Research Regarding the Improvements of Tribological Behavior in Three Cone Bits Bearings

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Sliding bearings in three cone bits are lubricated in heavy conditions. To improve tribological behavior, samples of bearings materials were made with implants of antifriction materials with different rapport between implant and free base material in the presence of different greases. Antifriction material has a greater dilatation coefficient than base material. If the implant dimension is too small, the solid lubricant capability to cover the base material does not enssure a proper friction coefficient. If the implant dimension is too great the external load could not be supported. On Amsler A135 the proper implant rapport, measuring friction coefficient and wear were established. The behavior of the greases containing PTFE was also established. In a second phase of the tests a device for testing three cone bits bearings at real axial loads was designed and realized. With SPIDER 8 device and inductive traducers we established the friction coefficients and the temperature on friction surface, depending on implants dimensions and grease lubricant type.

Keywords: *three cone bits bearings, friction coefficient, temperature.*

1. INTRODUCTION

In hydrocarbons, but not only, wells, drilling bits are of great importance. This complex device works at great deep supporting loads, especially at fast drilling, greater than 300 kN and speed over 500 rpm [1]. In drill bit active surfaces we have abrasive, erosive, corrosive, adhesive and impact wear at variable loads. These heavy working conditions are rarely met in surface industry, so construction, materials and technology used in drill bits manufacturing have to solve many problems.

In order to improve durability of drill bits, the paper present the results and the solutions to raise the durability in three cone bits sliding bearings. In Figure 1 we could see that sliding bearings 5 and 6 is close of sealing 3. It's very important that lubricant is not contaminated with drilling fluid. Because properties of rubber used at sealing are maintained till 80 °C, the temperature in sliding bearings must not exceed this temperature.

To diminish friction coefficient copper implants are used [2,3]. Loading capacity of sliding bearings depends of surface cover capacity of copper implants. Grease lubricant type is also important above wear and friction behavior. In this order this work establishes the proper implant rapport and the behavior of a new lubricant grease above wear, friction coefficient and temperature in three cone bits sliding bearings.

2. EXPERIMENTS

The speed and grease influence, measuring friction coefficient, wear and temperature, were established on a universal testing machine, type Amsler A135. It was also established the behavior of the greases containing PTFE. In a second phase of the tests a device for testing three cone bits bearings at real axial loads was designed and realized. With SPIDER 8 device and inductive traducers we established the friction coefficients and the temperature on friction surface, depending on implants dimensions and grease lubricant type.

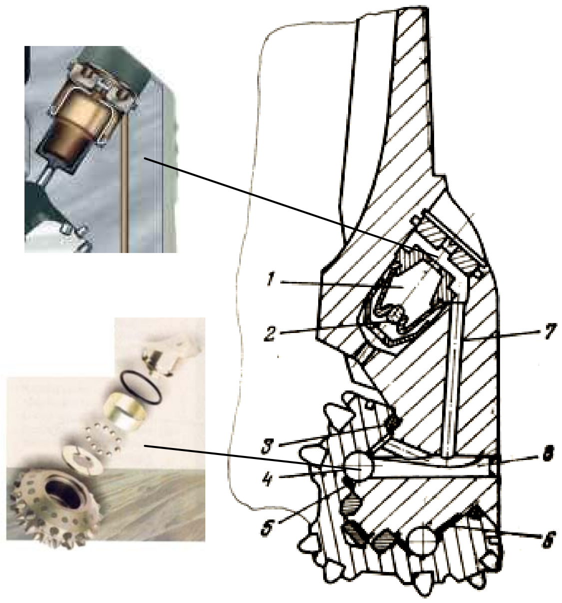

Figure 1. Sealing and lubrication of bearings

2.1 Experiments on the Amsler machine

The samples presented in Figure 2 [4,5] were made of:

- 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, max.

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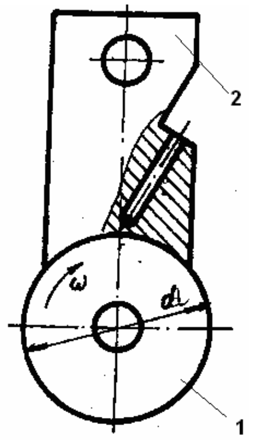
0.025 % S and P and max. 0.3 % Cu) with implants of copper;
- cylinder surface layer of METCO Stellite 20.

On shoe surface implants of copper were made, as presented in Figure 3 [3].



1 – Cylinder (d_i = 30, 40 and 60 mm); 2 – Shoe

Figure 2. Amsler samples

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 (Fig. 2).

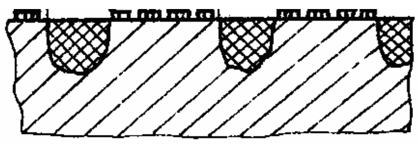


Figure 3. Implants on shoe surface

The testing conditions were:

- normal load 1250 N in wear tests;
- cylinder rotation speed 200 rpm;
- lubricant classical grease and new grease with PTFE.

In Figure 4 are presented the results for friction coefficients.

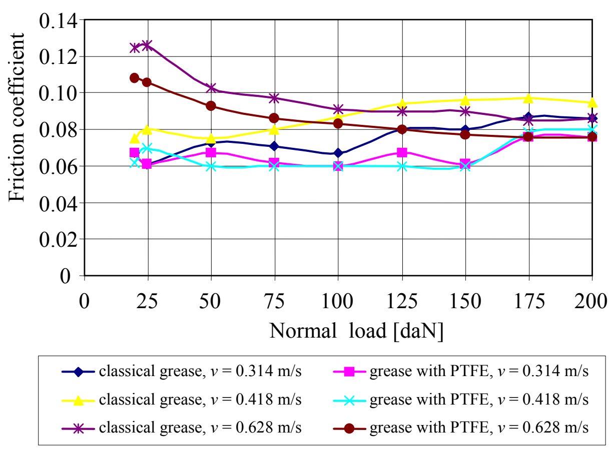


Figure 4. Friction coefficient vs. normal load

The cylinder samples diameters were 30, 40 and 60 mm. The capability of shoe copper implants to cover the cylinder surface is maximum at the minimum tested diameter. As it is shown in Figure 4 the friction coefficients are smaller at 0.314 m/s (diameter 30 mm) and in the presence of new grease with PTFE.

Figure 5 represents the gravimetric wear curves at sliding speed of 0.418 m/s.

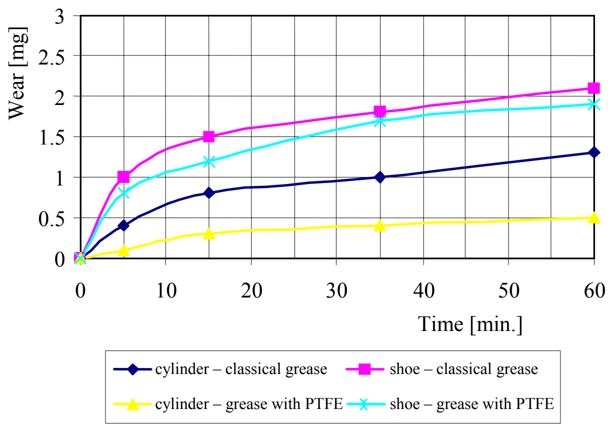


Figure 5. Wear curves at sliding speed of 0.418 m/s

Similar wear curves were obtained at 0.314 m/s and 0.628 m/s. The wear values are smaller at minimum sliding speed (friction length is smaller) and in the presence with a new lubricant grease.

In Table 1 are presented the temperature results.

Table 1. Temperature results on Amsler shoe sample

Sliding speed, v_a [m/s]	Lubricant	Time [min.]	Temperature [°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 Table 1 it could be observed that temperatures were smaller in the presence of a new grease with PTFE powder. Because the lubrication was realized manually, in an open system, the obtained temperature values were rather over the recommended values.

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

Plain axial sliding bearing has the purpose to support the entire axial load which acts on cone during the drilling.

In Figure 6 is represented the construction of the axial sliding bearing and in Figure 7 the relative position of the copper implants, depending on the zone covered with stellite [2,3].

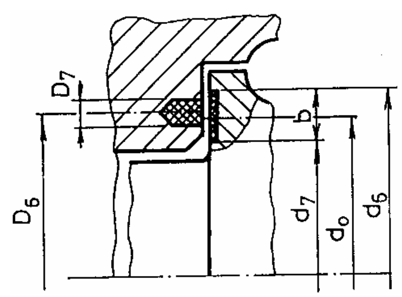


Figure 6. Construction of axial sliding bearing

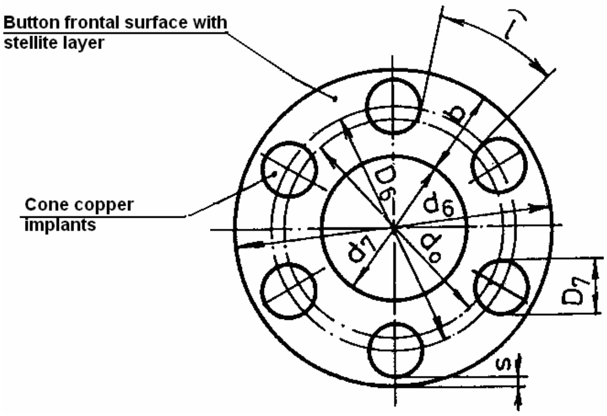


Figure 7. Relative position of implants

Taking into account that:

- n – represents the implant number;
- *l* – distance between two implants;
- $K = \frac{l}{D_7}$ – the covering coefficient.

In Table 2 are presented the dimensions for axial sliding bearing drill bit type S – 8 ⅜ GJ.

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]
S – 8 ⅜ GJ	50	35	7.5	42.5	45
	D_7 [mm]	n implants	l [mm]	K	s [mm]
	5	6	18.55	3.71	0

To evaluate the friction coefficient and temperature a device, as shown in Figure 8 [2], was designed and realized.

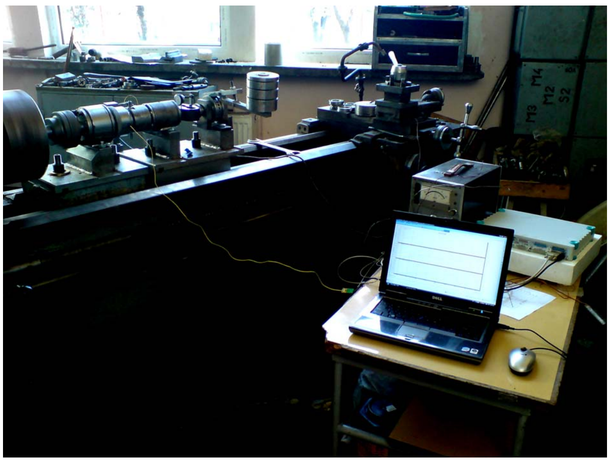


Figure 8. Device for testing three cone bits axial sliding bearings

Axial load and friction torque are measured using two strain gauges and a strain traducer type SPIDER 8 and Catman Easy software program. Temperature was measured with a J type thermocouple. Figure 9 shows the samples dimensions [2].

Samples with 6, 8 and 12 copper implants were tested at an axial load of 5000 N and rotation speed of 120 rpm in the presence of classical grease and a new grease with PTFE.

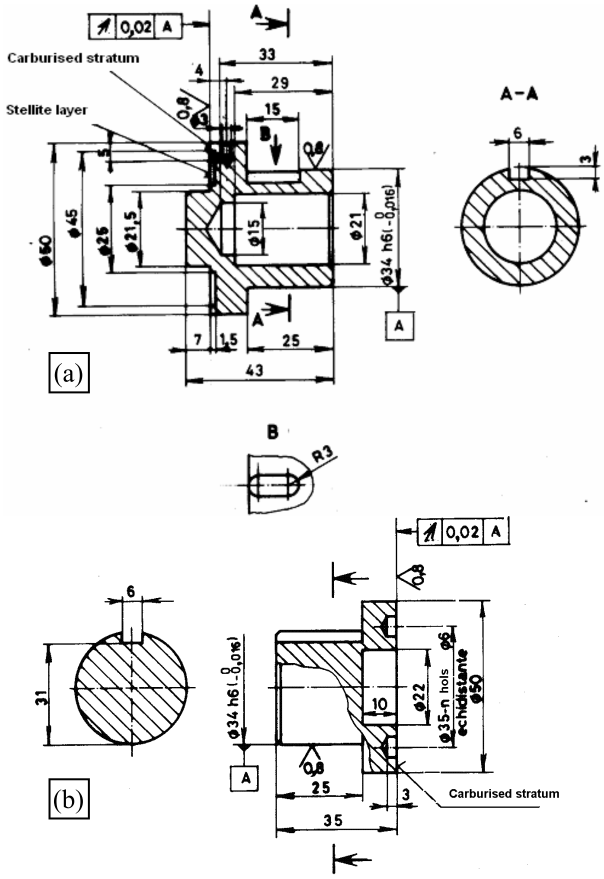


Figure 9. Samples dimensions: (a) fixed sample button type with stellite layer and (b) mobile sample type con with implants

In Figure 10 the friction coefficients results are represented at couple button with stellite layer and cone carburized and with 8 copper implants in the presence of grease with PTFE and in Figure 11 the classical drill bit grease was used.

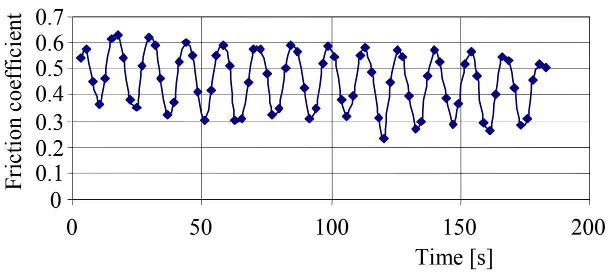


Figure 10. Friction coefficient at couple materials with 8 copper implants and grease with PTFE

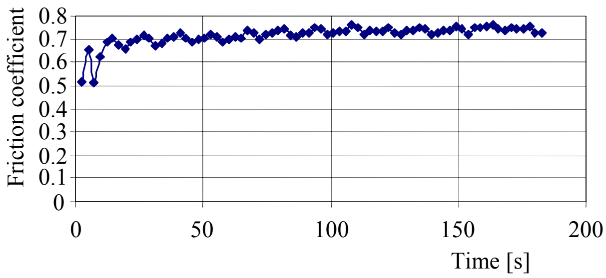


Figure 11. Friction coefficient at couple materials with 8 copper implants and classical drill bit grease

In Figure 12 it is shown the temperature variation at couple button with stellite layer and cone carburized and with 8 copper implants in the presence of grease with

PTFE and in Figure 13 the medium was classical drill bit grease.

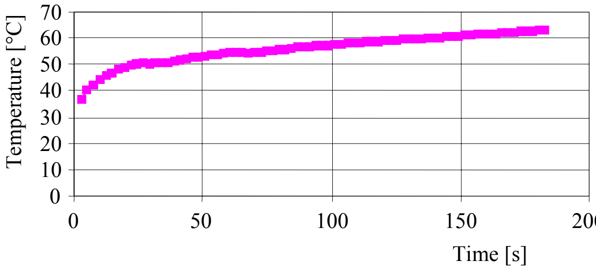


Figure 12. Temperature variation at couple materials with 8 copper implants and grease with PTFE

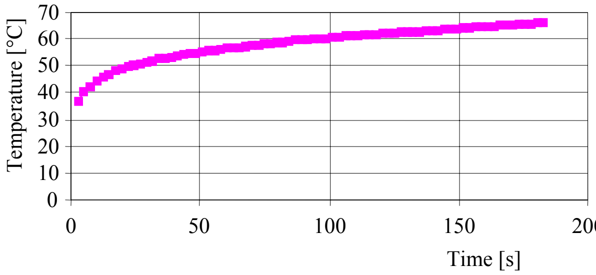


Figure 13. Temperature variation at couple materials with 8 copper implants and classical drill bit grease

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

Table 3. Friction coefficients and temperature results

Materials couple	Lubricant	Friction coefficient	Temperature [°C]
Carburized stratum/ Stellite layer	Classical grease	1.30	80
	Grease with PTFE	0.87	70
Carburized stratum with 6 implants/ Stellite layer	Classical grease	0.90	67
	Grease with PTFE	0.82 – 0.87	63
Carburized stratum with 8 implants/ Stellite layer	Classical grease	0.75	66
	Grease with PTFE	0.3 – 0.6	62
Carburized stratum with 12 implants/ Stellite layer	Classical grease	0.55 – 0.80	74
	Grease with PTFE	0.75	70

3. CONCLUSIONS

The main conclusions resulted after the tests are:

- using PTFE powder in the actual drill grease to obtain a new grease, the friction coefficient and temperature on the friction surface were reduced;
- in the presence of actual drill grease the friction coefficient rises;
- in the presence of drill grease with PTFE the friction coefficient decreases with a tendency to stabilize at a smaller value than at the friction start;
- temperature rises with a smaller gradient in the presence of drill grease with PTFE;
- copper implants on the frontal carburised surface of axial sliding bearing diminish friction coefficient and temperature;
- in drill bit 8 ⅜ GJ for the three types of implants number, the best solution was with 8 copper implants when the smallest values for friction coefficient and temperature were obtained;
- friction coefficient at drill grease with PTFE powder has important variation due to forming and disbonding the Teflon layer.

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ИСТРАЖИВАЊЕ ПОБОЉШАЊА ТРИБОЛОШКИХ КАРАКТЕРИСТИКА ЛЕЖАЈА ЗА ТРИ КОНИЧНА УМЕТКА

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Клизни лежаји са три конична уметка се подмазују при раду у отежаним условима. У циљу побољшања триболошких карактеристика израђени су узорци од материјала за лежаје са имплантима од материјала који дају мало трење, а са различитим односом између материјала импланта и основног материјала. Узорци су испитивани у условима подмазивања са различитим врстама техничких масти. Материјал импланта је имао већи коефицијент истезања у односу на основни материјал. Ако су димензије импланта премале чврсто мазиво не формира потпуни слој на основном материјалу и не обезбеђује се одговарајући коефицијент трења. Ако су димензије импланта превелике онда не може да се издржи спољашње оптерећење. Правилан однос импланта је утврђен на уређају *Amsler A135*, мерењем коефицијента трења и величине хабања. На истом уређају је испитан и утицај техничких масти које садрже у себи ПТФЕ. У другој фази испитивања пројектован је и реализован уређај за испитивање лежаја са три конична уметка при реалном аксијалном оптерећењу. Помоћу уређаја *SPIDER 8* утврђени су коефицијент трења и температура на клизној површини у зависности од димензија импланта и врсте техничке масти.