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SELECTION OF POLYURETHANE FOR THE FRICTION PAIR OF A DRILLING MACHINE DUE TO TRIBOLOGICAL PROPERTIES

WYBÓR POLIURETANU NA WĘZŁY TRĄCE MASZYN SKRAWAJĄCYCH NA PODSTAWIE WŁAŚCIWOŚCI TRIBOLOGICZNYCH

Key words:

polyurethane, hardness, tribological properties

Słowa kluczowe:

poliuretan, twardość, właściwości tribologiczne

Summary

The paper discusses the influence of the hardness of polyurethane MPC on tribological properties, which are the averages and instantaneous coefficients of friction and the temperature of the friction pair. For the tests, polyurethane of the following Shore hardness was selected: 75^0 Sh A, 80^0 Sh A, 85^0 Sh A, 90^0 Sh A. The tests were performed using an Amsler wear testing machine.

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INTRODUCTION

Polyurethanes have various applications in technology. Polyurethane can be used as an additive for lubricating oils **[L. 1]** or as construction material when various chemical elements, compounds, or glass fibres are added **[L. 2, 3].**

There have been studies **[L. 1]** on the impact of polyurethane and α-alumina as an additive for lubricating oil on abrasion resistance. The addition of 2% of Al_2O_3 to the lubricating oil containing polyurethane increased abrasion resistance to 27.4%. The SEM image of the worn surface after using two modifiers, Al_2O_3 and polyurethane, at the same time showed less wear and lower surface roughness. Moreover, there have been studies on the influence of the percentage content of talc in the polyurethane composite on mechanical properties, wettability, and tribological properties **[L. 3].** The results of the experiment have shown that the coefficient of friction increases when the percentage of talc in the composite increases. The surface roughness in the process of friction was lower for the composite. Hao-Jie Song and Zhao-Zhu Zhang **[L. 6]** used nano-fillers SiC and ZrO_2 in polyurethane. The combination of friction was a polyfluo wax / polyurethane composite coating filled with nano-SiC or nano-ZrO_2. The results showed that the best effects were obtained with 5% weight content of nano-CrO_2.. B. Golaz et al **[L. 4]** conducted the tests on the effect of the following fillers: graphite, TiO_2, MoS_2, ZrO_2 and nanoparticles of SiO_2, on rheology, thermal properties, mechanical properties, and wear.

The addition of short glass fibres to polyurethane **[L. 2]** resulted in the reduction of the coefficient of friction and wear rate.

A characteristic feature of polyurethanes is their specific segmented chain structure of type $(AB)_n$. Macro particles are arranged alternately with rigid and flexible (elastic) segments. When the content of rigid segments is more than 40%, they form a continuous phase, accompanied by an increased hardness of the polymer. In elastic polyurethanes, the content of flexible segments is 60–80% of the polymer **[L. 11]**. Plastics have wide application in machine components. According to Z. Lawrowski **[L. 7]**, polymers as sliding plastics are used in pure or modified forms, and the modification is the change of the structure resulting from the changed conditions of manufacturing or processing. The advantages of plastics as sliding materials include good sliding properties, good chemical resistance, corrosion resistance, and the ability to form thin antifriction coatings. Besides their advantages, plastics have some disadvantages. The main disadvantage is the low resistance to temperature and likelihood to be destroyed after crossing the permissible thermal state. Plastics have a high coefficient of thermal expansion and low thermal conductivity.

EXPERIMENT

Experiment method

Tribological properties, the coefficient of instantaneous and average friction, and the temperature of the friction pair for polyurethane MPC of different hardness were determined with the use of an Amsler wear testing machine. The friction pair was loaded with 250 N, 300 N, 350 N, 400 N, 450 N at a constant speed of 200 rotations / min.

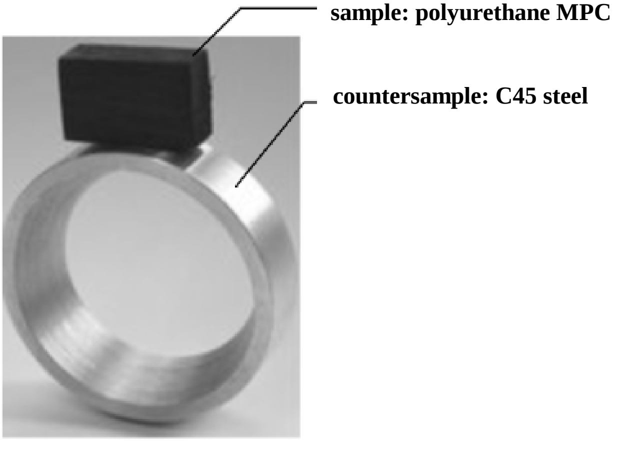

Fig. 1. Experimental friction pair
Rys. 1. Badana para trąca

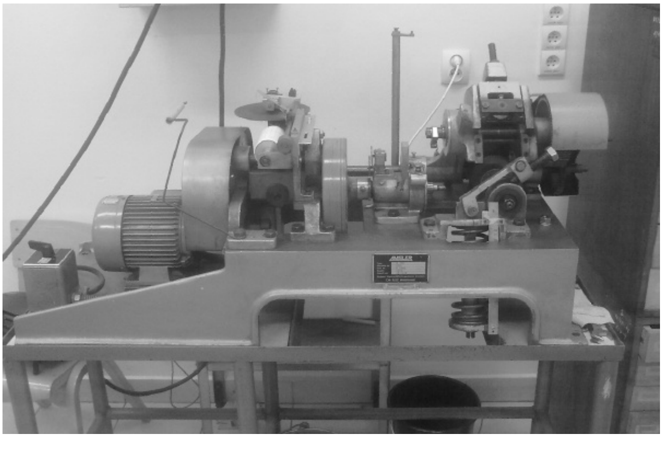

Fig. 2. AMSLER wear testing machine
Rys. 2. Tester Amslera

Using the test results the average coefficient of friction $\mu_{śr}$ and the instantaneous coefficient of friction μ were calculated according to the following formula:

$$\mu_{śr} = \frac{A \cdot 10^3}{P \cdot D \cdot \pi \cdot n_c},$$

where: A – work of friction [Nm],
P – sample loading [N],
D – sample diameter[m],
n_c – total number of rotations in one test,

$$\mu_{ch} = \frac{2M_t}{P \cdot D},$$

where: M_t – friciton torque[Nm],
P – sample loading [N],
D – sample diameter [m].

Sample and counter sample

The samples of polyurethane MPC of hardness, 75^0 Sh A, 80^0 Sh A, 85^0 Sh A, 90^0 Sh A were selected for the tests. The samples had the following hardness and tensile resistance properties: a sample of 75° Sh A hardness with a tensile resistance of 25 MPa and an elongation 60%; a sample of 80° Sh A with a tensile resistance of 54 MPa and an elongation of 40%; a sample of 85^0 Sh A with a tensile resistance of 59 MPa and an elongation 30%; a sample of 90°Sh A with a tensile resistance of 62 MPa and an elongation of 10%. A counter sample of C45 steel of surface roughness index Ra = 1.453 μm and Rockwell hardness C 60 HR was chosen. The tests were conducted without the presence of the lubricant.

Hardness Measurement

The hardness of polyurethane MPC was measured with a Shore durometer (type A). The measurement tool was an indenter made of hardened steel rod with a diameter of 1.25±0.15. The shape and dimensions of the Shore indenter (type A) is shown in **Figure 3 [L. 9].**

The indenter was pressed into the sample of 10mm thickness with a force of 8.0 mN and then the hardness was read.

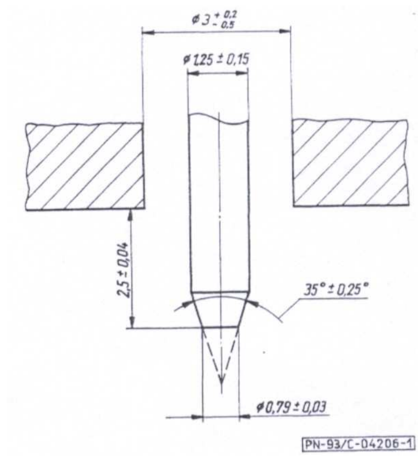

Fig. 3. Shape and dimensions of the indenter of the Shore durometer (type A)[L. 9]
Rys. 3. Kształt i wymiary wgłębnika twardościomierza Shore'a (odmiana A) **[L. 9]**

TEST RESULTS

In the process of friction, polyurethane MPC, which was selected for the tests, had different values of tribological properties depending on its hardness. The highest value of the friction torque was obtained for polyurethane of 80^0 Sh A hardness and the lowest for polyurethane of 90^0 Sh A hardness.

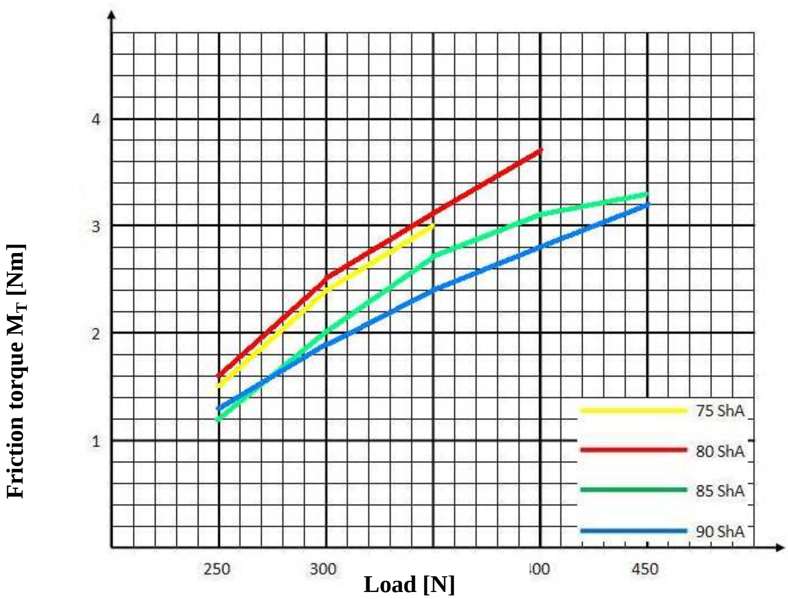

Fig. 4. The influence of polyurethane MPC load and hardness on friction torque
Rys. 4. Wpływ obciążenia i twardości poliuretanu MPC na moment tarcia

The highest value of the instantaneous coefficient of friction (μ_{ch}) was obtained for polyurethane of 80^0 Sh A hardness and the lowest for the polyurethane of 90^0 Sh A hardness.

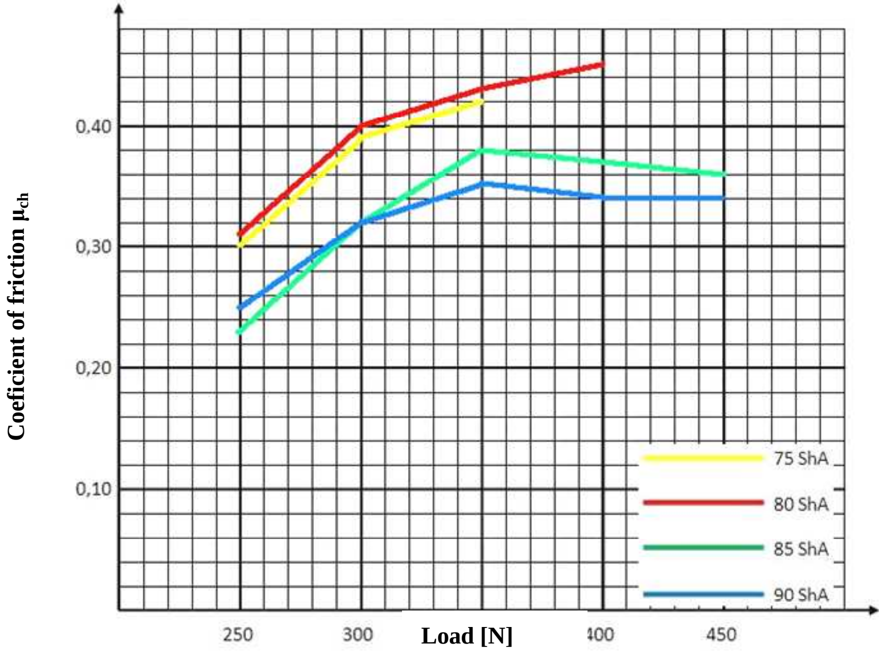

Fig. 5. The influence of polyurethane MPC load and hardness on the instantaneous coefficient of friction (μ_{ch})

Rys. 5. Wpływ obciążenia i twardości poliuretanu MPC na chwilowy współczynnik tarcia (μ_{ch})

The average coefficient of friction (μ_{sr}) had the highest value for polyurethane of 75^0 Sh A hardness and the lowest for the polyurethane of 90^0 Sh A hardness.

The temperature of the friction pair varied and was dependent on the hardness of polyurethane. The lowest temperature was obtained for polyurethane of 90^0 Sh A hardness and the highest for the polyurethane of 75^0 Sh A hardness.

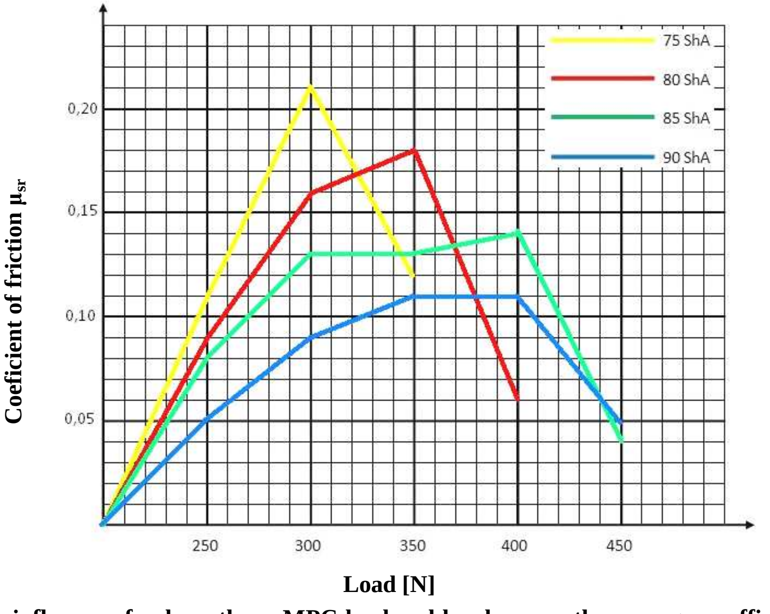

Fig. 6. The influence of polyurethane MPC load and hardness on the average coefficient of friction

Rys. 6. Wpływ obciążenia i twardości poliuretanu MPC na średni współczynnik tarcia

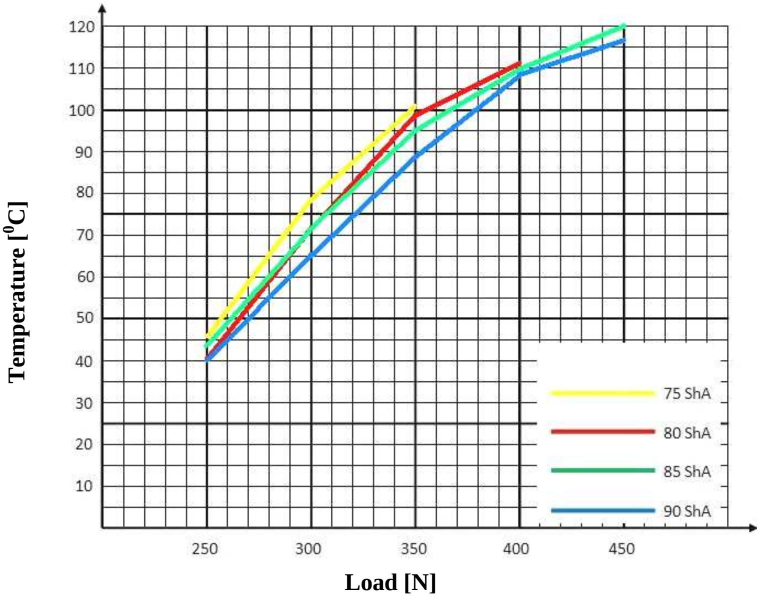

Fig. 7. The influence of polyurethane MPC load and hardness on the temperature of the friction pair

Rys. 7. Wpływ obciążenia i twardości poliuretanu MPC na temperaturę pary trącej

SUMMARY

The aim of this study was to find the polyurethane whose tribological properties are beneficial for the work of the friction pair of a drilling machine (the lowest temperature, the lowest coefficient of friction). The analysis of the test results proved that the best polyurethane for the friction pair was polyurethane of 90^0 Sh A hardness. Soft polyurethanes of 75^0 Sh A and 80^0 Sh A hardness had the highest values of the average and instantaneous coefficient of friction and the highest temperature of the friction pair. The temperature of the friction pair C45 / polyurethane 75^0 Sh A at a load of 300 N was 78.5^0C. However, for the friction pair C45 / polyurethane 90^0 Sh A in the same test conditions, it was 65^0. The temperature rise of the friction pair changes the material properties. A lower temperature of the friction pair C45/polyurethane 90^0 Sh A contributed to the improvement of tribological properties compared to other polyurethanes.

The increase in hardness of polyurethane caused the reduction in the average and instantaneous coefficient of friction and in the temperature of the friction pair.

Conclusions:

1. The tribological properties of polyurethane depend on its hardness.
2 The increase in load causes an increase in the temperature of the friction pair and the increase in the average and the instantaneous coefficient of friction.
3. The increase in hardness of polyurethane reduces the instantaneous and average coefficient of friction and the temperature.
4. For the friction pair of a drilling machine, polyurethane of 90^0 Sh A should be used.

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Streszczenie

W pracy przedstawiono wpływ twardości poliuretanu MPC na właściwości tribologiczne, określany poprzez wartość średnią i chwilową współczynnika tarcia i temperatury pary trącej. Do testów użyto poliuretanu o twardościach: 75^0 Sh A, 80^0 Sh A, 85^0 Sh A, 90^0 Sh A. Badania przeprowadzono z wykorzystaniem testera Amslera.