D. GOLUBOVIĆ, P. KOVAČ, D. JEŠIĆ, M. GOSTIMIROVIĆ, V. PUCOVSKY

ISSN 0543-5846
METABK 51(4) 518-520 (2012)
UDC – UDK 669.13:620.178.1:621.78=111

WEAR INTENSITY OF DIFERENT HEAT TREATED NODULAR CAST IRONS

Received – Prispjelo: 2011-12-05
Accepted – Prihvaćeno: 2012-04-30
Preliminary Note – Prethodno priopćenje

In the paper we investigate the relationship between the wear intensity of two nodular cast irons and their heat treatment conditions. Disks tempered by austempering and isothermal procedure were used. The wear test was realized by using Pin and Disk tribometer. Measurement of the disks wear, after the contact for duration of 30 min, was done by the PQ meter. The quantity of the wear products in lubricant is determined by the PQ index. The best wear resistance posses the disk isothermally tempering with 30 minutes holding at 390 °C temperature.

Key words: nodular cast iron, wear, heat treatment

Intenzitet habanja kod različito toplinski poboljšanog nodularnog lijeva. U ovom radu je ispitivana zavisnost između intenziteta habanja dva nodularna lijeva kao i uvjeta pri njihovoj toplinskoj obradi. Uzorci za ispitivanje nodularnog lijeva su bili poboljšani klasičnim i izotermalnim postupkom. Ispitivanje intenziteta habanja je realizirano uz pomoć Pin on Disc tribometra. Mjerenje pohabanosti diska, nakon trenja u trajanju od 30 minuta, je obavljeno na PQ metru. Količina čestica nastalih kao produkti habanja, u sredstvu za hlađenje i podmazivanje je određena PQ indexom. Najveću otpornost na habanje posjeduje disk izotermalno temperovan na 390 °C u trajanju od 30 minuta.

Ključne riječi: nodularni lijev, habanje, toplinska obrada

INTRODUCTION

Wear intensity of the tribomechanical systems depends, not only on physical and chemical characteristics of materials that they are made of, but also, to a significant extent, on the kind and conditions of their heat treatment.

Experimental investigations of tribological and other characteristics of nodular cast irons, that were conducted at several laboratories of large industrial systems and universities, have shown that they also depend on conditions of their heat treatment [1, 2, 3]. Measurement methodology and election of tribomechanical system materials is presented in [4].

Ductile iron with different nodule counts was used austempered by conventional and successive austempering processes at 315 and 375 °C for different period [5]. Specimens with the optimal mechanical properties were used to study the effect of austempering process on the wear behavior of austempered ductile iron (ADI). The paper [6] details the heat treatment of ductile cast iron to yield ADI and also examines its mechanical and abrasive properties. Study of effect of graphite morphologies on the tribological behavior of austempered cast iron is in [7].

In this paper a part of results of tribological investigations of two kinds of nodular cast irons characteristics, in sliding conditions with and without lubrication, is presented. Investigations were conducted within the framework of a larger scientific research program of tribological character.

MATERIAL AND METHOD

In investigation program, two types of nodular cast irons were included: GJL-500-7 and GJL-700-2. Microstructure of nodular cast iron used in this study is shown in Figure 1 and Figure 2. The material chemical composition is shown in Table 1. Test operations were performed on tribometer

Pin on Disk with linear contact. Nodular cast irons disks were used as samples, tempered by austempering and isothermal procedure.

In Table 2 conditions under of the heat treatment of disks made of nodular cast irons GJS-500-7 and GJS-700-2 are shown.

The part of the experimental program, which results are presented in this paper, was conducted on tribometer with the sliding speed of 1,3 m/s and external loading F = 20 daN. The conditions of limiting lubrication were realized in all test operations. The study included experimental tests in the duration of 60 minutes of effec-

D. Golubović, Faculty of Mechanical Engineering, East Sarajevo, Bosnia and Herzegovina.
P. Kovač, M. Gostimirović, V. Pucovsky, Faculty of Technical Science, University of Novi Sad, Serbia.
D. Ješić, Faculty of Engineering, University of Banja Luka, Bosnia and Herzegovina.

Table 1 **Chemical composition of nodular cast irons GJL-500-7 and GJS-700-2 / wt %**

Type of material	C	Si	Mn	Mg	P	S	Cu
GJS-500-7	3,85	2,9	0,076	0,035	0,02	0,04	1,3
GJS-700-2	3,76	2,35	0,51		0,02	0,004	1,43

Table 2 **Conditions of heat treatment of disks made of nodular cast irons**

Type of material	Heat treatment		Results of heat treatment	
	Ta °C	Tp °C/t in min	Average HB	The base information of structures
GJS-500-7 /30´	900	390/30´	363	Nodules of graphite in the ausferritic matrix
GJS-700-2 /30´				
GJS-500-7 /C		520/90´	302	Deformation nodules of graphite in the martensitic matrix
GJS-700-2 /C				

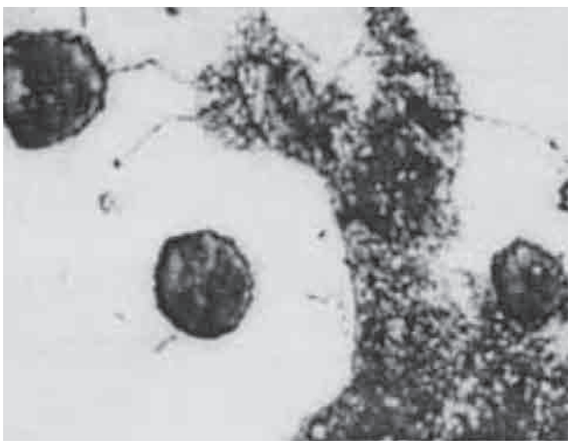

Figure 1 Microstructure of EN-GJS-500-7, charge 5815-13, magnified 500 times and corroded, with ferrite-perlite base

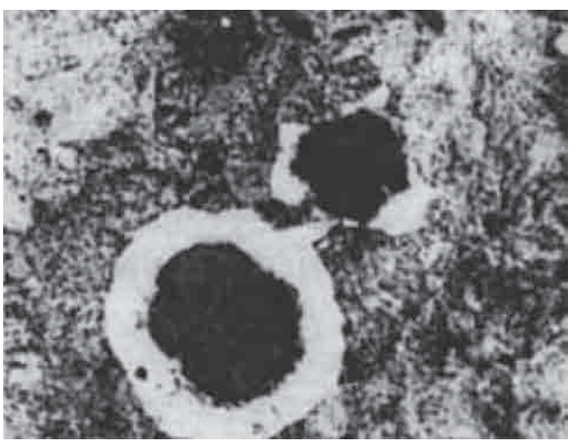

Figure 2 Microstructure of EN-GJS-700-2, charge 5766-13, magnified 500 times and corroded, with mainly-perlite base

tive contact. In all the experimental operations lubrication was realized by passing of the lower part of disk through the oil bath, where there was always the same quantity (2-3 ml) of the POI-AR 32K oil. The oil was changed at the same time as the disk and putted into the special containers for further wear products measurement.

Pins were made of steel C 40E and cast iron GJL-250. Measurement of the disks wear, after the duration contact of 30 min, was done by the PQ 2000 Particle Quantifier. The quantity of the wear products in lubricant was determined by the PQ index.

RESULTS AND DISCUSSION

The procedure of austempering of disks was realized by their heating up to the austenization temperature (900 °C), keeping them at that temperature for 90 minutes, and quick cooling (in water or air) down to temperature of 520 °C.

Isothermal tempering of both kinds of disks from nodular cast irons was done by their heating up to the temperature of 900 °C, keeping on that temperature for 60 minutes and quick cooling down to the temperature of 390 °C. At this temperature the formation of martensite still does not begin. At the temperature of 390 °C disks of both nodular cast irons were kept for 90 respectively 30 minutes. In this way the ausferritic microstructure was obtained, that should lead to a smaller wear intensity of disks, namely the elements of tribomechanical systems.

Indices of wear intensities of disks made of nodular cast iron GJS-500-7 are shown in Figure 3, as a function of the kind of the heat treatment. Two pins were used in the experiments (steel C 40E and cast iron GJL-250).

The same type of results obtained for disks made of nodular cast iron GJS-700-2, also for two pins (steel C 40E and cast iron SL250), are shown in Figure 4.

The wear intensity on both Figures was obtained by measuring the PQ index and by dividing the obtained values with contact duration time, for both nodular cast irons and two pins.

The value of this PQ index is directly proportional to the quantity of wear products (greater than 5 ÷ 10 microns) that is contained in the oil used for lubrication of the contact zone during the sliding of disk along the pin.

$$PQ = K \cdot Q \qquad (1)$$

Q is the quantity of wear products per mg of oil produced during sliding of one element of the tribomechanical system over the other for t minutes. K is constant parameter dependent on the many variables of contact condition (sliding speed normal force, type of oil etc.).

PQ index in % is defined:

$$I_{PQ} = (PQ_i / PQ_c) \cdot 100\ \% \qquad (2)$$

where: PQ_i - the measured value of the PQ index, namely the quantity of wear products in the sample of oil used in realization of contact of Pin and Disk heat treated by isothermal procedure; PQ_c - the measured value of the PQ index, in realization of contact of Pin and Disk austempered.

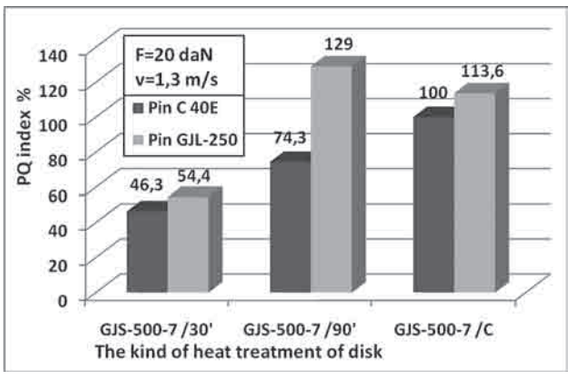

Figure 3 Wear intensity indices for disks made of nodular cast iron GJS-500-7, with different heat treatment

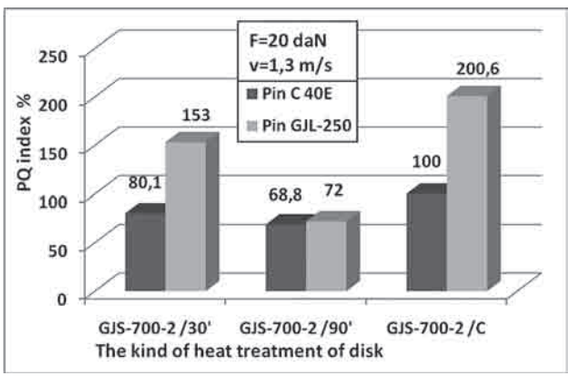

Figure 4 Wear intensity indices for disks made of nodular cast iron GJS-700-2, with different heat treatment

Both materials had better PQ index in % when pin GJL-250 was used and vice versa. From Figure 2 and Figure 3 it is obvious that best PQ index in % had nodular cast iron GJS-700-2 /C and then GJS-700-2 /30´ with pin GJL-250.

In Figure 5 the influence of disk material type on wear intensity for both austempering (C) and isothermal tempering procedure (30 and 90 minutes) is illustrated. The highest wear resistance posses the disk isothermally tempered for 30 minutes holding at temperature of 390 °C.

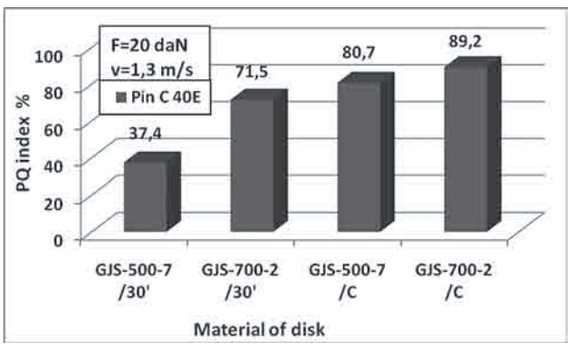

Figure 5 The influence of disc material on wear intensity.

CONCLUSIONS

According to obtained results the following conclusion can be suggested:

- In contact with steel and cast iron the biggest wear resistance posses the disk isothermally tempered with 30 minutes holding at 390 °C temperature;
- The influence of kind of heat treatment on wear intensity depends also on the type of material of the contact pair;
- Differences in the wear intensity of disks made of nodular cast irons GJS-500-7 and GJS-700-2 are smaller in realization of contact with steel than with cast iron pin.

In order to determine the optimal conditions of heat treatment of nodular cast irons, from the wear point of view, it is necessary to realize the complex program of investigations. In this program variables would also show the sliding speed and external loading.

REFERENCES

[1] D. Ješić, Tribological Properties of Nodular Cast Iron, monography Journal of the Balkan Tribological Association, Sofia, 2000, p 125.

[2] H. Mayer, B. Barbezat: Proceeding of the 2nd International Conference on Austempered Ductile Iron, University of Michigan, Ann Arbor (1986), pp. 99-115.

[3] K. Brandenberg, Machining Austempered Ductile Iron, Manufacturing Engineering, 128 (2002) 5.

[4] B. Sovilj, I. Sovilj-Nikić, D. Ješić, Metalurgija, 50 (2011) 2, 107-111.

[5] M. N. Ahmadabadi, H.M. Ghasemi, A.M. Osia, Wear, 231 (1999) 2, 293-300.

[6] J. Zimba, D. J. Simbi, E. Navara, Cement Concrete Composites, 25 (2003) 6, 643-649.

[7] A. R. Ghaderi, M.N. Ahmadabadi, H.M. Ghasemi, Wear, 255 (2003) 1-6, 410-416.

Note: The responsible for English language is Gordana Rašković, The Sworn Court Interpreter, Novi Sad, Serbia.