Studies of Behavior Melting Temperature Characteristics for Multi Thermocouple In-Core Instrument Assembly

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Introduction

Bottom-up type in-core instruments (ICIs) are used for the pressurized water reactors of OPR-1000, APR-1400 in order to measure neutron flux and temperature in the reactor. It is a well-known technique and a proven design using years in the nuclear field. ICI consists of one pair of K-type thermocouple, five self-powered neutron detectors (SPNDs) and one back ground detector. K-type thermocouple's purpose is to measure the core exit temperature (CET) in the reactor. The CET is a very important factor for operating nuclear power plants and it is 327℃ when generally operating the reactor in the nuclear power plant(NPP) in case of OPR-1000. If the CET will exceed 650℃, Operators in the main control room should be considered to be an accident situation in accordance with a severe accident management guidance(SAMG). The Multi Thermocouple ICI is a new designed ICI assuming severe accident conditions. It consists of four more thermocouples than the existing design, so it has five K-type thermocouples besides the thermocouple measuring CET is located in the same elevation as the ICI. Each thermocouple is able to be located in the desired location as required. The Multi Thermocouple ICI helps to measure the temperature distribution of the entire reactor. In addition, it will measure certain point of melted core because of the in-vessel debris of nuclear fuel when an accident occurs more seriously. In this paper, to simulate a circumstance such as a nuclear reactor severe accident was examined.

Test Method

❑ *Multi Thermocouple ICI*
- ✓ *Two samples of Multi Thermocouple ICI were manufactured as shown in Figure 1. They were exactly produced as same as the actual production. Only difference is the length and intervals.*
- ✓ *Each thermocouple was located with 20 centimeter spacing from the end. The latter part was connected to an extension cable to obtain EMF signal data.*

❑ *Electrical Induction Furnace*
- ✓ *The temperature of furnace was maintained at 1610℃ during the melting test.*

❑ *Data Acquisition System*
- ✓ *Temperature and voltage data of thermocouples were acquired by data acquisition of Agilent 34970A while it was inserted into the furnace at a constant rate.*

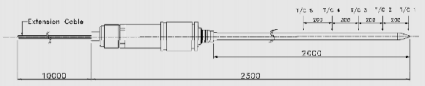

Fig. 1. Test Sample of Multi Thermocouple ICI

Fig. 2. Test Samples and Electrical Induction Furnace

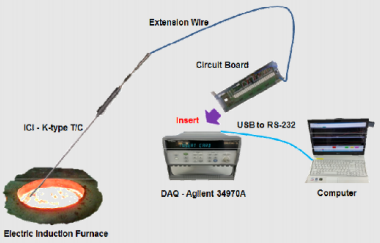

Fig. 3. The Diagram of Test Method

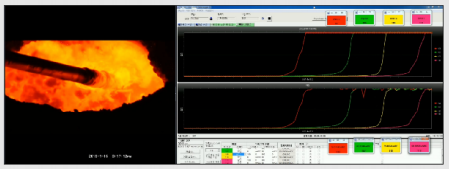

Fig. 4. Insertion Test and Data Acquisition

Test Results & Conclusions

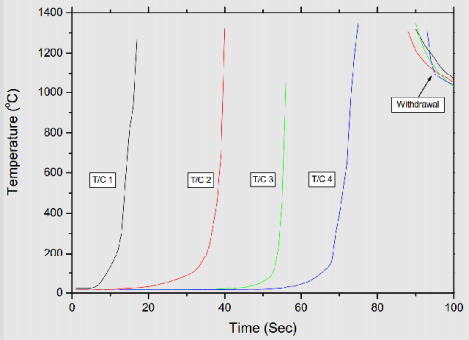

Fig. 5. Test Result of Sample No. 1

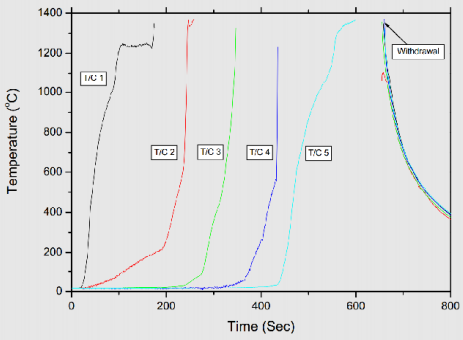

Fig. 6. Test Result of Sample No. 2

Table. I. Temperature data of Sample No. 1

T/C No.	Last Temp. (℃)	Maximum Temp. (℃)
1	1270.34	1316.23
2	1321.93	1305.93
3	1047.58	1346.24
4	1358.87	1316.55

Table. II. Temperature data of Sample No. 2

T/C No.	Last Temp. (℃)	Maximum Temp. (℃)
1	1327.85	1347.10
2	1370.44	1370.44
3	1326.28	1356.62
4	1231.43	1370.37
5	1367.82	1326.73

❑ *Multi Thermocouple ICI (Sample No.1)*
- ✓ *Once each thermocouple junction was melted, it was directed to the infinite value of EMF in the program.*
- ✓ *The reason for directing the four thermocouples at approximately the same temperature at the withdrawal point is that all junctions of the four thermocouples were re-made at a single point by melting.*

❑ *Multi Thermocouple ICI (Sample No.2)*
- ✓ *the sample was inserted very slowly into the furnace. So the values of EMF between last temperature and withdrawal temperature were severely hunted.*

❑ *Conclusions*
- ✓ *The K-type thermocouples of Multi Thermocouple ICI was confirmed experimentally to be able to measure up to 1370℃ before the thermocouples have been melted.*
- ✓ *And after the thermocouples were melted by debris, it was able to be monitored that the signal of EMF directed the infinite value of voltage.*
- ✓ *Therefore through the results of the test, it can be assumed that if any EMF data among the Multi Thermocouple ICI will direct the infinite value, the reactor core will be damaged as to the position of installed that thermocouple.*
- ✓ *Also, It is able to know that if the temperature data of the thermocouple will be decreased below 1300℃ by properly controlled after a severe accident, it can be confirmed to re-make a new thermocouple junction at a withdrawal point.*
- ✓ *In that case, the operators of nuclear power plant can make sure that the severe accident mitigation action is effective.*

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