EXPERIMENTAL RESEARCHES ON RUNNING PROPERTIES OF NON-CONVENTIONAL TREATED STEELS FOR BEARINGS

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Abstract: In the conditions of strongly competition, in the present it is looking for new solutions to obtain bearings with prices as far low as possible, with delivery schedule as far short, but, in the same time, with running properties as far suitable, dimensional stability in running, low level of noise, high reliability, stable properties in running, good behavior in the most different conditions of environment and running, but all of this is not always possible to be obtained by classical heat treatments. The non-conventional heat treatments are modern and efficient processes, which, if are correctly applied in the chain of technological operations, determine considerable improvements of the properties of bearings. In this paper are presented the results of experimental researches on the abrasive wear out of bearings steels which are cryogenically heat treated and in ultrasonic activated liquids.

Keywords: abrasive wear out, residual austenite, cryogenic cooling, heat treatment, bearings.

1. INTRODUCTION

After the final treatment, it is important that bearing steels to present a high hardness, which lasts a long time for a prescribed reliability.In the case of bearings, the hardness represents the unique criterion to verify in mass the quality of finished product. The standard in force SR EN ISO 6508-1/2002 stipulates the execution of bearings with delivery hardnesses of 59...63 HRC.

The variants of heat treatments giving hardnesses over the admitted limits conduct at the cold hardening of the surface layer and at the decrease of the crushing resistance of the working surfaces submitted at the little surface stresses.The increased values of the hardnesses determine a great resistance at wear out.

2. THE STUDIED MATERIAL DURING HEAT TREATMENTS

It was submitted to researches the following steels: 100Cr6 and 100CrMnSi6-4. These steels make part of the group of those the group of good quenchability steels for bearings and are regulated by SR EN ISO 683-17-2002. The 100Cr6steel is, after the chemical composition, the equivalent of the RUL 1 and 100CrMnSi6-4 is the the equivalent of the RUL 2 steel, according to STAS 1456/1-89 and STAS 11250-89. SR EN ISO 683-17-2002 replaces STAS 1456/1-89 and STAS 11250-89.

The heat treatment variants include in their cyclograms, besides the classical heat treatment and the heat treatments under 0ºC, at *-30ºC, -60ºC, -70ºC, -90ºC, -120ºC* and at *-196ºC* and the heat treatment in ultrasonic field.

The temperature of 850°C is the temperature of austenisation for the 100Cr6 steel and the 830°C temperature for the 100CrMnSi6-4 steel.

The specimens taken from the rings of bearings are 100Cr6 and 100CrMnSi6-4 steels and submit to the classical heat treatments realized in many variants in function of tempering temperature after quenching (variants A_i), where:

A_1 = 150ºC;
A_2 = 170ºC - classical heat treatment;
A_3 = 190ºC;
A_4 = 210ºC;
A_5 = 230ºC;
A_6 = 350ºC;

Cryogenic heat treatment was realized:

B_1 = -30ºC + tempering at 170ºC;
B_2 = -60ºC + tempering at 170ºC;
B_3 = -90ºC+ tempering at 170ºC;
B_4 = -120ºC+ tempering at 170ºC;
B_5 = -196ºC+ tempering at 170ºC.

The treatment in ultrasonic field (quenching) was realized in two variants in which differs the energy of ultrasonic field, the frequence being the same:

C_1: f = 40 Hz; I = 2 W/dm^2;
C_2: f = 40 Hz; I = 3 W/dm^2.

3. THE USED APPARATUS AND THE RESEARCH METHOD

For the study of the behavior at the abrasive wear out it was used an laboratory – type experimental installation. The installation is equipped with a diamond disc on a frontal surface being in a rotation movement with n = 320 r.p.m. on which is applied with a constant force a cylindrical specimen through the agency of a 2:1 multiplication lever and of a weight.

The installation has good stiffness and ensures a correct precision of the researches, permits the measurements by weighting of the losses of the specimens. Also, it permits the direct measurement of the volume losses by abrasion, measuring by the aid of a dial gauge the displacement during the tests of the end of the lever for pressing the specimens. The installation is equipped with a speed counter, which permits the determination of the length of the friction path. Measuring the mass losses, it is determining the wear out intensity.

The scheme of the abrasive wear out test is given in the figure 1.

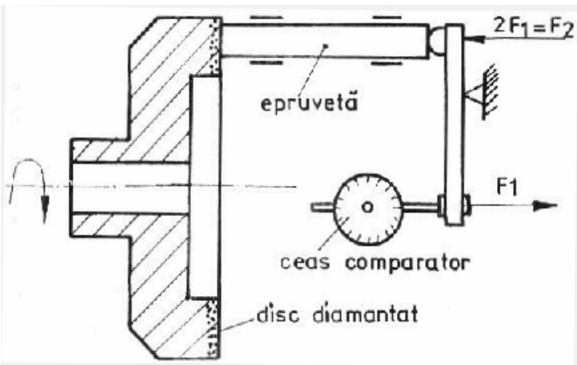

Fig. 1. The scheme of the abrasive wear out test

The experimental measurements have endorsed the determining of the mass losses by abrasion. As much these losses are smaller, as much the wear out resistance is greater.

4. THE EXPERIMENTAL RESULTS

The determining of the abrasive wear out resistance was realized on cylindrical specimens with dimensions of ф 8 x 65 mm, which are heat treated according to the proposed variants. The specimens were pressed with $F_2 = 2F_1 = 2$ daN on the frontal diamond surface of a abrasive disc in a rotation movement with n = 320 rot/min. The experiments were made in the following conditions:
$D_d = 90$ mm; (D_d - the average diameter of frontal friction of the diamond disc);
v = 90,5 m/min; (liniar friction speed; dry friction); F = 2daN/mm^2; (F – the press force of the specimen);
L = 5428,67 m; (L – the length of the path in an hour);S = 50,26 mm^2; (S – the frontal plane surface of the contact specimen-disc); friction time = 1 hour; precision of determining of the mass of abrased material = 0,0001 g.
The wear out of the diomond disc was considered neglectable and the developped temperature during the friction process being reuced did not influence the specimen structure.
The wear out resistance was appreciated by determining the mass loss Δm defined by STAS 8069-87 as being the value of the ratio between the cumulated mass Δm_c and the time wasted for it

$$V_m = \frac{\Delta m_c}{t}, \text{ [g/h]} \tag{1}$$

The mass wear out intensity, according to the same standard, it is calculated with the relation:

$$I_m = \frac{\Delta m_c}{L \cdot S}, \text{ [g/m}^3\text{]} \tag{2}$$

In the table 1 are given the average values of the mass losses Δm which are determined by an analytic balance on three specimens for each variant of heat treatment, after 10, 20, 30, 40, 50 friction minutes, the cumulated mass loss after 1 hour and the mass wear out intensity.

Table 1. The mass losses by abrasive wear out

Steel	Variant	Δm, [g], after time in min						Δm_c, [g],	V_m [g/h]	I_m,[g/m^3]
		10	20	30	40	50	60			
100Cr6	A_1	0,001	0,003	0,008	0,011	0,016	0,039	0,039	0,039	0,1459
	A_2	0,002	0,004	0,010	0,015	0,020	0,051	0,051	0,051	0,1429
	A_3	0,004	0,006	0,011	0,016	0,047	0,084	0,084	0,084	0,3078
	A_4	0,004	0,006	0,010	0,015	0,047	0,083	0,083	0,083	0,3041
	A_5	0,005	0,007	0,012	0,016	0,046	0,086	0,086	0,086	0,3151
	A_6	0,005	0,008	0,014	0,020	0,058	0,105	0,105	0,105	0,3848
	B_1	0,001	0,003	0,006	0,009	0,015	0,034	0,034	0,034	0,1246
	B_2	0,0008	0,001	0,002	0,005	0,0022	0,011	0,011	0,011	0,0403
	B_3	0,0005	0,0009	0,0015	0,002	0,0041	0,009	0,009	0,009	0,0329
	B_4	0,0002	0,0004	0,0005	0,006	0,008	0,0025	0,0025	0,0025	0,0091
	B_5	0,0001	0,0002	0,0004	0,0005	0,0005	0,0017	0,0017	0,0017	0,0062
	C_1	0,001	0,002	0,004	0,007	0,008	0,022	0,022	0,022	0,0806
	C_2	0,001	0,002	0,004	0,005	0,004	0,016	0,016	0,016	0,0586
100CrMnSi6-4	A_1	0,001	0,002	0,003	0,005	0,007	0,018	0,018	0,0180	0,0072
	A_2	0,001	0,003	0,004	0,005	0,0079	0,0219	0,0219	0,0219	0,06597
	A_3	0,004	0,006	0,011	0,016	0,040	0,077	0,077	0,077	0,28522
	A_4	0,003	0,005	0,010	0,015	0,038	0,071	0,071	0,071	0,2602
	A_5	0,003	0,006	0,012	0,016	0,057	0,094	0,094	0,094	0,3445
	A_6	0,004	0,007	0,017	0,026	0,048	0,102	0,102	0,102	0,3738
	B_1	0,001	0,003	0,007	0,011	0,018	0,040	0,040	0,040	0,1466
	B_2	0,0002	0,0004	0,0005	0,0009	0,0022	0,0044	0,0044	0,0044	0,0161
	B_3	0,0001	0,0003	0,0003	0,0005	0,0006	0,0018	0,0018	0,0018	0,0065
	B_4	0,0001	0,0002	0,0003	0,0004	0,0006	0,0016	0,0016	0,0016	0,0058
	B_5	0,0001	0,0001	0,0002	0,0003	0,0003	0,001	0,001	0,001	0,0036
	C_1	0,0007	0,0009	0,001	0,008	0,0084	0,018	0,018	0,018	0,0806
	C_2	0,001	0,002	0,003	0,003	0,005	0,014	0,014	0,014	0,0513

Analysing the results from the table 1, it is observed both at 100Cr6 steel and at 100CrMnSi6-4 steel that in the same time with the increase of the tempering temperature, the mass losses have greater values because the hardness decreases. In the same time with the increase of the tempering temperature takes place the coagulation of the carbides which are separated from the martensite, decomposition of the residual austenite and the formation of an analogue tempering structure and, therefore, the structural heterogeneity [4]. In this case the wear out resistance decreases.

At the small values of the mass losses Δm are asociated high hardnesses and very reduced quantities of residual austenite.

The phenomenon of abrasive wear out at bearings is dependent of a multitude of factors of materials and heat treatments: the quantity of residual austenite, the total quantity of martensite, the dispersion and the homogeneity of the carbides, factors which at their turn are in a strongly and complex interdependence.

5. CONCLUSIONS

In conclusion, it may asset that in the case of bearings steels, which are heat treated in diffeerent variants, including cryogenic cooling or in ultrasonic activated liquid, have the best wear out resistance.

The variants of heat treatments B_2, B_3, B_4 (quenching + cryogenic cooling at -60ºC, -90ºC and -120ºC + tempering at 170ºC) are superior from the point of view of wear out resistance.

The 100CrMnSi6-4 steel presents less mass losses, therefore a greater wear out resistance comparing with 100Cr6 steel.

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