CONSIDERATIONS ON HEAT TREATMENTS OF MARTENSITIC STAINLESS STEELS

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Abstract: *In the paper some considerations are made on stainless steel alloyed with chromium and average carbon content. These steels are used in heat-treated condition by tempering and returning. The properties obtained are influenced by the regime applied to the final treatment (tempering and recovery) and the technological parameters; at the same time changes in the metallographic structure are also observed. On the specimens of the material in the state of delivery were successively made the technological operations of annealing, tempering, returning with the parameters described in the paper. Then the specimens thus performed were subjected to tests on some mechanical and structural characteristics respectively. Thus, the correlations between the thermal treatment parameters, the metallographic aspect and the mechanical properties were revealed.*

Keywords: *martensitic stainless steels, heat treatments*

1. INTRODUCTION

Steels acquire their stainless steel property by high chromium content. Thus, in stainless steel, chromium percentages range from 10 to 20%. To improve some qualities related to increased corrosion resistance, low or high temperatures are added to the chemical composition of molybdenum and especially nickel [2, 3, 4].

The chromium-alloyed stainless steels have predominantly ferritic structure, and those chromium and nickel alloyed, the austenitic structure [5].

To obtain high hardness, the carbon content is increased to 0.3 ... 1.0% in chromium-precursor alloys. Chromium steels are subjected to final thermal treatments and are designed for the manufacture of bearings (rings, balls, rollers) working in corrosive environments, and high wear resistant tools and tools (knives, cutting tools, punches, tools surgery) [4, 6].

Thermal treatment parameters are used for TTT (for isothermal refrigerant transformations) and TRC (continuous coil). In 1 and 2 there are TTT diagrams for stainless steel with 0.4% C and 13% Cr, and Figures 3 and 4 for the same quality steel TRC diagrams.

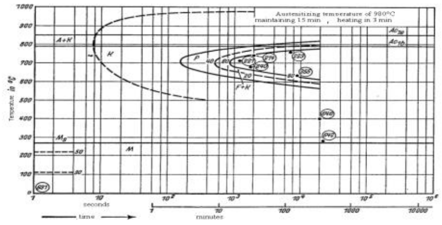


FIG. 1. TTT Diagram for Austenitizing temperature of 980°C [1]

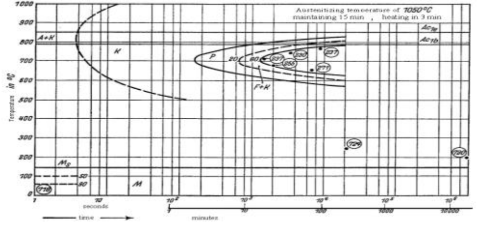


FIG.2. TTT Diagram for austenitizing temperature of 1050°C [1]

From these diagrams we find the following [1]:

- increasing the austenitizing temperature from 980 to 1080 ° C results in:
- lowering the temperature of critical point Ms by more than 100 ° C;
- precipitation of chromium carbides takes place at a higher speed.

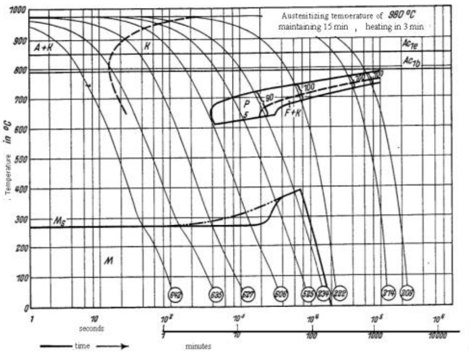


FIG. 3. TRC diagram for austenitizing temperature of 980°C [1]

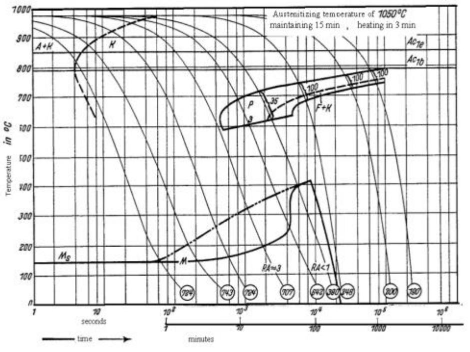
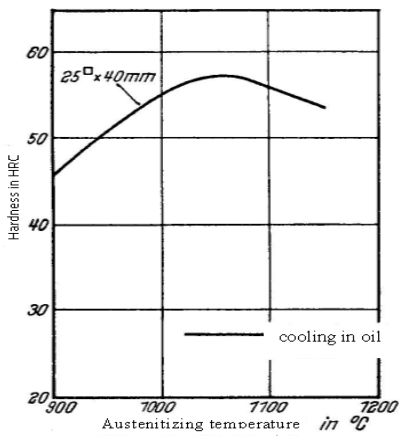


FIG. 4. TRC chart for austenitizing temperature of 1050°C [1]

TRC charts are used to study the kinetics of transformations to continuous cooling, encountered during tempering, normalization, annealing. And under these conditions the austenitizing temperature influences the thermal parameters as follows: increasing the austenitizing temperature decreases the Ms temperature by approx. 130 ° C and speeds up the precipitation of carbides.

The austenitizing temperature also influences sensitively the hardness of the quality products as in Figure 5 and 6.



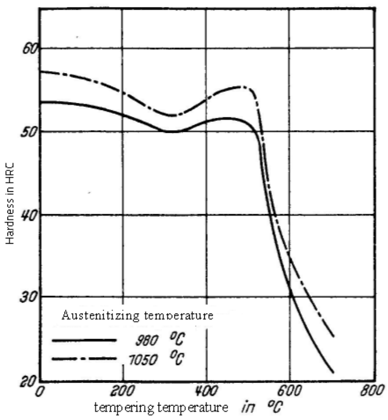


FIG. 5. Influence of austenitizing temperature on hardness after hardening [1]

FIG. 6. Influence of austenitizing and tempering temperature on hardness [1]

The maximum hardness is achieved by tempering from approx. 1050°C. Lower temperatures result in lower hardness due to the dissolution of a smaller amount of carbon in the matrix. Increasing the temperature above 1050°C is not recommended due to increased granulation.

The return gives the final mechanical characteristics of the products, so the attention must be given to these operations. The operating temperature is selected at subcritical values depending on practical requirements.

Figure 6 describes the evolution of hardness according to temperature; generally the temperature increase results in a decrease in hardness. In the present case there is an abnormality at temperatures between 400 ... 500°C when the hardness increases as a result of the transformation of the residual austenite and precipitation of carbides.

2. EXPERIMENTAL ATTEMPTS

For the experimental study of martensitic stainless steels, steel 40Cr130 was chosen, the chemical composition of which is shown in Table 1, and the critical transformation temperatures in Table 2.

Table 1. Chemical composition of 40Cr130 steel.

The steel brand	Chemical composition [%]						
	C	Si	Mn	P	S	Cr	Ni
40Cr130	0,45	0,42	0,48	0,022	0,0010	13,21	0,23

Table 2. Critical points

The steel brand	Ac_1 [°C]	Ac_3 [°C]	The temperature of the martensitic critical point Ms, [°C]	
			Austenitization at 980°C	Austenitization at 1050°C
40Cr130	790	850	270	145

From this steel were made specimens for thermal treatments and measurement of mechanical characteristics.

For hardness and structures were used cylindrical samples with Φ20 × 15mm, and for resilience prismatic samples with U-shaped notch, according to the rules in force.

Thermal treatments and practical results are presented in the tables 3 - 5.

Table 3. Thermal treatment of annealing

The steel brand	Temperature [°C]	Time [h]	Cooling mode	Hardness HBW	Resilience KCU [J/cm^2]
40Cr130	770		Oven at 600 ° C, then cooling in air	198	60

On the anneling samples as in the above table, final heat treatment and recovery treatments were applied (Table 4).

Table 4. Heat treatment of hardening

The steel brand	Temperature [°C]	Duration of maintenance [h]	Cooling mode	Hardness HBW	Resilience KCU [J/cm^2]
40Cr130	1050	1,5	ulei	447	2,2

Table 5. Thermal treatments for recovery

The steel brand	Temperature [°C]	Duration of maintenance	Cooling mode	Hardness HBW	Resilience KCU [J/cm^2]
40Cr130	600	1h 45 min	oil	285	8,4
	650	1h 45 min	oil	202	16
	700	1h 45 min	oil	229	18
	750	1h 45 min	oil	219	46

From the values obtained and presented we find a reasonable correlation between hardness and resilience. The hardness obtained by hardening diminishes by increasing the return temperature, increasing resilience accordingly.

It is mentioned that the return temperatures were chosen at higher temperatures than the maximum hardness threshold (Figure 6) in order to obtain an average set of hardness-resilient characteristics.

Thermal treatment parameters and cooling conditions also influence metallographic structures, as in Figures 7-10.

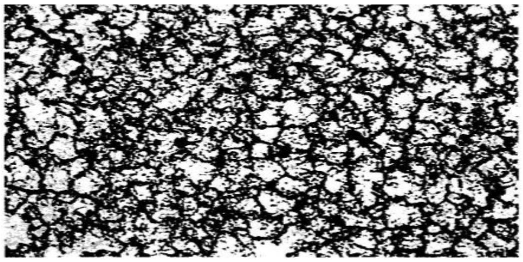


FIG. 7. Steel 40Cr130 in reworked state. Royal water attack; 500: 1[1]

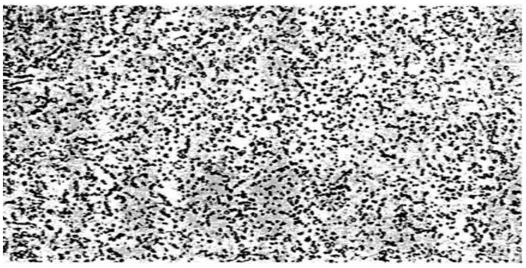


FIG. 8. Oil 40Cr130 in oil at 1050°C. Royal water attack; 1000: 1[1]

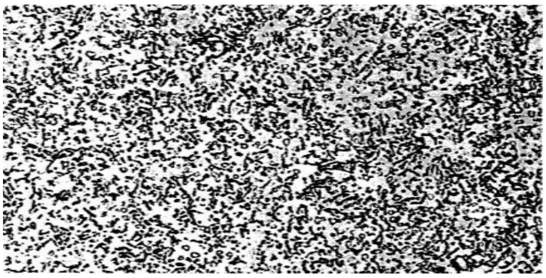


FIG. 9. Steel 40Cr130 after hardening and return to 600 ° C. Royal water attack; 1000: 1[1]

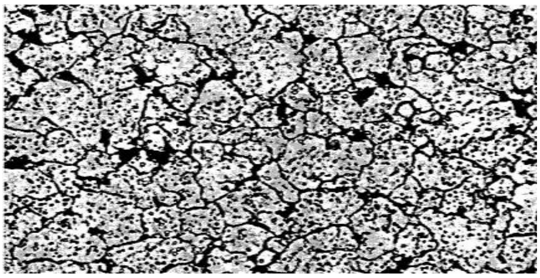


FIG. 10. Steel 40Cr130 after hardening and return to 750°C. Royal water attack; 1000: 1[1]

The annealed structure is composed of carbides and pearlite. After hardening in the structure, martensite (matrix) and non-insulated chromium carbides were formed during heating.

The return leads to detensioning, secondary carbide precipitation, and in the structure is seen the return martensite and small islands of perlite.

CONCLUSIONS

- Chrome alloyed stainless steel undergoes austenitic transformation by heating at temperatures above 800 ° C. This is also proven by obtaining high hardness by hardening, the structure being martensitic; this being the result of allotropic transformation;

- Carbon content of approx. 0.4% binds much of the chromium in the form of carbides, as well as the large amount of precipitated phases. The poorer matrix in chromium undergoes austenitic transformation;

- Recovery at temperatures above 600 ° C and higher, causes a significant decrease in metallic hardness; the processes taking place in the alloy are the following:

- Calming martensiety →martensita de revenire;
- Calming martenita → pearl (partial);
- Secondary chromium carbide precipitation, etc.

REFERENCES

[1] Max-Plank-Institut: *Atlas zur Wärmebehandlung der Stähle*;
[2] I. Cheşa: *Alegerea şi utilizarea oţelurilor*, Bucureşti, Ed. Tehnică, 1984;
[3] I. Cheşa, ş.a.: *Mărci şi produse din oţel, Bucureşti*, Ed. Tehnică, 1989;
[4] I. Giacomelli, A. Munteanu: *Tratamente termice*, Universitatea din Braşov, 1980;
[5] I. Georgevici, I. Mitelea, I.D.: Utu *Oteluri inoxidabile martensitice "moi"*, Editura: Politehnica, Timisoara, 2008;
[6] T. Dulămiţă, E. Florian: *Tratamente termice şi termochimice*, EDP Bucureşti, 1982.