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The lubricant and implants influence above tribological behaviour at three cone bits bearings

K e y w o r d s

Three cone bits bearings, friction coefficient, copper implants.

S u m m a r y

Sliding bearings at three cone bits are lubricated in heavy conditions. To improve tribological behaviour, samples of bearing materials were made with implants with antifriction materials having different rapports between the implant and free base material in the presence of different greases. Tests made on a CSM microtribometer and on an Amsler A135 were to establish the proper implant rapport, measuring friction coefficient, and wear. The behaviour of the greases containing P.T.F.E was also established. In a second phase of the tests was designed and realised a device for testing three cone bits bearings at real axial loads. A SPIDER 8 device and inductive traducers were used to establish the friction coefficients and the temperature on the friction surface, depending on implants' dimensions and grease lubricant type.

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1. Introduction

A drill bit is a complex device working at great deep supporting loads, especially at fast drilling, greater than 300 kN and speed over 500 r.p.m., [1]. At three cone drill bearing active surfaces, we have abrasive, erosive, corrosive, adhesive and impact wear at variable loads. These heavy working conditions are rarely meet in surface industry, so construction, materials and technology used in drill bit manufacturing have to solve many problems.

This paper presents the results and the solutions to increase the durability of three cone bits sliding bearings. It is very important that the lubricant to not be contaminated with drilling fluid. Because the properties of rubber used for sealing are maintained at 80°C, the temperature in sliding bearings must not exceed this temperature.

The loading capacity of sliding bearings depends on the surface cover capacity of the copper implants used [1, 2]. This work is to establish the proper implant rapport and the behaviour of new lubricant grease about wear, friction coefficient, and temperature at three cone bits sliding bearings.

2. Experiments

On universal testing machine type Amsler A135, we established the speed and grease influence, and measured the friction coefficient, wear, and temperature. The behaviour of the greases containing P.T.F.E. was also established. On the CSM microtribometer, the friction coefficient related to the implant rapport was also established. In a second phase of the tests, was designed and realised a device for testing three cone bits bearings at real axial loads. With SPIDER 8 device and inductive traducers, we establish the friction coefficients and the temperature at the friction surface in relation to implant dimensions and the grease lubricant type.

2.1. Experiments on Amsler machine

Tests were made on cylindrical surface couple, [1, 2] consisting of the following:

– Shoe material 20MoCrNi06 (0.17...0.23%C, 0.60...0.90%Mn, 0.20...0.35%Si, 0.35...0.65%Cr, 0.35...0.76%Ni, 0.20...0.30%Mo, S and P max.0.025%, Cu max. 0.3%) with implants of copper;
– Cylinder surface layer of METCO Stellite 20.

On shoe surface implants of copper [1] were made. Temperature was measured with a thermocouple type J and a multimeter type APPA 306. The thermocouple was inserted in the shoe sample close to the friction surface.

The testing conditions were as follows:

– normal load 1250 N at wear tests;

– cylinder rotation speed 200 r.p.m;
– lubricant:
  – classical grease;
  – new grease with P.T.F.E.

In Figure 1 are presented the results for friction coefficients.

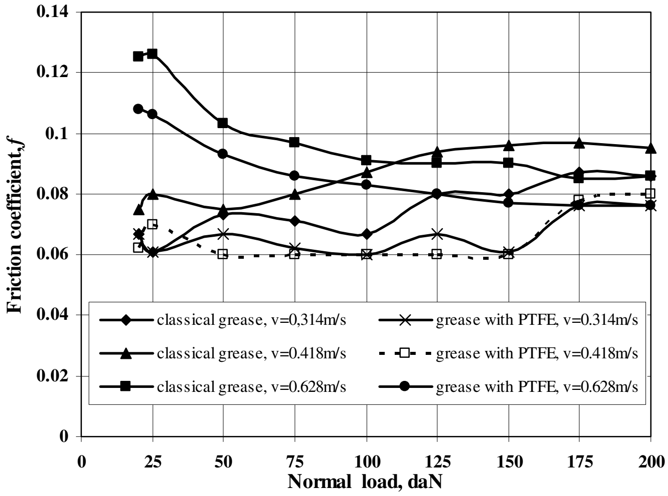


Fig. 1. Friction coefficient vs. normal load

The cylinder samples diameters were 30 mm, 40 mm and 60 mm. The capability of shoe copper implants to cover the cylinder surface is maximum at the minimum tested diameter. As shown in Fig.1, the friction coefficients are smaller at 0.314 m/s (diameter 30 mm) and in the presence of new grease with classical P.T.F.E.

Figure 2 represents the gravimetric wear curves at sliding speed of 0.314 m/s.

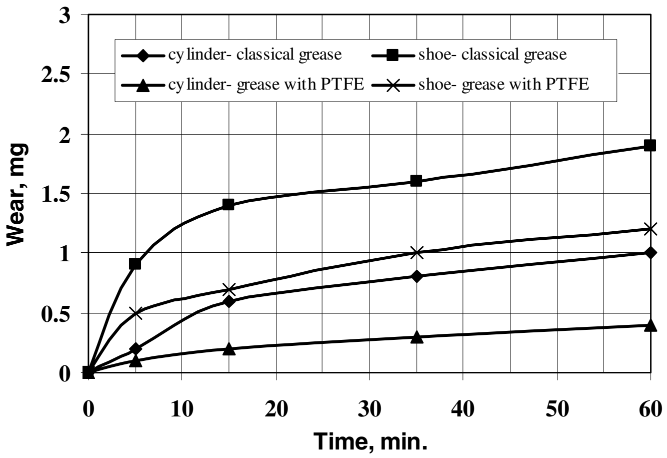


Fig. 2. Wear curves at sliding speed of 0.314 m/s

Similar wear curves were obtained at 0.418 m/s and 0.628 m/s. The wear values are smaller at minimum sliding speed (friction length is smaller) and in the presence o new lubricant grease.

Table 1 presents the temperature tests results [1].

Table 1. Temperature results on Amsler shoe sample

Sliding speed, v_a, m/s	Lubricant	Time, min.	Temperature, ^{0}C
0.314	Classical grease	60	82
	Grease with PTFE		76
0.418	Classical grease		84
	Grease with PTFE		81
0.628	Classical grease		88
	Grease with PTFE		83

From the values presented in Tab. 1, it could be observed that temperatures were smaller in the zpresence of new grease with P.T.F.E. powder. Because the lubrication was realised manual, in an open system, the obtained temperature values were rather over the recommended values.

2.1. Experiments on CSM microtribometer machine

Tests were made on plane surface couple, [3, 4] consisted of the following:

- Disk sample: carburized, layer METCO Stellite, 12 copper implants, 15 copper implants;
- Plane sample (static partner): surface 15.21 mm^2 with layer of METCO Stellite 20;
- Dry friction, air temperature 20^{o}C, relative humidity RH=48.7%;
- Sliding speed 0.2199 m/s;
- Normal load 4N; and,
- Friction length 100m.

Figure 2 indicates the friction coefficients vs. friction length results for disk with 12 copper implants disposed at an 11 mm diameter, which means a sub-unitary rapport between implants length and the rest of material length.

Changing the rapport between the length of implant and the length of rest of material at a rapport of 1, obtained at 15 implants, tend to smaller values for the friction coefficient as presented in Figure 4.

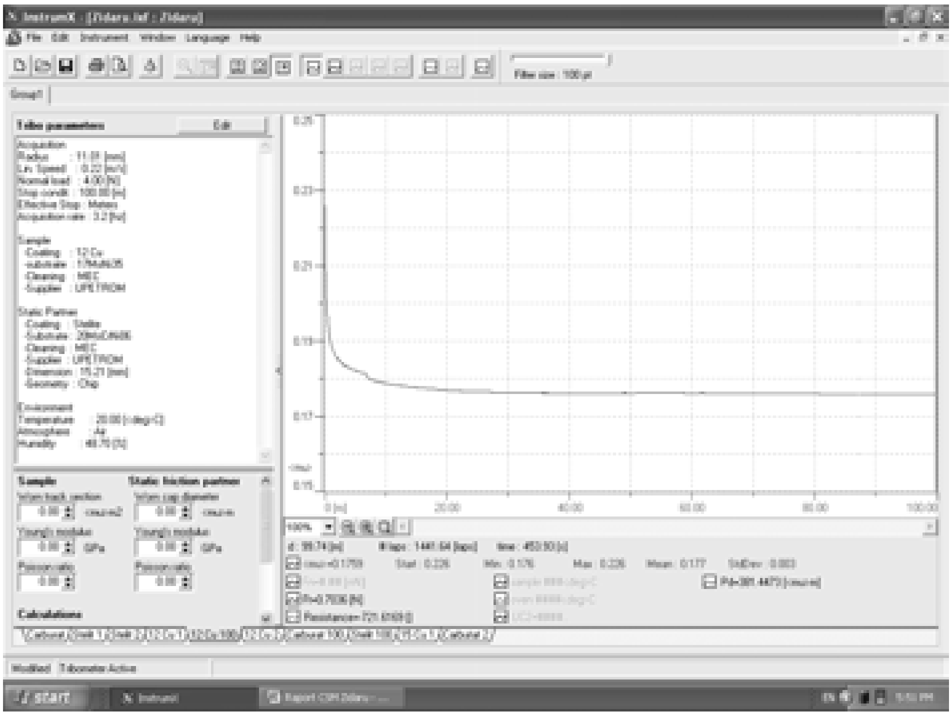


Fig. 3. Friction coefficients vs. friction length for disk with 12 copper implants

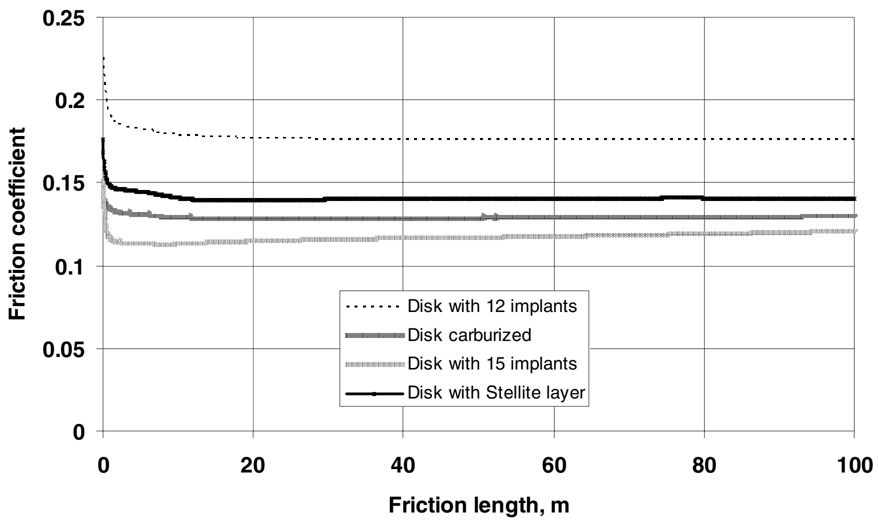


Fig. 4. Friction coefficients vs. friction length

2.3. Experiments on a device for testing three cone bits bearings at real axial loads

A plan axial sliding bearing is designed to support the entire axial load, which is the action on cone during the drilling. Figure 5 represents the construction of the axial sliding bearing, and Figure 6 represents the relative position of the copper implants depending on the zone covered with stellite [1, 2].

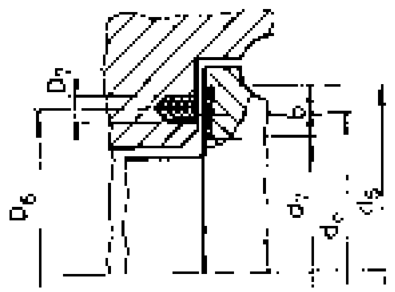


Fig. 5. Construction of axial sliding bearing

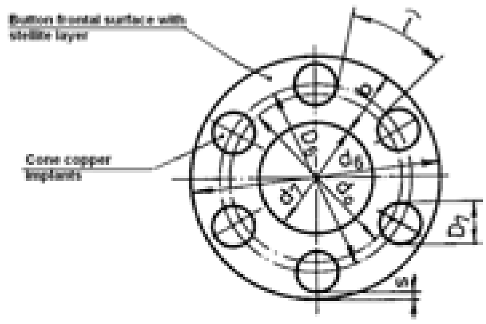


Fig. 6. Relative position of implants

Taking into account the following:
n – represents the implant number;
l – distance between two implants; and,
$K = \frac{l}{D_7}$ the covering coefficient.

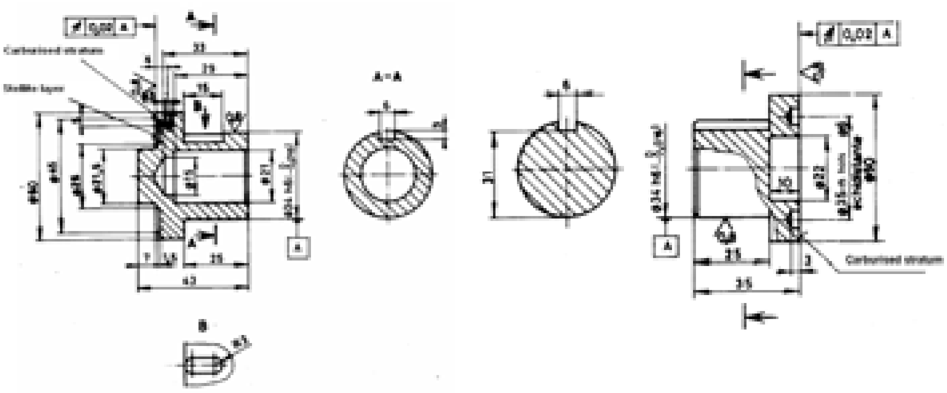
Table 2 presents the dimensions for axial sliding bearing drill bit type S– 8 ⅜ GJ [1].

Table 2. Dimensions of axial sliding bearing

Type and drill dimension	d_6 mm	d_7 mm	b mm	d_0 mm	D_6 mm	D_7 mm	n implants	l mm	K -	s mm
S – 8 ⅜ GJ	50	35	7.5	42.5	45	5	6	18.55	3.71	0

To evaluate the friction coefficient and temperature, a special device [1, 2] was designed. Axial load and friction torques are measured using two strain gauges and a strain traducer, type SPIDER 8, and Catman Easy soft program. Temperature was measured with a J type thermocouple. **Figure 7** shows the samples dimensions [1, 2].

Samples with 6, 8 and 12 copper implants at an axial load of 5000 N and rotation speed of 120 r.p.m. in the presence of classical grease and new grease with P.T.F.E. were tested.



a b

Fig. 7. Samples dimensions: *a* – fixed sample button type with stellite layer; *b* – mobile sample type con with implants

Figure 8 represents the friction coefficient results at couple button with a stellite layer and a cone carburized and with 8 copper implants in the presence of the classical drill bit grease

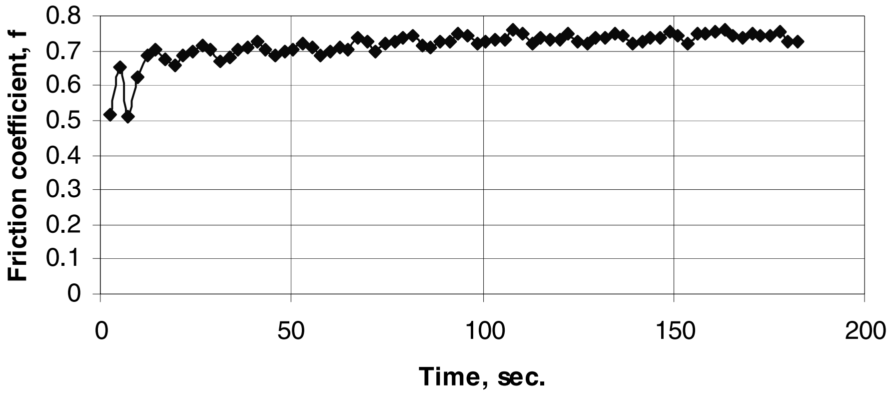


Fig. 8. Friction coefficient at couple materials with 8 copper implants and classical drill bit grease

Similar results were obtained in different conditions and are presented in Table 3.

Table 3. Friction coefficients and temperature results

Materials couple	Lubricant	Friction Coefficient	Temperature °C	Materials couple	Lubricant	Friction coefficient	Tempera-ture °C
Carburized stratum/ Stellite layer	Classical grease	1.30	80	Carburized stratum with 8 implants/ Stellite layer	Classical grease	0.75	66
	Grease with P.T.F.E.	0.87	70		Grease with P.T.F.E.	0.3 – 0.6	62
Carburized stratum with 6 implants/ Stellite layer	Classical grease	0.90	67	Carburized stratum with 12 implants/ Stellite layer	Classical grease	0.55 – 0.80	74
	Grease with P.T.F.E.	0.82 – 0.87	63		Grease with P.T.F.E.	0.75	70

3. Conclusions

Main conclusions resulted after the tests are as follows:

- Using P.T.F.E. powder in the actual drill grease to obtain a new grease, the friction coefficient and temperature at the friction surface were reduced; and, in the presence of drill grease with P.T.F.E., the friction coefficients decrease with a tendency to stabilise at a smaller value than at the starting friction.
- A temperature rise is with a smaller gradient in the presence of drill grease with P.T.F.E.
- Copper implants on the frontal carburized surface of axial sliding bearing diminish friction coefficient and temperature and at drill bit 8 3/8 GJ for the three types of implants number, the best solution was with 8 copper implants, when the smallest values for the friction coefficients and temperature were obtained.

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