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Manufacture of LVDT Core for Nuclear Fuel Test

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1. Introduction

In the Nuclear fuel irradiation test, The HANARO (High-flux Advanced Neutron Application Reactor)[1] which is research reactor was irradiating neutron to making Nuclear Fuel Test Rig.

In the development and performance assessment of nuclear fuel, measuring the characteristics of fuel is one of the important thing such as strain and internal temperature of irradiated fuel and internal pressure of fuel due to fission gas.

For the measurement of the fuel it is utilized various sensors such as thermocouples, SPND and LVDT. Which are used in various fields, LVDT (Linear Variable Differential Transformer) are sensors for measuring the electrical signal by converting the physical variation such as force and displacement into a linear motion.

In general, the use of LVDT to measure the internal pressure of fuel pin at nuclear fuel test. There is case that Joung[2] used LVDT to measure internal pressure of DCF (Dual Cooled nuclear Fuel test rig). in this study, was Designed the LVDT Core for to measuring strain of nuclear fuel and nuclear fuel pin cladding tube, and the applicability was investigated

2. Basic principles and characteristics of the LVDT

2.1.Basic principles of the LVDT

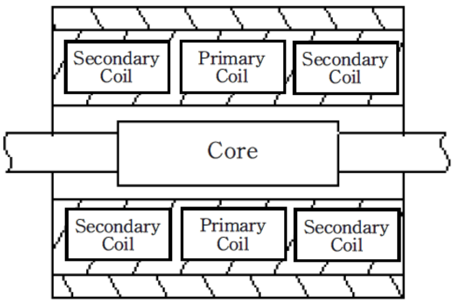

Fig. 1. LVDT core and coils

Generally LVDT was composed of the fixed coil and core moved the linear direction. LVDT is measured electronic signal to betide while the magnetic core within the coil consisting of three is moving a linear direction, as shown in Fig.1. Therefore, LVDT is possible to measure various types of physical variation depending on the structure of the core assembly.

2.2. Characteristics of the LVDT

One of the most important features of LVDT operates without friction. The LVDT core is movable without a mechanical contact with the center of a coil wound around a hollow form. This can be a great advantage in the field requiring precision measurement. it can estimate the semi-permanent life, Because there is no contact between the core and the coil, so sensing devices has no abrasion.

Other features, LVDT have high resolution and quick detection to a variation on account of it operates with electronic signal. Resolution of LVDT is determined by the signal of noise and performance of using electronic equipment.

3. LVDT core design and manufactured

When irradiated with neutrons in the nuclear fuel, fission reaction causes temperature to rise. Accordingly, the deformation of fuel and cladding tube is generated. In order to measure this, elongation type LVDT is required.

Fuel pin is immersed in coolant and become high temperature and high pressure and radioactivity when experimented irradiation test. LVDT core should be combined to cladding tube into end plug type for measuring longitudinal displacement of tube or fuel. In addition, LVDT core required to sealing technique which should be withstood internal pressure generated at the time of irradiation and able to be prevented from leaking. Thus, the basic material of core assembly has been selected as Zircaloy-4 to welding with cladding tube. Which is a key component of LVDT core assembly, core was chosen as AISI 403 that has to magnetic properties. And core pin was chosen as AISI 316L.

3.1. Design for fuel displacement measurement

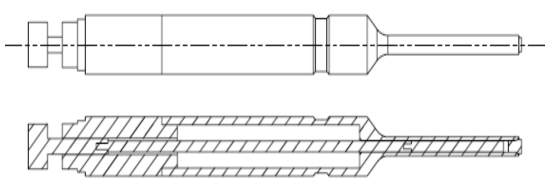

Fig. 2. Drawing of LVDT core for fuel displacement measurement

Fig. 2. shows drawing of LVDT core for fuel displacement measurement. For measuring longitudinal displacement of fuel, direction of movement of core is modified to be consistent with direction of fuel, and contacted with fuel. When fuel is expanded and spring is compressed, core is moved by expanded fuel. In fuel is contracted case, core is moved by elasticity of spring.

3.2. Design for cladding tube length deformation measuring

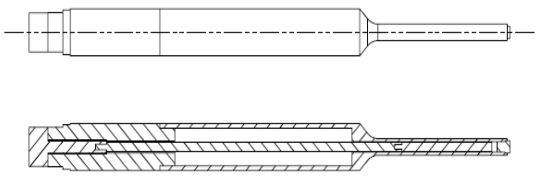

Fig. 3. Drawing of LVDT core for cladding tube length deformation measuring

Fig. 3. shows drawing of LVDT core assembly for measuring length deformation of cladding tube. Core pin and end-plug of cladding tube are fastened with bolts mechanical structure. And they are received an external force due to spring between fuel and core pin. LVDT core assembly for fuel displacement measurement was combined to coil assembly, but LVDT core assembly for measuring length deformation of cladding tube was not combined to coil assembly, for smooth contraction and expansion of cladding tube.

3.3. LVDT core manufactured

Welding of each part was used the fiber laser welding that has narrow width of heat affected zone and less damage of welding material. Welding of plug and holder that is zircaloy-4 refer to Hong's study[3], and 304 and 316L stainless steel was conducted based on a study of Hong[3] and Kim[4]. Following Fig. 4. is a photograph of manufactured core.

Fig. 4. LVDT core assembly (a) For fuel displacement measurement (b) For cladding tube length deformation measuring

3.4. LVDT Signal Check

LVDT readout unit is a device for injecting a current to coil and indicates voltage of position of core in coils. Manufactured core assembly was coupled with existing coil assembly, after was check a change in voltage signal in accordance with movement of core. As shown in fig.5 was checked that voltage change which is displayed in a box when core moved.

Fig. 5. Signal Check to use LVDT readout unit

4. Conclusions

In this study, LVDT core of elongation type design and manufacture for measuring longitudinal displacement of fuel and length deformation of cladding tube when neutron irradiated. Manufactured core was confirmed by LVDT readout unit at output signal about move of core.

Base on this, following study should calibrate signal output from LVDT according to actual position of core, and perform on signal processing technique on out-pile system. For further works, performance verification is required at in-pile irradiation test.

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