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Design and Fabrication of a Module of Multi-Channel Test Machine for HANARO

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Abstract

A module of a mechanical test machine with multi-specimen for HANARO was designed and fabricated. The module was designed to be installed in the multi-channel test machine. The multi-channel test machine contains four modules which stay in the up and bottom parts of the test machine with 90 degree distortion. Each module of the machine has 50 mm length specimen, yoke, bellows, pin, grip, push rod and LVDT. The parts are made of 304 stainless steel by electro-discharge machining. One of the important characteristics of the module is that it can examine four specimens in a mult-channel test machine simultaneously or independently.

1. Introduction

The materials for nuclear plant have critical problems such as degradation by irradiation effect. Successful operation of HANARO has stimulated domestic irradiation study of materials, which requires design and fabrication of an in-pile tester for HANARO.[1-2] Since the in-pile tester which already developed can install one sample inside, it needs to develop multi-channel mechanical test machine for the experimental efficiency and various users. Hence, the objective of this study is to design and fabricate a module which is a main part of the multi-channel mechanical test machine for HANARO.

2. Experimental Method

A module of multi-channel test machine of HANARO was designed and fabricated. The module was able to apply tensile stress to a plate specimen homogeneously by external gas pressure. To design the module, dimension of a special capsule of HANARO was reviewed. Similar test machines used in JAERI, NRU and NRX in AECL were surveyed, especially, design criteria, loading mechanism, specimen holding mechanism and monitoring displacement, respectively.[3-7] Every drawing was made using Auto-CAD.

3. Results and Discussion

In order to design and fabricate a module of a multi-channel mechanical test machines for HANARO, similar test machine such as dimension of a special capsule of HANARO, design criteria of JAERI were surveyed. One of the design criteria of JAERI is that it can work under the fast neutron fluence of 10^{21} n/cm^2, at test temperature of 550℃. JAERI found the followings by mock-up tests : (1) determination of assemble method and maximum tolerance at welding part (2) maximum load and connection resitance ar moving part (3) creep test with aluminum specimen and performance test with aluminum creep test. Considering the JAERI criteria and HANARO normal working conditions, the design criteria of the module was that the module was sustained at the working conditions of <400℃, 3 watt/g of gamma heating rate, $5x10^{20}$ n/cm^2, neutron flux and maximum load of 200 MPa with a fixed dimension of HANARO.

For the determination of number of modules installed in the multi-channel test machine, shape and size of the specimen was initially considered. If the specimen length is 50mm, the module length becomes about 300 mm. The outer diameter is mainly fixed by the size of a commercial LVDT. After surveying similar test machines used in KAERI, JAERI and AECL in detail, the module was designed to apply load to a plate specimen by applied pressure, determining load-displacement by LVDT, and controlling internal temperature by thermocouples and heater unit with three separate chambers.

Fig. 1 and 2 is the schematic drawing of the module designed in this study and photo of the module. One of the important characteristics of the module is that four specimens can be under loading separately or simultaneously. The module designed in this study is a quarter part of the machine has a load induced part, a loading mechanism part, a specimen holding part, a deformation measuring part, tubing and wire for outer connection with three separate parts : high pressure chamber, main chamber and connecter chamber. The high pressure chamber is located at the bottom of the module which contained bellows inside to apply tensile load to the specimen through the contraction of the bellows by external gas pressure. The main chamber is located in the middle of the module which contained grips, yokes, specimen, a push rod, heater and bearing. For applying a load to specimen, the grips, yoke and a push rod were used. The grips consist of two separate parts, upper and lower grips. The lower grip was attached on the top of the pressure chamber and the upper grip was connected to a rectangular yoke, respectively. A plate specimen was placed between two grips. A heater was located around the gauge length part of the specimen. The heater separated as two sections which heating element was silicon carbide with aluminium oxide insulate. Thermocouples were attached to the specimen and the heater for the temperature monitoring and controls. The temperature was also able to be controlled by gas flows into the main chamber of the multi-channel test machine. A push rod was on the top of the rectangular yoke, which was connected to a linear voltage differential transformer. The push rod was supported by a bearing with graphite sliding. The center of the bearing contained a graphite o-ring through which the push rod was able to move back and forth smoothly. The load was transferred to the specimen by the working mechanisms in which the contraction of bellows by gas pressure moves a yoke and an upper grip connected to a specimen, simultaneously. The connecter chamber is located at the end of the module which has one

gas feed. The electric outlets of each module are directly connected to the connection chamber of a multi-channel test machine. Considering the capsule diameter and each connector size, six feed-though connectors were installed for gas lines, electrical line and thermocouples. Tubing and wire for outer connection are also included in each channel of the machine. Each part was prepared by spark machining and welding before assembling. Considering the dimension of a special capsule used in HANARO, four module can be installed in the capsule. Two of four modules are upper and lower channels with 90 degree tilts in the multi-channel test machine with diameter and length of 600x750mm, respectively.

4. Summary

A module of a multi-channel test machine of HANARO was designed and fabricated based on the design criteria of the working conditions of <400℃, 3 watt/g of gamma heating rate, $5x10^{20}$ n/cm^2, neutron flux and maximum load of 200 MPa with a fixed dimension of HANARO. Four modules which stay in the up and bottom parts of the test machine with 90 degree distortion. Each module of the machine has 50 mm length specimen, yoke, bellows, pin, grip, push rod and LVDT. The parts are made of 304 stainless steel by electro-discharge machining. One of the important characteristics of the module are that four specimens in a mult-channel test machine can be under loading separately or simultaneously at different temperature.

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6. References

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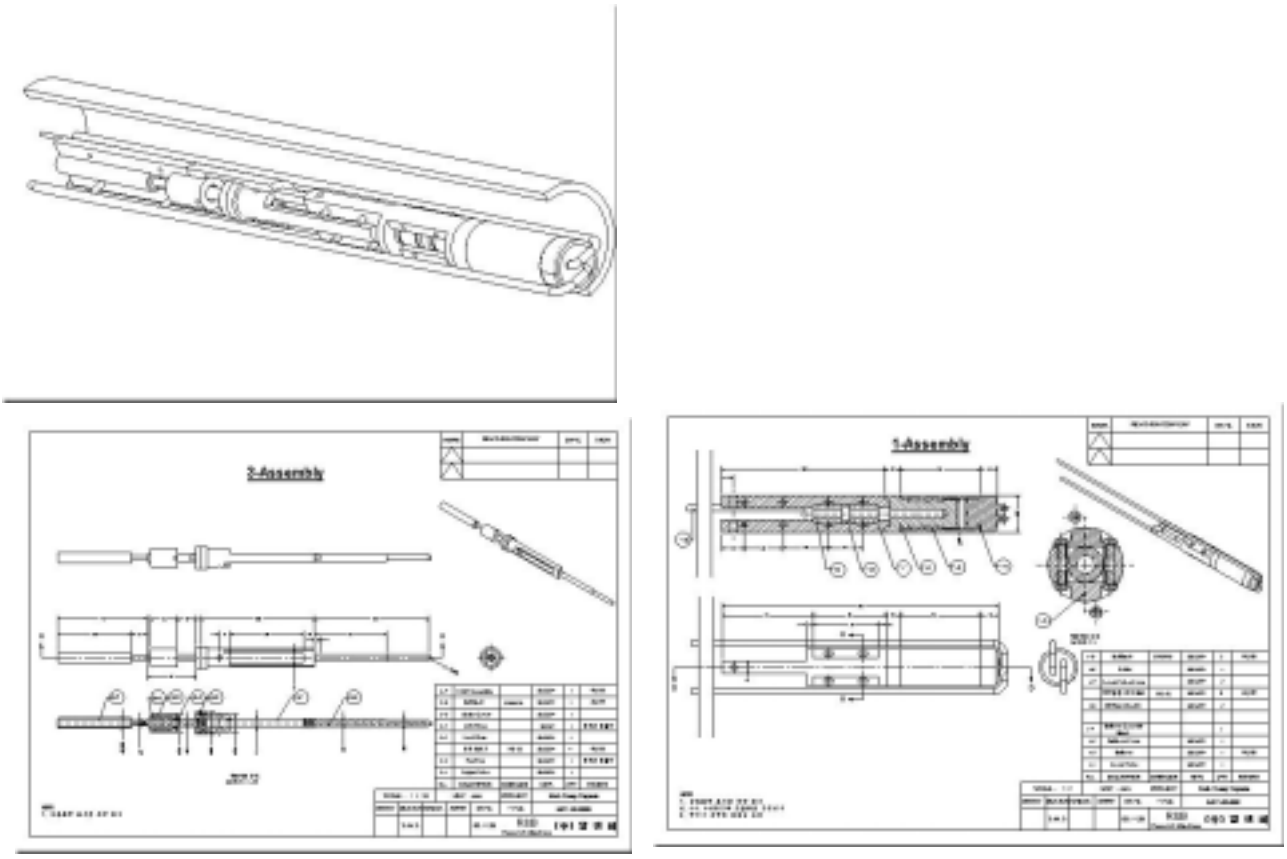

Fig. 1. Drawings of assembled parts of a module

Fig. 2. Photo of a module : opened section