

The Development of LVDT for the Pressure and Elongation Measurement of an Irradiation Test Fuel Rod

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1. Introduction

Irradiation test using a capsule has been performed for fuel or material performance test in the test reactor. Instruments and instrument attachment technology have been developed for an irradiation test. The LVDT (Linear Variable Differential Transformer) is measuring the elongation and the pressure of nuclear fuel rod during the irradiation test. This device is a radiation resistant LVDT to use in a research reactor. The LVDTs for an irradiation test have been used Norway Halden's development LVDTs in the KAERI but the KAERI is developing a new LVDT since 2007 because of high cost. This paper describes about the design of LVDT and the fabrication of LVDT that is developed until present.

2. Design of LVDT for Elongation Measurement

The elongation LVDT can be used for the measure of fuel stack elongation and material elongation. Fig. 1 is design of the elongation LVDT. Halden's elongation LVDT is consisted of two parts of LVDT and core assembly. A core assembly of Zir-4 material and an out tube of inconel material are connected with a screw. But the elongation LVDT of the KAERI is used Zir-4 material and two parts are welded by laser. Also MI (Mineral Insulated) cable for primary cable and second cable uses one cable with 4 conductors. LVDT bobbins are used alumina materials for the high insulation [1].

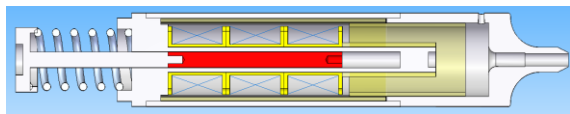


Fig. 1. Design of the Elongation LVDT

3. Design of LVDT for Pressure Measurement

The pressure LVDT is used for the measure of fission gas pressure during an irradiation test. Fig. 2 is design of the pressure LVDT. A LVDT is a same design like an elongation LVDT but lower part has a metal bellows. The material of pressure transducer and LVDT is a same Zir-4, so it can be welded easily. But bellows material is STS300 and it must be welded with Zir-4 material. Therefore we are studying about dissimilar welding of STS to Zir-4.

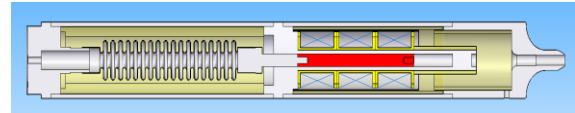


Fig. 2. Design of the Pressure LVDT

4. Fabrication of LVDT

The welding is very important for fabrication of LVDT. We are using a fiber laser welding system as shown in Fig. 3. A 150W laser welding system consists of a welding head, monitoring vision system and rotary index. That system is used He gas as shielding gas. LVDT parts were performed microstructure tests about welding specimen as Fig. 4. Finally, we made an elongation LVDT as Fig. 5 but need several technologies like assembly technology of LVDT, dissimilar welding and the development of welding jig [3].



Fig. 3 Fiber Laser Welding System

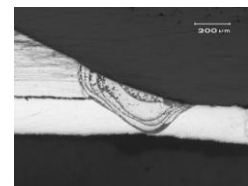


Fig. 4 Microstructure of a welded MI cable



Fig. 5 Fabrication of the Elongation LVDT

5. Design of Instrumented Fuel Rod for Elongation and Pressure Measurement using LVDT

We have a plan about HANARO irradiation test for LVDT performance test in this year. Fig. 6 is an instrumented fuel rod that is installed a designed elongation LVDT. The elongation LVDT is installed in lower part and the C-type thermocouple is installed in upper part for the measurement of centerline temperature of fuel. Also, Fig. 7 is an instrumented fuel rod that is installed a designed pressure LVDT. The pressure LVDT is installed in lower part and the C-type thermocouple is installed in upper part [2]. These instrumented fuel rods will be installed in an irradiation capsule.

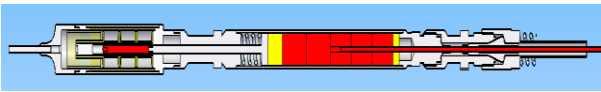


Fig. 6. Instrumented Fuel Rod for Elongation Measurement

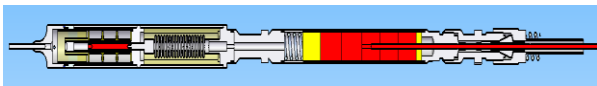


Fig. 7. Instrumented Fuel Rod for Inner Pressure Measurement

5. Conclusion

The elongation LVDT and pressure LVDT for HANARO irradiation test was designed newly. The designed LVDT is very simple and compact as compare to the Halden LVDT. But it is easy to install and sensor characteristic is good. The elongation LVDT was fabricated for the first time but there are several technologies to develop. Double instrumented fuel rod (LVDT and thermocouple) was designed and LVDT instrumented fuel rod will be install in the irradiation capsule. As a future plan, this LVDT will proceed to an irradiation test at the HANARO reactor in this year.

Acknowledgements

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