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# Development of a Periodic Loading System using a Bellows

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## 1. Introduction

An instrumented capsule is one of the devices to investigate the irradiation effects of the nuclear reactor materials and components being used in a research reactor, HANARO. Among various capsules, a special capsule for in-pile creep and fatigue tests has been under development since 2002. A bellows was used to apply the constant load to the specimen in the creep capsule, and various studies have been performed to determine the specification of the bellows [1]. But the load's concept for the fatigue test is slightly different with the creep test. It is necessary to repeat a force with a constant period and amplitude during the life of the specimen. Thus, for the fatigue test using an instrumented capsule, it is important to realize the load's shape being applied to the specimen. In this study, the out-pile loading system using the bellows to apply the actual fatigue capsule is developed, and it is performed by modifying the previous system which was developed for the out-pile creep test. The basic structure, the control system and the main function related to the new loading system are described, and the preliminary test results and the future works are also discussed.

## 2. Structure of the Loading System

The capsule mainbody made of STS 316L materials is a cylindrical shell, 60mm in diameter and 2mm in thickness and 870mm in length, and includes all components, which are necessary for the creep or the fatigue tests. Thus, the actual capsule for the in-pile creep tests is designed and manufactured by considering these geometrical restrictions [2]. The bellows used in out-pile loading system take into account the restrictions.

Figure 1 shows the schematic diagram of the loading system. The system consists of four main parts; a loading, a display panel, a helium supply tube and PC control parts. The loading part includes the specimen, the bellows, the load carrying rod and the yoke. When the helium gas of a high pressure is supplied to the bellows through the pipeline, the force due to the compression of the bellows is transferred to the specimen through the rod and the yoke. Next, the force of the specimen is eliminated when the helium pressure becomes zero. By repeating the above procedures the periodic load for the fatigue test can be realized.

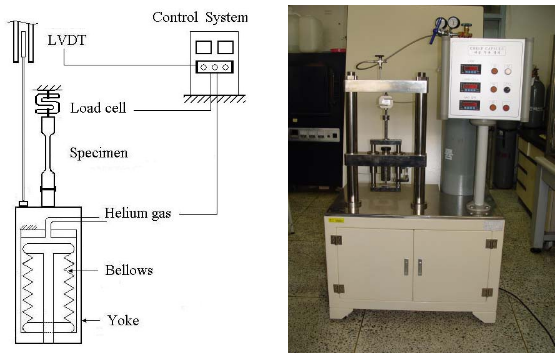


Figure 1. Schematic view and photo of a loading system

Figure 2 shows the shape of the bellows made of Hastelloy C-276 materials before the assembly. The diameter of the bellows is 34mm and the spring constant is 1.2 kgf/mm. The maximum moveable distance of the load-carrying rod is designed as 10mm by considering 40% of the specimen's gage length, 25mm.

The load applied is measured by using a load cell installed at the top of the specimen, and the displacement of the specimen can be measured using a LVDT(linear variable displacement transducers) connected to the yoke. These signals are displayed at the computer monitor and the display panel simultaneously, and will be stored in the personal computer.

Figure 2. Bellow shape before assembly

The distance from the helium gas tank to the capsule mainbody to be located in to the reactor core during the irradiation test is about 40m, and the 1/8 inch tube will be used in the real capsule. But a 9m tube of 1/4 inch is designed by calculating the volume of the helium and used in the out-pile loading system. The helium supply tube connects the gas tank to the bellows through the regulator, the pressure transducer (PT), the solenoid valve (SOV) and the metering valve (MV) et al.. The

opening/closing of the valves and the operation of the loading system can be performed using the PLC (programmable logic controller) and a Citect V.5.21G MMI (man machine interface) program [3]. Figure 3 shows the schematic diagram of the pervious and new devices, and the function of the main parts is as follows;
- LVDT: Measure the displacement of the specimen
- PT: Control the gas pressure by solenoid values
- MV: Control the gradient of the pressure with the time
- P1(or P2): Lower(or upper) limit of the pressure
- T1(or T2): Stay time of the pressure

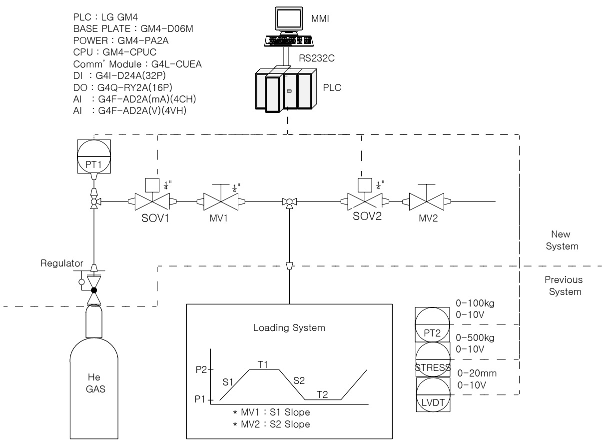


Figure 3. Schematic diagram of pervious and new devices

## 3. Preliminary Test and Future Works

In order to confirm the basic performance of the developed out-pile loading system, a test using the spring specimen is performed. Figure 4 shows the example of the pressure and displacement time history (period: 10 sec, pressure amplitude: 3~8 $kgf/cm^2$). In this case the displacement is measured by the LVDT. Because the periodic load of a triangular shape was designed for the fatigue test, the realization of the triangular shape's load using the new system is first confirmed. As shown in Figure 4, the new loading system creates a good shape of the triangular wave periodically. This means that it is possible to apply it to the fatigue test using the real capsule. The displacement shows the linear increment although the gradient in the case of the small load is slightly different. We are planning to test the aluminum tensile specimen of a circular shape with a small diameter to verify the performance of the loading system and the possibility of the fatigue test.

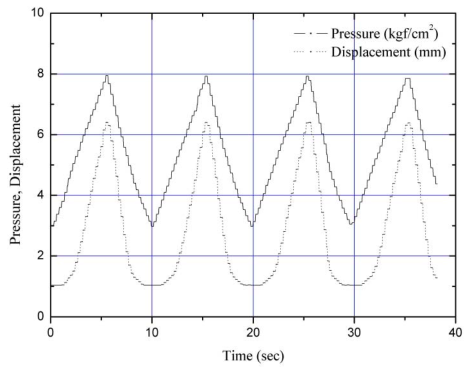


Figure 4. Pressure and displacement time history

## 4. Conclusion

The out-pile loading system using the bellows is developed by modifying the previous out-pile loading system for the creep test. The length of the helium supply tube is determined as 9m by considering the helium volume of the actual capsule. The shape control including the amplitude, the stay time and the period of the load is possible by controlling the valves and using a MMI program. From the preliminary test, it is expected that the new loading system using the bellows and the MMI program is an applicable device for the fatigue test. An additional test for the tensile specimen made of aluminum materials will be performed.

## ACKNOWLEDGEMENTS


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