EFFECT OF MATERIAL FRICTION BALL ON COEFFICIENT OF FRICTION STEEL E335

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Abstract

This work examines the influence of the ball of the material on the friction coefficient of the selected sample. AISI 1010 steel beads, AISI 420 / C stainless steel, polypropylene and ZrO2 were selected for the experiment. A sample of E335 was selected as the sample material according to EN 10025. The friction coefficient was measured using the "Ball on disk" method. The device parameters were set to three radii of 18, 20 and 22 mm, after which the ball of the selected material rotated. Measurement was performed at room temperature 23 ° C and lasted 4 min. The load parameter was selected at 10 N. Finally, metallographic analysis of the sample was carried out, and Vickers hardness was also measured to determine the effect of the hardness of the bead material on the resulting coefficient of friction.

Keywords: coefficient of friction, ball, steel, tribology, microhardness.

1 Introduction

Tribology is a teaching that deals with the behavior of touching surfaces by mutual movement or when attempting to move one another. The movement may be sliding, rolling, rotating, impacting or oscillating. At the same time, two or more types of motion can be applied. The task of tribolology is to ensure that the mutual movements of surfaces in the presence and absence are carried out with the least loss of energy and materials [7, 8]. This role is gaining increasing momentum in recent years when energy and materials prices are rising. In general, they are going to tribologically more demanding devices with a lower weight, but they work at a higher load, at higher speeds at a higher temperature level and often at higher pressures [3, 4]. New requirements for friction elements and materials are created. Based on this work, it was found out how the material has a change in the coefficient of friction in the selected sample. The main objective was to gain insights into how the balls of the specified diameter and the surface of the steel disk reach the value of the friction coefficient [12]. The diploma thesis can contribute to the widening of the knowledge about the influence of individual types of milling materials on the coefficient of friction.

2 Selection of sample material

The steel E335 was selected to examine the issue. The reason for choosing this steel was relatively easy to obtain this material. E 335 is a steel of the usual high carbon content specified by EN 10025. It is suitable for static and dynamic machine components that are not required to be credited. Components exposed to high pressure (shafts, spindles, sprockets, sprockets, levers, wedges, supports, sleeves, bolts and nuts, pins, pulleys, clutches, axial bearing segments and liners, pins, pinions, press spindles and the like).

Table. 1 *Chemical composition of steel E335*

Chemical composition of steel					
Chemical element	**C**	**Si**	**P**	**S**	**N**
[%]	max. 0.22	max 0.55	max. 0,045	max. 0,04	max. 0,009

The fitting of E335 steel is carried out at temperatures between 1100 and 800 ° C. Normalization annealing takes place in these temperature ranges of 850 to 870 ° C [2]. Soft annealing ranges from 680 to 720 ° C. Water hardening takes place at temperatures of 830-860 ° C and hardening in the oil at 840-870 °, i.e. about 10 ° more than quenching into water. Launching takes place at temperatures between 560 and 670 ° C. [1, 11] The resulting chemical composition is shown in Tab. 1.

2.1 Selection of ball-bearing material

To solve the work were selected spheres made of low carbon steel, stainless steel, plastic and ceramics. Specifically, these materials AISI 1010, AISI 420 / C, polypropylene and zirconia ZrO2 were selected. The properties of all steels as well as their chemical length are shown in Tab. 2.

Table. 2 *Compare the test ball properties*

AISI 1010	**Chemical element [%]**	**C**	**Mn**	**Si**	**P**	**S**
		0,07 ÷ 0,13	0,30 ÷0,60	0,15÷0,35	<0,035	<0,035
	Hardness HV 3	HV 697				
AISI 420/C	**Chemical element [%]**	**C**	**Mn**	**Si**	**P**	**Cr**
		min. 0,15	max. 1	max. 1	<0,040	12 - 14
	Hardness HV 3	HV 610				
POLYPROPYLENE	**Hardness HV 3**	HV 167				
ZrO2	**Chemical element [%]**	**ZrO**			**Y2**	
		94,8			5,2	
	Hardness HV 50	HV 1350				

3 Experiment and results

Realization of experiments related to the objectives of the work was carried out at the Faculty of Special Technology at the Department of Mechanical Engineering. Experiments associated with sub-objectives were also carried out in the laboratories of the Department of Mechanical Engineering at the Faculty of Special Technology. Measurement was performed on a Brucker UMT-3MT [9]. This device is a universal tribometer, where we can measure more ways of wear. The temperature of the device can be set to 1000 ° C maximum. The device has more advantages, i.e., j. high precision, allows measuring at different temperatures and short measurement time [4,5]. The spin force is determined in the range of 0.25-1000 N [6, 10]. The method of "Ball on Disc" was used in the experiment; this method consists in pushing a fixed ball-shaped body into the test material by a predetermined force. The four pressure spheres were made of different materials of the same diameter of 4.765 mm. The overall schematic of the device as well as the description of the individual parts is shown in Fig. 1. The experiment parameters were set to a load of 10 N at a constant speed of 250 rpm for 240 sec. Prior to the measurement, the hardness of E 335 was also measured by Vickers hardness measurement. The hardness value was determined from the five measurements on each sample and then the average value was 341 HV5.

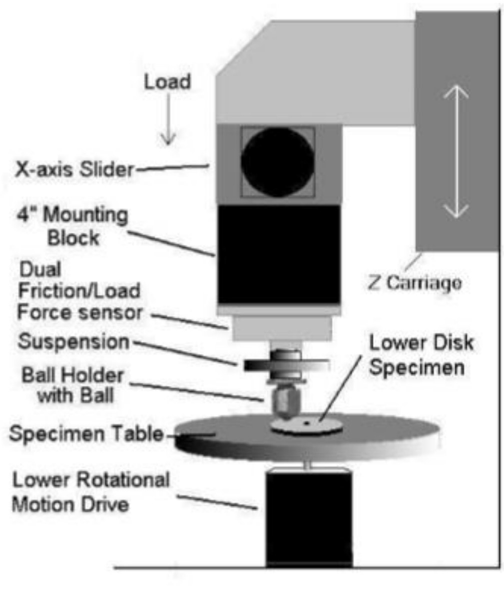

Fig. 1 *Description of individual parts of the device*

3.1 Metallographic analysis

For the qualitative results, the microstructure of the samples was also performed. This measurement was performed on a NEOPHOT 32 optical microscope. The resulting structure is shown in Fig. 2.

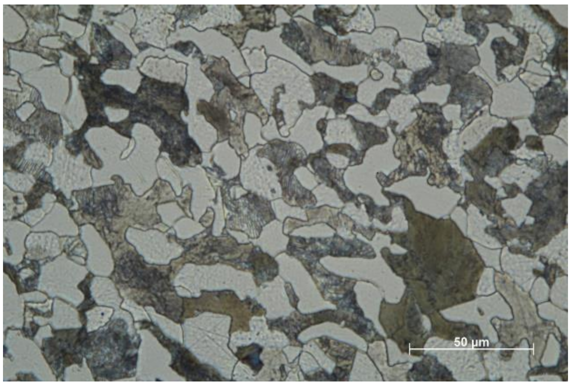

Fig. 2 *Ferritic perlite steel structure E335*

Fig. *3 Visible stretches the structure in one direction*

The measured steel after 3% etching was evaluated as ferritic - perlite. Ferrite was predominantly in lamellar form. Also Fig. 3 it is to be seen that the particles are stretched in one direction probably resulting from the processing of the steel.

3.2 Friction coefficient

We measured the measured values of the individual measurements in the tables and made a graphical evaluation using Fig. 4. The graph shows that the polypropylene ball at a 20 mm radius of rotation had a more than 330% lower friction coefficient than a ceramic zirconia ball. The ceramic ball is 80% harder than polypropylene. The polypropylene ball at a 20 mm rotation radius had a 225% lower friction coefficient than the AISI 1010 steel ball. As the steel ball is harder than 3% polypropylene, it is the smallest difference in hardness between the beads.

Table. 3 *Dependence of COF values on the diameter of the friction imprint*

	Ball materials			
R [mm]	**AISI 1010**	**AISI 420/C**	**POLYPROPYLÉN**	**ZrO2**
18	0,268	0,126	0,143	0,147
20	0,384	0,266	0,17	0,573
22	0,262	0,482	0,147	0,726

The polypropylene ball at a 20 mm turning radius had a friction coefficient of more than 55% lower than the AISI 420 / C stainless steel ball. However, the polypropylene ball is 11.3% harder than the stainless steel ball. The stainless steel ball and the polypropylene ball have the smallest difference in the coefficient of friction between them. For a AISI 1010 and polypropylene steel ball, a 20 mm turning radius has been dropped. With a 22 mm turning radius, the coefficient was lower than the 20 mm radius of rotation. These values indicate that measurement uncertainty appears to have occurred. Since the value of friction coefficient with increasing diameter has to rise, according to available literature.

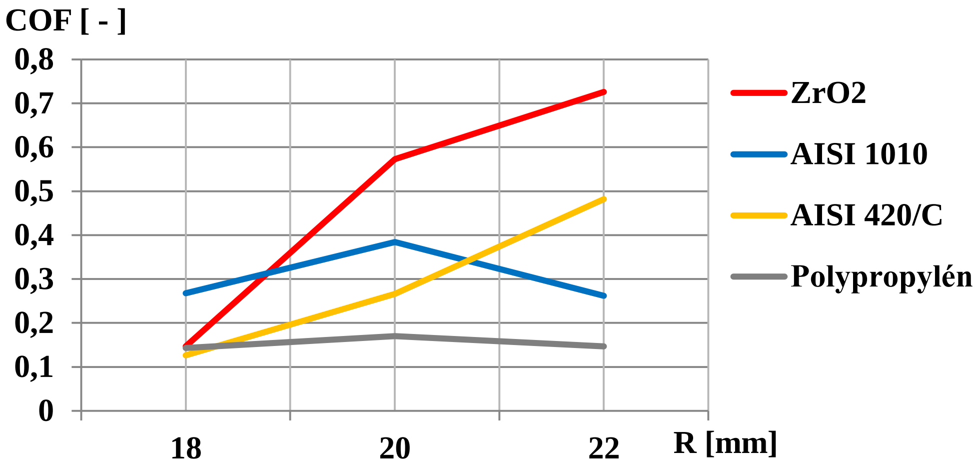

Fig. 4 *Graphical comparison of friction coefficient values for all materials*

3.3 Coefficient of friction depending on the hardness of the beads

Bearing hardness from individual Vickers [HV] materials and friction coefficient at R20 mm radius are shown in Tab. 4. Subsequently, these values were processed in the form of the graph in Figure 5 and compared to each other. The graph clearly shows that the zirconium-ZrO2 ball and the highest hardness were up to 1222 HV. We can also see what effect the hardness of the material has on COF. We can say that the hardness of the material has a significant effect on the resulting COF value.

Table. 4 *The averaged hardness and friction coefficient of individual materials*

Materials	HV	COF
AISI 1010	697	0,384
AISI 420/C	595	0,573
POLYPROPYLEN	674	0,170
ZrO2	1222	0,266

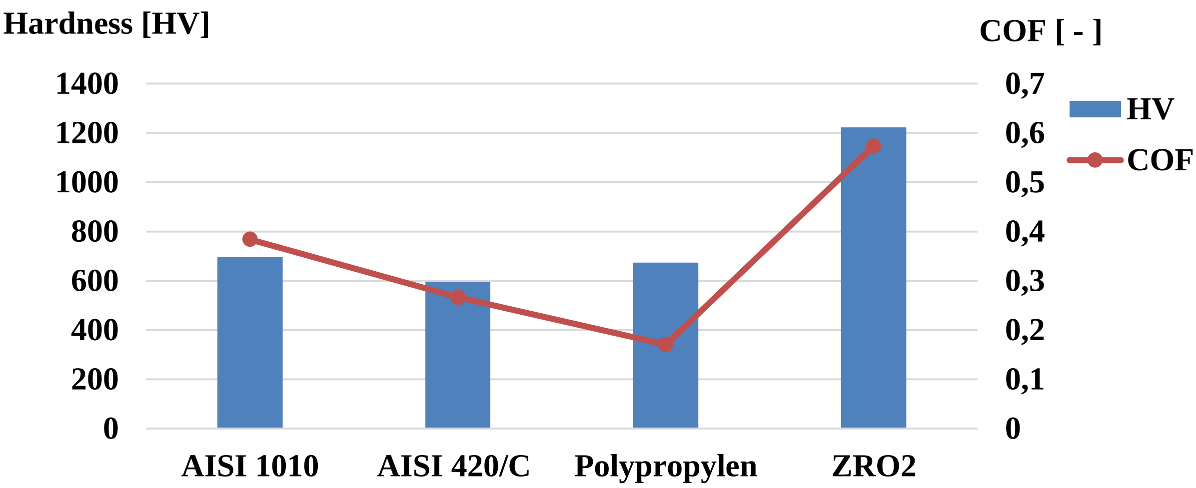

Fig. 5 *Graphical comparison of hardness and friction coefficient*

In this ceramic ball, the highest COF value was reached, namely 0.57. The second heaviest ball was made of low carbon steel AISI 1010 and had a hardness of 697 HV. COF for this material reached 0.38. Here we see that COF drops with a decrease in hardness. The third heaviest ball was made of polypropylene and had a hardness of 674 HV. The COF for this ball has the lowest value. This may explain that polypropylene is a completely different composition. Its chemical and physical properties differ from ceramic as well as steel materials. The lowest material hardness value was measured on AISI 420 / C steel.

4 Conclusion

The aim of the work was to investigate the influence of material distortion on the friction coefficient of selected steel, to determine the influence of selected brake parameters on the change of selected mechanical properties and especially to analyze the effect of friction strips on the milling coefficient.

The results obtained from the individual types of measurements were implemented in the tables and graphs that were subsequently described and explained. Based on these results, the main objectives of the study and the study of the influence of selected materials on the balls on the friction coefficient of the selected material on steel by "ball on disc" were evaluated. ZrO2 and low carbon steel significantly affect the mechanical properties of the steel surface E335. Polypropylene plastic the ball affects the mechanical properties of the steel surface E335 by 330% less than the zirconium zirconia ZrO2.

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