Friction between Self-Lubricating Rings and Travellers and Their Wear

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Abstract

The purpose of this research is to discover experimentally the characteristics of the friction between self-lubricating rings and travellers and their consequent wear.

With the aid of a Ring Traveller Friction Tester, the authors have investigated the degree of friction between rings and travellers and the amount of their wear. Lubricating oil of various viscosity degrees was used in the investigation. Findings :

(1) The viscosity degree of lubricating oil has no bearing on the wear of rings, although their wear varies with the type of the ring.

(2) The viscosity degree of lubricating oil and the type of the oiling mechanism used do have a bearing on the wear of travellers.

(3) The viscosity degree of lubricating oil has no bearing on the coefficient of ring-traveller friction, although the coefficient of friction varies with the type of the ring.

Introduction

Large packages and speed-up are major current efforts of the spinning industry to improve the efficiency of spinning and twisting frames.

Large packages and speed-up demand a reduction in the ring-traveller friction.

Self-lubricating rings are specifically designed to meet this demand. Self-lubricating rings now in use may be divided roughly into two types. One type is made of case-hardening steel or bearing steel and has lubricating bores or grooves. We call this type an OL ring. The other type is made of sintered ferro-alloy and is saturated with oil. We will call this type an OM ring.

The authors have studied the coefficient of friction of the ring and traveller and their wear with the use of a Ring Traveller Friction Tester and lubricating oil of varying viscosity degrees. The authors' purpose is to obtain fundamental data which can be used as a guide in the design.

Fig. 1. Forms of ring flanges of self-lubricating rings.

ing of a new oiling mechanism and in deciding what type of self-lubricating ring to use and what metal it should be made of.

1. Rings and Travellers Tested

1-1. Types of the Rings and Their Oiling Mechanisms

OL and OM rings were tested (Table 1). They are used to spin wool, synthetic fibers and their blends. The forms of their flanges are shown in Figure 1.

1-2. Metals of Which Made

The metals of which OL and OM rings are made are given in Table 2. Figure 2 is a microscopic photo showing the structure of an OM

ring. The porosity of the OM ring and the weight of the oil with which it is saturated are shown in Table 3.

1-3. Hardness

The hardness of the OL and OM rings is shown in Table 4.

1-4. Travellers

Travellers of all types tested were as nearly the same in weight as possible. Five travellers

Types	Forms of flanges	Dia. (mm)	Oiling mechanism	Number of rings tested
OL rings	Conical type (A)	50	Holder oil-pot → bores (1 at top, 3 inside)	4
	Vertical type (A)	50	Holder oil-pot → bores (3 inside)	4
	Conical type (B)	50	Holder oil-pot → groov (1 at top, 3 inside)	4
OM rings	Conical type (C)	50	Holder oil-pot → oil held in it	1
	Vertical type (C)	50	Holder oil-pot → oil held in it	1
	Horizontal type (C)	50	Holder oil-pot → oil held in it	4

(A), (B) and (C) were from different makers.

Table 2. Metals of Which Tested Rings Were Made

Types	Quenching structure	Carbon content of surface (%)
OL rings		
Conical type (A)	Surface: fine martensite Center: ferrite	1.1
Vertical type (A)	Surface: fine martensite Center: ferrite	1.1
Conical type (A)	Whole: fine martensite	1.0
OM rings		
Conical type (C)	Mostly: fine martensite and troostite	1.0
Vertical type (C)	Entirely: coarse accicular martensite	1.0
Horizontal type (C)	Entirely: fine martensite	1.0

Table 3. Porosity of Rings and Amount of Oil Saturated with

Types	Conical type (C)	Vertical type (C)	Horizontal type (C)
Porosity (%)	20.7	22.3	23.2
Amount of oil saturated with	1.0 g	0.7 g	0.6 g

Table 4. Hardness of Rings

Unit: Shore hardness						
Hardness	OL rings			OM rings		
	Conical type (A)	Vertical type (A)	Conical type (B)	Conical type (C)	Vertical type (C)	Horizontal type (C)
Surface	91.0	90.5	86.0	28.5	28.0	38.0
Cross section	27.1	63.5	59.8	26.0	29.5	33.0

Note: OL rings measured by Vickers micro hardness tester (load: 500g). OM rings measured by Rockwell hardness tester (A scale). Hardness degrees listed are the mean values, converted into Shore hardness, of measurement of three points of surface and cross section of each ring by Rockwell or Vickers hardness testers.

of each type were tested in combination with one ring (Table 5).

Travellers of hardnesses within the limits of Vickers hardness 660-690 were tested so as to reduce the hardness difference between them to a minimum. The travellers were made of a metal which met the specifications of JIS (Japan Industrial Standards) SWRH 6A.

1-5. Lubricating Oil

The lubricating oil used in our test was a compounded oil for self-lubricating rings — a mineral oil mixed with chloride as an extreme pressure agent. The characteristics of the oil are shown in Table 6.

2. Method of Experiment

2-1. Ring-Traveller Friction Tester

We used a 10-spindle type Ring Traveller Friction Tester in this experiment. The mechanism of the tester and the method used to measure friction torque are as explained in a previous article⁽¹⁾ by the authors.

Table 5. Combinations of Travellers and Rings

Types of rings	Traveller type	Count of traveller	Weight of traveller	Number of travellers tested
Conical type	SBA	No. 26	0.075 g	5/ring
Vertical type	SK	No. 26	0.075 g	5/ring
Horizontal type	G	No. 3	0.075 g	5/ring

Fig. 3. Outline of conditions of experiment.

2-2. Conditions of Experiment

Spindle speed: 7,000 r.p.m.

Temperature and relative humidity:

20~25 °C, 60~70% R.H.

Under the conditions outlined in Figure 3 we tested two factors at the same time — the kinds of the rings and the viscosity of the lubricating oil — repeating the test four times in a random layout. The results were analyzed by a two-way layout analysis of variance.

2-3. Cleaning and Oiling of Rings

The rings we cleaned every four hours. Each time the cleaning consisted of leaving them three hours in trichlorethylene 60°~80°C hot and then degreasing them completely by compressive air.

The OL rings were oiled by oiling the lubricator (cotton yarn). The OM rings were oiled, through compressor oiling implements, with an oil heated at 60°~80° — after a measurement of the wear of the rings. The amount of the oiling of the OM rings was about 60% of the capacity of the oil pot attached to the holder on each ring.

Table 6. Characteristics of Lubricant

Lubricants	Viscosity at 20°C (centipose)	Oiliness (film strength)	Stability
CL ring oil No. 15	180—200	20kg/0.1mm ²	150°C/10 hours
CL ring oil No. 30	3,240—3,260	20kg/0.1mm ²	150°C/10 hours

(a) Coefficient of friction if lubricant CL No. 15 used

(b) Coefficient of friction if lubricant CL No. 30 used

Fig. 4. Relation between coefficient of ring and traveller and duration of test

3. Results

3.1. Wear and Coefficient of Friction

Figure 4 shows the relation between the mean value of the coefficient of the ring-traveller friction and the duration of the test; Figure 5, between the mean value of the wear of the rings and the duration of the test; and Figure 6, between the mean value of the wear of the travellers and the duration of the test.

The mean value of the wear of the rings after 20-hour tests, the mean value of the wear of the travellers after four-hour tests and the mean value of the coefficient of the ring-traveller friction after 20-hour tests were obtained.

(a) Wear of ring if lubricant CL No. 15 used

(b) Wear of ring if lubricant CL No. 30 used

Fig. 5. Relation between coefficient of friction of ring and traveller and duration of test.

Fig. 6. Viscosity degree of lubricant vs. wear of travellers.

The results of variance analyses based on these values are given in Tables, 7, 8 and 9.

3.2. Roughness of Rings

As a matter of interest, the pre- and post-test roughness of that area of the rings which came

Table 7. Analysis of Variance on the Wear of Ring

Factors	S	ϕ	V	F ₀
Viscosity of oil	495.4	1	495.4	41.37
Type of ring	405,275	5	81,055	3.95*
Interaction	53,679	5	10,735.8	1.91
Variations of error	245.97	12	20,498	
Total variations	705,419	23		

Table 8. Analysis of Variance on the Wear of Rings

Factors	S	ϕ	V	F ₀
Viscosity of oil	888.2	1	234.4	1.78
Type of ring	23,109.9	5	2,674.2	20.25**
Interaction	4,457.8	5	281.7	2.13
Variations of error	1,202	12	132	
Total variations	29,657.9	23		

Table 9. Analysis of Variance on the Coefficient of Friction

Factors	S	ϕ	V	F ₀
Viscosity of oil	234.4	1	234.4	1.78
Type of ring	13,370.8	5	2,674.2	20.25**
Interaction	1,408.3	5	281.7	2.13
Variations of error	1,583.5	12	132	
Total variations	16,597	23		

Table 10. Roughness of Rings

Unit: 1/1,000mm

Lubricants	rings					
	Conical type (A)		Vertical type (A)		Conical type (B)	
	a*	b**	a	b	a	b
CL No. 15	0.6	0.2	0.6	0.3	0.6	0.7
CL No. 30	0.6	0.2	0.5	0.4	0.9	0.7
Lubricants	OM rings					
	Conical type (C)		Vertical type (C)		Horizontal type (C)	
	a	b	a	b	a	b
CL No. 15	4.8	3.6	4.2	1.9	3.0	2.3
CL No. 30	3.8	2.0	5.9	2.2	2.6	2.0

a*: before test; b**: after test

Note: Values listed are the mean values of measurement of three points on each of four rings tested.

into contact with the travellers is shown in Table 10.

Conclusions

With the aid of Ring-Traveller Friction Tester and lubricating oil of various viscosity degrees, the authors have compared the wear of rings and travellers of types at present in common use and the coefficient of the ring-traveller friction. The results show that :

(1) Wear of ring — The viscosity degree of lubricating oil has no bearing on the wear of rings (Table 7). However, the wear of rings differs in amount, depending on the type of the ring. A test of their significant differences has shown that a conical-type OM ring (C) is subject to heavier wear than the OM ring (C) and five other types.

Every ring develops steady wear in a short time. An OL ring is subject to less wear than an OM ring. The main reason is the difference between the metals of which they are made and the difference in their hardness.

Nearly all rings tested showed a significant difference between their pre- and post-test roughness, the post-test roughness being smaller in degree.

(2) Wear of travellers — The viscosity degree of lubricating oil has a bearing on the wear of travellers (Table 8). On the wear of rings, however, the viscosity degree of lubricating oil has no bearing, in the authors' opinion. The wear of rings seems to be induced by their oiling mechanisms, i.e., the types of rings. Tests have shown that rings of the same type present no significant difference, with the confidence limit of 95%, in the degree of the effect of differences in the viscosity degree of lubricating oil.

Significant differences were observed in the wear of travellers among a conical-type OL ring (B) and five other types, the conical type OL ring (B) showing the highest degree of wear.

The viscosity degree of lubricating oil has a bearing on the wear of a traveller, depending on the type of the ring with which it is combined. The heavier wear which the conical-type OL rings

(B) developed than the other rings is to be explained, in our opinion, chiefly by the difference in the oiling mechanism and by the absence of a proper boundary lubrication layer in the conical type OL.

(3) Coefficient of friction — The viscosity degree of lubricating oil has no bearing on the coefficient of the ring-traveller friction (Table 9), but the type of the ring does have a bearing on the friction coefficient. The following results have been obtained from a test of the significant difference in the friction coefficient among the six types of rings tested:

(3-a) The conical type OL (A) shows the lowest coefficient of friction of all.

(3-b) The conical type OL (B) shows the highest coefficient of friction of all. The other five types show no significant difference among them in friction coefficient. The degree of friction between a self-lubricating ring and a traveller depends to a large extent on the type of the oiling mechanism of the ring.

A self-lubricating ring forms a boundary friction layer between it and the traveller with which it is combined. Not all the area of a boundary friction is formed by a layer of lubricating oil between two conflicting objects. The area of a boundary contact is, in fact, formed by a layer of lubricating oil (fluid or boundary layer) and by a dry layer between two conflicting objects. The larger the layer of lubricating, the smaller the friction between two conflicting objects and their wear.

It follows, then, that a self-lubricating ring should be saturated with a kind of oil which expands the fluid boundary layer between the ring and the traveller it comes into contact with.

It follows, further, that a self-lubricating ring and a traveller it comes into contact with should be made of such metals as reduce their wear in the dry boundary of the ring-traveller contact and that the ring and traveller should be so finished as to be subject to the least possible wear.

Reference

- [1] H. Kanai and H. Kubota; *J. Text. Mach. Soc., Japanese edition*, Vol. 12, No. 5, p. 361 (1959)