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# Basic Design of the Performance Test Facility for Fuel Assembly Hydraulics and Vibrations Analyses

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## 1. Introduction

For a development procedure of an LWR fuel assembly, the accomplishment of a performance target must be verified through out-of-pile tests of a fuel assembly and its components. Most leading nuclear fuel companies in the world have already constructed a out-of-pile test facility except for a critical heat flux test facility, and have utilized it to develop an advanced fuel assembly [1]. The mechanical /structural performance test equipment [2] for the components of a fuel assembly and a fuel assembly mechanical characterization facility [3] have already been installed at KAERI, and a hydraulic test loop[4] will be constructed this year.

One of the ongoing LWR fuel projects at KAERI is to construct a compatibility test facility to measure and analyze the pressure loss, the lift force, the flow induced vibration and the fretting as well as to verify the compatibility of different fuel assemblies in a transient reactor core. It also includes the implement an impact test facility to verify the analysis models of a fuel assembly in the case of an earthquake and severe accidents for the developed mechanical test facility.

This paper briefly introduces the basic design of the compatibility test facility to be constructed, and summarizes the operation concept and the applications of the facility.

## 2. Test Facility

### *2.1 Outline*

This compatibility test facility of the fuel assemblies is named PLUTO from Performance Test Facility for Fuel Assembly Hydraulics and Vibrations. PLUTO is a facility to comprehensively test the thermal hydraulic characteristics and the compatibility of fuel assemblies such as the compatibility, the pressure loss, the lift force, the flow induced vibration and the long-term wear test. The PLUTO will be basically constructed for a PWR fuel assembly, and it will be considered to test for the fuel assemblies of other reactors.

The design parameters of the PLUTO are summarized as below.

- Design Pressure : 4 MPa (Tsat : 250.4 $^{o}$C)
- Design Temperature : 250 $^{o}$C

Hereby, the maximum operating conditions at the inlet of the test section are determined as follows.

- Operating Pressure : 3 MPa (Tsat : 233.9 $^{o}$C)
- Operating Temperature: 210 $^{o}$C
- Operating Flow Rate : 1400 m$^{3}$/hr

### *2.2 Basic Design and Composition*

The PLUTO consists of the primary circulation loop, the test sections, the instrumentation and control, the data acquisition system, the power supply, and the auxiliary systems.

Primary Circulation Loop

The primary circulation loop consists of the main circulation pumps, two test sections, an expansion tank, a main heat exchanger, pipes and valves, and support structures as illustrated in Fig. 1. The working fluid, which is of the water is circulated by the main circulation pumps and flows out test section outlet through the fuel assembly, and the temperature and pressure of the water are controlled by the main heat exchanger and the expansion tank. The temperature of the water is increased by the heat energy from the main circulation pumps, however a loop heater is added to accelerate this increase.

Test Section

Both test sections stand in a row as test section A and B to make a practical application of each test object independently. Test section A consists of a flow housing and a pressure vessel for two fuel assemblies and test section B consists of these for a single fuel assembly.

Instrumentation and Control

The instrumentation and control system is to control the operating condition and to measure the temperatures, the pressures, and the flow rates of the main circulation loop and the auxiliary system.

The basic design of this system is illustrated in Fig. 2. The control system to operate the facility is formed as the MMI(Man-Machine Interface) System. MMI System consists of a primary system and an automatically alternated auxiliary system for the endurance test required for a long-term operation.

Data Acquisition System

All kinds of parameter signals from the loop and the test section are gathered in the DAS(Data Acquisition System) to convert it into each physical quantity and to store and analysis of the test data.

Power Supply

The total power, about 1500 kVA for an operation of this facility is supplied from the power distributor which transforms 6.6 kV of the main transformer substation into 440 VAC and 220 VAC into the facility and the

control room, respectively. General electric power of the building is used for the PC in the control room, illuminations, general working lights, and so on.

Auxiliary Systems

The auxiliary systems are the equipments required to operate and manage this facility except for the systems as stated above. These systems are summarized as follows.

- Water purification and monitoring system
- Water storage/supply system
- Cooling tower
- Nitrogen gas supply of expansion tank
- Utilities such as city water, demi-water, compressed air, general power supply, and so on.
- Vent and drain system
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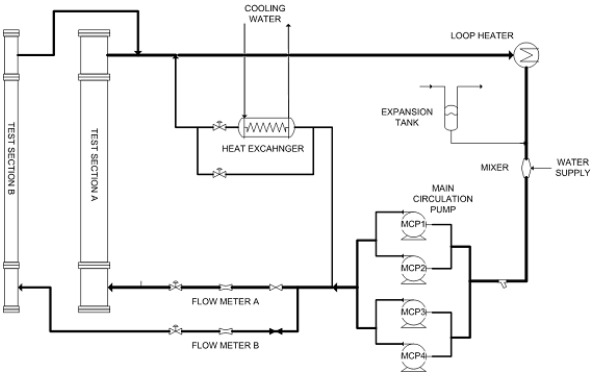


Fig. 1 The schematic diagram of the test facility

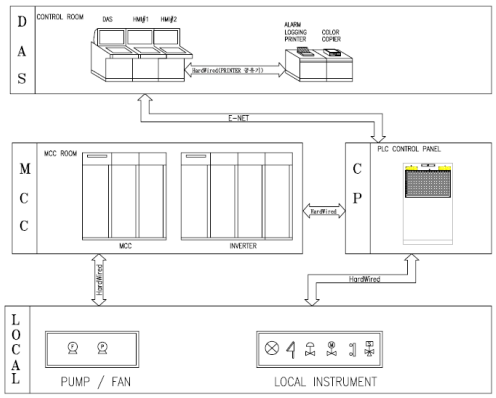


Fig. 2 The configuration of the control system

## 3. Concepts of Operation

*3.1 Preperation of operation*

When the storage tank is filled with the demi-water, the water is circulated through the water circulation loop which consists of the water storage tank, the purification and monitoring system, and the water supply pumps. After the water is achievs the level of quality, the water is filled into the main circulation loop with the water supply pump. At the same time, the vent procedure for the main circulation loop and the pressure measurement lines is carried out

*3.2 Start-up and Heat-up*

The main pumps are started to create a circulation in the main loop, and then the loop heaters are run. To increase the water temperature in the main loop, effectively, the load of the main pumps and the loop heaters are controlled by the MMI system. The pressure in the main loop is increased according to increase of volume expansion. The increased pressure is controlled by the flow rate of bleed line and the pressure of nitrogen gas in the expansion tank.

*3.3 Steady State Operation and Data Acquisition*

The temperature, pressure, and flow rate at the inlet are controlled at the set value by MMI system. In the steady state condition, the test data is acquired.

*3.4 Loop Cooling*

The flow rate of the working water and the cooling water in the main heat exchanger is maintained at a maximum and the loop heater is turned off. The cooling rate is maintained below 55 $^{o}$C/hr to prevent a drop of the water level in the expansion tank and the water temperature must be sufficiently lower than the saturation temperature.

## 4. Summary

KAERI is performing a project for developing a compatibility test facility and the relevant technology for an LWR fuel assembly. It includes the compatibility test and the long term wear test for dual fuel assemblies, and the pressure drop test, uplift force test, flow-induced vibration test, damping test, and the debris filtering capability test for a single fuel assembly. The P&ID and GA drawing for a basic design have been completed. The test facility will be constructed by the middle of 2008. It will be the most up-to-date facility in the world when it is successfully constructed.

## ACKNOWLEDGEMENT

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