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Study of tribological properties of chosen types of environmentally friendly oils in combined friction conditions

Štúdium tribologických vlastností vybraných druhov olejov šetrných k životnému prostrediu v podmienkach zmiešaného trenia

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Abstract

This contribution describes the possibilities of using the ecological oils Mogul HEES 46, Hydros 46, Fuchs Plantohyd 46S and Shell Naturelle 46HF-E in a slide assembly. It compares their chosen properties reciprocally. A sliding pair was made up of a shaft from steel 14 220 and of a bearing shell. The bearing shell was fully of bronze, centrifugally moulded, with the trade mark B60 M4. The sliding pair worked during the whole experiment in combined friction conditions.

Keywords: ecological oil, sliding node, tribotestor

Abstrakt

Príspevok popisuje možnosti použitia ekologických olejov Mogul HEES 46, Hydros 46, Fuchs Plantohyd 46 S a Shell Naturelle 46 HF-E do klzného uloženia. Porovnáva ich vybrané vlastnosti navzájom. Párová klzná dvojica bola tvorená hriadeľom z ocele 14 220 a puzdrom. Puzdro bolo celobronzové, odstredivo liate, s obchodným označením B60 M4. Klzná dvojica pracovala počas experimentu v podmienkach zmiešaného trenia.

Kľúčové slová: ekologický olej, klzný uzol, tribotestor

Introduction

Environmental protection is an actual topic already for several years, and it becomes a preferred problem in the established trend of economic development. The growth of economy also includes the intensification of agricultural production. One of the possibilities of ecological behaviour is also the utilisation of ecological oils in the field of agricultural machines. This contribution deals with the use of ecological oils in the tribological system and with the study of their properties during the tribological process. The tribological process is characterised by material interactions of frictional bodies, lubricant and the surroundings, which take place in space and time, whereby tribological states in the tribological system are classified by time (Blaškovič, 1990).

Materials and Methods

A device Tribotestor M`06 was used for the performance of tribological experiments. This universal test device enables the performance of various types of tests – the tests of limit load (seizing test), tests of boundary velocity (velocity seizing test), capacity tests for the determination of pv diagram, and life (durability) tests.

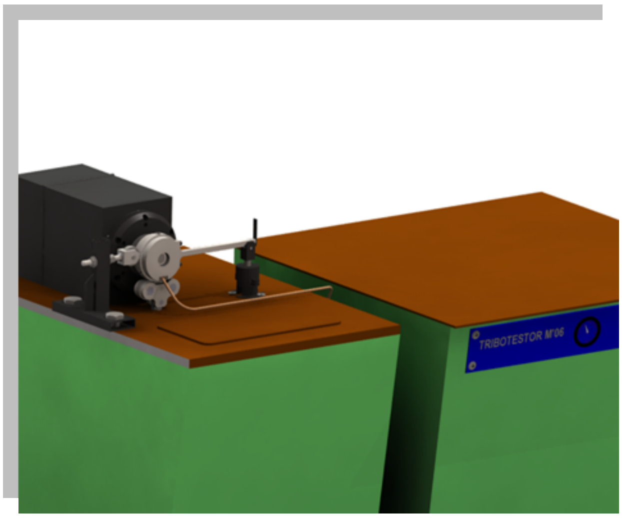

Figure 1: Measuring device Tribotestor M`06

The test device consists of three main parts. The test part itself is made of drive units of the rotational motion of samples, vertical loading force and a measuring head. Another part contains the elements of a pneumatic circuit and all electronic devices. The last part is a control-evaluating unit in the form of a connected desktop computer. Starting, checking, control, data collection and test evaluation are performed on the connected computer.

Our experiment was performed using the seizing test.

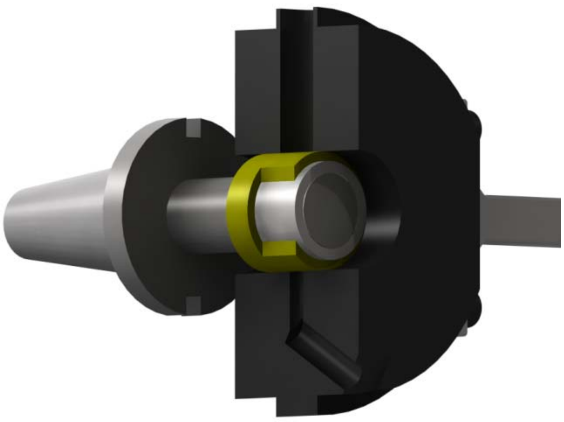

Figure 2: Detailed view of the measuring head and test samples

Figure 2 shows the measuring head and test samples. Sliding angle is made of the pair of bodies, creating a planar contact by a rotating test shaft against the test bearing shell. The bearing shell is fixed in the measuring head. Bearing shells from the company KaJo Metal were fully of bronze, centrifugally moulded, with the trade mark B 60 M 4, and with the dimensions: ϕ 30 mm for outer diameter, ϕ 25 mm for inner diameter and 20 mm for the length of the bearing shell. The bearing shell of the test shaft with ϕ 25 mm for outer diameter and with 25 mm length was made from steel 14 220 and fixed to the cylindrical part of the supporting shaft. The supporting shaft was attached to the drive unit by shrink conic connections through tightening force over the internal thread in the cone. The sliding node was lubricated with the test ecological oil that was gravitationally dropping through the upper part of the measuring head.

The tested lubricating mediums were the ecological oils Mogul HEES 46, Hydros 46, Fuchs Plantohyd 46 S and Shell Naturelle 46 HF-E.

Mogul HEES 46 is an ecological oil produced on the base of synthetic esters. It is designated for extremely stressed hydrostatic systems of machines and equipment working yearly at temperatures between -20 °C and 80 °C. There is expected a similar lifetime as the lifetime of petroleum oils.

Hydros 46 is a biodegradable oil on the base of saturated synthetic esters. It is characterised by excellent properties under high pressure and temperature, multiple extension of exchange intervals. It is neutral to seals, preserves its properties also under high frosts, and has good lubrication properties and minimum foamability.

Fuchs Plantohyd 46 S is an environmentally friendly, fast biodegradable oil on the base of synthetic esters of HEES type, according to the standard VDMA 24 568. It is usable in all hydraulic and circulation systems that require using the oil of the ISO VG 46 class. It is suitable for mobile and stationary hydraulic systems.

Shell Naturelle 46 HF-E is a fully synthetic, environmentally friendly hydraulic oil. It is determined for usage in hydraulic and liquid transmission systems. Shell Naturelle 46 HF-E is an easily biodegradable hydraulic oil with a low ecotoxicity, particularly suitable for use in ecologically sensitive fields.

Experimental tests were performed under the following operating conditions:

- revolutions 180 min^{-1}, constant throughout the test duration in a clockwise direction;
- test duration was 70 min, of which 10 min represented running-up;
- loading in the range from 500 N to 3,000 N, according to Fig. 3.

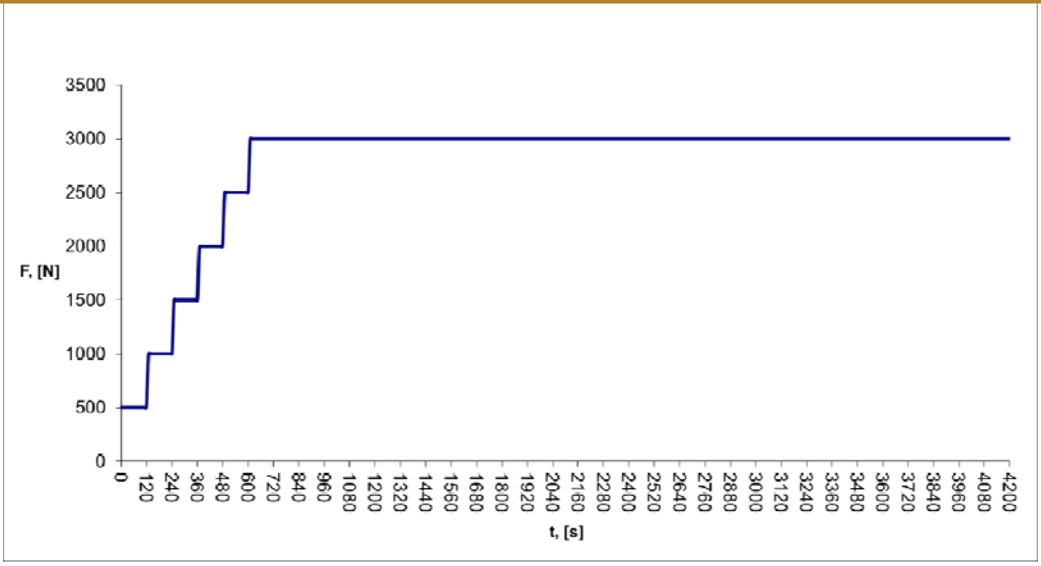

Figure 3: Course of loading force in dependence on time

Results and Discussion

After completion of experiment, the values of friction coefficient and temperature were determined for chosen ecological oils by statistical analysis.

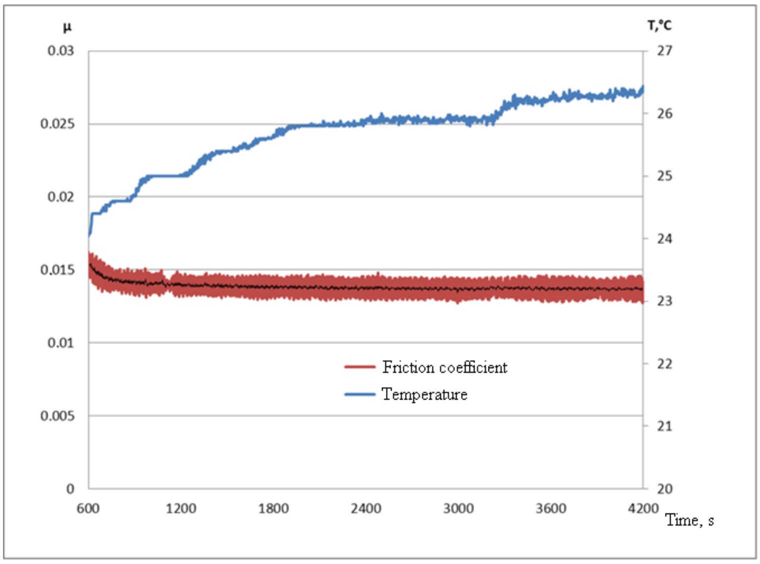

Figure 4: Course of the temperature and friction coefficient of Mogul HEES 46

Figure 4 describes the course of the friction coefficient and temperature of Mogul HEES 46 during the experiment. After running-up, the value of friction coefficient was 0.016; it was gradually reduced to value 0.013. The course of friction coefficient is markedly wide, which indicates differences between particular tests. Throughout the experiment, there were no deviations, and the course is stabilised. After running-up, temperature was 24 °C; it gradually increased to the final value of 26.5 °C.

The course of the friction coefficient and temperature of Hydros 46 is depicted in Fig. 5.

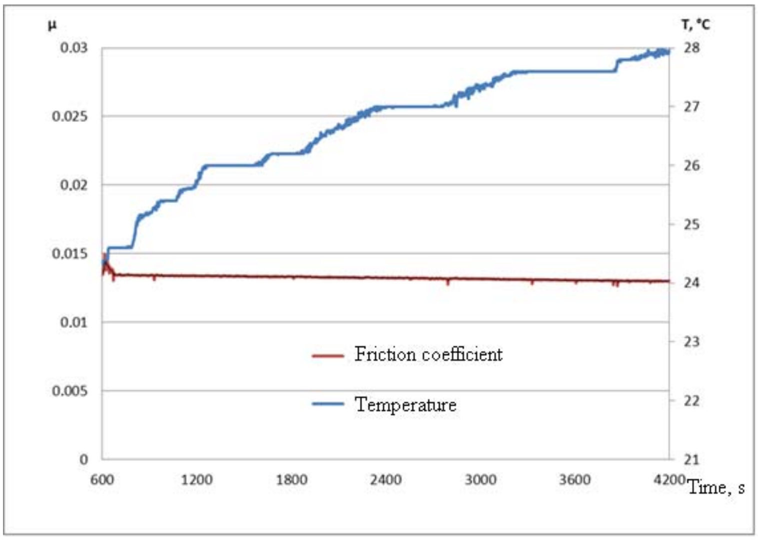

Figure 5: Course of the temperature and friction coefficient of Hydros 46

Similarly as with the previous oil, also Hydros 46 has a stabilised course of friction coefficient. The dispersion of values during the experiment is lower. The balance of particular tests follows from this fact. After running-up, the value of friction coefficient was 0.015, and during the experiment, it fell to value 0.013. Initial temperature was 24.3 °C; at the end of experiment, it reached 28 °C.

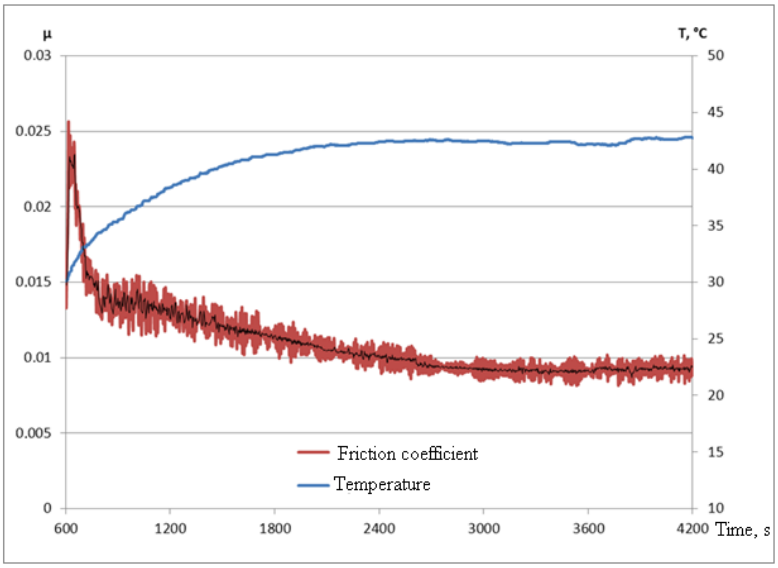

Figure 6: Course of the temperature and friction coefficient of Fuchs Plantohyd 46 S

The course of the temperature and friction coefficient of Plantohyd 46 S from the producer Fuchs is depicted in Fig. 6. According to the course of friction coefficient, we can see the sensibility of the oil to loading change; however, the oil is quickly adapting to loading change, and the value of friction coefficient falls. In the first half of experiment, the dispersion of values is outstanding, but dispersion decreases in the second half of experiment. It means a balancing of differences between particular tests. The value of friction coefficient after running-up was 0.025, and during the experiment, its value reached 0.009. Initial temperature was 30 °C; at the end of experiment, it reached 42.8 °C.

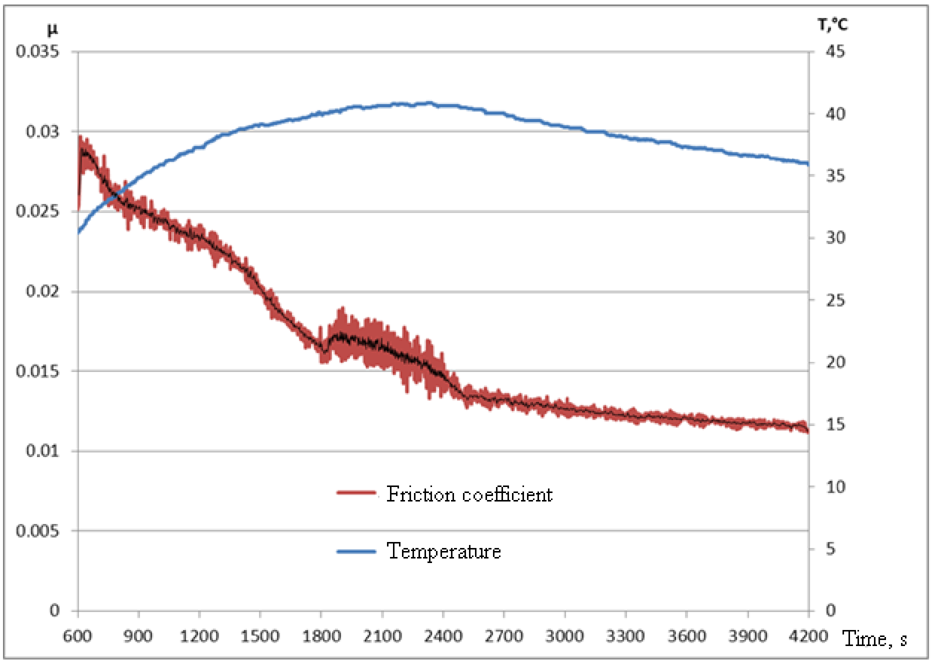

Figure 7: Course of the temperature and friction coefficient of Shell Naturelle 46 HF-E

The last tested oil was Naturelle 46 HF-E from the producer Shell. Experiment confirmed the sensitivity of the mentioned oil to loading change and subsequently a slow decline of friction coefficient values during twenty minutes. Consequently, the dispersion of friction coefficient values increased, and its value increased slightly. Initial temperature was 30 °C, the value of meridian was 40.8 °C, and temperature reached 35.8 °C at the end of experiment.

Conclusion

Figure 8 compares the friction coefficient of tested ecological oils reciprocally. According to similarity of the friction coefficient course, the oils can be divided into two groups. Mogul HEES 46 and Hydros 46 belong to the first group. Their course and values are almost identical; Hydros 46 has a considerably lower dispersion of particular tests. The second group includes Fuchs Plantohyd 46 S and Shell Naturelle 46 HF-E. Both oils are markedly sensitive to loading change. The friction coefficient of Fuchs Plantohyd 46 S is almost immediately adapting to increased loading, its value declines quickly. In comparison with it, the value of the friction coefficient of Shell Naturelle 46 HF-E was falling gently. By comparing the values of friction coefficient in all of the oils at the end of experiment, we obtain the following sequence: Fuchs Plantohyd 46 S, Shell Naturelle 46 HF-E, Hydros 46 and Mogul HEES 46.

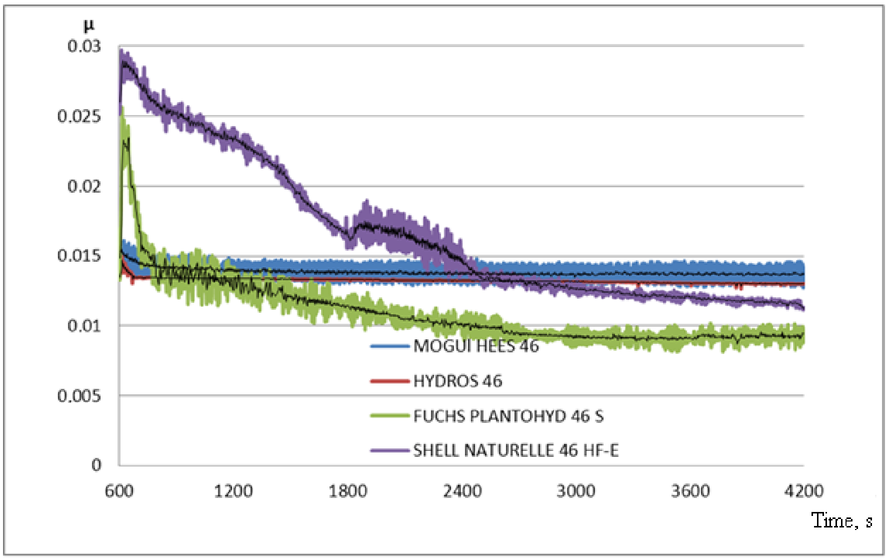

Figure 8: Comparison of friction coefficients of four ecological oils

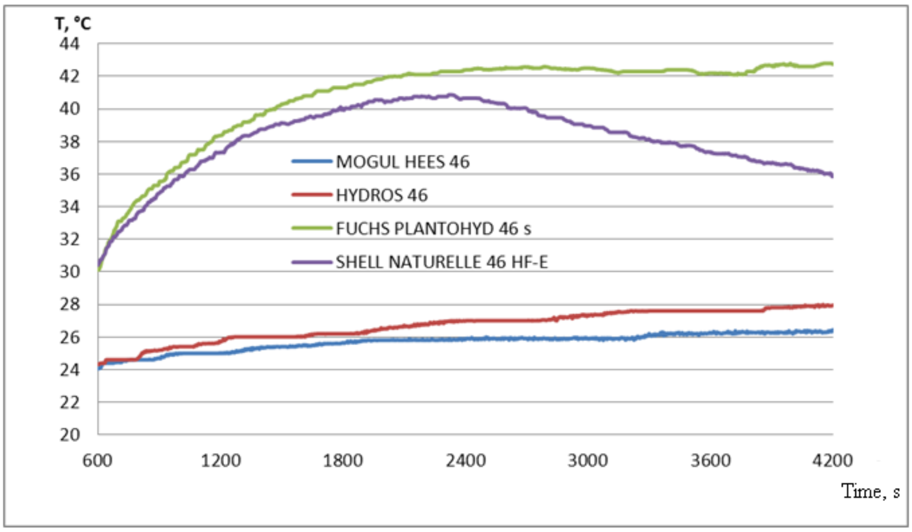

Figure 9: Comparison of temperatures of four ecological oils

The comparison of temperatures of the tested oils is shown in Fig. 9. Similarly as in the case of friction coefficient, also here we can divide the oils into two groups. The first group includes Mogul HEES 46 and Hydros 46. Their initial temperature after running-up is comparable, i.e. 24 °C for Mogul HEES 46 and 24.3 °C for Hydros 46. During the experiment, the temperature of the ecological oil Hydros 46 increased more rapidly than the temperature of the ecological oil Mogul HEES 46. At the end of experiment, the difference of temperatures was 1.7 °C. In the second group, there are included Fuchs Plantohyd 46 S and Shell Naturelle 46 HF-E. The value of temperature after running-up is the same with both oils, at the level of 30 °C. In both cases, temperature increased uniformly till the half of the test. Subsequently, the temperature of Shell Naturelle 46 HF-E started to fall till value 35.8 °C. Fuchs Plantohyd 46 S reached the temperature of 42.8 °C.

Obtained results are comparable with the values obtained by Kročko (2012). Subsequent life tests will give a definitive answer to the usability of the examined oils in the field of slide assembly.

Acknowledgements

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