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ENERGETIC AND ECONOMIC ASPECTS OF TRIBOLOGICAL PROPERTIES OF AUSTEMPERED NODULAR CASTING

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Abstract: Tribological properties of austempered ductile irons, as well as of other materials, are determined by measuring the friction force in tribo-mechanical systems (energetic aspect) and by measuring wear parameters (economic aspects). Tribological properties of two types of austempered ductile irons are presented from both of these aspects. Experimental investigation was realised on "Pin on Disk" tribometer. PQ index was used as a wear parameter for wear intensity determination.

Keywords: Tribological properties, energetic aspect, economic aspect.

1. INTRODUCTION

Tribological processes (friction and wear processes), going on in the contact zone of tribo-mechanical systems during their functioning cause the energy consumption on overcoming the motion, changes of shape and dimensions of the critical element of the system [1,2].

The element of tribo-mechanical system which during the contact reaches the critical value of wear first, after which the function of tribo-mechanical system is not possible, is its critical element. The wear parameter of the tribo-mechanical system must be regarded in connection with this element.

Material of the critical element of tribo-mechanical system, which is in contact with other two elements and ensures the existence of a small friction force during the relative motion, has good tribological properties from the energetic aspect. The existence of small friction force in contact zone in a tribo-mechanical system means small energy consumption during contact realization.

The material of the critical element of tribo-mechanical system, which in contact with two other tribo-mechanical system elements ensures its longer life, in reference, larger wear resistance has good tribological properties, too. In that case the critical element of tribo-mechanical system is worn slowly. The consequence is small exploitation costs of corresponding production and transportation of equipment in industrial and transportation systems. This is why the tribological properties defined in this way can be called tribological properties from the economic aspect [3−5].

Tribological properties of the critical element material determined from both aspects are relative, because they depend on the contact conditions and on the properties of other two elements of tribo-mechanical system.

Tribological properties of tribo-mechanical system elements from energetic aspect are determined by measuring the friction force and friction coefficient during different contact conditions (sliding speed, normal load, temperature, etc.). From the economic aspect, tribology properties of the material are determined by measuring the selected wear parameter on the critical element of tribo-mechanical system. The problem of determining tribological properties of the materials from economic aspect is very complex, because of many possible wear parameters influences, as well as a critical point of wear [6−7].

In this paper we present experimental results of tribological properties of austempered ductile irons from both aspects, energetic and economic. Tribological properties from energetic aspect are determined by measuring the friction coefficient and from economic aspect by measuring the PQ index, which represents the wear intensity.

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2. EXPERIMENTAL STUDY AND TECHNIQUE

The main goal of this investigation was to find a connection between tribological properties of austempered ductile irons and its heat treatment. Tribological properties of two types of austempered ductile irons are determined by measuring the friction force (energetic aspect) and PQ index (economic aspect).

The experimental procedures are realized on a "Pin and Disk" tribometer with line contact geometry between the discs. Discs A and B were made of austempered ductile irons and a pin of carbon steel (Figure 1).

The discs were made of two types of austempered ductile irons and were isothermal and classical heat treated with different conditions. Chemical composition of discs of materials A and B and the heat treatment of discs procedure are presented in Table 1.

The pin of carbon steel was used in all experimental operations. Gear oil C was used in the tribo-mechanical system contact as lubricant.

The contact conditions are defined by normal loads from 5 to 20 daN, sliding speeds was from 1.05 to 1.6 m/s with boundary lubrication.

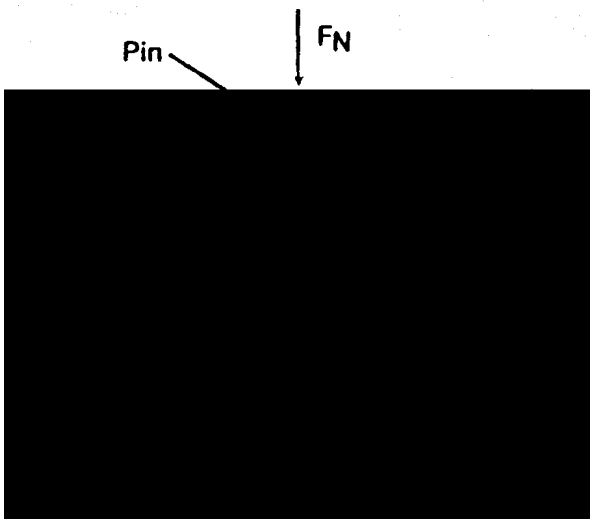

Figure 1. Contact geometry between the disk and the pin

For measuring the PQ index PQ 2000 Particle Quantifier was used. The samples of lubricants with the contents of discs wear products were collected from the lubricant bath.

The experimental program is realized on the tribometer TPD-95-C in the Laboratory for Metal Cutting and Tribology, the Faculty of Mechanical Engineering, Kragujevac, Figure 2.

Table 1. Chemical composition and heat treatment of discs

Disc material	Heat treatment		Chemical composition						
	Ta °C	Tp °C/t in min	C	Si	Mn	Mg	P	S	Cu
A	900	b-520/60 a-320/90 320/30	3.85	2.9	0.076	0.035			
B	900	b-520/60 a-320/90 320/30	3.76	2.35	0.51		0.02	0.004	1.48

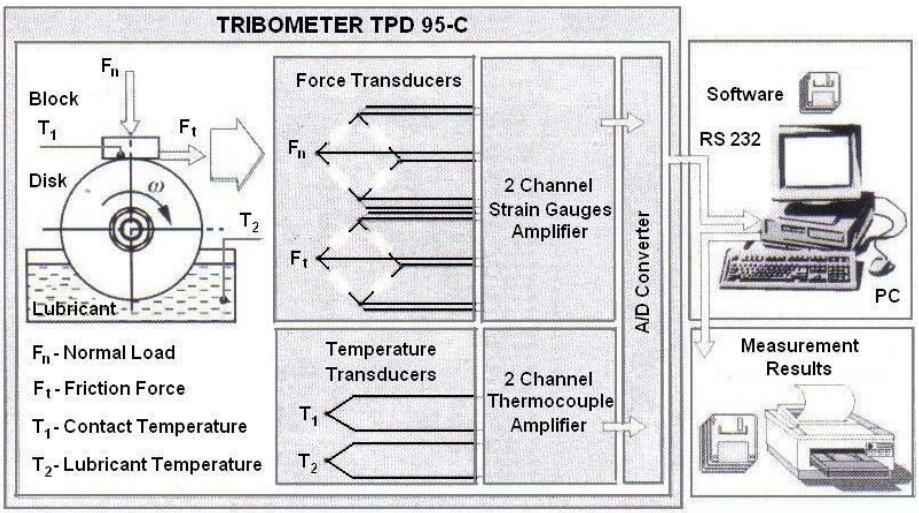

Figure 2. Tribometer TPD 95-C „Pin on Disk“ with accompanying instruments [7]

3. EXPERIMENTAL RESULTS

Measurement of friction forces during Pin and Disc contact realization allows us to determine the friction coefficient. It means that the energetic aspect of tribological properties of both materials (A and B) can be compared by the determined friction coefficient. The relation between two coefficients of friction that relate to two types of austempered ductile irons, thermally treated by isothermal and classical procedure is presented in Figure 3.

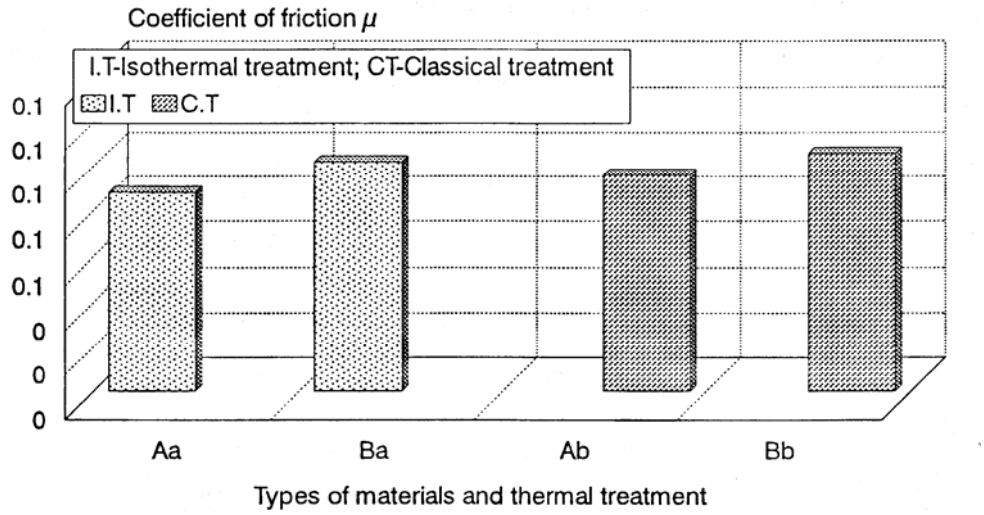

Figure 3. Coefficient of friction between Pin and Discs

The comparison of tribological properties of different materials can be realized by corresponding indices. In this case the tribological properties of austempered ductile iron A are better than the tribological properties of austempered ductile iron B for 15.9% in reference to 10.4%:

$$I_{\mu Aa} = \frac{\mu_{Ba}}{\mu_{Aa}} 100 = 115.9\%$$

$$I_{\mu Ab} = \frac{\mu_{Ba}}{\mu_{Aa}} 100 = 110.4\%$$

The results of measuring PQ indices show the quantity of products wear for the lubricant samples and are shown in Figure 4.

The differences of tribological properties of the same materials (A and B), that measured by PQ indices gives higher values than in the first case:

$$I_{PQAa} = \frac{PQ_{Ba}}{PQ_{Aa}} 100 = 144.7\%$$

$$I_{PQAb} = \frac{PQ_{Ba}}{PQ_{Aa}} 100 = 150.5\%$$

It means that the determined economic aspect of tribological properties of materials A and B give different results compared to the determined tribological properties of the same material if the energy aspect is used.

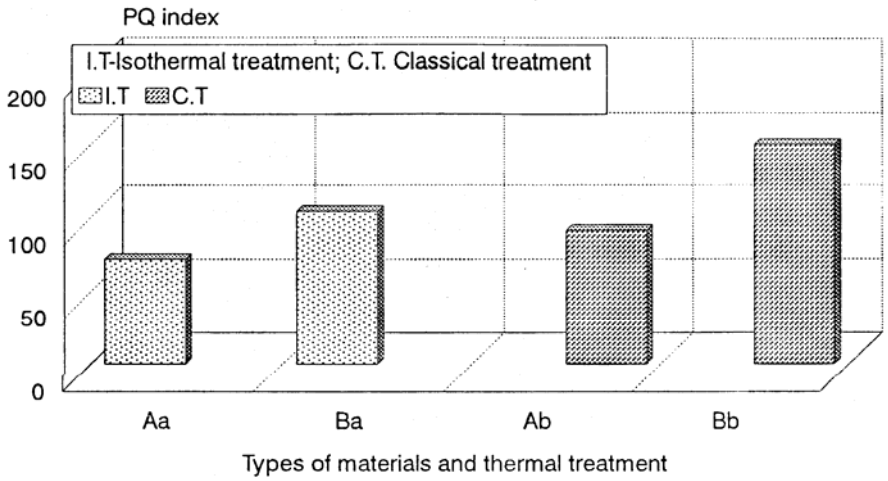

Figure 4. Experimental data of PQ indices

4. CONCLUSION

The results obtained during the investigation show that the tribological properties of materials are relative and that, besides the other factors, they depend on the chosen method for their determination. Based on the experience it can be concluded that differences of tribological properties are higher if the economic aspects are used for their determination.

Tribological properties of austempered ductile irons depend to a great extent on the heat treatment procedure. The optimal conditions of isothermal heat treatment for every type of this material are different.

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ЕНЕРГЕТСКИ И ЕКОНОМСКИ АСПЕКТИ ТРИБОЛОШКИХ ОСОБИНА АУСТЕМПЕРОВАНОГ НОДУЛАРНОГ ЛИВА

Сажетак: Триболошке особине аустемперованог нодуларног лива, као и од других материјала, одређују се мерењем у трибо-механичким системима силе трења (енергетски аспекти) и мерењем параметара хабања (економски аспекти). Триболошке особине две врста аустемперованог нодуларног лива су представљен са ова два аспекта. Експериментални програм је реализован на трибометару „Пиндиск“. Одређен је и PQ индекс који се користи као параметар за одређивање интензитета хабања.

Кључне речи: триболошке особине, енергетски аспект, економски аспект.