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THE EFFECT OF CARBON CONCENTRATION ON THE RETAINED AUSTENITE CONTENT AND THE MECHANICAL PROPERTIES OF TRIP STEEL WIRE ROD OBTAINED FROM THE STELMOR CONTROLLED COOLING LINE

WPŁYW ZAWARTOŚCI WĘGLA NA ILOŚĆ AUSTENITU SZCZĄTKOWEGO I WŁASNOŚCI MECHANICZNE WALCÓWKI O STRUKTURZE TRIP OTRZYMANEJ NA LINII REGULOWANEGO CHŁODZENIA STELMOR

The austenite content of the multiphase TRIP-structure steels depends, inter alia, on the carbon concentration and the properly selected parameters of the two-stage heat treatment.

Under the existing industrial conditions, it is possible to (approximately) reproduce approximately the optimal parameters of the two-stage wire rod heat treatment via the controlled wire rod cooling from the end temperature of rolling on the Stelmor line.

The investigation of the retained austenite content of TRIP wire rods with a varying carbon concentration, produced under industrial conditions, has been discussed and the effect of the multiphase structure of these wire rods on their mechanical properties has been determined in the paper.

Keywords: TRIP steel, Stelmor line, wire rod.

Ilość austenitu w wielofazowych stalach o strukturze TRIP zależy miedzy innymi od zawartości węgla oraz odpowiednio dobranych parametrów dwustopniowej obróbki cieplnej.

W warunkach przemysłowych, przybliżone odwzorowanie optymalnych parametrów dwustopniowej obróbki cieplnej walcówki jest możliwe poprzez jej regulowane chłodzenie, z temperatury końca walcowania na linii Stelmor.

W pracy przedstawiono badania ilości austenitu szczątkowego w walcówkach TRIP o różnej zawartości węgla, otrzymanych w warunkach przemysłowych oraz określono wpływ wielofazowej struktury tych walcówek na ich własności mechaniczne.

1. Introduction

Developing the production of TRIP wire rod in industrial conditions on the Stelmor controlled cooling line is possible with the correctly selected technological parameters of both the rolling process and the two-stage cooling on the Stelmor line [1÷3].

The proper configuration of these parameters makes it possible to (approximately) reproduce approximately the optimal parameters of the two-stage heat treatment of the material which yields the multiphase TRIP structure containing retained austenite.

This technology can be used for production of TRIP wire rod from different steel grades, which provides the possibility of obtaining a wide range of new products with properties differing from conventionally rolled ferritic-pearlitic structure wire rods [4].

The paper discusses the investigation of the retained austenite content of TRIP steel wire rods produced under industrial conditions from steel with a varying carbon concentration, and compares their properties with the properties of wire rods of the same material rolled following the conventional technology.

2. Original investigation

Wire rods of three low-carbon steel grades, namely G4Si1, S355J2 and 27MnSi5, each of a diameter of 5.50 mm, were used for testing. Their chemical compositions are given in Table 1.

TABLE 1
Chemical compositions of wire rods of different steel grades /wt %

Grade of steel	C	Mn	Si	P	S	Cr
G4Si1	0.08	1.44	0.847	0.008	0.019	0.03
S355J2	0.18	1.39	0.228	0.011	0.008	0.03
27MnSi5	0.25	1.32	0.270	0.012	0.006	0.17

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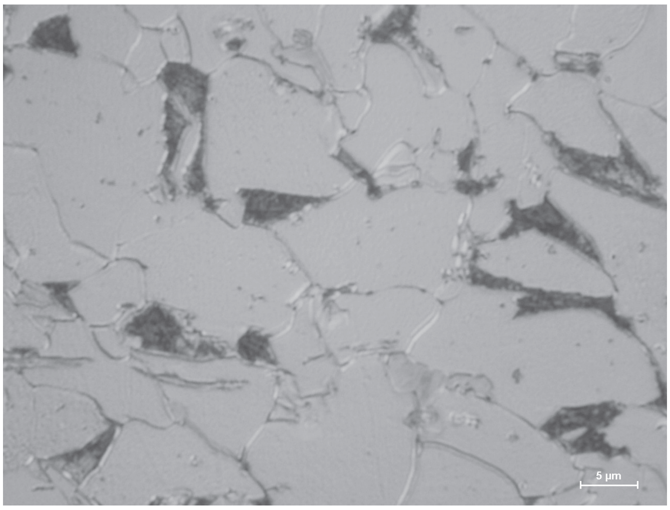
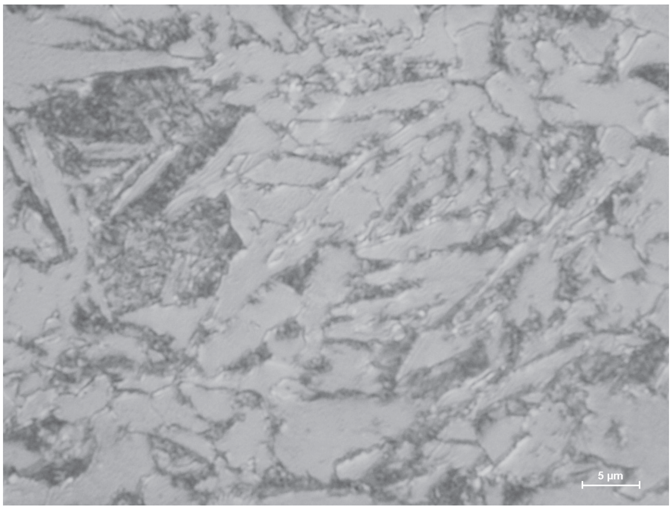
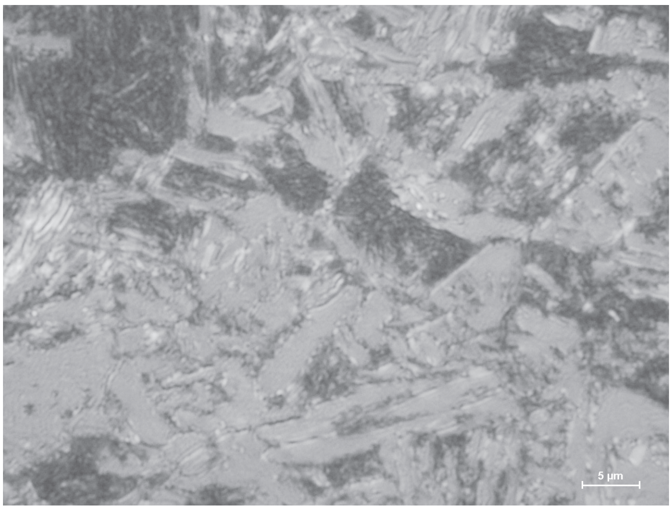
In order to determine the retained austenite content of wire rod made of the respective grades of steel obtained via the controlled cooling on the Stelmor line producing the TRIP structure, microsections were prepared, which were then etched with sodium pyrosulfate to reveal the phase v_γ in the structure (Fig. 1).



a). G4Si1



b). S355J2



c). 24MnSi5

Fig. 1. Multiphase structure of TRIP wire rod made of different steel grades

The retained austenite content of wire rod of the resptive steel grades was determined by three methods, both on the surface and in the axis of the wire rod. The results are given in Table 2 and represented in Fig. 2.

TABLE 2

Retained austenite content v_γ on the surface and in the axis of wire rod of different steel grades

Grade of steel	Carbon content %	Retained austenite content v_γ %		
		Axis	Surface	Mean value
G4Si1	0.08	3.40	3.10	3.25
S355J2	0.19	6.80	4.20	5.50
27MnSi5	0.25	7.90	6.80	7.35

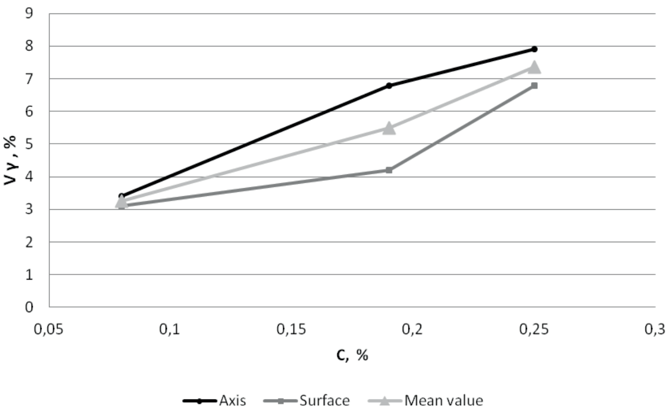


Fig. 2. Retained austenite content of wire rods of different steel grades as a function of percentage carbon concentration

From the test results shown in Table 2 and in Fig. 2 it can be found that the average retained austenite content of the multiphase steel structure increases virtually proportionally with the increase in carbon concentration in its chemical composition, which provides a basis for predicting the retained austenite content of wire rod of other steel grades (with a different %C concentration) rolled into the identical diameter with the same rolling process parameters, as well as the two-stage cooling on the Stelmor line.

To compare the effect of the TRIP structure on the wire rod properties, the R_m and R_e were determined and the R_e/R_m plasticity reserve factor was calculated for wire rods of three multiphase structure steel grades and then juxtaposed with the properties of wire rods of the same steel grades with the ferritic-pearlitic structure and the identical diameter, rolled following the conventional technology.

The results are given in Table 3 and shown in Fig. 3.

From the test results shown in Table 3 and in Fig. 3 it can be found that the TRIP structure wire rod has tensile strength higher by 8 to 53%, depending on the grade of steel used.

At the same time, the TRIP wire rod has higher plasticity compared to the ferrite-pearlite structure wire rod, as indicated by the “plasticity reserve” factor which has a value lower by 24% for TRIP wire rod of G4Si1 steel, by 21% of S355J2 steel and by 2% of 24MnSi5 steel.

TABLE 3

Mechanical properties of TRIP ferrite-pearlite structure wire rod of different steel grades

Grade of steel	Carbon content %	TRIP structure				Ferrite-pearlite structure			
		R_e MPa	R_m MPa	R_e/ /R_m	A5 %	R_e MPa	R_m MPa	R_e/R_m	A5 %
G4Si1	0.08	312	613	0.509	63	386	532	0.726	36
S355J2	0.19	335	622	0.539	31	407	577	0.705	34
27MnSi5	0.25	630	962	0.655	16	418	630	0.663	27

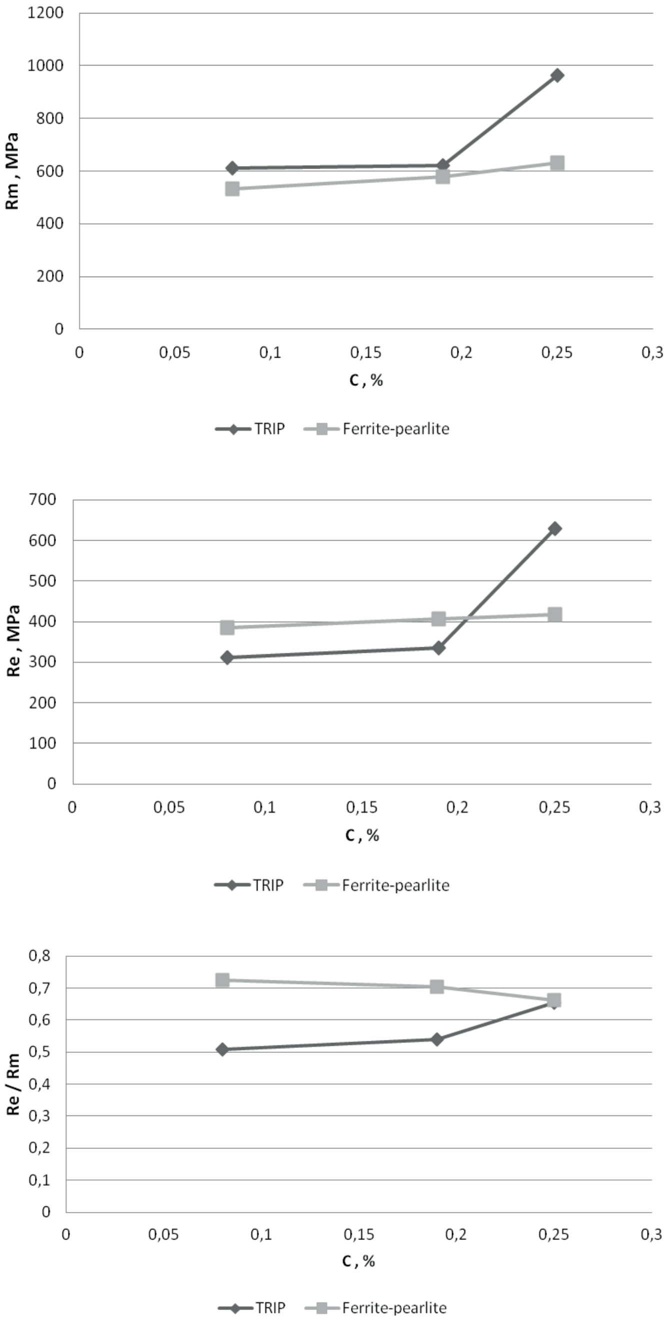


Fig. 3. Mechanical properties and Re/Rm factor of TRIP ferrite-pearlite structure wire rod as a function of %C concentration

3. Summary

By selecting the appropriate parameters of the rolling process and the controlled cooling on the Stelmor line, multiphase structure TRIP wire rod of different steel grades can be obtained, in which the retained austenite content is proportional to the percentage carbon concentration in the chemical composition of the steel.

TRIP structure wire rod made of different steel grades is distinguished by the higher tensile strength and, at the same time, higher plasticity compared to wire rod of the same steel grades rolled following to the conventional technology.

This provides the capability to implement a new range of wire rod with better properties, which should be of benefit to the wire drawing industry.

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