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THE APPLICATION OF CRYOGENIC TREATMENT ON COLD PLASTIC DEFORMATION STEELS

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Abstract: *In the structure of the tools alloyed steels after the hardening appreciable quantities of residual austenite are kept. The paper studies two parallel ways which reduce the amount of residual austenite, namely by multiple temperings,respectively by less than zero degrees Celsius treatment. Are highlighted some of the benefits of cryogenic treatment related to reducing the total heat treatment time and production costs. The experimental attempts were effectuated on two alloyed steels, which were cold plastically deformed, namely W1.2379 and W1.2767 (according to EN ISO 4957).*

Theoretical considerations

Generally, at the alloyed tool steels after hardening to martensite, in the structure are preserved austenite quantities, called residual, in amounts that can reach and even overcome 40 ... 50%. Because its presence in the structure leads to the hardness and dimensional stability decrease, it is unwanted. Subsequent heat treatment operations, among other goals aimed to reduce the amount of residual austenite in quantities of a few percent, which may not influence in a negative way the effects shown above.

Residual austenite which results after the hardening is due to the fact that the final temperature after the hardening is under the Ms point of the steel. Martensitic critical points decrease simultaneous with increasing the content of carbon and in the majority of the alloying elements, reaching to negative temperatures.

Removal of residual austenite by transforming it into other structures may take place by increasing the temperature of the Ms and Mf points, which is obtained by multiple tempering. During the tempering occurs the precipitation of secondary phases and thus, the impoverish of the solid solution of carbon and alloying elements, followed by the increasing of the martensitic critical temperature, decreasing the residual austenite stability and its transformation usually in martensite;

- decreasing the temperature of the material as more as under Ms, closeness and rarely overcoming the Mf' point, namely the application of cooling below zero degrees, most often between -50 ° C and -120 ° C, depending on the case.

Experimental attempts

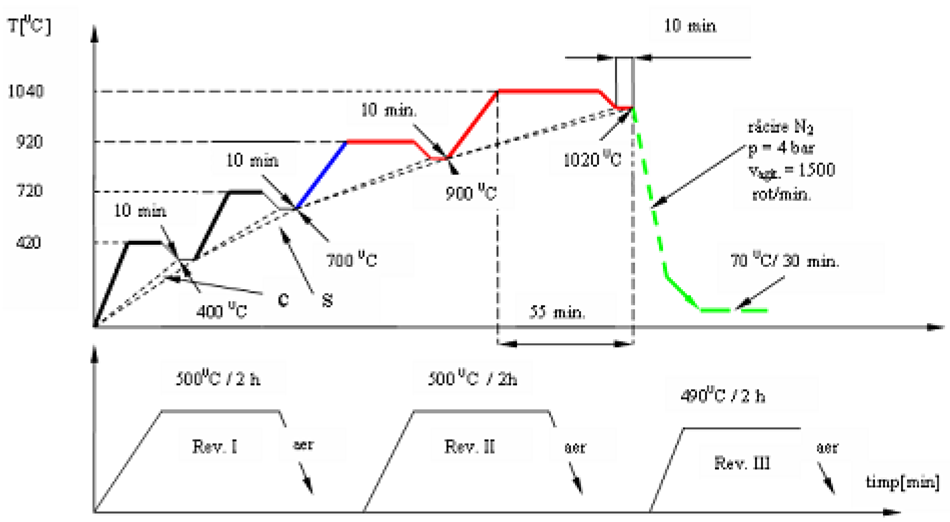
Experimental attempts had the purpose to study the possibilities of reducing the residual austenite and the kinetics of these transformations. The researches were effectuated on samples of two tool steels of cold plastic deformation, which are presented in Table 1.

Table 1

No.	Steel's type (according to EN ISO 4957)	Chemical composition[%]									
		C	Si	Mn	P	S	Cr	Mo	V	W	Cu
1	W1.2379	1,549	0,424	0,376	0,012	0,018	11,87	0,875	0,781	-	0,003
2	W1.2767	0,391	0,329	0,422	0,021	0,018	1,242	1,517	0,226	-	0,009

The samples utilized had a cylindrical shape for measuring the hardness and metallographic study; on these were determined the chemical composition by the spectral analysis method and respectively standard samples for determining the resilience on them.

Samples of both tool steels were simultaneous subjected to regular heat treatment (hardening and tempering) and respectively to heat treatment containing the cryogenic variant (hardening and under-zero degrees treatment), according to the graphs in figures 1 and 2.



a.

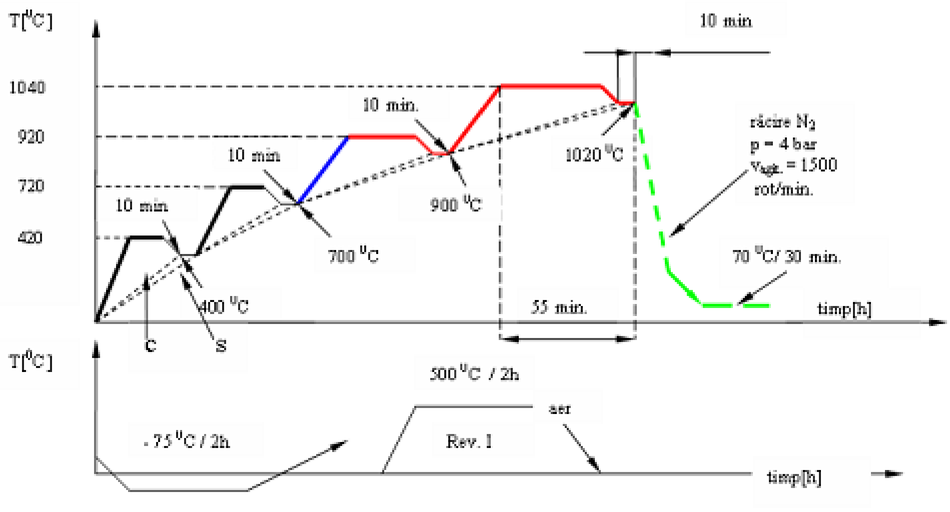


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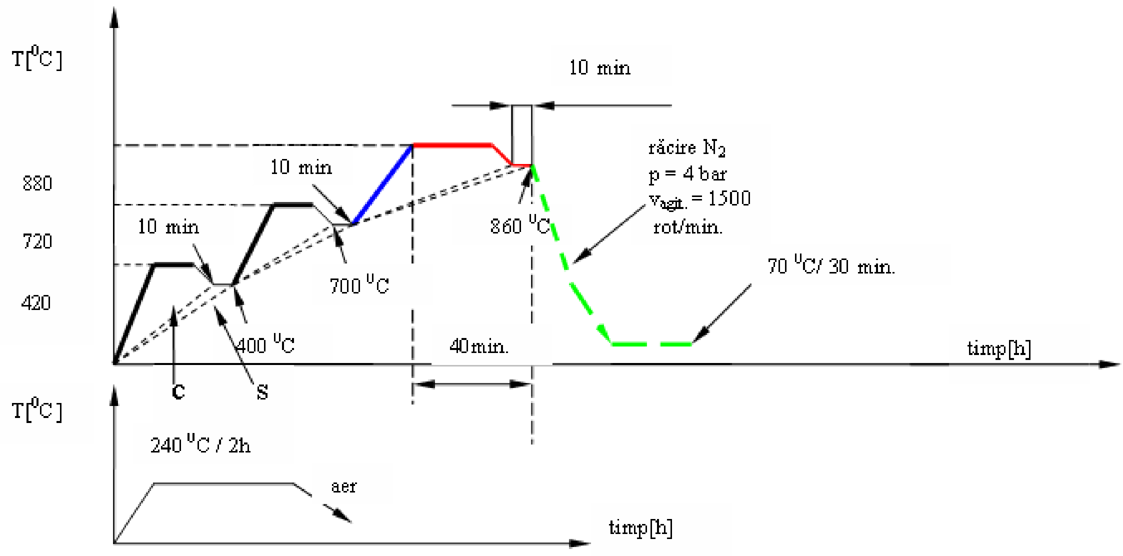
Fig.1. Heat treatments on W1. 2379 steel samples: a) hardening and multiple tempering, b) hardening, under-zero degrees treatment and tempering.



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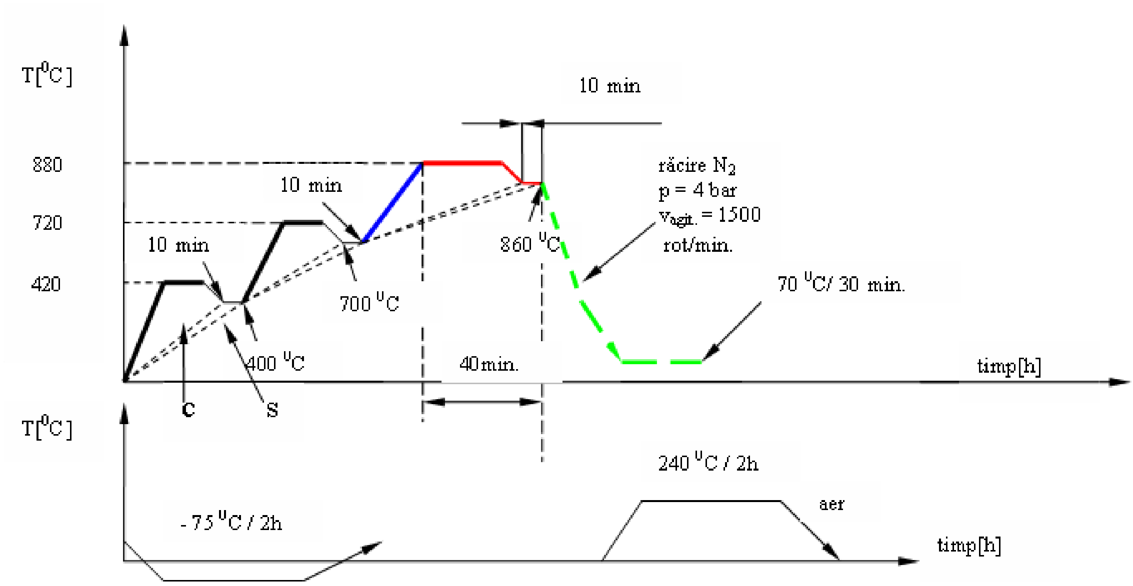

b.

Fig.2. Heat treatments applied to W1. 2767 steel samples: a) hardening and multiple tempering, b) hardening, under-zero degrees treatment and tempering.

It is found that for each steel in both regular and the one with cryogenic treatment, hardening was effectuated in an oven with vacuum.

On treated samples as above, studies were effectuated regarding the structure, the hardness, the amount of residual austenite, the resilience. The obtained results are presented below in Table 2 for W1.2379 steel and in Table 3 for W1.2767 steel.

Practical results obtained

Table 2

No.	Vaccum hardening t[°]	Cryogenic treatment t[°]	Tempering t[°]	Hardness [HRC]	Resilience KCU [J/cm^2]	Residual austenite [%]
1	1020	-	-	63,2...63,5	-	20...25
2	1020	-	1 tempering /525	59,1...59,7	-	20...25
3	1020	-	3 tempering 500/500/450	58...59,1	4,83	<20
4	1020	-75	-	64,3...64,7	-	<15
5	1020	-75	1 tempering/525	59,2...60	4,15	<15

Table 3

No.	Vaccum hardening t[°]	Cryogenic treatment t[°]	Tempering t[°]	Hardness [HRC]	Residual austenite [%]
1	860	-	-	53,3...54,1	5...10
2	860	-	1 tempering/240	48,9...49,4	<5
3	860	-75	-	53,7...54,9	<5
4	860	-75	1 tempering/240	49,1...49,7	<5

Some structures of the studied samples are presented in figures below.

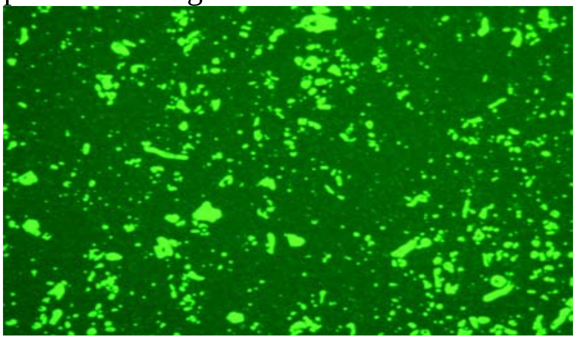

Fig. 3 W1.2379 steel after hardening in vacuum and three consecutive tempering. NitalAttack.200: 1

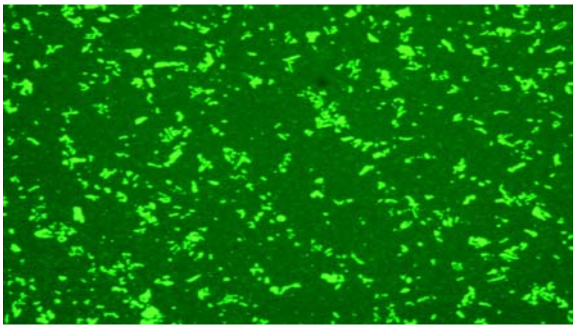

Fig.4. W1.2379 steel after hardening in vacuum, cryogenic treatment and one tempering to 525 ° C. Nital attack. 200:1

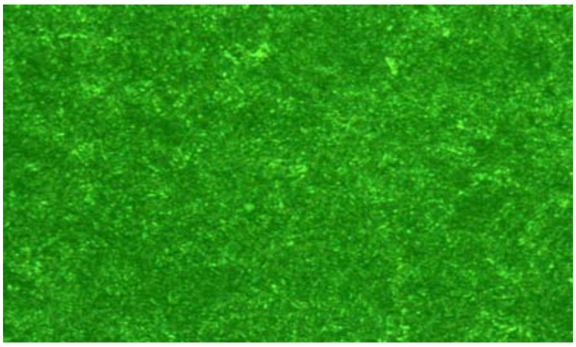

Fig.5. W1.2767 steel after hardening in vacuum and one tempering to 240 °C. Nital attack. 500:1

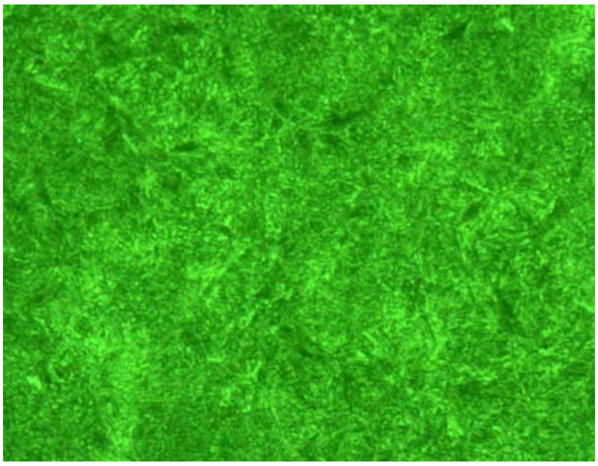

Fig.6. W1.2767 steel after hardening in vacuum, cryogenic treatment and one tempering to 240 ° C. Nital attack. 500:1.

In the above steel structure can be found martensite in different amounts, carbides and residual austenite.

Conclusions

From the above are found the following conclusions:

a) for the W1.2379 steel:

- after quenching are obtained over 63 HRC hardness and in the structure are preserved in appreciable quantities of residual austenite;
- after applying three consecutive tempering residual austenite content decreases with almost 5%. At the same time, it is found also the hardness decrease with 5-6 Rockwell units. The effect of tempering is higher than the one of the residual austenite transformation;
- after hardening and under-zero degrees treatment (without annealing) the hardness increases easily, but the amount of residual austenite decreases substantially; the following tempering has no effect on the residual austenite but the hardness decreases with almost 5HRC;
- the resilience of the treated samples by hardening and three tempering is with about

15% higher than after the under-zero degrees cooling version, which is normal;
- the structure of cryogenical treated sample is finer than the usual treated ones.

b-for W1.2767 steel:
- the lower carbon and alloying elements content favors a more complete transformation at heat treatment, so smaller amounts of residual austenite than the W1.2379 steel;
- both annealing and cryogenic treatment have similar effects on the residual austenite transformation;
– due to lower heat treatment temperatures (both at hardening and tempering) structures obtained are extremely fine.

Cryogenic heat treatment leads to the increase of the hardness and also increases the wear resistance of cold plastic deformation tools.

Due to decrease, (moderate) of the resilience, decreases slightly the shock resistance too, so it is not recommended to the tools working with big shocks. Under-zero degrees heat treatment leads to the elimination of at least one annealing operation (at steels which need three or more tempering), with positive effects on reducing total heat treatment time and production costs.

References

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