moisture-proof connection methods is shown in Fig. 2. The signal cables (green color) on the upside in this figure are K-type thermocouples and those on the bottom (white color) are SPNDs.

2.3 Soundness confirmation

The soundness of the moisture-proof connection of the signal cables was confirmed after joining the cables. A visual inspection was complemented to confirm the specimens treated with test conditions. All the samples connected by the moisture-proof connection were well-connected. To reduce the measurement errors to a minimum, the insulation resistance of moisture-proof connected signal cable for electrical verification was measured using a Megger (SM-8220). The insulation resistance values of all samples fulfilled by the moisture-proof connection experiment were more than 10 [GΩ]. The soundness of the moisture-proof connection method has been confirmed through electrical measurements and analyses.

3. Conclusions

The moisture-proof connection process of MI and extension cables, which are used to transmit signals from the sensors, was investigated using connection methods. In the connection test, moisture-proof technologies extending the signal cables from the MI cables were newly developed for use as a signal cable for certain sensors. The soundness of the connected specimen was confirmed through a visual inspection and electrical measurements. All samples connected by the moisture-proof connection process were satisfied for the general requirements.

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