

THE INFLUENCE OF CRYOGENIC AND ULTRASONIC TREATMENTS ON THE QUANTITY OF RESIDUAL AUSTENITE IN STEELS FOR BEARINGS

MIRELA GHEORGHIAN, DORU CIUCESCU

University of Bacau

Abstract: After quenching and tempering the bearing steel, being a hypoeutectoid one, presents a structure containing martensite, residual austenite and carbides. The rotation precision and the functional role of the bearings impose a good dimensional stability and high mechanical properties. These properties depend on the nature of the natural constituents, their size and distribution and, also, on the degree of structural homogeneity. The technological parameters (temperature and maintaining time) influence the quantity of transformed austenite and the kinetics of this transformation. In this paper is presented the variation of quantity of residual austenite with the cooling temperature under 0°C for the variants of classic treatment: 5 variants of cryogenic treatments and 2 variants of treatment with cooling in ultrasonic field for the 100Cr6 and 100CrMnSi6-4 steels. For these variants of treatments were realized measurements of the quantity of residual austenite by diffraction with X-rays.

Keywords: residual austenite, cryogenic cooling, heat treatment, bearings.

1. INTRODUCTION

In our days, the major part of bearings is classic treated: quenching in oil followed by low tempering. After this heat treatment are obtained values for hardness more than 60 HRC, good wear resistance, but middle values for reliability and dimensional stability. Their cause is the presence of a great quantity of residual austenite (10-18%). This austenite will be transformed in martensite and will modify the dimensions of constructive elements with direct implications in the increase of noisy level and of the possibility of gripping them. The dimensional instability affects the use of devices (tools, verifiers) and precision pieces, at which the dimensional modification is produced during their storing and using. The dimensional stability guarantee becomes, however, a major condition in the case of the pieces of complex equipment, of high precision, as well as in aviation, where the dimensional instability may produce the blocking of commands, the disturbing of mechanical and hydraulic systems, being the causes of grave accidents. The austenite is a solid solution in Fe_γ in which the carbon atoms occupy the octahedric positions in a face-centered lattice, transforming exothermically in martensite due to thermo-mechanical shocks and stress conditions (at bearings- Hertz cycle stresses).

This transformation provokes in steel an increase in volume (expansion) and, therefore, dimensional modifications but, also, modifications of stress state, which reduce considerably the durability of bearings. The rotation precision and the functional role of bearings impose to them a good dimensional stability and good mechanical properties during functioning. These properties depend on the nature of structural constituents, on their size and distribution or the degree of structural homogeneity.

The substantial modifications of running properties have as causes the important modifications in the composition, structure and understructure of bearing steels.

The technological parameters of cryogenic treatment influence the quantity of transformed austenite and the kinetics of this transformation.

The variation of the residual austenite quantity was studied for the variants A₂ (classic heat treatment), B₁, B₂, B₃, B₄, B₅ (cryogenic treatment) and the variants C₁, C₂ (cooling in ultrasonic field) for 100Cr6 and 100CrMnSi6-4 steels.

2. THE STUDIED MATERIALS

The experimental researches concerning the influence of non-conventional heat treatment on the quantity of carbides were realized on the following steels: 100Cr6 și 100CrMnSi6-4. These steels make part from the group of good quenchability steels for bearings and are regulated by SR EN ISO 683-17-2002.

The 100Cr6 steel is, after the chemical composition, the equivalent of the RUL 1 and 100CrMnSi6-4 is 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 chemical composition of the steels, which is spectrographically determined with the Quantovac 460 ARL (U.S.A) –type apparatus is given in the table 1; in the first line are given the prescribed values and in the second one are given the determined values of steel charges. The difference between these steels is the manganese and silicon content.

Table 1 The chemical composition of researched steels [1]

Chemical composition [%]								
Steel (SR EN ISO 683-17)		Si	Mn	P	S	Cr	Mo	Others
100Cr6 (RUL 1)	0,93-1,05	0,15-0,35	0,25-0,45	0,025	0,015	1,35-1,6	Max.0,1	Al max.0,05
Determined values	0,98	0,30	0,36	0,018	0,014	1,45	-	-
100CrMnSi6-4 (RUL 2)	0,93-1,05	0,45-0,75	1,0-1,20	0,025	0,015	1,4-1,65	Max.0,1	-
Determined values	1,00	0,51	1,15	0,015	0,01	1,48	-	-

3. EXPERIMENTAL RESEARCHE BY X-RAYS DIFFRACTION

The experimental researches focusing on the increase of residual austenite and carbides were made by X-rays diffraction on a diffractometer Siemens D 5000, using a molybdenum tube [2]. The working conditions and the parameters of the molybdenum tube (voltage, current, minimal and maximal power, wave length of the radiation $K\alpha_1$, $K\alpha_2$ and $K\beta$ in Å) are given in the figure 1.

Table 2. The results of diffraction tests

The type of steel and the variant of treatment		γ_{200}	m_{200}	γ_{220}	m_{211}	γ_{111}	m_{110}
100Cr6 B ₂	2θ , ° I, [cps]	22.68 [7.80]	28.72 [25.70]	32.54 [5.10]	35.35 [36.20]	19.64 [4.60]	20.19 [88.90]
100CrMnSi6-4 B ₂	2θ , ° I, [cps]	22.68 [7.30]	28.71 [26.10]	32.49 [5.15]	35.36 [41.20]	19.62 [3.80]	20.23 [87.50]
100Cr6 C ₁	2θ , ° I, [cps]	22.62 [4.90]	28.74 [28.30]	32.46 [3.40]	35.38 [44.60]	19.71 [3.20]	20.16 [92.25]
100CrMnSi6-4 C ₁	2θ , ° I, [cps]	22.72 [4.50]	22.68 [27.90]	32.35 [3.15]	35.35 [43.80]	19.68 [2.75]	20.18 [93.05]

For the calculation of percentage volume of residual austenite $V\gamma$ it was created a page in Excel, in which are calculated all diffraction parameters after the standard methodology [3]. It is calculated $V\gamma_{\text{teoretic}}$ in ideal diffraction conditions and $V\gamma$ in real conditions, taking into consideration the diffraction angle 2θ for each pick.

4. FINAL RESULTS

The centralized results of the researches concerning the proportion of the residual austenite remained after the cryogenic treatment for 100Cr6 and 100CrMnSi6-4 steels are synthesized in table 3.

Table 3. The quantity of residual austenite (A_{rez}) after the classic (A₂), cryogenic (B_i) and ultrasonic (C₁) heat treatment

The variant of heat treatment	Temperature [°C]	Residual austenite [%]	
		100Cr6	100CrMnSi6-4
A ₂ (clasic)	170	11,24	14,35
B ₁	-30°C + tempering at 170°C	8,45	9,83
B ₂	-60°C + tempering at 170°C	5,82	5,50
B ₃	-90°C + tempering at 170°C	3,295	5,29
B ₄	-120°C + tempering at 170°C	1,92	3,60
B ₅	-196°C + tempering at 170°C	1,01	2,38
C ₁	I=2W/dm ²	5,55	5,40
C ₂	I=3W/dm ²	4,80	4,52

From the study of variation of residual austenite in function of cooling temperatures under 0°C may be observed that the transformation of austenite in martensite is more advanced as much as the cooling temperatures are lower.

6. CONCLUSIONS

From the analyze of results concerning the variation of residual austenite quantity in function of temperature and maintaining time, after stabilization in time and distabilization at the cryogenic temperature of liquid nitrogen, it results the following conclusions:

1. From the point of view of the decrease of residual austenite quantity and the nature of cooling medium, the optimal quenching treatment, when the stability conditions impose it, is the cooling at -60°C , case in which are obtained significant decreases of residual austenite quantity.
2. For the severe conditions imposed to the stability in time of constructive components of bearings and, especially, those of 100CrMnSi6-4 steel, may be applied the cooling at -90°C .
3. When applying the treatments under 0°C are necessary precautions in cooling speed. It is imposing that the bringing at the room temperature to be made with a reduced speed, as much as possible, in order to transforme in martensite, also, a part of remained austenite.

REFERENCES

- [1]].*** SR EN ISO 683-17: 2002- *Oțeluri pentru tratamente termice. Oțeluri aliate și oțeluri pentru automate. Partea 17: Oțeluri pentru rulmenți.*
- [2]*** *** E 975-95- *Standard Practice for X-Ray Determination of Retained Austenite in Steel with Near Random Crystallographic Orientation*, American Society for Testing and Materials.
- [3] Higginson, R. L., Sellars, C.M., - *Worked Examples in Quantitative Metallography*, Metal Scientific, England, vol. 9, 1988.
- [4] Popescu, N., Gheorghe, C., Popescu, O.- *Tratamente neconventionale*, E.T. Bucuresti, 1990.