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THE INFLUENCE OF LUBRICANT CARRIER AND LUBRICATION CONDITIONS ON MECHANICAL-TECHNOLOGICAL PROPERTIES OF HIGH CARBON STEEL WIRES

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In this paper the effect of the type of soap powder and lubricant carriers on lubrication conditions in multipass drawing process of high carbon steel wires has been determined. The wire drawing process was conducted in industrial conditions by means of a modern multi-die Koch drawing machine. For wires drawn on borax and phosphate lubricant carriers the mechanical-technological properties have been carried out, in which yield stress, tensile strength, uniform elongation, number of twists and number of bends were assessed. It has been proved that the application of phosphate lubricant carrier and also the rotary die in the first draft in an essential way improve the lubrication condition in high speed multipass drawing process and makes it possible to refine the mechanical properties of wires.

Key words: steel wire rod, lubricant carrier, drawing, mechanical properties

INTRODUCTION

The intensification of the drawing process changes the deformation conditions forcing producers to use new technological solutions in the field of surface treatment, lubrication and drawing process [1-6].

The work [1] shows that the application of high drawing speeds in the multipass drawing process of high carbon steel wires causes deterioration of lubrication condition, increases strength properties and a decline in plasticity and technological properties of the wire. In order to improve the quality of drawn wires in many drawing mill phosphate lubricant carrier has been introduced.

Therefore, the present work makes an attempt to assess the influence of the type of lubricants and lubricant carriers on lubrication conditions and the mechanical properties of high carbon steel wires.

MATERIAL AND APPLIED DRAWING TECHNOLOGIES

The 5,5 mm wire rod from high carbon steel grade C72 (0,74 % C) and C78 (0,79 % C) has been applied. After patenting, itched and the application of lubricant carriers, the wire rod was subjected to a drawing process on a multi-stage drawing mill, using conventional dies angle $\alpha = 6$ °, the following technological variants:

– variant A - borax lubricant carrier, steel C72, the 1 - 4 drafts CONDAT sodium lubricant, while the drafts 5 - 10 TRAXIT sodium lubricant (old technology),
– variant B - phosphate lubricant carrier, steel C78, rotary die on the first draft, Traxit sodium lubricant (new technology),
– variant C - phosphate lubricant carrier, steel C78, rotary die on the first draft, Tracol calcium-sodium lubricant (new technology).

The distribution of single drafts, G_p, total draft, G_c, and drawing speeds, *v* for wires drawn according to A, B and C variants are summarized in Tables 1 and 2.

Table 1 **Distributions of single drafts, total draft and drawing speeds for wires drawn according to variant A**

Draft	ϕ / mm	G_p / %	G_c / %	v / m/s
0	5,50	-	-	-
1	4,92	20,0	20,0	2,12
2	4,38	20,8	36,6	2,67
3	3,90	20,7	49,7	3,37
4	3,50	19,5	59,5	4,18
5	3,12	20,5	67,8	5,26
6	2,80	19,5	74,1	6,53
7	2,50	20,3	79,3	8,19
8	2,22	21,2	83,7	10,39
9	2,00	18,8	86,8	12,80
10	1,78	20,8	89,5	16,16

THE RESULTS AND DISCUSSION

For the wires drawn according to variant A, B and C the amount of lubricant on wire surface was determined. Figure 1 shows the effect of lubricants and lubricant carriers on lubrication conditions in the multipass drawing process of high carbon steel wires.

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Table 2 **Distributions of single drafts, total draft and drawing speeds for wires drawn according to variants B and C**

Draft	ϕ / mm	G_p / %	G_c / %	*v* / m/s
0	5,50	-	-	-
1	5,00	17,4	17,4	1,73
2	4,48	19,7	33,7	2,16
3	4,00	20,3	47,1	2,71
4	3,60	19,0	57,2	3,35
5	3,24	19,0	65,3	4,13
6	2,92	18,8	71,8	5,08
7	2,64	18,3	77,0	6,22
8	2,40	17,4	81,0	7,53
9	2,19	16,7	84,2	9,04
10	2,01	15,8	86,6	10,73
11	1,85	15,3	88,7	12,73
12	1,70	15,6	90,5	15

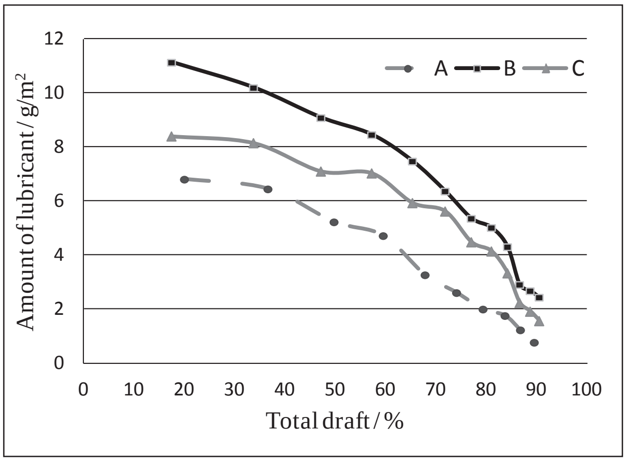

Figure 1 The amount of lubricant on the wire surface in total draft function for wires drawn according to A, B and C variants

The study showed that borax lubricant carriers in traditional technology of drawing high carbon steel wire rod do not guarantee to download and keep the process of drawing with the sufficiently large amount of lubricant on the surface of drawn wires. The use of phosphate lubricant carriers and the rotary die in the first draft allows a significant improvement of the lubrication conditions. The differences between the variants increase with increasing total draft. By 90 % total draft, the wires drawn on phosphate lubricant carriers (variant B and C), in comparison to the wires drawn on borax lubricant carriers (variant A), characterized by respectively 250 and 120 % greater amount of lubricant. The studies also suggest that the appropriate selection of lubricant in the high speed drawing process may affect additional improvements to lubrication conditions. For the final wires drawn according to variant B, in relation to the wires of the variant C, an average of more than 30 % increase of the lubricant on the wire surface was noted.

To determine the effect of lubrication conditions on the wires properties, in this study the mechanical properties, which define: a yield strength $R_{0,2}$, tensile strength R_m, coefficient $R_{0,2}/R_m$. uniform elongation A_r, the number of twists N_t and number of bends N_b for wire rods and wires drawn according to variant A, B and C, have been estimated (Figures 2 - 7).

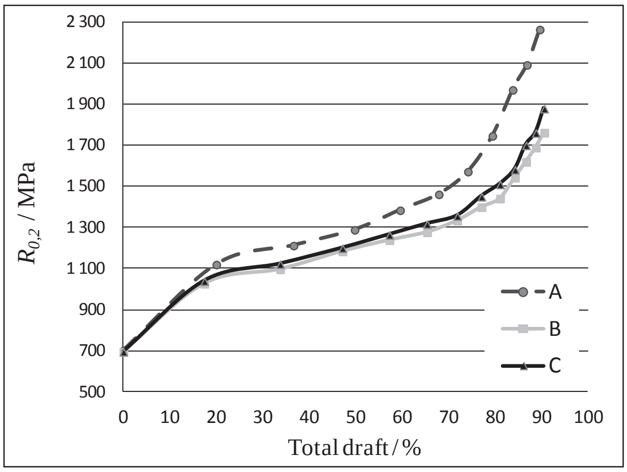

Figure 2 The yield stress for wires drawn according to A - C variants in total draft function

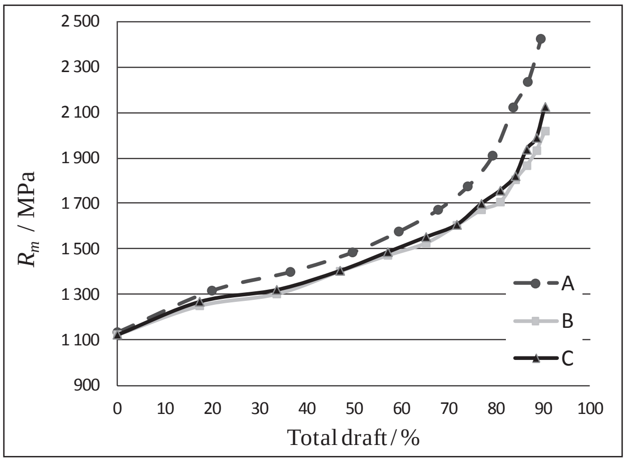

Figure 3 The tensile strength for wires drawn according to A - C variants in total draft function

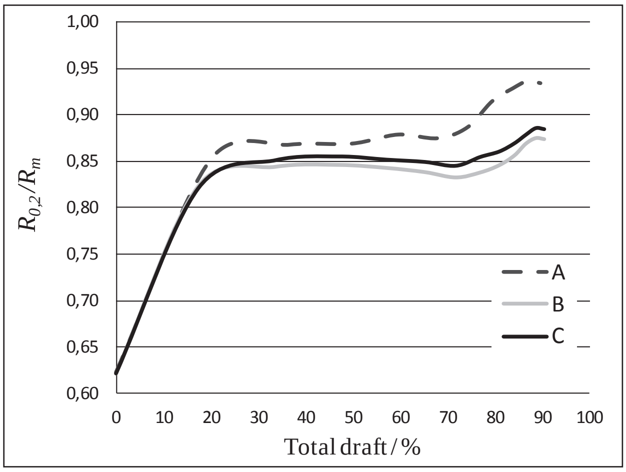

Figure 4 The coefficient $R_{0,2}/R_m$ for wires drawn according to A - C variants in total draft function

Based on the results shown in Figures 2-7 it can be seen that in the high speed multipass drawing process

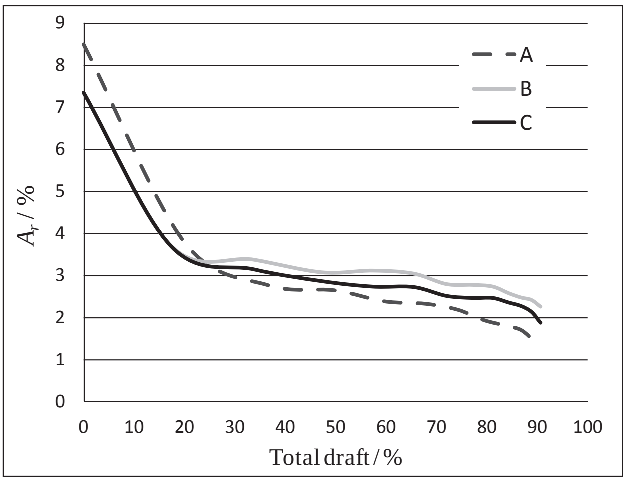

Figure 5 The uniform elongation for wires drawn according to A - C variants in total draft function

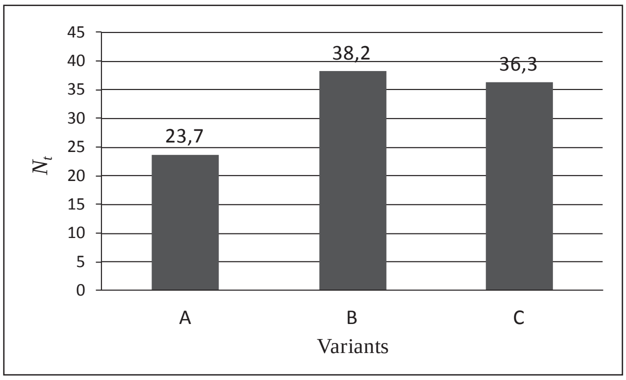

Figure 6 The number of twists for final wires drawn according to A - C variants

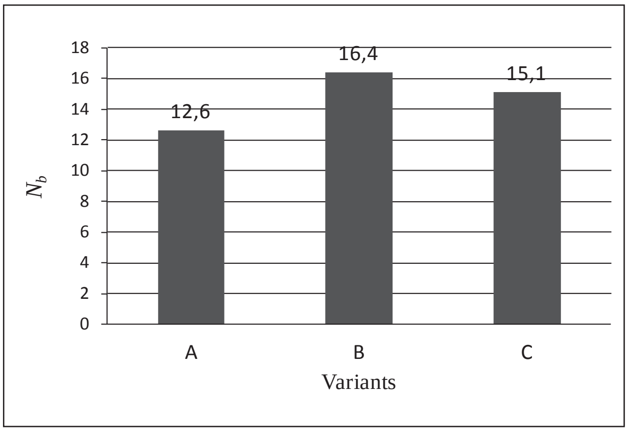

Figure 7 The number of bends for final wires drawn according to A - C variants

the lubrication conditions belong to a group of parameters of the drawing process, in which they significantly affect the properties of the wires. The improvement of lubrication conditions in the wires drawn on the phosphate lubricant carrier contributed to the decline in work hardening of wires, manifested lower values of $R_{0,2}$ and R_m and also improved plasticity properties (lower values of $R_{0,2}/R_m$ coefficient). With the increase of the total draft differences between the drawing variants increase and for G_c = 89 % are distinct. The wires from B variant, in comparison to the wires from the variant A, characterized lower by 22 % the yield strength and 17 % tensile strength. Improved lubrication conditions in the wires drawn according to variant B had a positive impact on their plastic properties, which confirms higher by more than 40 % uniform elongation. The study also showed that at the same lubricant carrier the appropriate selection of lubricant may contribute to further improvement of the properties of plastic wires. For the final wires drawn according to variant B, in relation to the wires of the variant C, there was 15% increase in uniform elongation and a decrease of about 5 % of the yield strength and tensile strength.

The deterioration of lubrication conditions and increased work hardening of the wires drawn on borax lubricant carrier affected the obtained for this variant the number of twists and the number of bends (Figures 6 - 7). The study showed that the wires drawn with the usage of borax lubricant carrier have definitely worse technological properties. For the final wires from A variant, in relation to the wires of variant B and C, lower by 60 % of the number of twists and lower by 15 % the number of bends have been noted. In contrast, for the drawing speed of 15 m/s, there was insignificant effect of lubricant on the resulting number of twists and the number of bends in the wires drawn on the phosphate lubricant carrier with. The differences between A and B variants, depending on the total draft, were about 5 %. It is believed that drawing speeds above 20 m/s can result in formation of more significant differences.

CONCLUSIONS

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

Borax lubricant carrier in traditional technology of high speed multipass drawing process of high carbon steel wires does not guarantee to download and keep in drawing process a sufficiently large amount of lubricant on the surface of drawn wires. This increases the strength properties ($R_{0,2,}$ R_m) of wires, with a simultaneous decrease of their plasticity ($R_{0,2}/R_m$, A_r) and technological properties (N_t, N_b).

The application of phosphate lubricant carrier and the rotary die in the first draft makes it possible to improve in a significant way lubrication conditions and it creates more favorable conditions for deformation in the multistage drawing process of steel wires and partially compensates the negative impact of high drawing speed on wire properties.

Further improvement of the lubrication conditions in high speed multipass wire drawing process can be achieved by appropriate selection of drawing lubricants, and by providing a new type of dies.

The obtained investigation results could be utilized in the wire drawing industry in the implementation of new production technologies of high carbon steel wires.

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