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THE IMPACT OF THE HEAT TREATMENT PARAMETERS ON PATENTING LINE ON MECHANICAL-TECHNOLOGICAL PROPERTIES OF STEEL CORD WIRES

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In the paper the influence of modification of patenting process on steel cord properties has been assessed. It was found that the wires of pearlite structure, in comparison to the wires of pearlite-bainite structure, characterized much better properties which is confirmed by higher tensile strength by more than 12 %, higher by 1,6 % the number of twists and higher by 3,6 % the number of bends. It was found that weaving steel wire cord causes a decline in its exploitation properties, which should be associated with an additional deformation of the wire in the cords manufacturing and the size of the decline depends on the type of wire structure.

Key words: steel cord wires, drawing, structure, mechanical properties

INTRODUCTION

The development of the automotive industry and the unrelenting demand for transport services, against whom it is committed to increase demands caused that seeks to increase capacity cars, and thus increased the requirements for tire performance properties.

Currently, there is a [1-4] need to produce ultra strength steel cords for tires for use on vehicles which run above 240 km/h. The cord must be characterized both by high strength properties (more than 3 500 MPa), as well as high fatigue resistance. According to the authors, such properties can be achieved by modifying the conditions of patenting steel wires [5].

Therefore, the study attempts to assess the impact of fatigue on the steel cord strength properties.

MATERIAL AND APPLIED DRAWING TECHNOLOGIES

The material for the study was ϕ 5,5 mm wire rod from C76 grade (Table 1).

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

C	Mn	Si	P	S	Cr	Ni	Cu	N
0,76	0,62	0,21	0,007	0,012	0,05	0,03	0,05	0,02

After the surface treatment, wire rod of the diameter 5,5 mm was drawn on ϕ 1,65 mm diameter wire. The material was subjected to a heat treatment in industrial conditions on the line to patenting and brazing with two different temperatures in the heating furnace and the bath lead. Table 2 shows the heat treatment parameters, wherein: SPT- standard technology, NPT - new technology.

Table 2 **The parameters of the heat treatment**

Parameters		Temperature / °C	
		SPT	NPT
Line speed, m/min		26	26
Furnace Temperature / °C	1^{sth} zone	920	985
	1^{sd} zone	945	1 010
	1^{th} zone	950	1 030
	1^{th} zone	950	1 030
	1^{th} zone	950	1 030
The temperature of the bath lead / °C	1^{sth} zone	555	600
	1^{sd} zone	560	605

The standard technology of wire patenting assigned to steel cord involves heating the steel in each zone to the temperature of 960-980 °C and the cooling temperature in about 560 - 570 °C. The standard heat treatment (STP variant) allows for pearlite-bainite structure (with the amount of upper bainite 15 %).

New patenting technology (variant NTP) involves heating the wire to temperature above 1 000 °C in a standard furnace, annealing at this temperature and then it is followed by rapid cooling in a lead bath at the temperature of 600 °C. This type of heat treatment of steel wire will be called by the authors as a high-temperature process. The purpose of a high temperature patenting, was to obtain the troostyt structure, fine-dispertion pearlite, providing good plastic properties of the material and very high strength.

After passing from a patenting line the wire was subjected to a surface treatment, ie. washing in water, pickling in electrolytic bath H_2SO_4, by washing in a

M. Suliga, R. Kruzel, Czestochowa University of Technology, Faculty of Production Engineering and Materials Technology, Czestochowa, Poland

base band NaOH and brassing. The ϕ 1,65 mm wire was wet drawn in 19 drafts on the diameter of 0,3 mm. Table 3 shows the distribution of single drafts G_p, total draft G_c and drawing speed *v* in the various sequences.

Table 3 **The distribution of single drafts, total draft and drawing speed in wet drawing process**

Draft number	ϕ / mm	G_p / %	G_c / %	*v* / m/s
0	1,650	-	-	-
1	1,500	17,36	17,36	0,36
2	1,380	15,36	30,05	0,43
3	1,250	17,95	42,61	0,52
4	1,150	15,36	51,42	0,61
5	1,050	16,64	59,04	0,73
6	0,960	16,41	66,15	0,88
7	0,880	15,97	71,56	1,05
8	0,800	17,36	76,49	1,27
9	0,725	17,87	80,69	1,54
10	0,665	15,87	83,76	1,83
11	0,610	15,86	86,33	2,18
12	0,560	15,72	88,48	2,58
13	0,515	15,43	90,26	3,05
14	0,470	16,71	91,89	3,67
15	0,430	16,30	93,21	4,38
16	0,395	15,62	94,27	5,19
17	0,360	16,94	95,24	6,25
18	0,330	15,97	96,00	7,44
19	0,300	17,36	96,69	9,00

Then the wires of a diameter 0,3 mm with variants of SPT and the NPT, carried out in industrial conditions, steel cord of the construction of 2x0,30 was produced. The cord is commonly used in the manufacture of automobile tires.

RESULTS

To determine the effect of heat treatment on the properties of wires and steel cords, in the work mechanical and technological properties were studied. The study concerned semi-finished wire of ϕ 1,65 mm wire after patenting and the ϕ 0,3 mm wires directly after drawing (variant S) and wires woven with steel cords (variant W). Breaking tests were made on the machine Zwick Z100, in specially designed and constructed for this purpose clamping made of so thin cord, according to the norm for 10 samples of each type of cord. The technological investigations of the wires were conducted on twisting ZKZE 01/1 and on the device ZOZP 01/04. The results are given in Tables 4 - 6, where: R_m - ultimate tensile strength N_t - number of twists, N_b - number of bends.

Table 4 **Results of mechanical-technological investigation of ϕ 1,65 mm wire after patenting**

Variant	SPT	NPT	Δ / %
R_m / MPa	1 210	1 207	0,3
N_t	42,3	43,l	1,9
N_b	12,7	12,1	4,7

Table 5 **Results of mechanical-technological investigation of ϕ 0,3 mm wires from SPT variant**

Type of wire	Straight	Woven	Δ / %
R_m / MPa	3 341	3 013	9,8
N_t	111,6	96,3	13,7
N_b	44,8	38,7	13,6

Table 6 **Results of mechanical-technological investigation of ϕ 0,3 mm wires from NPT variant**

Type of wire	Straight	Woven	Δ / %
R_m / MPa	3 755	3 611	3,8
N_t	109,8	104,8	4,6
N_b	43,2	40,6	5,6

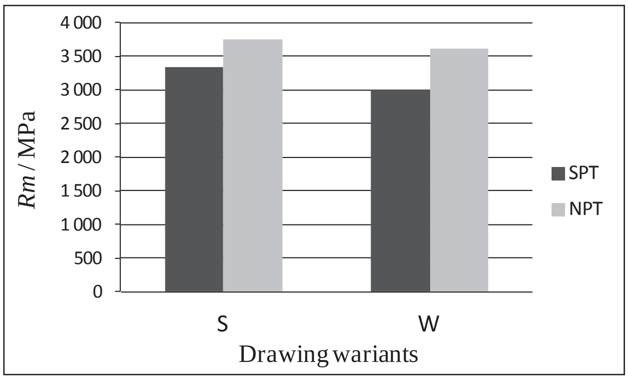

Figure 1 The tensile strength for ϕ 0,3 mm wires drawn according to SPT and NPT variant

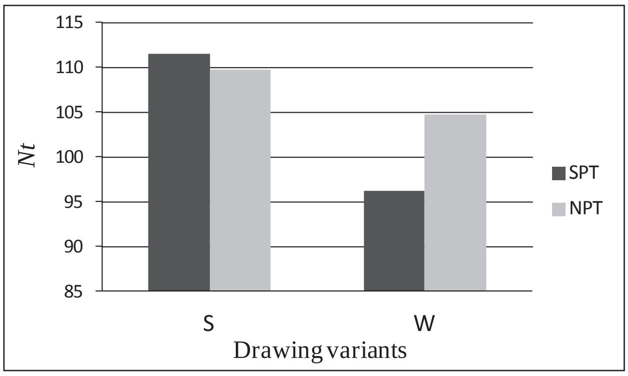

Figure 2 The number of twists for ϕ 0,3 mm wires drawn according to SPT and NPT variant

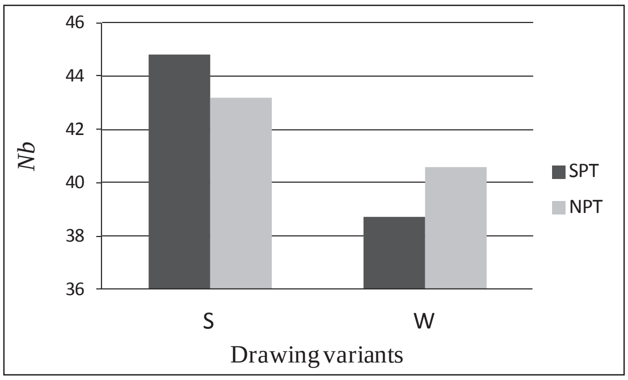

Figure 3 The number of bends for ϕ 0,3 mm wires drawn according to SPT and NPT variant

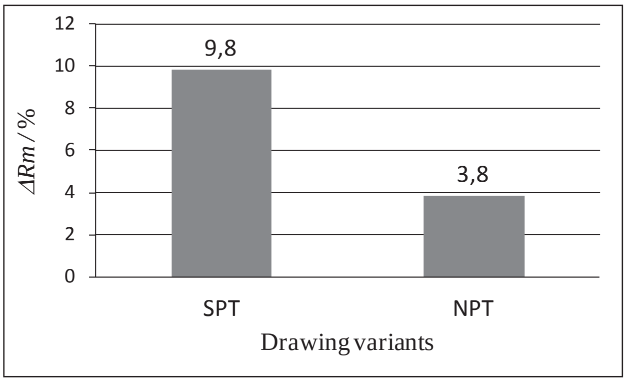

Figure 4 The percentage decline of the tensile strength decrease caused by steel cord stranding for ϕ 0,3 mm wires drawn according to SPT and NPT variant

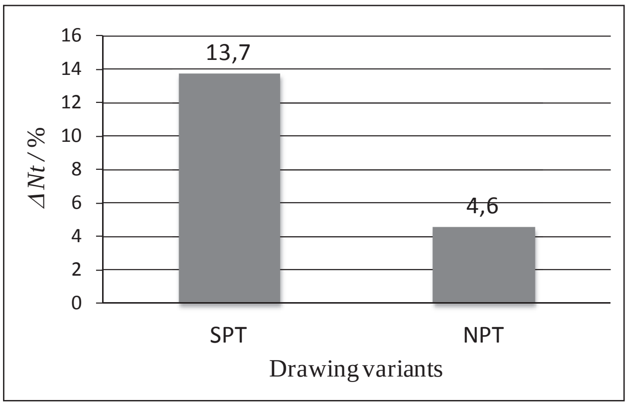

Figure 5 The percentage decline of the num- ber of twists decrease caused by steel cord stranding for ϕ 0,3 mm wires drawn according to SPT and NPT variant

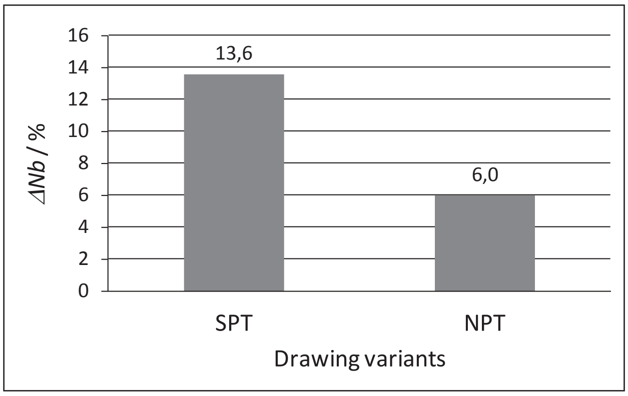

Figure 6 The percentage decline of the num- ber of bends decrease caused by steel cord stranding for ϕ 0,3 mm wires drawn according to SPT and NPT variant

The research presented in Tables 4 - 6 and Figures 1 - 3 shows that heat treatment parameters on the line to patenting steel wire cord significantly affect its mechanical and technological properties. The wires after the high temperature heat treatment (variant NPT), in relation to the wire after standard heat treatment (embodiment SPT), exhibit much higher strength properties, which is confirmed by higher by more than 12 % of the tensile strength.

Modified heat treatment also influenced favorably of technological properties of the wire. The wires with variant NPT relative to the wires of the variant SPT, characterized respectively by 1,6 % more twists and 3.6% greater number of bends. The results suggest that high carbon steel wires of a pearlite structure drawn from a large total draft demonstrate greater capacity strengthening than the wires of pearlite-bainite structure; increase R_m of more than 400 MPa (with a similar tensile strength semi-finished wires after patenting 1,65 mm, Table 4). In addition, an increase in strength properties of the wires after high temperature heat treatment (variant NPT) did not cause a deterioration of their technological properties.

The research has shown that wires woven with steel cords (W variant) have a lower tensile strength, the number of twists and the number of bends in relation to those after drawing (S variant). The decrease in the mechanical properties was observed for both types of wires to the standard heat treatment (SPT variant) and after high temperature treatment (NPT variant). This is confirmed by the results listed in Tables 5 - 6 and Figures 4 - 6.

The decrease in exploitation properties of wire after stranding it in the cord should be connected with an additional deformation of the wire in the cords manufacturing. While stranding the wire in the cord is twisting and bending. This increases material fatigue and decreases its property. The application of the new heat treatment lines for patenting wire cord restrains the decrease in its mechanical and technological properties. The wire after the high temperature heat treatment (variant NTP) relative to the wires after standard heat treatment (variant SPT), have had more than two times lower loss of tensile strength, the number of twists and the number of bends.

CONCLUSIONS

From the experimental studies carried out, the following findings and conclusions have been drawn:

1. Modifying the standard heat treatment parameters on the line to patenting wire steel cord significantly affects the improvement of its properties. The wires after high temperature heat treatment (variant NPT) in relation to the wire after standard heat treatment (variant SPT) exhibit higher tensile strength at 12 %, 1,6 % in the number of twists and 3,6 % higher the number of bends.
2. Weaving steel wire cord causes a decline in its exploitation properties, which should be associated with an additional deformation of the wire in the manufacturing cords.
3. The wires from NPT variant after woven from steel cord, in comparison to these after standard heat treatment (variant SPT), demonstrate a more than twice less likely tendency to decrease in tensile strength, the number of twists and the number of bends.
4. The results can be applied in wire industry while the implementation of new production technologies of steel cord.

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Note: The professional translator for English language is Krzysztof Skorupa, Myszków, Poland