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INFLUENCE OF HEAT TREATMENT TECHNOLOGY ON THE STRUCTURE AND PROPERTIES OF THICK SHEET STEEL ASTMS14 DEGREE F

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ABSTRACT

In this paper, based on the researches carried out a heat treatment technology can be determined which further lead to an optimum set of mechanical properties according to the technical conditions: A. Annealing (austenite at temperature 920 °C, exposure 2 minutes/mm, water cooling) and B. Tempering (heating at temperature 680 °C, exposure 4 minutes/mm, air cooling). The micro-structural analysis showed the structural modifications which takes place when tempering within 580 – 700 °C. Upon heating, the martensite out of balance structural tend to get transformed. To be able to characterize steels in terms of their physical and mechanical properties, a significant role is played by the pull tests. The following mechanical characteristics was determined: ultimate strength (R_m), yielding point standing ($R_{p0,2}$), breaking elongation (A_5) and the resilience test (KV_L).

KEYWORDS: annealing, tempering, structure, properties, martensite

1. Introduction

Based on the researches carried out a heat treatment technology can be determined which further lead to an optimum set of mechanical properties according to the technical conditions: *annealing* (austenite at temperature 920 °C, exposure, 2 minutes/mm, water cooling); *tempering* (heating at temperature 680 °C, exposure 4 minutes/mm, air cooling) [1-3].

To be able to characterize steels in terms of their physical and mechanical properties, a significant role is played by the pull tests: ultimate strength (R_m), yielding point standing ($R_{p0,2}$), breaking elongation (A_5) and the resilience test [4-6].

Upon heating, the martensite out of balance structural tend to get transformed. The process is based on diffusion whose amplitude is higher when the temperature is higher too [7-9].

The micro-structural analysis showed the structural modifications which takes place when tempering within 580 – 700 °C.

2. Experimental researches and results

The following research schedule was designed to determine the heat treatment parameters:

- austenite at 900 °C, 920 °C, exposure time 2 minutes/mm;
- water cooling;
- tempering temperatures: 580 °C, 600 °C, 620 °C, 640 °C, 660 °C, 680 °C, 700 °C, exposure time 4 minutes/mm.

The heat treatment research schedule is given in Table no. 1.

Table 1. *Experimental conditions*

Austenite temperature [°C]	Exposure time [min]	Cooling agent	Tempering temperature [°C]	Exposure time [min]	Tempering agent
920	40	water	580 600 620 640 660 680 700	80	still air

To be able to characterize steels in terms of their physical and mechanical properties, a significant role is played by the pull tests.

For this purpose, samples were taken transversally with respect to the rolling direction to make STAS 200 – 75 samples.

The test consists in applying slow smooth loads in ambient environment.

The following mechanical characteristics are determined:

- yielding point standing for the ratio of the load where the length is increasing and the initial cross section area of the blank;
- ultimate strength which is the ratio of the max load and initial cross section area of the sample;
- breaking elongation: A_5
- breaking throttle: $\Psi = \frac{S_o - S_u}{S_0} \cdot 100$

The resilience test is actually a bending test by shock and serves the purpose of assessing the material tenacity.

Table 2. *Mechanical properties*

No	Austenite temperature [°C]	Tempering temperature [°C]	Mechanical properties under annealed and tempered conditions			
			R_m [N/mm²]	$Rp_{0,2}$ [N/mm²]	A_5 [%]	$KV_{L-46°C}$ [J]
1	900	580	1092	1005	15	54;52;53
2		600	1075	1000	16	61;62;63
3		620	1058	995	16.5	66;67;68
4		640	1030	972	16.5	74;75;73
5		660	995	944	18	93.5;95;96.5
6		680	920	848	20	112.5;115;117.5
7		700	786	786	22.5	123;125;124
8	920	580	1105	1011	15.5	51;50;52
9		600	1068	998	16.5	58;58;58
10		620	1061	990	16.5	63;62;64
11		640	1035	965	17	72;70;68
12		660	989	937	17.5	95;94;93
13		680	923	873	21	102;100;101
14		700	782	791	22	115.5;115;114.5

The test consists in breaking by one strong hit with a pendulum hammer Charpy, a sample fitted with a V – shaped groove in the middle which freely leans against two seats to determine the breaking energy.

The samples are cooled in systems made of heat insulated recipients. Cooling agents are ethyl alcohol and carbon snow.

The results obtained are given in Table 2 for the annealed and tempered samples.

The value of the mechanical characteristics obtained further to the heat treatments applied have been statistically processed and illustrated vs. heat treatment parameters, in Fig. 1; 2; 3 and 4.

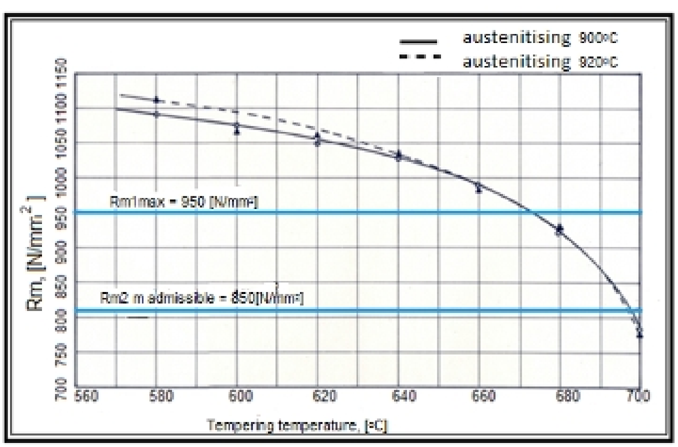


Fig. 1. *Effect of tempering temperature the ultimate strength, R_m [N/mm²]*

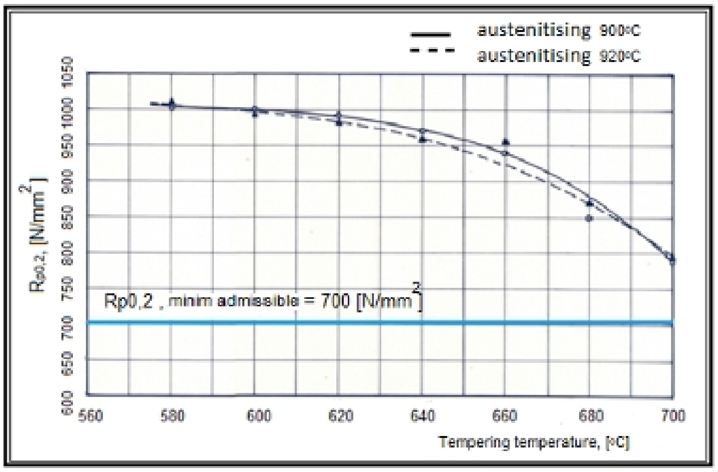


Fig. 2. *Effect of tempering temperature the yielding, R_{p02} [N/mm²]*

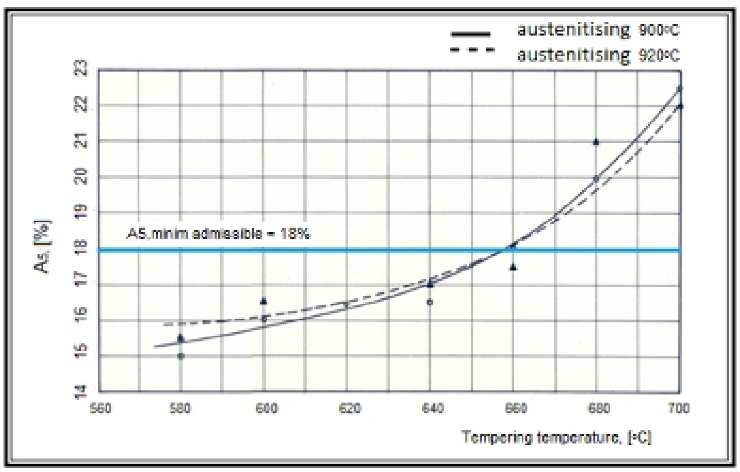


Fig. 3. *Effect of tempering temperature on the breaking elongation, A_5 [%]*

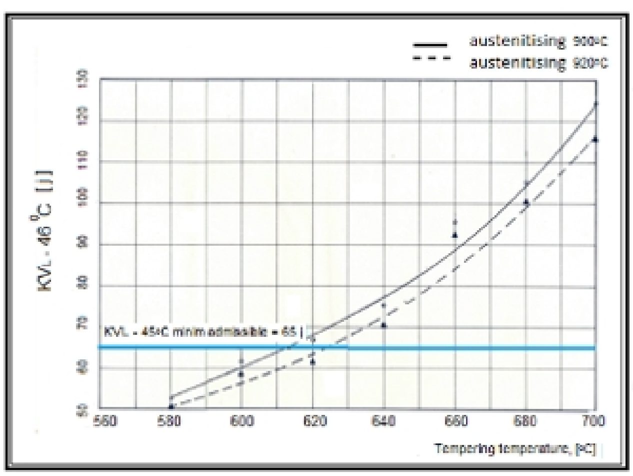


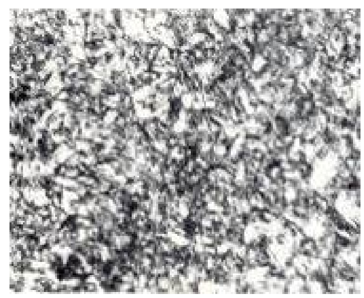
Fig. 4. *Effect of tempering temperature on cross resilience, KV_L [J]*

From the heat treated materials, according to the research schedule, metallographic samples were taken. The micro-structural analysis revealed the structural transformations occurring during tempering at various temperatures within 580 – 700 ^{o}C interval. The results obtained the microstructures corresponding to the tempering temperature in the above mentioned interval are given in the Figure 5 bellow.

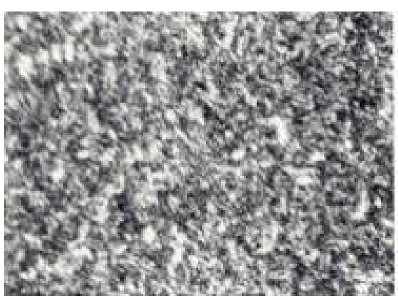
T_{rev} = 580 ^{o}C

T_{rev} = 600 ^{o}C

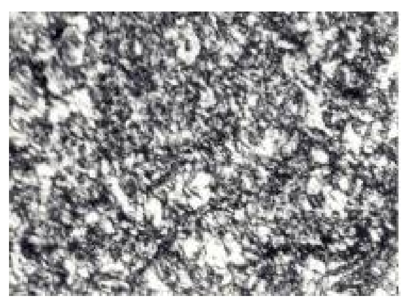
T_{rev} = 620 ^{o}C



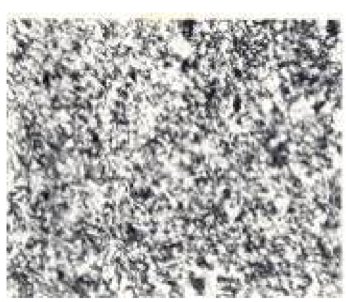
T_{rev} = 640 ^{o}C



T_{rev} = 660 ^{o}C



T_{rev} = 680 ^{o}C



T_{rev}=700 ^{o}C

Fig. 5. *Microstructures corresponding to the tempering temperature at various temperatures within 580 – 700 ^{o}C interval*

4. Conclusions

The ultimate strength and the yielding point decrease while the tempering temperature increases within 580 – 700 °C.

Plasticity characteristic, A_5 % and tenacity KV_L increase when the tempering temperature increases. An optimum assembly of strength and tenacity properties can be obtained for austenite temperatures when tempering takes place.

The micro-structural analysis showed the structural modifications which take place, upon heating, the martensite out of balance structured tend to get transformed. The process is based on diffusion whose amplitude is higher when the temperature is higher too, with smaller tempering temperatures, the martensite needles gets segmented.

High temperature heating causes a more acute fragmentation process, the fragments turns into globes and the globe carbons keep on increasing so that at tempering temperature, the structure is made up of a feritic matrix and globular perlite.

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