Pressure Drop and Blower Performance Tests in Very High Temperature Helium Experimental LooP (HELP)

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1. Introduction

Korea Atomic Energy Research Institute (KAERI) has developed the gas loops to develop and verify the key components of the nuclear hydrogen production system. At the present, KAERI is operating a small-scale gas loop for feasibility tests of process heat exchanger [1] and a very high temperature Helium Experimental LooP (HELP) [2] for verification tests of bench-scale prototypes for high temperature key components in Very High Temperature gas-cooled Reactor (VHTR).

Figure 1 presents the HELP assembled with the key components. The size was designed for the verification test of a 150kW-intermediate heat exchanger or the simulation test in a 1/6 scaled down fuel block. The loop consists of the primary loop and the secondary loop. The primary loop and the secondary loop simulate VHTR and intermediate loop in nuclear hydrogen production system, respectively. The loops were designed to withstand the maximum temperature of 1000°C, the maximum pressure of 9.0 MPa, and the normal mass velocity of 0.5 kg/sec. The working fluid is helium as the actual coolant of VHTR. The primary loop is composed of a preheater, a high-temperature heater, a hot gas duct, intermediate heat exchangers, a water-cooled U-tube heat exchanger, a gas-bearing circulator, a passive venting system and gas filters. The secondary loop has the same system configuration as the primary loop except a high temperature heater. Two loops share a helium supply system, a helium purification system and the water loop for a cooling tower as Figure 2.

Figure 1 Whole View of HELP

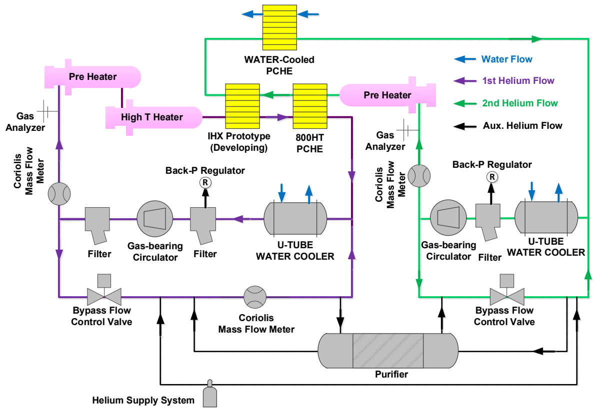

Figure 2 Schematic Diagram of HELP

In this study, the experimental results of the bypass line pressure drop and blower performance at the nitrogen condition are analyzed to predict the main line mass flow rates without heaters.

2. Gas-Bearing Blower & Control Valve

Gas-bearing type is selected as the circulator of HELP not to use the oil which is the source of C/C composite oxidation at the high temperature. Figure 3 shows the gas-bearing circulator. Its design pressure, design mass velocity, and compression ratio are 9.0 MPa, 0.5 kg/s (@4 MPa, He), and 1.04, respectively.

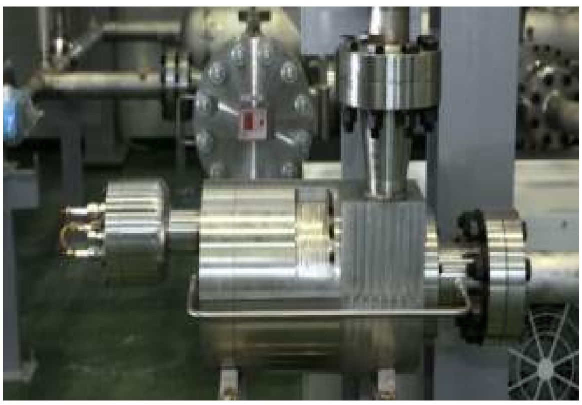

Figure 3 Gas Bearing Circulator

The high speed squirrel-cage induction motor and internal water cooling jacket is selected for higher operation temperature than that of the circulator in the small-scale nitrogen loop [1]. The gas temperature near the motor is always measured to prevent heat-damage of the motor and the bearing

As the bypass flow control valve, the sliding gate valve in Figure 4 was selected to minimize the pressure drop in the valve. Its advantages are fits into tight spaces, variable KVS values, excellent leak tightness, optimal flow control, and others.

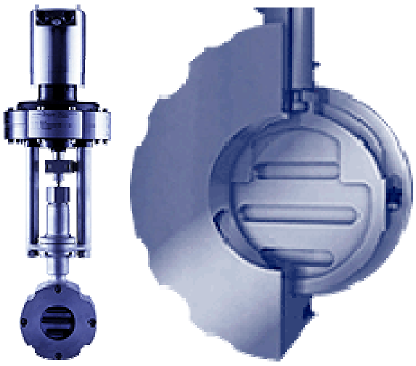

Figure 4 Sliding Gate Valve

3. Results and Discussion

In this study, the pressure drops were measured between inlets and outlets of the primary bypass line and the primary blowers. Mass flow rate of the bypass line was measured by a coriolis flow meter. The system pressure and the temperature at the outlet of the blower were also measured to calculate the volumetric flow rate in the bypass line. Nitrogen as the working fluid resulted in the limitation of the rotating speed (300 Hz) and the system pressure (18.3 bar). Since the thermal conductivity of nitrogen was smaller than that of helium, the overheating of the motor might cause the heat-damage of the blower bearing and motor.

Figure 5 shows the loss coefficients of the bypass line and the main line including the U-tube cooler and two filters obtained from the experimental data. Opened fraction of the sliding gate valve decreased the loss coefficient. The loss coefficient of the U-tube cooler and two filters were always constant.

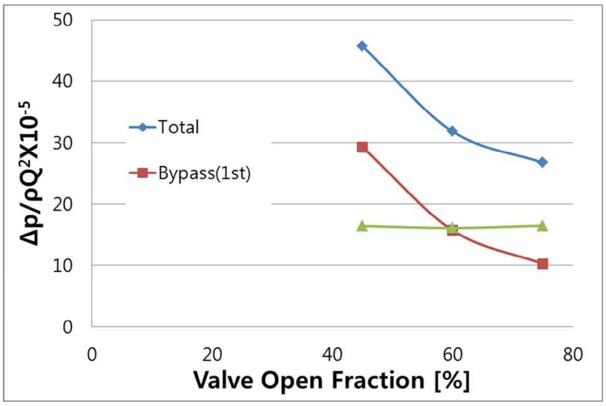

Figure 5 Loss Coefficients of Primary Line

Figure 6 shows the mass flow rates with various loss coefficients of the line including a preheater, a high temperature heater, printed circuit heat exchangers and others. The mass flow rates were calculated at the same power of the blower condition with 75% valve opened fraction and 18.2 MPa nitrogen. The calculated results show that it is reasonable to infer that the blower has enough performance to obtain the 6 kg/min as the main line mass flow rate at the helium experimental condition.

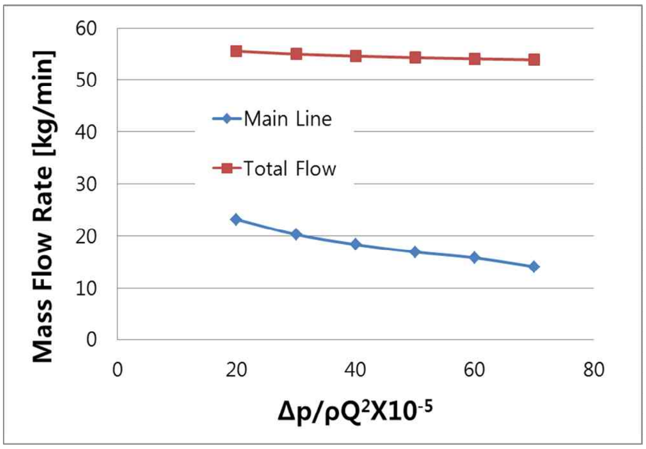

Figure 6 Mass Flow Rates with Various Loss Coefficients

4. Conclusion & Future Works

The blower performance test results show that there is no problem in operation with the designed experimental condition. In this year, the performance tests of HELP will be performed at high temperature and high pressure conditions. After HELP performance tests, IHX prototype tests will be carried out for the verification of IHX fabrication technologies.

ACKNOWLEDGMENTS

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REFERENCES

[1] C. S. Kim et al., "Performance Test of Nitrogen Loop with Hybrid Heat Exchanger for SO_3 Decomposition of Nuclear Hydrogen Production," Proceedings of ICAPP'11, Paper 11454, Nice, France, 2011.

[2] C. S. Kim et al., "Very High Temperature Helium Experimental Loop," Transactions of the Korean Nuclear Society Spring Meeting, Jeju, Korea, 2012.