RESEARCH OF TRIBOLOGICAL CHARACTERISTICS OF ADI IN CONTACT WITH MODIFICIETED MATERIALS WITH DIFFERENT COATTINGS

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Abstract: *The existing level of application of hard coatings due to relatively high deposition temperatures is largely limited to the tool area. However, special interest deserves the possibility of applying contemporary PDV procedures for the conversion of constructional steels used for the manufacture of elements of the most varied tribomehanical sistems.Friction and wear behavior of different types of nodular cast irons in contact with carbon steel were studied. The lubricated sliding line contact was performed on the Pin and Disk tribometer. Value of wear were determined by PQ index. Pins were made of carbon steel without and with three types of coating (TiN, TiZrN, TiAIN) on the tool rake surface.*

Keywords: *Friction, wear, coating, sliding contact, PQ index.*

1. INTRODUCTION

Tribological properties of materials can be determined by measuring the friction force (friction or energy aspect) and by measuring the magnitude of any wear parameter of the critical element of tribo-mechanical system [1, 2].

The value of the friction force in the contact zone as well as the value of wear parameter of the critical element of tribo-mechanical system after the certain time of contact duration, depends upon numerous factors that are defining the conductions under which contact is realized (loading, sliding velocity, type of lubricant, surface integrity, etc.) [3, 4].

Comparing of tribological properties of two different materials during contact with, for instance, any steel has to be realized under the constant condition [5, 6].

In this paper friction and wear properties of two types of nodular cast iron EN-GJS-500-7 NL500 and EH GJS700-2 NL700 are compared by measuring the friction force and PQ index as wear parameters during contact with carbon steel and different type of coating.

Friction coefficients obtained within the range of 0.02 to 0.9 [1].

2. EXPERIMENTAL PROCEDURE

In this experimental investigation the geometry of line contact was realized on tribometer Pin and Disk TPD-93. Disks as specimens were made of both type of nodular cast irons heat treated in different ways, and (Tins were made of carbon steel without and with three types of coating (TiN, TiZrN, TiAIN) on the face surface [7].

The Table 1 shows chemical compositions and hardness of nodular cast irons NL500 and NL700 together with thermal treatment conditions.

Friction force and loading measurement is realized by strain gauges transducer and monitoring technique which include Amplifier and Recorder.

Wear intensity is determined by PQ index which indicates quantity od wear products in the sample of lubricant PQ index is measured by PQ Particle Quantifier PQ 2000 Model 501 (Swansea Tribology Centre).

Measuring of the friction force was performed in the experimental operations in which the contact between Block and Disk was realized with the three value of normal loading Fn (5 daN; 10 daN and 20 daN) and with the three sledding velocities.

Measuring of PQ index was performed in the experimental operations in which the contact between Pin and Disk was realized with the normal loading Fn=20 daN and the sliding speed v = 1.3 m / s.

Lubrication in the experimental operations was done with oil type POLAR 32K. The realized thickness of the oil film points to the phenomenon of the boundary lubrication.

The measured values of the friction force at the beginning and at the end of sliding (t = l min, t = 30min) were equal in all the experimental operations.

3. BASIC RESEARCH RESULTS

On the basis of the results of measurements of the friction force within the frame of the realized research program, was calculated friction coefficient as the function of the normal loading and sliding speed.

In Fig. 3 is illustrated the influence of the normal loading on the value of friction coefficient.

In Fig. 4 is presented the influence of the sliding velocity on the value of friction coefficient. Both Figures show that there is no big influence of the value of normal loading and sliding velocity on the value of the friction coefficient.

Table 1. Chemical compositions and hardness of nodular cast irons NL500 and NL700

Disk	Chemical composition in %								Ta [°C]	Ta [°C]/t [min]	Structural basisi
	C	Si	Mn	Mg	P	S	Cu	Wi			
NL500	3.85	2.9	0.075	0.035				1.5	900	520/60	Ferrite - pearlite
										390/30	
NL700	3.76	2.35	0.51		0.02	0.004	1.48	1.5		520/60	perlite
										390/30	

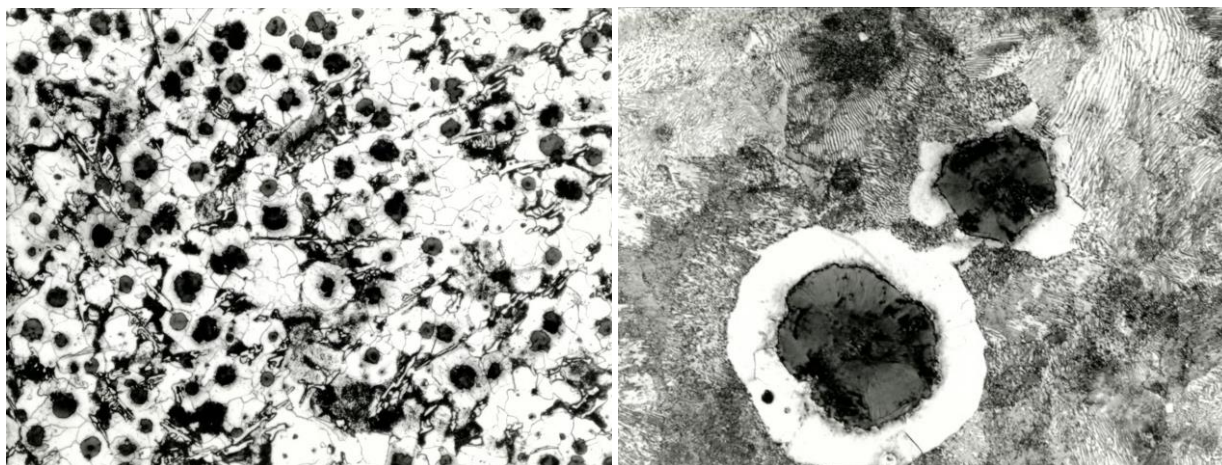Hardnes of NI HB 194. After isothermal threatment HB 363

Figure 1. NL500 - The batch 5844-13.a) Increase 100x etched with HNO_3 2%, NL700 - The batch 5766-13. Increase 500x etched with HNO_3 2%
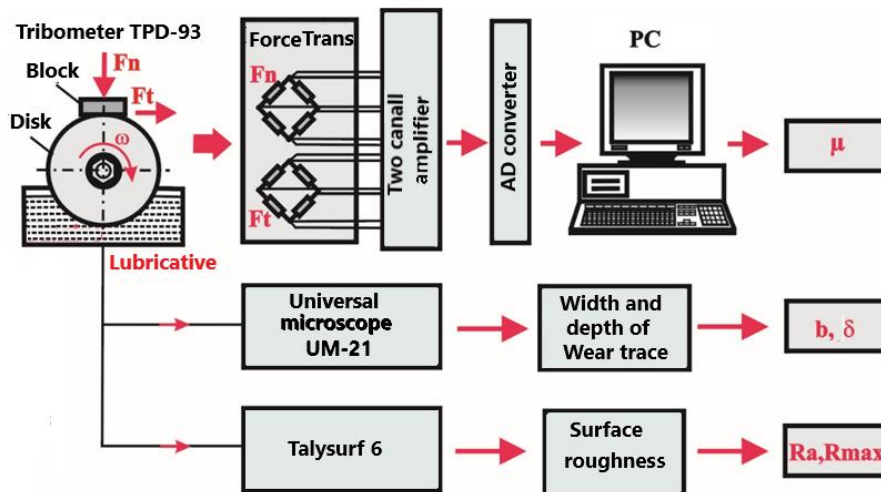
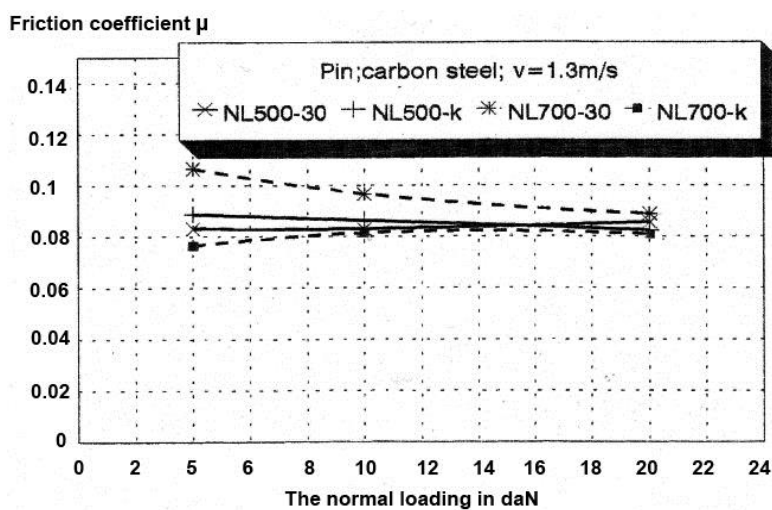**Figure 2.** Tribology parameters measurement

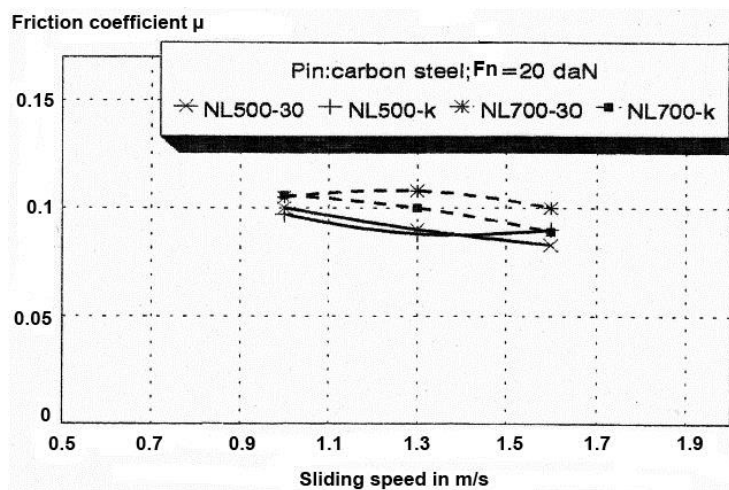**Figure 3.** Friction coefficient as a function of the normal loading

Figure 4. The friction coefficient as function of the sliding speed

The results of measurements of the friction force also show that the influence of the kind of heat treatment and type of nodular cast irons (disk material) on the value of friction coefficient is not small. From the aspect of the energy consumption for overcoming the friction in the tribo-mechanic systems, these differences in the value of friction force can be very significant.

Measuring of the friction force was also performed and in the experimental operation-sin in which the contact between Pins with three type of coatings (TiN, TiZrNn and TiAIN) and Disk was realized with the normal loading Fn=10 daN and the sliding speed v=1.3 m/s. Part of these results of measurements are shown in Fig. 4.

Results of measurements of the PQ indices, as a representative of quantity of the wear products produced during the realization of contact between the Pin and Disk for the period of 30 minutes, show that the intensity of wear of disk is greatly depends upon the type of nodular cast irons and the kind of their heat treatment.

It is known, that the value of the PQ index is directly proportional to the quantity of the wear particles that is contained in the sample of oil used for lubrication of the contact zone during the sliding of disk along the pin.

$$PQ = k \cdot q \qquad (1)$$

Where is q - the quantity of wear particles which is contained in the sample of oil produced during contact between elements of tribo-mechanic system for t minutes.

In Figure 4 are shown values of the PQ indices expressed in percent's obtained by realization of the part of the experimental program that is related to the contact between Pin made of carbon steel and disks made of two type of nodular cast irons bettered by classical and isothermal procedure.
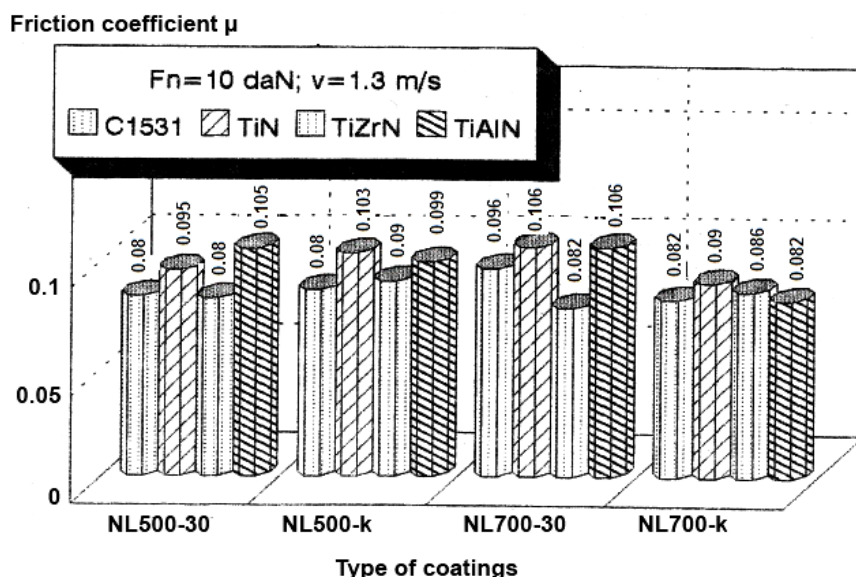

Figure 5. The friction coefficient as a function of the type of coatings
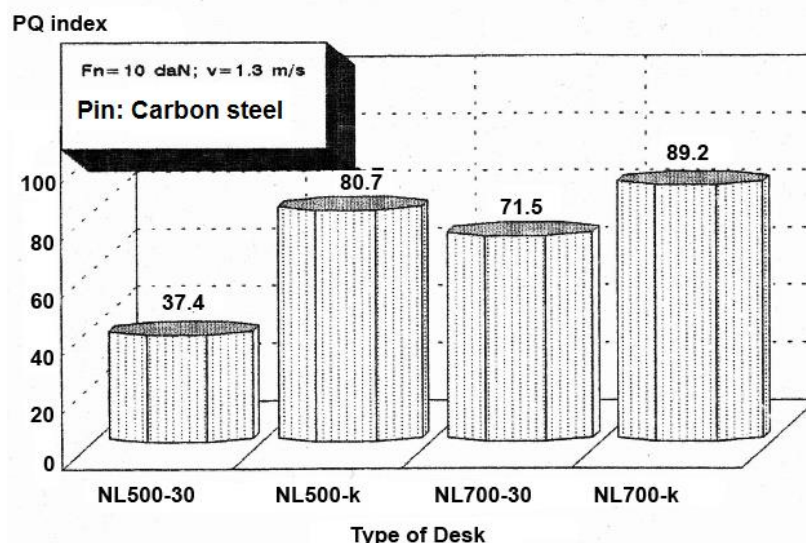

Figure 6. Values of the PQ indices for different type of disks

Results of the PQ indices measurements show that the tribological properties of disks, determined based on the magnitude of wear, are greatly influenced by the kind of betterment procedure and type of nodular cast irons.

If the wear intensity of the Disk is defined as the ratio between the quantity of wear particles obtained during the contact between it and the Pin, and the time of contact duration, and, on the other hand , the wear resistance is defined as the reciprocal value of the wear intensity, the following relations are valid:

$$I = \frac{Q}{t} \quad \left[\frac{mg}{\min}\right] \tag{2}$$

$$R = \frac{t}{Q} \quad \left[\frac{\min}{mg}\right] \tag{3}$$

$$I = \frac{P \cdot Q}{k \cdot t} \tag{4}$$

$$R = \frac{k \cdot t}{P \cdot Q} \tag{5}$$

The ratio between the wear intensity and wear resistance of Disks made of different materials or of the same material but heat treated under different conditions, is equal to the ratio of the respective values of the PQ indices.

4. CONCLUSION

Results obtained in this research point to the fact, before all, that friction and wear properties of nodular cast irons are relative and that they depend a great deal on the chosen criterion for their determination (friction coefficient or wear resistance).

The second conclusion is that the PQ index as a parameter of wear can be used as a relative value by which the resistance or intensity of wear of several material can be compared.

Friction and wear processes in the sliding contact depend much more upon the type of materials of tribo-elements and their heat treatment than loading and sliding velocity. The biggest influence on tribological properties of nodular cast iron has the condition of the isothermal betterment.

Friction coefficients obtained within the range of 0.02 to 0.9. Experimental investigations were carried out with a limiting lubrication of 25 ml.

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