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A Study of Magnetic Fluid Seals for Blood Sealing

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Magnetic fluid seals are used in a wide variety of gas and dust sealing applications. However, it is difficult to seal for liquid because of its characteristic. This study will be a basic guide for a magnetic fluid seal for liquid, especially for blood to be practically used in medical instruments such as rotary blood pumps by clarifying its seal properties. Sealing pressure test, durability test, and hemolysis test have been conducted for this seal. In this study, magnetic fluid, sealing fluid, eccentricity ratio, revolution speed were selected as parameters. As results of the tests, it has been found that the properties of magnetic fluid seal depend on the solvent and the saturation magnetization of magnetic fluid. Therefore, the selection of magnetic fluid is important for this seal. It also has been found that eccentricity ratio of the shaft caused harmful effect for seal properties. In conclusion, it has been showed that magnetic fluid seals could be possibly used in medical instruments such as blood pumps when blood come in contact with magnetic fluids.

Keywords : Blood sealing, Magnetic fluid seal, Sealing pressure, Durability, Hemolysis

1. INTRODUCTION

Magnetic fluid seals are used in a wide variety of gas and dust sealing applications. However, it is difficult to seal for liquid because of its characteristic. This study will be a basic guide for a magnetic fluid seal for liquid, especially for blood to be practically used in medical instruments such as rotary blood pumps by clarifying its seal properties.

2. METHODS

2.1 Experimental apparatus

Figure 1 shows a schematic diagram of experimental apparatus used in this study to examine a basic characteristic of the magnetic fluid seal. The sealing medium is sealed up with the magnetic fluid seal, and pressure in the chamber can continuously be taken into the computer though the A/D board. The pressure of the sealing medium can continuously be pressurized using a compressor and a tank.

Schematic diagram of the magnetic fluid seal used in this study is shown in Fig.2, and the inside diameter of the magnetic fluid seal is 10.1mm. In the standard, the shaft of 10.0mm in the diameter is supposed to be used, however, the shaft of 9.3mm in the diameter is used and the clearance between the shaft and the seal was enlarged from the standard in this study, because of the convenience of the setting the experimental conditions. W-40(solvent : water), HC-50(solvent : kerosine), N-504(solvent : isoparaffin) , and A-400(solvent : alkylnaphthalene) were used as magnetic fluids.

To examine the effect of the eccentricity of the shaft on the basic characteristics of the magnetic fluid seals, the seal casings in which the shaft hole was made to be eccentric for the shaft at a certain quantity were prepared.

2.2 Pressure test

The withstand pressure performance is mentioned as one of the important performances required as blood sealing devices. Then, the sealing medium was filled in the chamber of the experimental apparatus as shown in Fig. 1, the pressure in the chamber was continuously pressurized, and the withstand pressure performance of the magnetic fluid seal was examined in this research.

2.3 Durability test

The durability performance is mentioned as another important performances required as blood sealing devices. Then, the sealing medium was filled in the chamber as shown in Fig. 1, the pressure in the chamber was kept constantly, and the durability of the magnetic fluid seal was examined under various conditions.

2.4 Hemolysis test

In order to seal the blood by magnetic fluid seal in medical instruments such as rotary blood pumps when blood come in contact with magnetic fluids, not only both the withstand pressure and the durability performance are excellent but also the biocompatibility for the blood are required. Then, the hemolysis tests were carried out as one of the method of examining the biocompatibility for the blood with magnetic fluid. The hymolysis level was evaluated by MFI (Mechanical fragility index)[1].

3. RESULTS AND DISCUSSION

3.1 Pressure test

The withstand pressure performance of N-504 was the most excellent, and was HC-50, A-400, and W-40 in order. This is the order in which the saturated magnetization of the magnetic fluid is high. And, the withstand pressure decreases as the eccentricity ratio increases. Figure 3 shows the effect of the revolution speed and eccentricity ratio of the shaft on the withstand pressure. In the range of this experiment, the withstand pressure does not depend on the revolution speed at no eccentricity, and the withstand pressure gradually increases as the revolution speed increases at the eccentricity ratio of 50%.

3.2 Durability test

As for W-40 whose solvent was water, the seal was broken in 7.8 minutes, but as for other magnetic fluids whose solvent was the organic, the seal was not broken more than 24 hours which were the setting testing time. It has been understood that the durability performance decreases with an increase in the eccentricity ratio of the shaft. Figure 4 shows the effect of revolution speed on sealing time. The seal was not broken for three hours which were the setting testing time when the revolution speed was 0, and 1000[rpm]. The sealing time was decreased with an increase in the revolution speed in more than 2000[rpm].

3.3 Hemolysis test

As for W-40 whose solvent was water, it has been understood to take a very big hemolysis level compared with A-400, HC-50, N-50 whose solvent was the organic. The hemolysis level becomes small very much in order of A-400, HC-50, N-504. Figure 5 shows the effect of revolution speed on the hemolysis level. Figure shows that the revolution speed does not much affect on the hemolysis level.

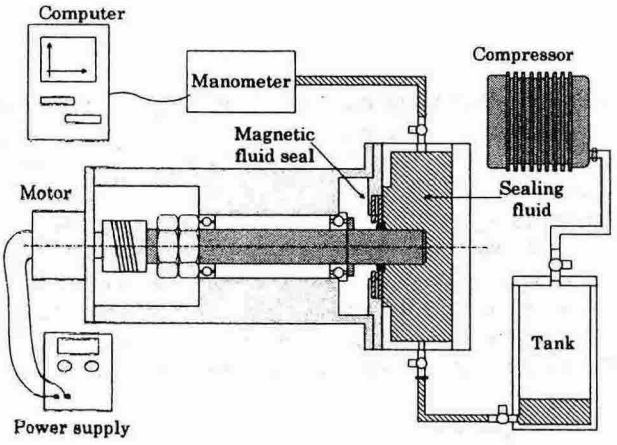

Fig.1 Schematic diagram of experimental apparatus

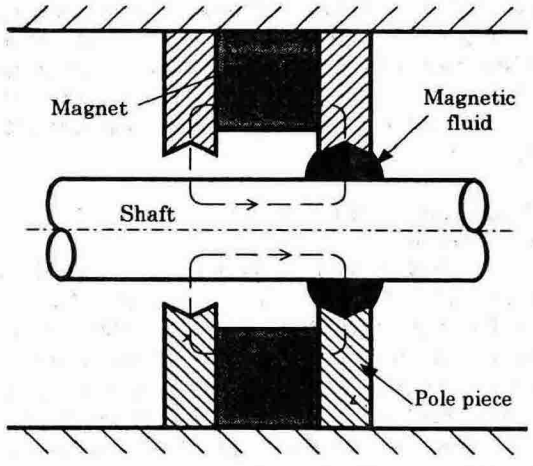

Fig.2 Schematic diagram of magnetic fluid seal

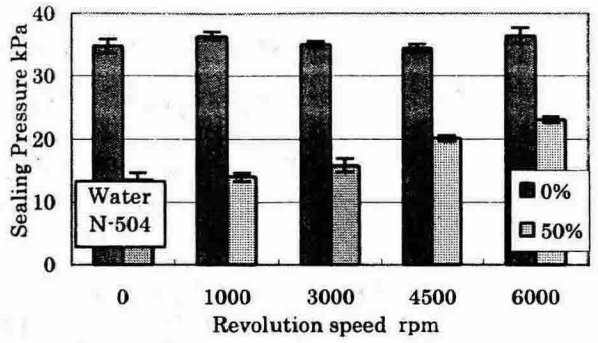

Fig.3 The effect of revolution speed on sealing pressure

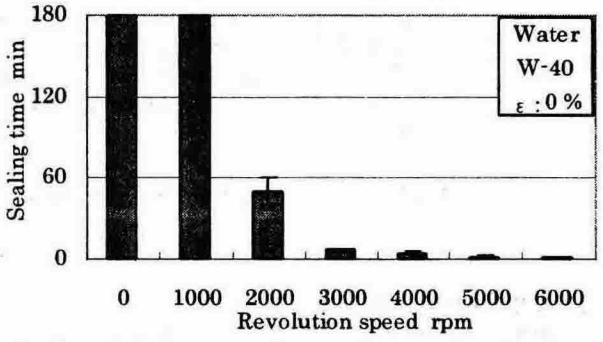

Fig.4 The effect of revolution speed on sealing time

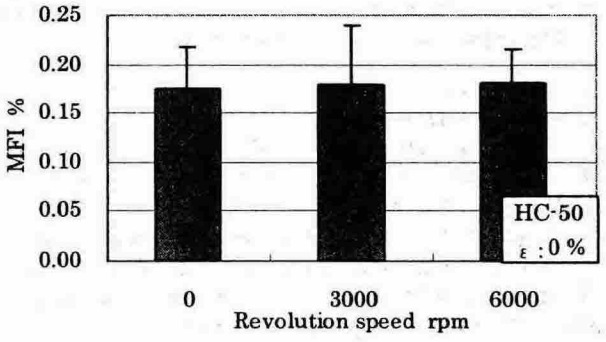

Fig.5 The effect of revolution speed on MFI

4. CONCLUSIONS

As results of the tests, it has been found that the properties of magnetic fluid seal depend on the solvent and the saturation magnetization of magnetic fluid. Therefore, the selection of magnetic fluid is important for this seal. It also has been found that eccentricity ratio of the shaft caused harmful effect for seal properties.

In conclusion, it has been showed that magnetic fluid seals could be possibly used in medical instruments such as blood pumps when blood come in contact with magnetic fluids.

5. REFERENCE

(1) M. V. Kameneva, K. O. Garrett, M. J. Watach, H. S. Borovetz, Red blood cell aging and risk of cardiovascular diseases: Clinical Hemorheology and Microcirculation 1998;18:p67-74