

Effect of Oil Component on Hardness of Heat Curing Oil Film in Solid State*

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The heat curing oil film method using thermosetting property oil film is a new oil film method. The components of the oil paste in the heat curing oil film method are Silicone, Titanium dioxide, Oleic acid and Hardener. 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, is developed by author. The heat curing oil film method is a very useful method for visualization of the steady air flow. The oil paste in the heat curing oil film method has been hardened with time from the sol to the gel by the hardener. The hardness of the heat curing oil film in the gel condition is measured by a rubber hardness meter and the effect of oil component on the hardness of the heat curing oil film in solid state is investigated in this paper.

Key Words : Flow Visualization, Oil Film Method, Heat Curing Oil Film Method, Gas Bearing, Hardness

1. Introduction

It is very important to visualize the stream line 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⁾. 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, more new information about the flow will be provided. However studies on this method have not yet been done.

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 newly developed by Ozawa⁽²⁾. The components of the oil paste in the heat curing oil film method are Silicone, Titanium dioxide, Oleic acid and Hardener. The oil paste in the heat curing oil film method has been hardened with time from the sol to the gel by the hardener. Where the sol and gel are the liquid state and the solid state respectively.

The heat curing oil film method applied for the visualization of the steady air flow in the clearance of parallel two plates. An oil paste in the sol is first painted on the wall surface of plate, and is blown off by the flow, leaving an oil deposit in the form of a plane flow pattern with varying oil film thickness.

The hardness of the heat curing oil film both the sol and the gel are measured by a penetrator. The hardness of the heat curing oil film in the gel condition is measured by a rubber hardness meter. The values of penetration of the heat curing oil film can be associated with the value of rubber hardness of one in the gel condition.

In this paper, the hardness of the heat curing oil film in the gel condition was measured by a rubber

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hardness meter and the effect of oil component on the hardness of the heat curing oil film in solid state is investigated.

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 δ in Fig.1 indicate the clearance of parallel two plates 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.

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 and was found to provide much useful information about flow⁽²⁾.

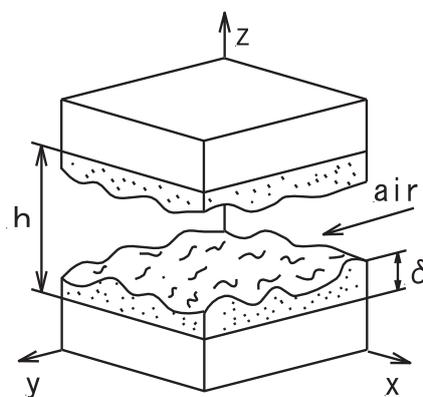


Fig.1 The flow visualization of the air flow in the clearance of Parallel two plates by using the heat curing oil film method.

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.

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. The Hardness of the Heat Curing Oil Film in Solid State

The heat curing oil film had been hardened with time from the sol to the gel by the hardener. The hardness of the heat curing oil film in the gel condition was measured by a rubber hardness meter based on JIS K 6301⁽³⁾.

4.1 The effect of Titanium dioxide

The hardness of the heat curing oil film in solid state in case of Table 1 had been measured by a rubber hardness meter. The effect of titanium dioxide on the hardness of the heat curing oil film in solid state is shown in Fig.2. The linear line in Fig.2 indicates the experiment data by a least squares method. It is shown from Fig.2 that the hardness of the heat curing oil film in solid state increases with increasing the mass of titanium dioxide. Silicone oil is a liquid, and titanium dioxide is a solid. It is due to the increase in mass ratio containing titanium dioxide in the heat curing oil film.

Table 1 Composition of oil paste

Oil	Additive agents		
Silicon	Titanium dioxide	Hardener	Oleic acid
m_s	m_t	m_h	m_o
* 10	1 ~ 10 (Step 1)	1	$0.04 \times m_t$

* : Mass ratio

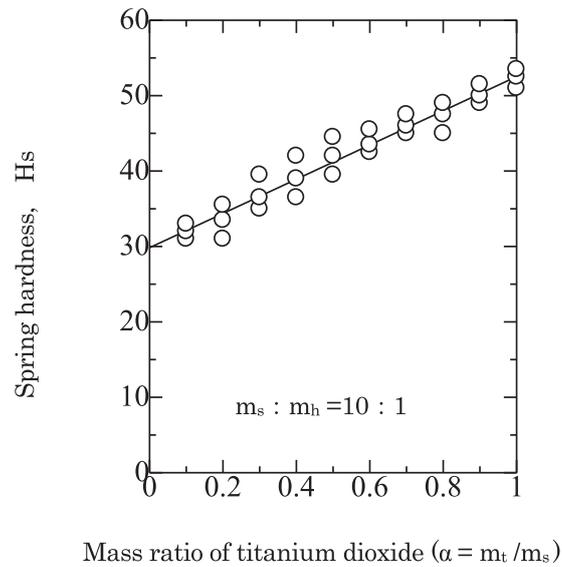


Fig.2 The effect of titanium dioxide on the hardness of the heat curing oil film in solid state.

4.2 The effect of Hardener

The hardener works as the curing catalyst for the heat curing oil film. The number of the quantity of the hardener contributes in the curing time from the sol to the gel of the heat curing oil film.

The hardness of the heat curing oil film in solid state in case of Table 2 had been measured by a rubber hardness meter. The effect of hardener on the hardness of the heat curing oil film in solid state is shown in Fig.3. The linear line in Fig.3 indicates the experiment data by a least squares method. It is shown from Fig.3 that the hardness of the heat curing oil film in solid state increases slightly with increasing the mass of hardener. This is because the number of the quantity of the hardener does not contribute greatly for the hardness of heat curing oil film in the gel state.

Table 2 Composition of oil paste

Oil	Additive agents		
Silicon	Titanium dioxide	Hardener	Oleic acid
m_s	m_t	m_h	m_o
* 10	5	0.25~2 (Step 0.25)	0.2

* : Mass ratio

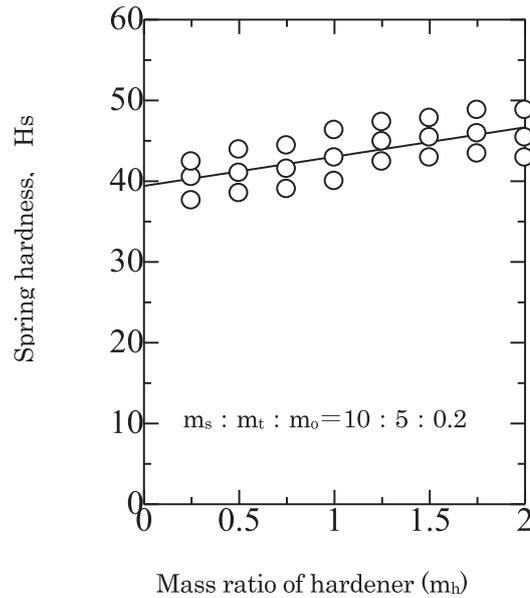


Fig.3 The effect of hardener on the hardness of the heat curing oil film in solid state.

5. 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 oil paste which is used in the heat curing oil film method contains the following components; Silicone, Titanium dioxide, Oleic acid and Hardener. The effect of oil component on the hardness of the heat curing oil film in solid state is investigated. The following can be concluded from the results.

- (1) Titanium dioxide is a white pigment. The hardness of the heat curing oil film in solid state increases with increasing the mass of titanium dioxide.
- (2) The hardener works as the curing catalyst for the heat curing oil film. The hardness of the heat curing oil film in solid state increases slightly with increasing the mass of hardener.

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