FROZEN HIGH ALLOYED STEELS

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Abstract. The work presents the improvement of the physical-mechanical and exploitation properties of high speed steels by the application of thermal treatments that include cooling down to -196^{0}C. Investigations were carried out on the qualitative parameters of the carbide phase (according to size), as well as on the durability of thermally treated tools. Thus, the increase of tools durability was appreciated through the increase of the amount of small size carbide(<1μm) uniformly distributed in the martensite mass, increased at the expense of the residual austenite and in correlation with the diminution of the 2nd order stresses from these steels.

Keywords: *High speed steels, cryogenic cooling, heat treatment, carbides, durability.*

1. INTRODUCTION

In spite of he fact that the cryogenic treatment applied to tools and machine elements has been used for more than 50 years, it has still some unknown and less studied.

Thus, one does not know the inner mechanisms by which his thermal treatment leads finally to substantial increases in tools durability. The explanation of the increased contribution of martensite to the prejudice of residual austenite is simplistic and unconvincing.

The increase of the physical, mechanical and exploitation properties must be explained by the important changes produced by treatment at the level of all the phases existing in steel and especially on the carburic phase.

This paper tries to argue the increase of high speed steels (HSS) tools durability by the changes produced by the cryogenic treatment on the carburic phase, especially on the number and dimensions of the carbides.

2. Experimental Researches. results

Our researches have implied four types of highly-alloyed steels belonging to HSS, namely *T1* (AISI), *M2* (AISI), *S3-3-2* (SEW 320) and *M1* (AISI) which have been classically and cryogenically treated according to the diagrams from ***Figure 1.*** The cryogenic treatments have been applied immediately after the classic oil hardening (B1, B2, B3 variants) or after hardening and tempering (C1, C2, C3 variants).

The determination of the quantitative parameters of the carburic phase has been done on a Quantimet 720 quantitative microscope equipped with a Hewlett-Packard 9810 A computer. The quantitative determinations of the carburic phase have been done at a magnifying power 500:1 and obtained values represent the average of the 30 researched fields. The researched quantitative parameters have been the following total area occupied by carbides (*A,%*), total sum of the diameters of the carbides existing on unit area in the researched fields (D_t, *mm*), average number of the carbides on mm^2 (N, mm^{-2}), carbides distribution on dimensional classes: 0-1 microns, 1-2 microns, 4-8 microns, 8-16 microns, 16-32 microns, greater than 32 microns.

The obtained values for these quantitative parameters are given in ***Table 1.***

The results of the determinations from ***Table 1*** point out great differences between the classic (*A*) and the variants containing a cryogenic treatment at -70^{0}C, -120^{0}C and -196^{0}C (B1, B2, B3, C1, C2, C3 variants), respectively, for one the same HSS as well as significant difference between types of steels treated by one the same variant.

Thus, the area occupied by carbides (*A,%*) is almost double for the *T1* and *M2* steels for the cryogenic variants as compared with the classic treatment variant. The number of carbides existing in the studied fields of the all steels cryogenically-treated is this times higher as compared with the classic treatment (A variant), while the number of carbides with dimensions under 1 micron is much greater after cryogenic treatments as compared with the classic treatment, ***Figure 2.***

These things determine in a greater part an increased durability of the cutting tools processed by treatments which contain a cooling at temperatures under 300 K. For practical conditions it is sufficient the temperature of -70^{0}C obtained by the evaporation of solid CO_2 (B1, C1 variants).

The durability has been obtained by measuring the time up to the appearance of critical wear on bask edge of some lathe tools made up of classically and cryogenically-treated steels.

The tools geometry has been $\alpha = 8^0$, $\gamma = 25^0$, $\lambda = 75^0$, $r = 1mm$, and the cutting regime of a C 1045 (AISI) steel has been intensive without a cooling liquid with $v = 32.67$ *m/min*, $s = 0.25$ *mm/rot*, $t = 2.5$ *mm.*

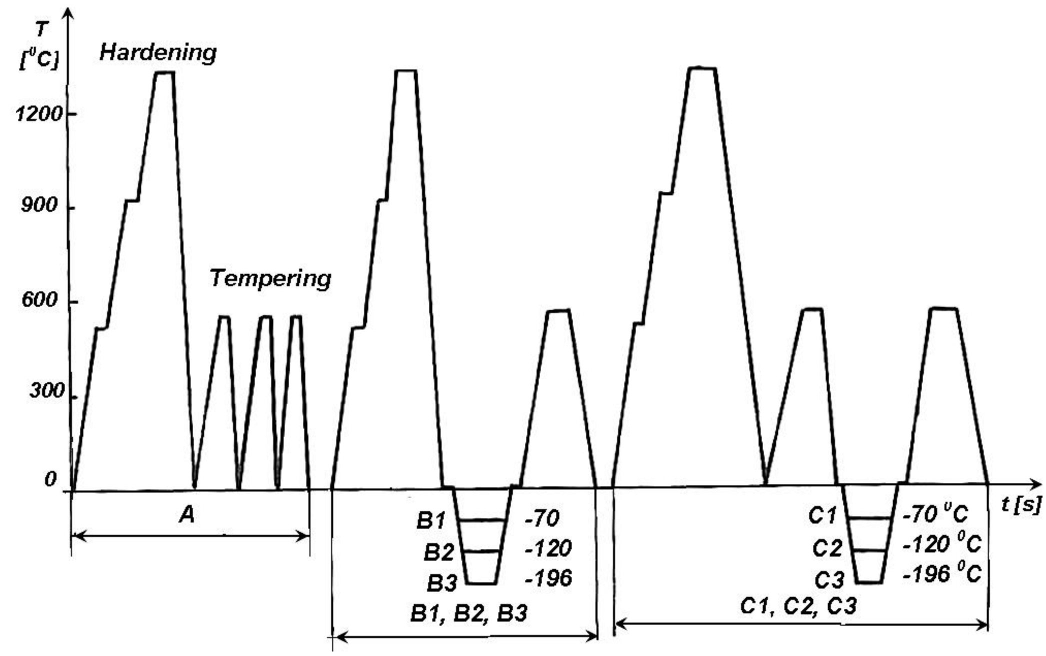

Figure 1. Applied heat treatment cycles.

Table 1. Quantitative Parameters of Carburic Phase

HT Var.	Steel	A %	D_t mm	D_m $x10^{-4}$mm	N mm^{-2}	N, mm^{-2}						
						0 - 1	1 - 2	2 - 4	4 - 8	8 - 16	16 – 32	> 32
A	T1	4.48	55.12	13	49,215.1	37,007	6,609	4,418	924	239	0	0
	M2	2.90	30.16	9	31,358.2	23,410	5,707	2,002	199	40	0	0
	S3-2-2	2.35	20.12	9	22,079.0	17,004	3,387	1,253	406	28	0	0
	M1	8.90	52.13	22	23,796.5	17,379	3,487	1,499	985	417	28	0
B1	T1	8.10	71.26	10	72,519.9	53,671	13,358	4,806	575	109	0	0
	M2	5.14	35.59	7	40,897.9	30,928	6,858	2,943	138	29	0	0
	S3-2-2	3.07	26.87	9	30,885.2	22,526	5,465	2,177	692	25	0	0
	M1	9.68	59.13	18	32,773.3	26,616	3,498	1,335	735	542	46	0
B2	T1	8.12	72.61	12	73,112.3	54,613	14,001	4,912	631	116	0	0
	M2	5.18	36.01	8	40,987.2	30,878	6,921	2,968	145	36	0	0
	S3-2-2	3.08	29.34	8	36,599.6	28,308	5,664	2,038	574	14	0	0
	M1	8.21	68.08	12	55,070.8	42,777	8,705	2,381	907	290	14	0
B3	T1	8.18	76.12	12	74,122.4	55,723	14,502	4,927	639	119	0	0
	M2	5.67	39.21	9	41,136.5	31,124	7,001	2,991	161	39	0	0
	S3-2-2	2.59	21.97	9	23,350.4	16,408	4,544	1,852	935	11	0	0
	M1	7.34	58.15	12	47,068.4	36,482	6,614	2,302	1,279	396	4	0
C1	T1	7.52	74.48	9	83,618.9	64,136	14,280	4,717	347	119	0	0
	M2	4.90	46.28	9	56,466.1	42,870	9,692	3,627	218	50	10	0
	S3-2-2	4.40	39.01	8	48,935.1	36,243	8,370	3,298	860	64	0	0
	M1	9.30	53.29	13	42,032.1	19,161	6,992	3,659	1,417	471	32	0
C2	T1	7.56	76.51	9	84,132.2	43,141	10,068	3,812	249	49	0	0
	M2	4.94	47.01	9	57,631.6	38,240	8,437	3,601	723	78	0	0
	S3-2-2	3.35	27.07	9	28,900.6	20,581	5,122	2,359	746	57	0	0
	M1	7.37	46.97	12	38,505.6	25,885	7,049	4,140	1,178	246	7	0
C3	T1	7.92	78.41	9	86,341.1	65,451	15,012	3,937	368	112	10	0
	M2	5.12	49.02	9	56,123.2	44,830	9,716	3,852	554	94	0	0
	S3-2-2	2.98	23.07	9	24,585.4	17,311	4,401	2,220	632	21	0	0
	M1	7.30	61.14	13	45,447.9	33,965	8,006	2,384	810	261	18	0

The durability values thus determined are given in ***Table 2.***
On comparing the data from Tables 1 and 2, one can see that the durability increases slowly with the increase of the carbides quantity and increases significantly with the density of the carbides under 1 micron, **Figure 3.**

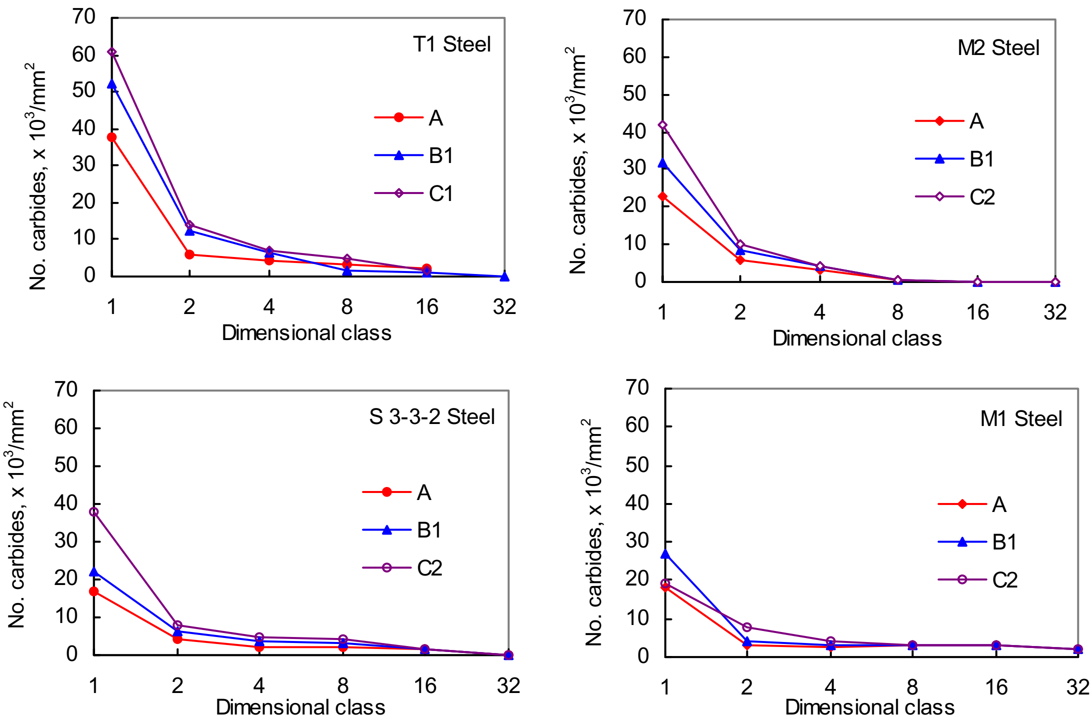

Figure 2. Carbides density distribution on dimensional classes.

Table 2. Durability of Lath Tools

Steels	HT Variant	Durability T, min.	Steels	HT Variant	Durability T, min.
	A	48		A	59
	B1	72		B1	74
	B2	76		B2	79
T1	B3	81	S3-3-2	B3	89
	C1	74		C1	79
	C2	81		C2	84
	C3	82		C3	84
	A	57		A	59
	B1	78		B1	69
	B2	78		B2	89
M2	B3	82	M1	B3	84
	C1	84		C1	79
	C2	86		C2	89
	C3	88		C3	94

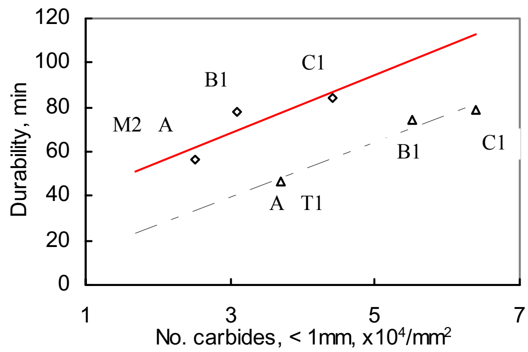

Figure 3. Carbides density distribution on dimensional classes.

3. CONCLUSIONS

The possibility of using the low temperature heat treatments for the high speed steels (HSS), points out the following conclusions:

a) The thermal treatment at negative temperatures determines the durability increases not only the supplementary martensite quantity introduced in high-alloyed steels, but also by increasing the carbides quantity on unit surface and especially by increasing the density of carbides with dimensions under 1 micron;

b) The lower the tools cooling temperature is, the greater the carbides quantity (and implicitly the greater the durability is);

c) The increase of the cryogenically-treated tools durability must be correlated as well the quantitative reduction of the 2-nd degree stresses from these steels;

d) The greater the quantity of the precipitated carbides at tempering is the higher alloyed the residual austenite and martensite will be.

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