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THE INFLUNECE OF THE PARTIAL SINGLE REDUCTION ON MECHANICAL PROPERTIES WIRES MADE FROM TRIP STEEL WITH 0,43 % C

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Large strain inhomogeneity is caused by the shape of deformation zone of die and by the friction between tool and deformed wire for multistage wire drawing processes. The influence on the value of the redundant strain by the use of different partial single reductions during all wire drawing process was observed. This problem is particularly important for TRIP steel wires drawing processes because the strain intensity influences on the speed of retained austenite transformation into martensite.

Keywords: steel, wires, TRIP steel, mechanical properties, fatigue strength, surface texture

INTRODUCTION

The quantity of retained austenite transformed into martnesite is influenced chiefly by effective strain and also, to some extent, by strain rate These parameters are determined in the drawing process by the magnitude of partial single reduction [1 ÷ 8].

In the work the influence of the partial single reductions on mechanical properties, fatigue strength and surface texture wires made from TRIP steel with 0,43 % of carbon content has been shown.

Is also shown that wires made from TRIP steel have higher values of tensile strength then wires made from high carbon steel with pearlite structure [9].

RESULTS OF INVESTIGATIONS

Tests were carried out for wires made from carbon steel with 0,43 % of carbon content and increased levels of silicon and manganese, which influence on retained austenite stabilization obtained after two-stage heat treatment process (Table 1).

Table 1 **Chemical composition of the steel tested /wt %**

C	Si	Mn	Al	Cr	Ni
0,43	1,36	1,47	0,05	0,10	0,12

The image of microstructure containing ferrite, bainite and retained austenite has been shown on Figure 1.

The amount of retained austenite was estimated after structure analysis in order to verify these results the X-ray crystallography research has been carried out. The results of investigations are in Table 2 and on Figure 2.

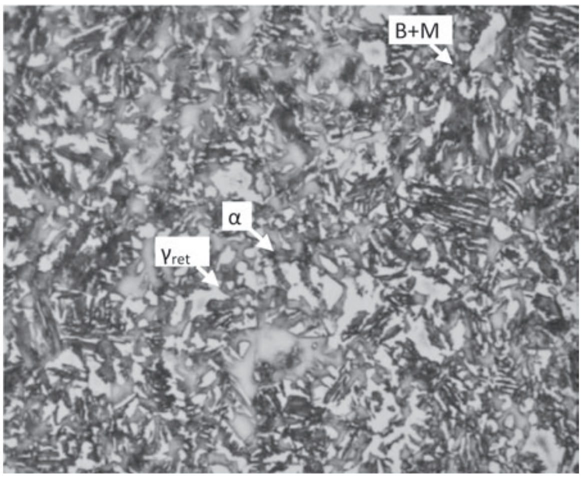

Figure 1 Microstructure of multiphase steel, B+M-martnesite, α- ferrite, γ_{ret}- retained austenite

Table 2 **The volume fraction of retained austenite for TRIP wire rod**

The amount of retained austenite	
Microstructure analysis $\gamma_{ret.}$ /%	X-ray crystallography $\gamma_{ret.}$ /%
27	24

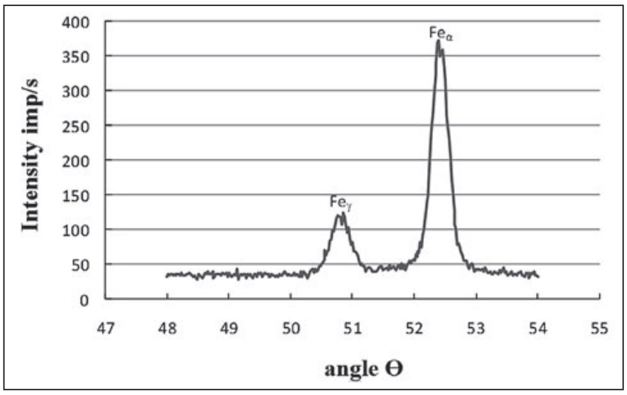

Figure 2 X-ray pattern for wire rod made from TRIP steel

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MECHANICAL PROPERTIES INVESTIGATIONS

The results of the research for wire drawing process conducted with small partial reductions (variant 1) and for large partial reductions (variant 2) were shown in table 3 and on Figures 3-5.

Table 3 **The results of mechanical properties research for TRIP wires drawn according to variant 1 (with small partial reductions) and variant 2 (with large partial reductions)**

	Variant 1			Variant 2		
ϕ wire /mm	R_m, /MPa	$R_{0,2}$ /MPa	$R_{0,2}/R$	R_m, /MPa	$R_{0,2}$, /MPa	$R_{0,2}/R_m$
6,3	843	429	0,51	843	429	0,51
5,6	1 350	974	0,72			
5,34	1 511	1 139	0,75	1 541	1 296	0,84
4,95	1 620	1 228	0,76			
4,6	1 589	1 421	0,89	1 676	1 542	0,92
4,22	1 672	1 530	0,92			
3,98	1 722	1 583	0,92	1 780	1 687	0,95
3,7	1 787	1 655	0,93			
3,44	1 802	1 711	0,95	1 878	1 821	0,97
3,18	1 914	1 818	0,95			
2,97	1 940	1 867	0,96	2 067	2 019	0,98
2,78	2 003	1 921	0,96			
2,6	2 041	1 974	0,97	2 122	2 097	0,99

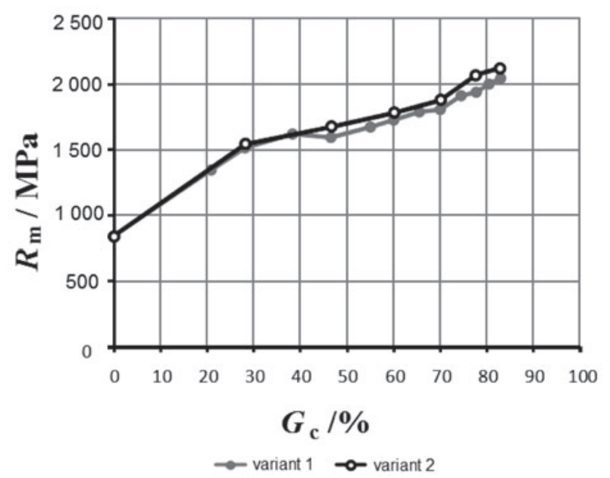

Figure 3 Variation in the tensile strength R_m for wires drawn according to variant 1 and 2 as a function of total reduction

From the analysis of data represented on Figures 3-5 it can be found that the increase of partial reduction during drawing process of TRIP wires causes the increase of mechanical properties. Wires drawn according to variant 2 (large partial reductions) have higher values of tensile strength R_m at about 4 % and yield strength $R_{0,2}$ at about 8 % and higher value of $R_{0,2}/R_m$ ratio, which may indicate a smaller "plasticity reserve".

At the same time was found that value of tensile strength for TRIP wires drawn with total reduction equal 83 % is at about 17 % higher than for wires made from high carbon steel (GD76A) with 0,76 % of carbon content and equal about 180 MPa [9].

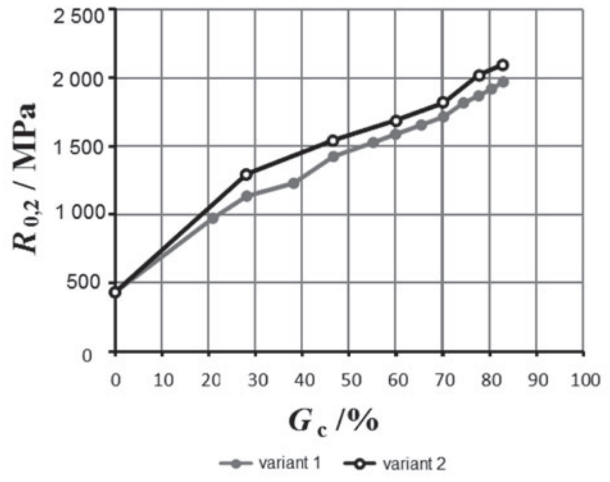

Figure 4 Variation in the yield strength $R_{0,2}$ for wires drawn according to variant 1 and 2 as a function of total reduction

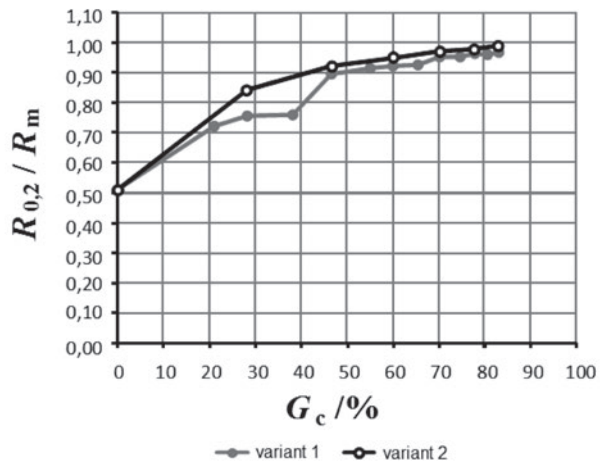

Figure 5 Variation in the $R_{0,2}/R_m$ ratio for wires drawn according to variant 1 and 2 as a function of total reduction

THE FATIGUE STRENGTH INVESTIGATIONS

The tests were conducted under rotary bending conditions and the results are summarized in Table 4.

Table 4 **The values of fatigue cycle number (N) up to the failure of final 2,60 mm diameter wires drawn with small partial reductions (variant 1) and with large partial reductions (variant 2) for two bending stress levels**

Value of Bending stress (σ_{max}) /MPa	
670	760
Variant 1	
Number of cycles up to the wire failure N	
17 481	9 765
Variant 2	
Number of cycles up to the wire failure, N	
14 791	5 516

The fatigue tests showed that the wires drawn with small partial reductions were characterized by a higher number of cycles up to the wire failure, compared to the wires drawn with large partial reductions.

We can observe the increase such difference between those two variants of drawing process with the increase of bending stress value, for σ_{max} = 670 MPa equal 18 %, for σ_{max} = 760 MPa equal 77 %.

Such significant differences between those two variant of drawing process my be due to higher strengthening of surface layer caused by the redundant strain and by differences in surface texture of drawn wires.

THE INESTIGATION OF SURFACE TEXTURE FOR FINAL WIRES

The worse surface texture of drawn wires can influences on the decrease values of fatigue strength. The results of surface texture investigations were placed in Table 5.

Table 5 **Mean values parameters of surface roughness for final wires with ϕ 2,60 mm drawn with small partial reductions (variant 1) and with large partial reductions (variant 2)**

Parameter	Variant of drawing process	Mean value of parameter
R_v /µm	1	2,155
	2	3,283
R_p /µm	1	2,966
	2	3,908
R_a /µm	1	1,135
	2	1,907
S_m /µm	1	11,796
	2	16,684

Wires drawn with large partial reductions are characterized with higher values of the height profile R_v and R_p and a higher value of the parameter deviation profile R_a compared to the wires drawn with small partial reductions.

Such formed surface can influences on the decrease values of fatigue strength. Simultaneously the fatigue strength is proportional to geometric surface area ration c/a $\cong S_m/R_a$, which for wires drawn with large partial reductions equal 8,75 and for wires drawn with small partial reductions equal 10,39, so is at about 18,8 % higher what influences on the decrease of "notch effect" and on increase of fatigue strength values for wires drawn with small partial reductions.

SUMMARY

It can be stated:

- by the determination of drawing process parameters we can inflenes on redudant strain values for TRIP wires and on mechanical properties of those,
- the tensile strength of final wires made from TRIP steel is higher than for wires made from high carbon steel with 0,76 % of carbon content and pearlite structure,
- wires drawn with small partial reduction has higher from 18 to 77 % number of cycles up to the wire failure then wires drawn with large partial reductions. It can be a result of lower value of redundant strain and lower straightening of surface layer.

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