# Operating Experiences of a Gas-Bearing Circulator in a Small-scale Gas Loop

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## 1. Introduction

A small scale gas loop that can simulate a VHTR (Very High Temperature Gas Cooled Reactor) is in operation at Korea Atomic Energy Research Institute [1]. Control of gaseous impurities in the circulating gas at a high-temperature experimental loop is a significant operating requirement for the loop maintenance. Especially, the oil vapor induced by a circulator will contaminate and damage the sophisticated high temperature components such as the heat-generation material in the high temperature heater. Therefore, the high temperature gas loop generally requires the circulation without lubricant as oil. A gas-bearing circulator is widely used in the industry for low-pressure turbo-machinery without the oil. In this study, we discussed operational experiences of a laboratory scale high-pressure gas bearing circulator of the small-scale gas loop.

## 2. Description of a Gas Bearing Circulator

### *2.1 Foil Bearing*

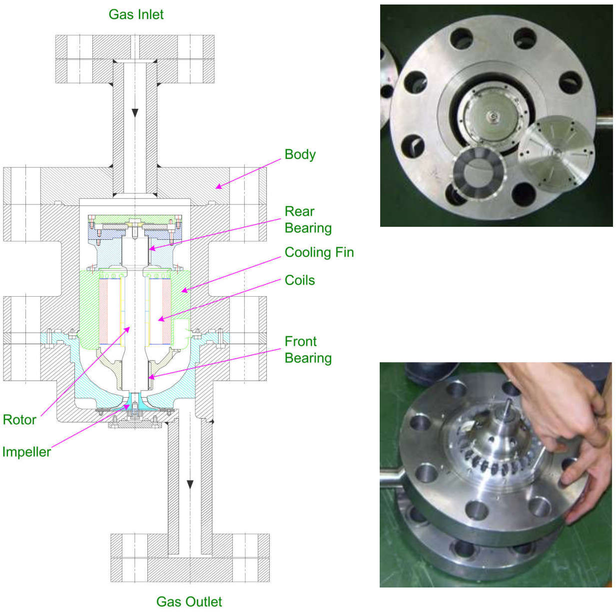
The shaft of the circulator of SSGL is a foil bearing type, one of gas bearing types. A shaft is supported by a compliant, spring loaded foil journal lining. Once the shaft is spinning fast enough, the working fluid pushes the foil away. The advantage of the foil bearing is an elimination of the oil systems, increased reliability, higher speed capability, the wide temperature capability, high vibration and shock load capacity, and a relatively quiet operation. The foil bearings easily wear by contacting with the shaft during a startup or shutdown of the circulator. To prevent an excessive wear on the gas bearings during a startup, the circulator motor accelerates the rotor to 30,000 rpm in less than one second. Unlike aero or hydrostatic bearings, foil bearings require no external pressurization system for the working fluid [2].

### *2.2 Circulator of the Small-scale Gas Loop*

The primary goal of the small-scale gas loop (SSGL) is the performance test of a laboratory scale process heat exchanger for the sulfur trioxide decomposition (Fig. 1). The design specification of a SSGL is as follows:

- Working fluid : Nitrogen
- Design Temperature : 1000°C
- Design Pressure : 6.0 MPa
- Design Flow : 2.0 kg/min

Fig. 1. Picture of the primary side of SSGL



Design P: 6.0 MPa
Inlet Temp.: < 50 ℃

Flow rate: 6.0 kg/min
RPM : ~ 36,000

Fig. 2. Lab-scale gas bearing circulator

This design condition determines the design specification of a circulator except for the design temperature. The design temperature of the circulator depends on outlet temperature of a system cooler. Figure 2 shows the body of the circulator mounted on two pairs of the ANSI Class1500 flanges with enough strength to withstand the design pressure of the loop. The diameter of impeller was 50 mm and the rotor was designed to adapt to a single stage and foil bearing system.

## 3. Operating Experience

In the initial testing of the circulators, design mass flow rate of the SSGL is not achieved due to the system pressure drop is inordinately higher than expected value. The main flow control valve is fully opened and the bypass flow control valve is closed. We find that both the U-tube type coriolis mass flow meter and the main flow control valve have the large pressure losses themselves. Therefore, the mass flow meter is replaced to new one and the main flow control valve is removed. The new system pressure drop is greatly improved and the mass flow rate is recovered as shown in Fig. 2. It is listed in Table I that the test results of both before and after modification of the SSGL at the similar experimental condition. The rotation speed of the motor is 600 Hz (~18,000RPM).

Since the initial testing of the circulator, the trouble of the circulator sometimes resulted from the overheating of the circulator internal. Main reason of the overheating is the solid particles in the circulator.

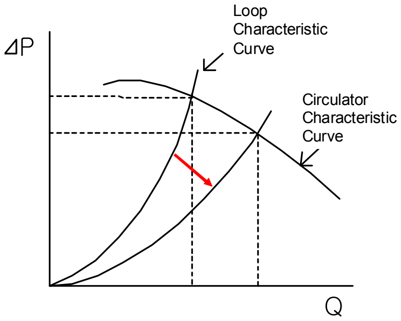
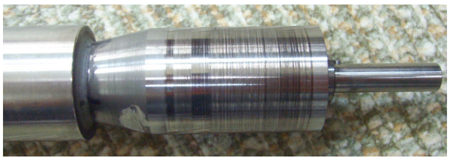


Fig. 2. The conceptual relationship between the system pressure drop and the circulator characteristic curve

Table I. Test results of the circulator

| Variables | Before Modification | After Modification |
|---|---|---|
| System pressure [bar] | 20, 30 | 19, 28 |
| Mass flow rate [kg/min] | 0.57, 0.95 | 2.06, 3.00 |
| Pressure drop [bar] | 0.37, 0.60 | 0.36, 0.5 |

(a) Thrust bearing (b) Trust bearing bush



(c) Radial bearing bush

Fig. 3 Pictures of a damaged bearing and bearing Bush

The solid particles are produced from the wear between the trust bearing and the radial bearing at the circulator internal. The solid particles generated by the friction of bearing parts accelerates the wear of the thrust bearing bush and the radial bearing bush as shown in Figure 3.

After a long time operation, the solid particles soiled between the stator and shaft; the inordinate temperature rising caused the separation from the shaft (Figure 4) and following a magnetism loss is happened by departure from the Curi temperature. Solid particles and high operation temperature are the interactive factors which accelerate the circulator to fail. Enough cooling flow in the circulator can prevent the deposition of the solid particles and the overheating of the shaft assembly. We make a hole on the bearing cover for supply the enough coolant to the bearing and the surface hardness of bearings is improved by a special coating with thermal process of the bush surface. In addition, the bypass flow control valve is always fully opened to supply cold coolant into the circulator internal as much as possible.

Fig. 4 Magnet separation from the shaft

## 4. Conclusion

We operate and upgrade a laboratory scale gas bearing circulator for a small-scale gas loop. The design pressure and mass flow rate of the gas bearing circulator is successfully achieved in the small scale gas loop. We found that the appropriate cooling of the circulator internal and the management of the solid particles in the bearing parts are the main issues for the stable operation of the gas bearing circulator.

## ACKNOWLEDGEMENTS

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## REFERENCES

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