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THE INFLUENCE OF DRAWING SPEED ON SURFACE TOPOGRAPHY OF HIGH CARBON STEEL WIRES

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Preliminary Note – Prethodno priopćenje

In this work the influence of the drawing speed on surface topography of high carbon steel wires has been assessed. The drawing process of f 5,5 mm wire rod to the final wire of f 1,7 mm was conducted in 12 passes by means of a modern Koch multi-die drawing machine. The drawing speeds in the last passes were: 5, 10, 15, 20 and 25 m/s. For final wires f 1,7 mm the three-dimensional analysis of the wire surface topography investigation was determined. It has been proved that the wire topography in the drawing process is characterized by a random anisotropy and the amount of directing the geometrical structure of the surface depends on the drawing speed.

Keywords: high carbon steel, drawing, wire rod, speed, surface topography

INTRODUCTION

Technical progress necessitates the producers of wire and wire products continuous improvement of manufacturing them. Another factor stimulating the development of drawing industry are economic considerations [1 - 5].

In order to increase competitiveness in the global market modern wire factory are forced to seek new solutions in order to increase their productivity and reduce production costs while maintaining high quality of products drawn [1].

Nowadays the main direction of development and modernisation of wire drawing mills is the implementation of the technology of high speed drawing process of high carbon steel wires that have been used in manufacturing of ropes, springs and steel cord.

The main obstacle in the implementation of this technology is heating of the surface layer of the wire that leads to the deterioration of lubrication, premature wear of dies and a decline in property of wires below the applicable industry standards [6 - 9].

From the literature and the author's own research shows that poor lubrication conditions at high speed drawing in traditional technology of drawing are associated with borax lubricant carrier that does not offer downloads and maintenance by drawing a sufficiently large amount of lubricant on the surface of drawn wires [6].

Consequently, the aim of this study is to determine the effect of high drawing speed on surface topography of high carbon steel wires.

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MATERIAL AND APPLIED DRAWING TECHNOLOGIES

The investigation of high speed multipass drawing process in conventional dies it has performed for high carbon steel wire grade C78D (0,79 % C). Before drawing, the wire rod was patented, itched and phosphated. The drawing process of f 5,5 mm wires in the final wire of f 1,7 mm was conducted in 12 passes, in industrial conditions, by means of a modern multi-die drawing machine Koch KGT 25/12, using conventional dies with an angle of drawing 2a = 12°.

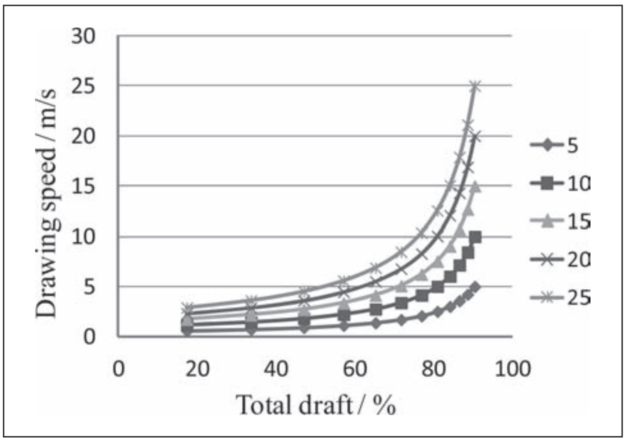

Figure 1 The distribution of drawing speeds in total draft function

The drawing speeds in the last pass, depending on the variant of the drawing, was respectively: 5, 10, 15, 20, 25. The distribution of drawing speeds in total draft function is presented in Figure 1. As a lubricant in the high speed multipass drawing process the sodium drawing powder has been applied.

RESULTS AND DISCUSSION

In order to establish the effect of drawing speed on wire roughness the surface topography of 1,7 mm final wires has been estimated.

The analysis of the geometric structure of the surface of the wires can be done based on a traditional 2D surface roughness measurement and based on a three-dimensional (spatial) surface analysis. Three-dimensional analysis of the surface topography allows for better assessment of the impact of process conditions on the state of drawing the wire surface layer, since it is not subjected to evaluation as in the case of 2D measurement of one line segment and a specific surface area of the wire. Analysis of surface topography in terms of 3D allows you to specify not only the parameters of the elevation and longitudinal surface features, but also the shape parameters of inequality and anisotropy of the surface [10].

3D surface topography studies were performed using profilometer Taylor Hobson 50, and the results were obtained with using software developed by TalyMap Platinum. The surface of the samples with dimensions of 0,55 mm x 1 mm in a transverse direction to the direction of drawing were analyzed.

To illustrate the surface topography changes by drawing wires at high speeds, the following parameters were selected to be analyzed:

- Amplitude parameters, ie roughness St (the distance between the highest and the lowest point of the surface, ten-point height of irregularities surface Sz (mean absolute height of the five highest and five lowest vertex cavities), root mean square roughness Sq;

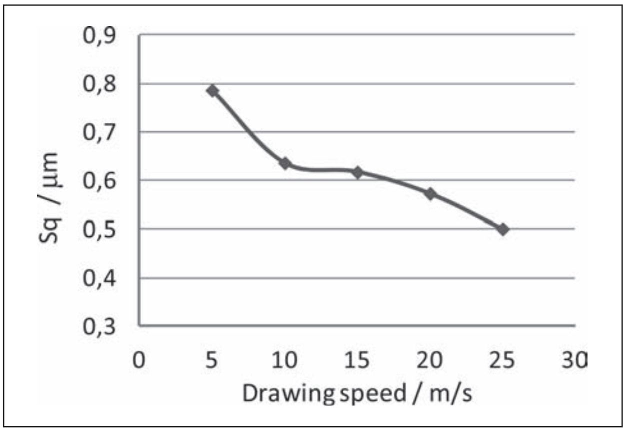

Figure 4 The effect of the drawing speed on Sq surface amplitude parameters of the f 1,7 mm final wires

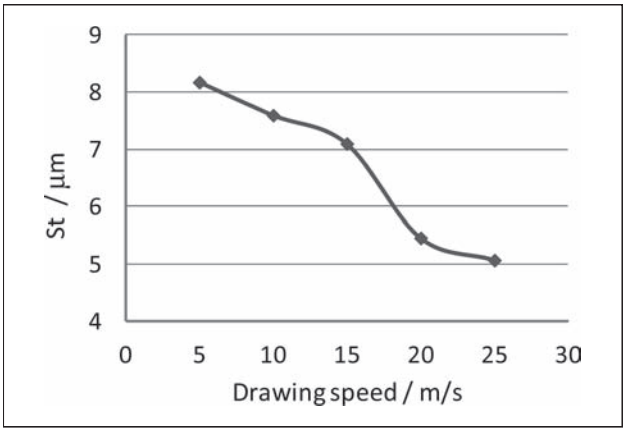

Figure 2 The effect of the drawing speed on St surface amplitude parameters of the f 1,7 mm final wires

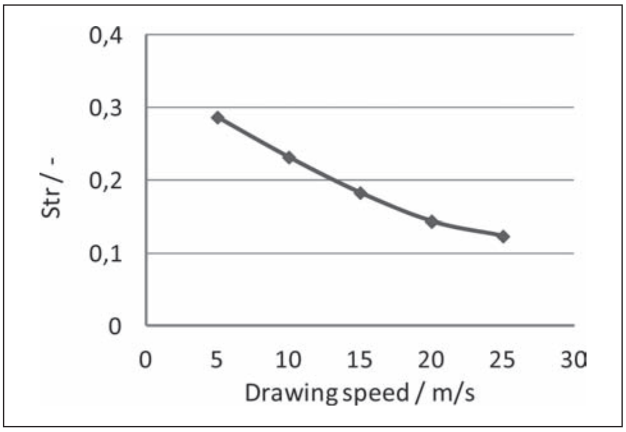

Figure 5 The effect of the drawing speed on Str surface spatial parameters of the f 1,7 mm final wires

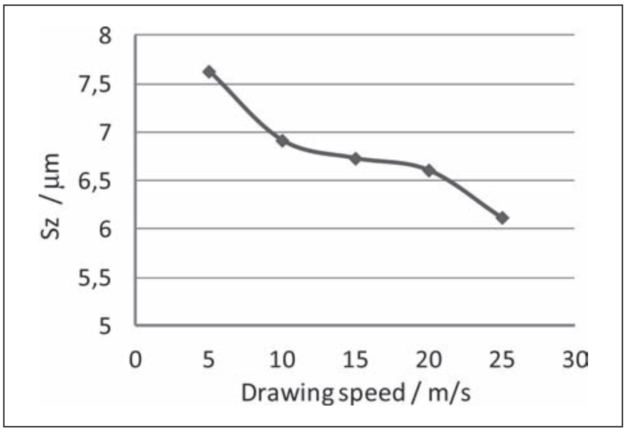

Figure 3 The effect of the drawing speed on Sz surface amplitude parameters of the f 1,7 mm final wires

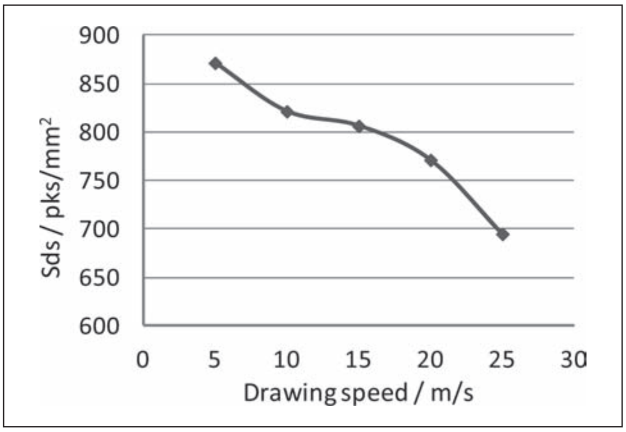

Figure 6 The effect of the drawing speed on Sds surface spatial parameters of the f 1,7 mm final wires

- The spatial parameters, namely: the ratio of surface texture Str (this parameter ranges from 0 to 1, with values close to 1 indicate a geometric structure surface with a high level of isotropy), the density of vertices Sds surface irregularities.

Figures 2 - 6 show graphs illustrating the effect of drawing speed on selected parameters of the geometric structure of the wire surface.

By analyzing the surface topography of drawn wires, it can be concluded that the surface configuration of the drawing process is characterized by a random anisotropy and the amount of directing the geometrical structure of the surface depends on the speed of the drawing, as evidenced by the work described in the parameter Str. With the increase of drawing speed anisotropy of the surface increases.

The multipass drawing process at high speeds, the amount of lubricant is insufficient for separation of friction surfaces, thus it occurs in many areas of direct contact of the wire surface and the die. Because the surface of the die is much harder and smoother than the surface of the wire, so at the point of contact and the shearing deformation of the drop wire surface, which leads to surface smoothing and textured in a certain direction, and the resulting new inequalities correspond to die surface. In addition, the incidence areas subject to shearing and deformation processes leads to greater heterogeneity of the surface texture manifested by the presence of local elevations and depressions.

In the presented study it has been shown that with increasing of drawing speed the wire roughness decreases. According to work [1] there is a direct relationship between the amount of lubricant on the wires and their roughness. The increase in drawing speed to 25 m/s resulted in drastic deterioration of lubrication conditions, which led to increase direct contact and friction surfaces grind of the wire surface. According to the author, a factor increasing smoothing the surface of the wires drawn at high speeds is not only a decrease in the amount of lubricant on the wires, but also deterioration of lubricity powder of drawing in a part sizing die. Significant smoothing of the surface of the wires drawn at a speed of 25 m/s confirms the parameters of amplitude, spatial and geometric structure of the hybrid surfaces which are from 20 to 50 % lower than those obtained for wires drawn at a speed of 5 m/s (Figures 2 - 6).

CONCLUSIONS

It has been proved that the wire topography in the drawing process is characterized by a random anisotropy and the amount of directing the geometrical structure of the surface depends on the drawing speed.

The increase in drawing speed causes a decrease in surface roughness of wires.

Significant smoothing of the surface of the wires drawn at a speed of 25 m/s confirms the parameters of amplitude, spatial and geometric structure of the hybrid surfaces which are from 20 to 50 % lower than those obtained for wires drawn at a speed of 5 m/s.

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

Ackowledgment

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