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The Heat Treatment Influence of 1.3343 High Speed Steel on Content of Residual Austenite

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Abstract

The heat treatment applied to high speed steel is in large measure dictated by the necessity of decreasing the residual austenite content. After hardening, a large amount of residual austenite it is found in the structure; this is unwanted because it is less hard than practical necessities and also unstable in time. As a result, the heat treatment has the purpose to conferee to tools mechanical properties that are required in exploitation, and in the same time, stable from structural point of view and of mechanical characteristics. In this purpose there are known several processes, as for example multiple tempering and treatment below zero degrees. In this paper, it is proposed the analysis of residual austenite from 1.3343 high steel speeds subject to multiple heat treatment operations, by determining after each, the quantity of residual austenite; this was made with X ray diffraction using a software package program. Research has revealed the decrease of residual austenite content with the number of tempering as well as with the treatment below zero degrees.

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Keywords: heat treatment; multiple temperings; residual austenite.

1. Introduction

The stability in time of the properties and of the dimensions on high speed steel tools represents a condition at heat treatment outcome [1-11]. In the same time due to chemical composition, the martensitic critical points at these high speed steels are at low temperatures, Ms, being below zero degrees [12-18]. Thus after hardening, in the

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structure, residual austenite it is found in appreciable proportion, at several dozens of percentage. The low hardness and the reduced stability can affect the tools behavior in exploitation. The heat treatment subsequent hardening has as principal purpose, the conferment of the mechanical and dimensional characteristics to these products as they are required [19-23]. Heat treatments for these are multiple tempering and treatment below zero degrees.

The influence of thermal treatment of rapid steels regarding the content of residual austenite and its determination in various stages of heat treatment represents an important topic in the studies and research carried out [24-28].

2. Experimental research

In terms of determination of residual austenite in various stages of heat treatment it has been chosen 1.3343 (Rp5) high speed steel with the following chemical composition shown in Table 1.

Table 1. The chemical composition

Steel type	Chemical composition in percent								
	C	Si	Mn	P	S	Cr	Mo	V	W
1.3343 (Rp5)	0,92	0,28	0,39	0,021	0,0011	3,43	4,71	1,71	5,95

In order to achieve results, high speed steel samples were subjected to hardening using equipment for vacuum heat treatment; the cooling was performed using an installation with purified nitrogen, strongly recycled. Working parameters at hardening are indicated in Table 2.

Table 2 Hardening parameters

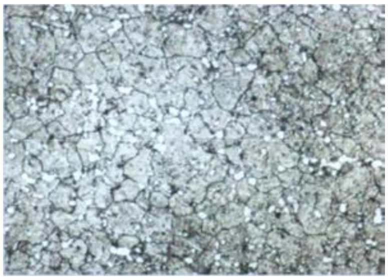
Steel type	Preheating			Final heating			Cooling	Hardness
	Press. [torr]	Temp. [°C]	Time [min]	Press. [torr]	Temp. [°C]	Time [min]		[HRC]
1.3343	10^{-1}	870	30	0,2...0,3	1190	7	purified nitrogen	60,5

Following the process the hardening samples were subjected to heat treatment operations destined to reduce the amount of residual austenite. Thus, after consecutive hardenings, there were applied tempering operations, according to Table 3.

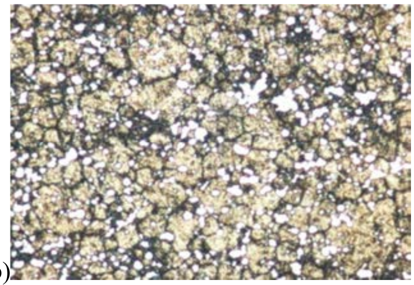
Table 3 Tempering parameters

Steel type	Tempering working parameters			
	Press. [torr]	Temp. [°C]	Time [min]	Cooling
1.3343	400	560	60	purified nitrogen

There has been effectuated multiple tempering, from 1 to 6, for several samples in parallel. A set of samples were also after hardening, subject to heat treatment below zero degrees, respectively at -40° C. In the following figures, the microstructures of samples treated as above, are presented.



a)



b)

Fig. 1. a) High speed steel 1.3343 vacuum hardening from 1190° C. NITAL Attack; 1000:1; b) High speed steel 1.3343 vacuum hardening from 1190° C and 1 tempering. NITAL Attack: 1000:1.

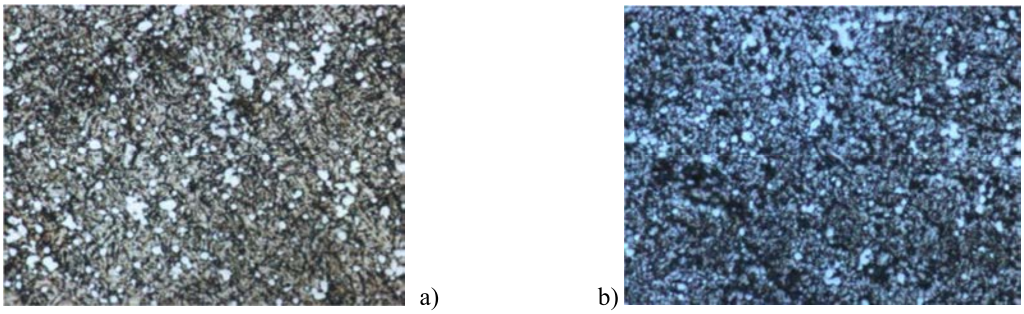


Fig. 2. a) High speed steel 1.3343 vacuum hardening from 1190° C and 3 consecutive temperings. NITAL Attack: 1000 :1; b) High speed steel 1.3343 vacuum hardening at 1190° C and 6 consecutive temperings. NITAL Attack: 1000:1.

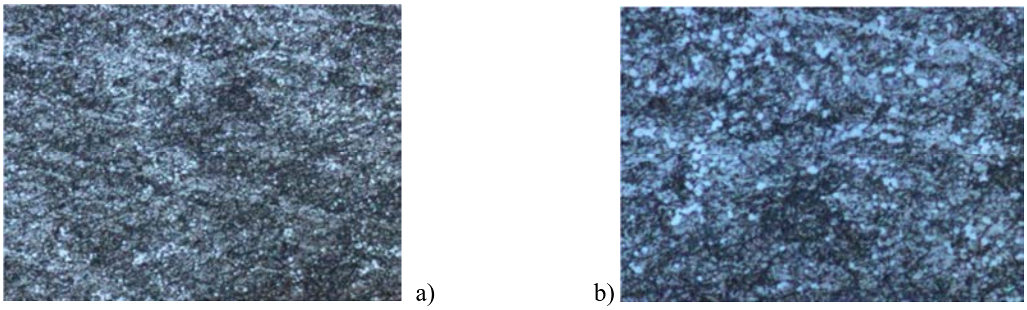


Fig. 3. High speed steel 1.3343 vacuum hardening from 1190° C and cooling at -40 C, 1h. Nital Attack: (a) 500:1; (b) 1000:1.

3. Determining the content of residual austenite

The high speed steel samples 1.3343 treated in many variations, as described above, were carried out by X-ray diffraction analysis using a PANalytical diffractometer XPert MPD. The diffraction spectra are given below.

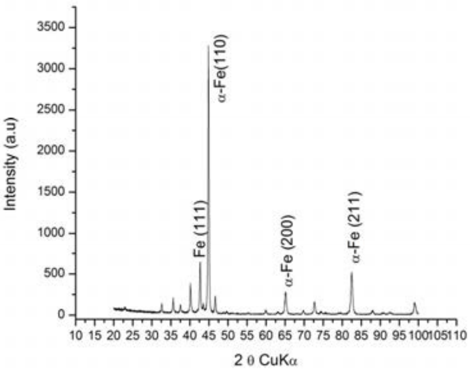


Fig. 4. X-ray diffraction spectra of 1.3343 high speed steel sample, after vacuum hardening

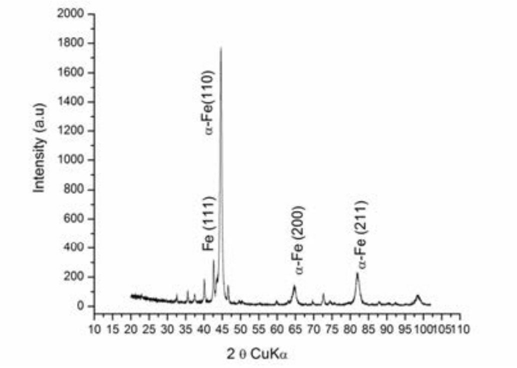


Fig. 5. X-ray diffraction spectra of 1.3343 high speed steel samples, vacuum hardening and 1 tempering at 560° C.

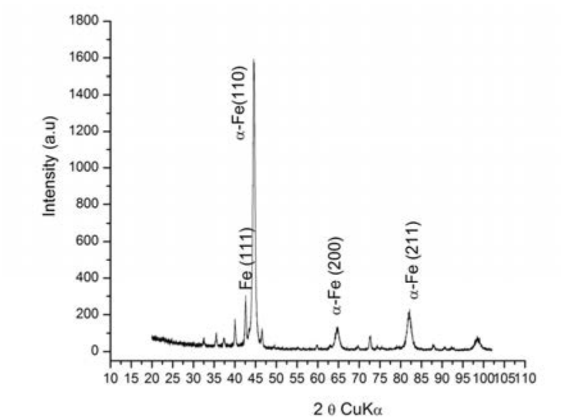


Fig. 6. X-ray diffraction spectra of 1.3343 high speed steel sample, vacuum hardening and 2 consecutive temperings at 560° C

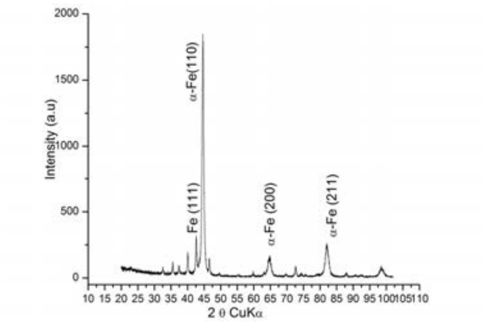


Fig. 7. X-ray diffraction spectra of 1.3343 high speed steel sample, vacuum hardening and 3 consecutive temperings at 560° C

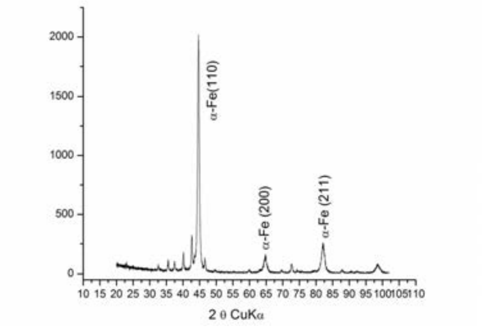


Fig. 8. X-ray diffraction spectra of 1.3343 high speed steel sample, vacuum hardening and 6 consecutive temperings at 560° C

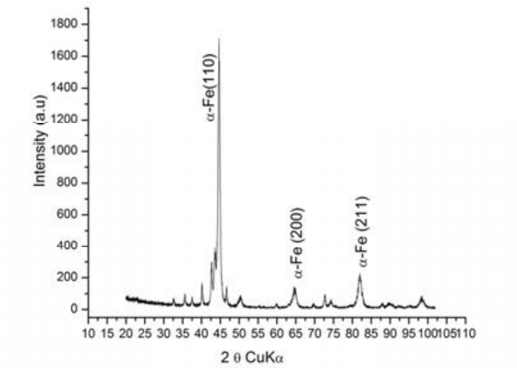


Fig. 9. X-ray diffraction spectra of 1.3343 high speed steel sample, vacuum hardening and cooling at -40°C for 1h

Considering that, to austenite with crystalline lattice cfc is corresponding the peak of the plane (111) from the diffractograms above, from qualitatively point of view, there is found a decrease of residual austenite content with the increasing of the number of temperings, respectively with treatment below zero degrees. For quantitative determinations were carried out spectra analysis using the software program package XpertHighScorePlus. The identification of crystalline phases was made on standard base XRD, JCPDS of International Centre of Diffraction, SUA. The investigation results regarding the hardness and the content of residual austenite are shown in table 4, where: H-hardness, and T-tempering.

Table 4. The hardness and the content of residual austenite in different stages

Properties	The initial state	After hardening (H)	H+1T	H+2 T	H+3 T	H+6 T	H+ treat. below 0°C
Hardness [HRC]	42,5	60,5	63,40	63,87	64,13	64,20	64,83
Res.austenite [%]	-	43,8	7,8	7,4	7,1	7,0	7,1

4. Conclusions

The results obtained based on the experimental attempts allow the following conclusions: the high content of residual austenite found after hardening, confirms data from the specialized literature; the tempering applied shortly after hardening, has a sensitive effect upon the residual austenite transformation; the major quantity of transformed structure occurs after the first tempering; along in the process, on subsequent temperings, gradually the percentage of transformed residual austenite is decreasing; the residual austenite transformation is accompanied by the hardness increasing, more visible after the first tempering and relatively insignificant following the process; the heat treatment below zero degrees causes in a single stage the drastically decreasing of residual austenite content, with visible effects on hardness. A subsequent tempering, with the stress relieving role, would lead to a slight decrease in hardness. In the same time, it is appreciated that through profound coolings the steel resilience decreases. As a result, the treatment below zero degrees is applied to the products at which the shocks in exploitation are trifling.

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