

# The Development of the Heat Curing Oil Film Method for a Compressible Steady Flow

Yasumi Ozawa\* and Takeyoshi Kimura\*

The heat curing oil film method using thermosetting property oil film is a new oil film method. The heat curing oil film method, in which not only the plane flow pattern in wall surface but also oil film thickness of the steady flow can be measured, was newly developed. The heat curing oil film method was used for visualization of the air flow in the clearance of an externally pressurized circular thrust gas bearing with a central supply hole and was found to provide much useful information about flow.

## 1. Introduction

It is very important to visualize the flow path of the flow for the evaluation of its basic characteristics. The oil film method is one method of visualizing the steady flow near the surface of the wall. In the conventional oil film method which is applied in the field of fluid mechanics, the plane flow pattern of the steady flow near the surface have been measured [1-4]. However this conventional oil film method is the visualizing method for the two dimensional steady flow.

If a new type of the oil film method visualizing the three dimensional flow pattern of the steady flow can be developed, many new information about the flow will be provided. However studies on this method have not yet been done.

In this paper, the heat curing oil film method, in which not only the plane flow pattern but also the oil film thickness of the steady flow can be measured, is newly developed. The experimental investigation was carried out to visualize the steady flow in the clearance between the thrust bearing and the flat plate for externally pressurized thrust gas bearings using the heat curing oil film method.

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\* Department of Mechanical Engineering

## 2. The Principle of the Heat Curing Oil Film Method

The oil paste which is used in the heat curing oil film method contains the following components; Silicone, Titanium dioxide, Oleic acid and Hardener. The oil paste is mixed well so as to remove any lumps of titanium dioxide from the oil paste. The oil paste is then left about some minutes for the titanium dioxide to completely disperse throughout the silicone. An oil paste is first painted on the wall surface, and is blown off by the flow, leaving an oil deposit in the form of a plane flow pattern with varying oil film thickness. Parameters  $h$  and  $\delta$  in Fig.1 indicate the bearing clearance and the film thickness of the oil deposit respectively.

The oil deposit is left about some hours to fix itself sufficiently with the hardener. However, since the hardened oil deposit is not hard enough to be measured by a profile meter, a harder replica of the hardened oil deposit is made from plastic casting materials, so that the film thickness of the hardened oil deposit can be measured by a profile meter. As the ratio of contraction of the plastic casting materials is very small, the replica of the hardened oil deposit is an accurate representation.

The thickness of the replica of the hardened oil deposit is measured by a profile meter, so that the film thickness of the hardened oil deposit is measured indirectly.

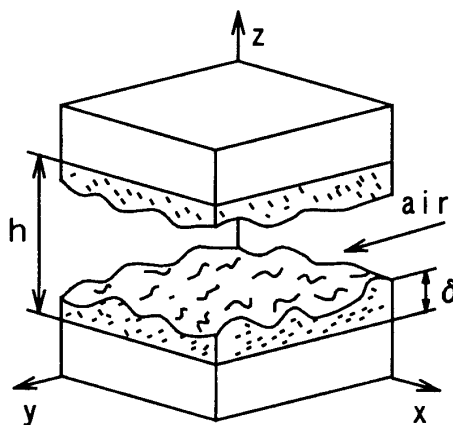


Fig.1 The flow visualization of the air flow in the clearance of Parallel two plates by using the heat curing oil film method.

### 3. Composition of Oil Paste in the Heat Curing Oil Film Method

The oil paste which is used in the heat curing oil film method contains the following components; Silicone, Titanium dioxide, Oleic acid and Hardener. The composition of oil paste in the heat curing oil film method is shown in Table 1.

Table 1 Composition of oil paste

Oil	Additive agents		
Silicon	Titanium dioxide	Hardener	Oleic acid
* 10	5	1	0.2

\* Mass ratio

#### 3.1 Oil

Silicone, an odorless, colorless and transparent oil, is chosen for the oil of the heat curing oil film method, because of its wide viscosity range ( $0.65 \times 10^{-6} \sim 1 \text{ m}^2/\text{s}$ ). It is thus very easy to choose the most suitable viscosity of silicone for the heat curing oil film method.

#### 3.2 Pigment

As silicone oil is a colorless and transparent oil, it is difficult to distinguish the oil pattern. To visualize the oil deposit pattern, titanium dioxide, which is a white pigment, is mixed with the colorless, transparent silicone.

#### 3.3 Additive

A little oleic acid is added to prevent coagulation of the titanium dioxide particles. The more the titanium dioxide particles are dispersed, the more the oil paste stuck to the wall surface, thus the flow pattern can be seen more easily.

#### 3.4 Hardener

The oil paste contains hardener which slowly hardens enabling the hardened oil film thickness to be measured by a profile meter. The condensation reaction involved the hardener in the oil paste, thus the oil paste hardened slowly.

#### 4. Experimental Apparatus

The arrangement of the experimental apparatus for the oil deposit is shown in Fig.2. The bearing clearance between the circular thrust gas bearing and a flat plate was established by thickness gauges. To visualize the flow near the surface of the wall of the externally pressurized thrust gas bearing, colorless and transparent acrylic resin sheet was used for the material of the flat plate, and black acrylic resin sheet was used for that of the bearing surface.

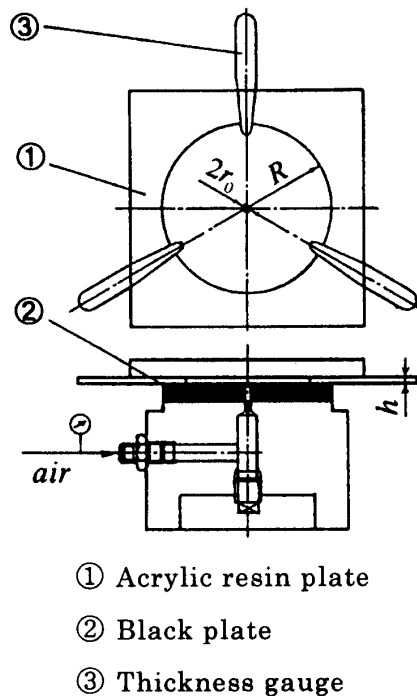


Fig.2 Experimental apparatus for the oil deposit.

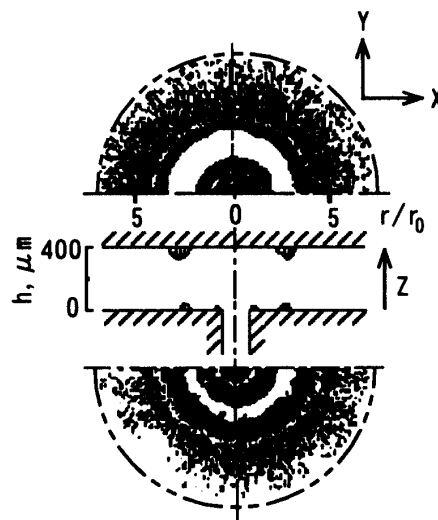
#### 5. Experimental Techniques

An oil paste was first painted on either the bearing surface or the flat plate, and was blown off by the supplied air, leaving an oil deposit in the form of a plane flow pattern with varying oil film thickness. The oil deposit was left about 30 hours to fix itself sufficiently with the hardener. However, since the hardened oil deposit was not hard enough to be measured by a profile meter, a harder replica of the hardened oil deposit was made from plastic casting materials so that the film thickness of the hardened oil deposit could be measured by a profile meter. As the

ratio of contraction of the plastic casting materials was small (less than 0.1 percent) the replica of the hardened oil deposit was an accurate representation. The thickness of the replica of the hardened oil deposit was measured by a profile meter having a contact stylus force  $0.05\text{ N}$  and a stylus transverse radius  $0.45\text{ mm}$ .

## 6 . The Oil Deposit Pattern on Bearing Surface

A continuous flow of air was supplied from an external high pressure source through the central supply hole. Typical flow patterns and values of oil film thickness of adhering oil deposits on the wall surfaces of the test bearing and the flat plate are shown in Fig.3. Parameters  $R$ ,  $r_o$ ,  $h$ , and  $P_s$  in Fig.3 indicate the bearing radius, the radius of air supply hole, the bearing clearance, and the supply pressure, respectively. The oil film thickness of adhering oil deposits on the bearing surfaces were measured by a profile meter. The white ring part shows the oil deposit and the black part shows the surface of the bearing or the flat plate. The white radial stripes of the flow pattern show the direction of the air flow. If the same total air volume was supplied to each clearance, the size of the pattern was the same in each case.



$$R/r_o = 15, h = 400\mu m, P_s = 0.4\text{MPa}(abs)$$

Fig. 3 Patterns and film thickness of adhering oil deposits on the bearing surfaces of an externally pressurized circular thrust gas bearing.

## 7. Conclusions

The heat curing oil film method, in which not only the plane flow pattern but also the oil film thickness of the steady flow can be measured, was proposed. The experimental investigation was carried out to visualize the steady flow in the clearance between the thrust bearing and the flat plate for externally pressurized thrust gas bearings using the heat curing oil film method, and was very useful to visualize the steady flow in the clearance of the externally pressurized thrust gas bearing.

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