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THE INVESTIGATIONS ON THE POSSIBILITY TO USE THE TRIP STEEL FOR WIRE PRODUCTS

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We can observe in the last years the growing interest on steels characterized by multiphase structure, which are composed of ferrite, martensite, bainite and/or retained austenite, the TRIP steel is including for such types of steels. Such kinds of steels have very high mechanical properties with keeping high plasticity. The determination the optimal parameters of steel heat treatment ensured the TRIP effect was shown in the work. The comparison analysis the mechanical properties between TRIP steel and ferrite-pearlite steel with the some chemical composition has been done.

The technological process calls for using the wires with better mechanical and plastical properties. In the last years were realized many works in order to improving wires with ferrite-pearlite structure by modification the parameters of rolling and drawing process, but the possibilities in this matter are becoming used up.

The TRIP steels are low and medium-carbon low alloying steels with multiphase structure composed of: ferrite, retained austenite, bainite and sometimes martensite.

Such type of structure guarantees high mechanical and plastical properties. The advantageous plastic properties are obtained with the use of TRIP effect- Transformation Induced Plasticity- that is the increase of steel plasticity caused by phase change, connected with presence in structure such components as: metastable austenite or dispersed retained austenite which during plastic deformation of steel can transform in matensite [1-2].

In the literature there are many works concerned with rolling and heat treatment process of sheets made from TRIP steel, but only a few concerned with wire drawing process.

The two main ways of production the sheets from TRIP steel are:

- the hot rolling process with the use of controlled cooling,
- the cold rolling process and continuous annealing of sheets in intercritical range.

The use of regulated cooling after hot rolling process can enable to the obtaining of wire rod with multiphase structure.This process can be done on rolling lines with the modern system of regulated cooling as Stelmor system

Whereas the TRIP effect in wires can be obtained by caring out the two-stage heat treatment process on existed patenting lines after modifications the technological parameters of line [3-5].

The two-stage heat treatment process making possible the obtaining TRIP structure was realized in laboratory conditions of Technical University of Częstochowa, for wire rod made from low-carbon steel with chemical composition as shown in table 1.

Table 1 – The chemical composition of low-carbon steel

C	Mn	Si	P	S	Cu	Ni	Cr	Mo	Sn	Al	N
0.09	1.57	0.90	0.01	0.008	0.02	0.01	0.003	0.007	0.006	0.001	0.003

The scheme of wire rod heat treatment process and the obtained structure after this process was shown in fig.1.

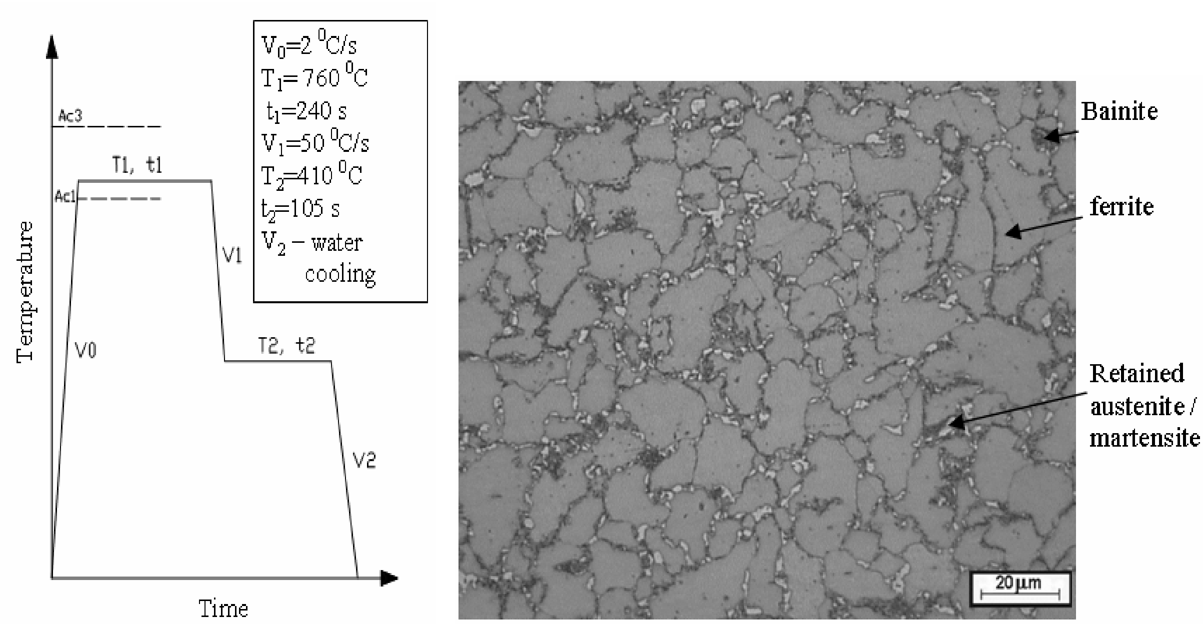

Figure 1 – The optimal scheme of wire rod heat treatment process and structure TRIP type etching by LePer reagent

The volume fraction of separate phases in multiphase structure was determined with the use of MET-ILO program and placed in table 2. To the comparison in table 2 the volume fraction of separate phases in initial ferrite-pearlite structure of wire rod after conventional rolling process was placed in the table 2. The wire rod after conventional rolling process and after two-stage heat treatment process were drawn in 11 draws from initial diameter 6.3 mm on final diameter 1.9 mm, with the total reduction equal G_c = 90.9%.

The influence of TRIP effect was defined by comparison of wires obtained parameters.

On fig.2 the work-hardening curves for TRIP and ferrite-pearlite steels for strain rate equal 1 s^{-1} were shown .The research was carried out on Gleeble 3800 simulator.

Table 2 – The volume fraction of phases

The state of material	The phases fraction				
	Ferrite, %	Pearlite, %	Bainite, %	Retained austenite +martensite[1], %	Retained austenite [2], %
Initial	76.5	23.5	-	-	-
After heat treatment process	74.6	-	16.8	8.6	7.8

[1] etching by LePer reagent
[2] etching by nital+pyrosulfate of sodium

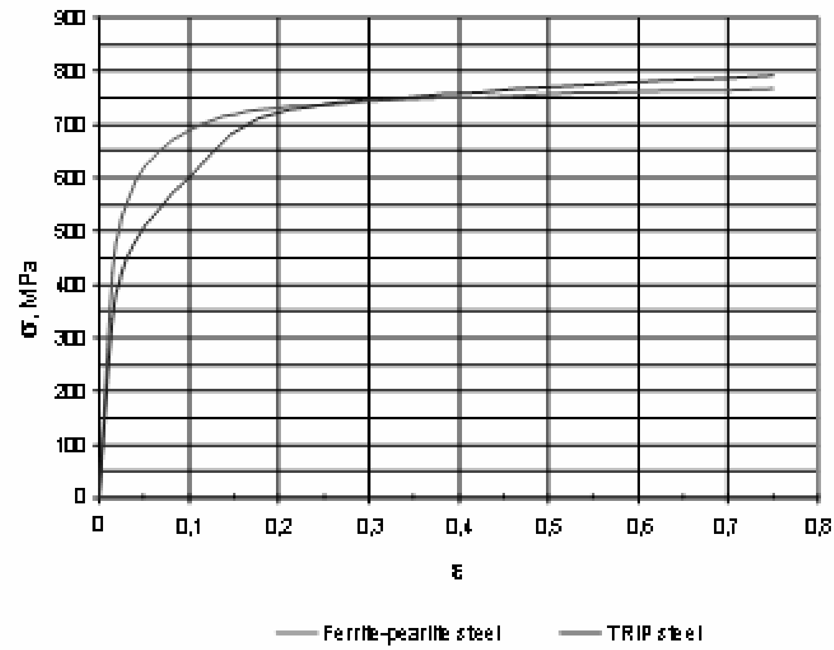

Figure2 – The comparisons of work-hardening curves for TRIP steel and steel without heat treatment (ferrite-pearlite steel)

For logarithmic deformation equal 0.24 (G_c = 21%) the steel without heat treatment with ferrite-pearlite structure strengthened much faster then TRIP steel. After exceeded the logarithmic deformation 0.35 (G_c = 29%) the plastical strain of ferrite-pearlite steel is increasing with the increase of total deformation.

It can be stated that the slower strengthening the TRIP steel in the range of deformation ε=0÷0.24 can be connected with the phase change of retained austenite which guarantee higher plasticity of steel and “move” the strengthening process in the way of higher deformations.

The authors of the paper assume that for higher contents of retained austenite (for example for steels with higher content of carbon) can be possible the extending of influencing the TRIP effect to the higher values of real strains.

On fig.3 the comparison of mechanical properties for wires made from low-carbon steel without heat treatment after conventional rolling process and for steels with TRIP effect was shown.

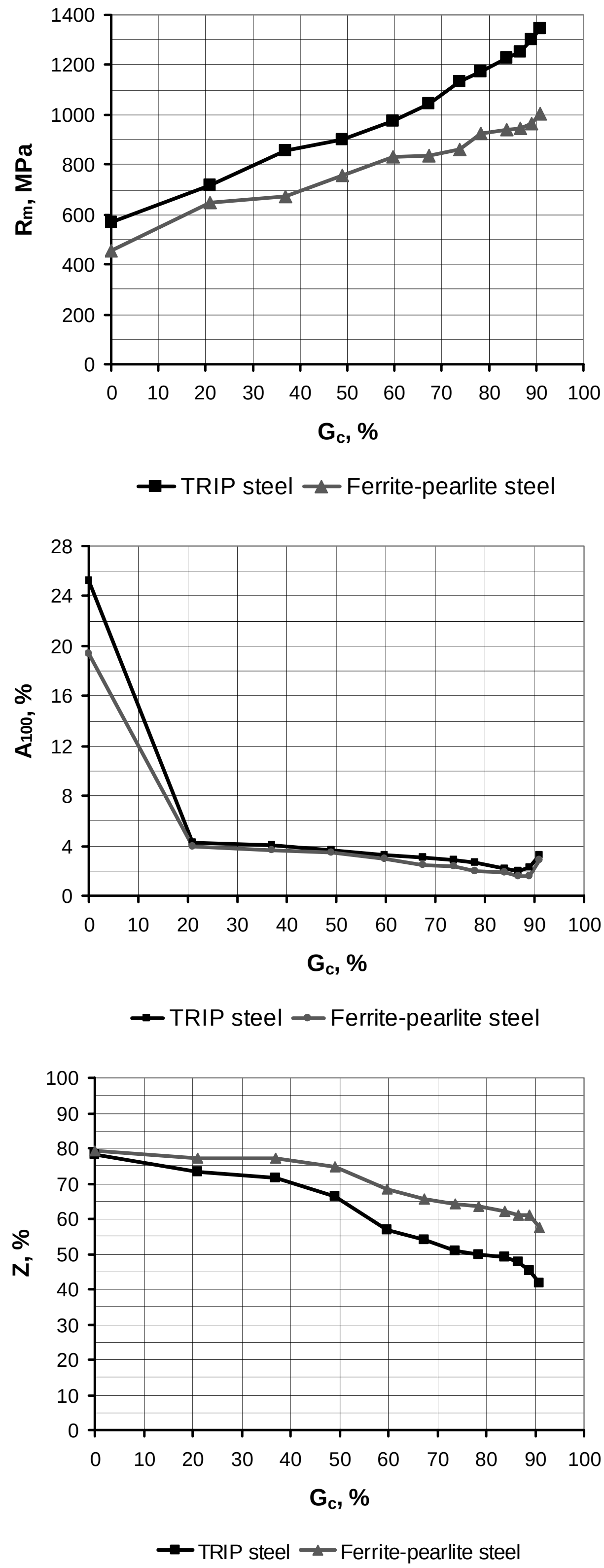

Figure 3 – The change of mechanical properties for two variants of steels in function of total reduction

It can be stated that heat treatment process in essential way improve the mechanical properties of wire rod such as: R_m and A_{100}.

The analysis the values of wire tensile strength we can noticed that to the total reduction 60% the differences in R_m for two variants of steels amount to 15%, they are increasing as increase the total reduction, and for the total reduction G_c=90.99% the wires with TRIP effect have higher uniform elongation A_{100} and not much lower the necking Z.

For higher deformations, wires made from both types of steels have almost the same uniform elongation A_{100}, but wires with TRIP effect shown insignificant increase of necking Z.

On the research base can be stated that rightly carried out heat treatment process allowed to obtaining the TRIP structure even for steels with the low carbon content (about 0.09%)

The wires with TRIP effect have much higher values of tensile strength (with the same plastic properties) as wires without heat treatment with ferrite-pearlite structure.

After analysis the scheme of two-stage heat treatment process we can say that exist the possibility of obtaining the TRIP structure for wire rod and for wires with the use of existing technological lines (like Stemor line or patentic lines) after small modifications.

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