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RESEARCH OF THE UNACCEPTABLE DEFECTS CAUSES IN THE MANUFACTURE OF REINFORCING ROPE

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In the production of reinforcing ropes, the patenting of wire rods is carried out under the technical production regulations. Patenting is a consequence of isothermal treatment, in which the decomposition of supercooled austenite is carried out in the lower part of the temperature range of diffusion transformation. In the microstructure of patented steel, there should be no structures of prostate, bainite, and martensite. Such a structure has a combination of ductility as well as good deformability with high reduction ratios. In the production of ropes, failure to comply with these technical requirements can lead to serious consequences. The article examines the defects that have arisen in the production of reinforcing ropes. In the course of the study, on the surface where the wires broke, uneven colors, scratches, and small flaws were revealed. For microstructural analysis of the metal was used Microscope Altami MET 1C. As a result of the microstructural study of steel, areas with large-lamellar perlite were identified, which led to a wire break.

Keywords: reinforcing ropes, microstructural analysis of steel, heat treatment

1 INTRODUCTION

Stabilized stressed reinforcing ropes with low relaxation significantly increase the performance of reinforced concrete products without increasing the number and cross-sectional area of metal reinforcement.

This article discusses the formation of defects in the production of reinforcing rope with a diameter of 12.0 mm from steel grade 80 produced by Kaz-Metis LLP.

2 EXPERIMENTAL STUDY AND DISCUSSION

Seven-wire reinforcing ropes are prestressed reinforcement and are a strand consisting of six wires of the outer layer, twisted in a spiral around one central wire (Figure 1) [1]. Ropes are made exclusively from hard-worked wire with a total reduction of approximately 70 to 80%.

In the process of manufacturing the rope, after it lays, the strand is subjected to pulling through the dies, which allows the final formation of the specified diameter of the rope and further low-temperature annealing in an induction furnace with a slight tension. Heat treatment makes it possible to remove excess stresses in the wire due to low relaxation, as well as to stabilize it.

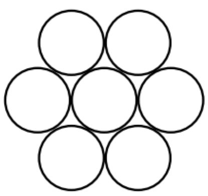


Figure 1: Cross section of a seven-wire reinforcing rope structure

Patenting of wire rods is carried out in WPL-2 (Wire patenting line) under the requirements of the technical regulations of Kaz-Metis LLP. Patenting is a kind of isothermal treatment, in which the decomposition of supercooled austenite is carried out in the lower part of the temperature range of diffusion transformation.

In the microstructure of patented steel, there should be no structures of prostate, bainite, and martensite. Excess ferrite or secondary cementite does not have time to form during patenting, i.e. the whole structure is quasi-eutectoid. This structure has a combination of ductility with high strength at the same time, as well as good deformability with high compression ratios. This ensures high strength properties of the wire after drawing while maintaining increased toughness and ductility. As a result, patenting is used to obtain rope wire.

3 METHODOLOGY AND EQUIPMENT FOR CARRYING OUT THE STUDY

The object of the study is a reinforcing seven-wire rope of ∅ 12.00 *mm*, with a yield strength of 1500 *N/mm²* (symbol: 12 K7-1500-S). The wire for the rope was made from an 80 nominal ∅ 12.0 *mm* wire rod of steel. During the production of a reinforcing seven-wire rope, one outer wire in the form of a "pencil" broke off.

During the production of a reinforcing seven-wire rope, one outer wire in the form of a "pencil" broke off. To study the causes of the wiring defect, we conduct a literary analysis. When drawing with rolled foreign particles, [2, 3] surface defects appear that do not have obvious signs, and they can be classified by GOST 21014-88. According to the results of studies, defects are classified as rolled scale. And in bars made of medium-carbon steel [4, 5], drawing causes elongation of grains in the direction of drawing with the direction of the fiber parallel to the wire axis. In the process of drawing, kinks and bends of cementite grains were observed, which can lead to the destruction of the finished product.

In cables made of carbon nanotubes, the emerging internal forces associated with the radial interaction between adjacent layers of fibers can affect the strength of the fibers and the elasticity of the cable. Such forces demonstrate a change in the helix pitch, opposite to the pitch of the cable axial stiffness, which suggests the existence of an optimal compromise between strength and rigidity [6].

In the manufacture of workpieces from low-carbon steel by the method of ultrafast cooling (UFC) [7], the mechanical properties of steel are effectively improved. The UFC process produces low-temperature transformation microstructures containing a significant amount of acicular AF ferrite. The mechanical properties became more satisfactory, due to the smaller average grain size, more volume fractions, and smaller secondary phase size.

The need for austenitization in the temperature range of 930-980 ° C in the production of high-strength reinforcement ropes [8] has been experimentally confirmed. This technology provides an increase in the degree of austenite homogenization, as well as suppression of the free ferrite formation in high-carbon hot-rolled workpieces.

In gas arc fusion welding of high-strength steel HY-80 using 90%, Ar + 10% CO2 protective gas and welding wire ER100S the highest hardness was observed for both butt and fillet welds. The butt weld type shows that the hardness of HAZ and WM at the bottom surface is higher than at the top surface due to less heat input, which contributed to a higher cooling rate and martensite formation [9].

The materials taken from open sources do not contain information on defects in drawing steel 80. For further investigation of the causes of the defect, two samples were taken from the fracture site with an actual ∅ of 4.13 mm, 300 mm long.

We prepare samples for visual inspection, and for this, we remove drawing lubricants from the surface. When examining the surface of the samples, they show a difference in tone (see Fig. 2), which extends approximately to a distance of 10-15 cm from the breaking point on each of the samples.

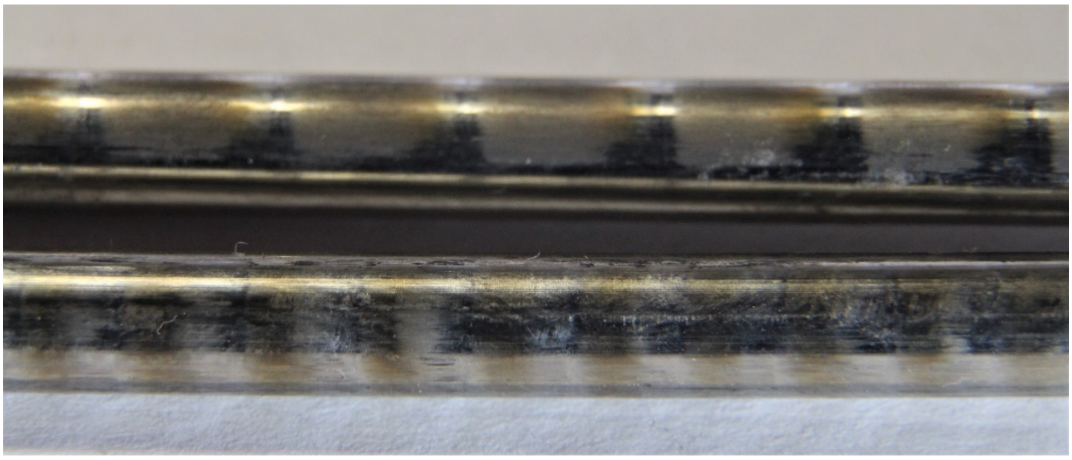


Figure 2: Appearance of the defect "heterogeneity"

For an extended deep analysis of the defect, the Altami MET 1C digital microscope was used. The defect looks like alternating light and dark stripes on the surface of the wire. The defect is generally about half the length of the wire in the sector. There are small bumps in the light areas and depressions in the dark areas.

Defect cause analysis:

1. The presence of moisture in the drawing grease or pulling through the "soap dish" the density of (wet) wire (wire rod);
2. Incorrect installation of the fiber in the “soap”, namely, the fiber outlet installed at the input of the wire (rod) into the fiber structure;
3. The formation of a tunnel in the drawing grease leads to a "dry" drawing.

During the analysis, we identify two parallel scratches and "small flaws" on one side, which extend over the entire length of both samples. In addition, in the place of the breakage on the opposite side, there are also small flaws up to 5 *mm* long (see Fig. 3).

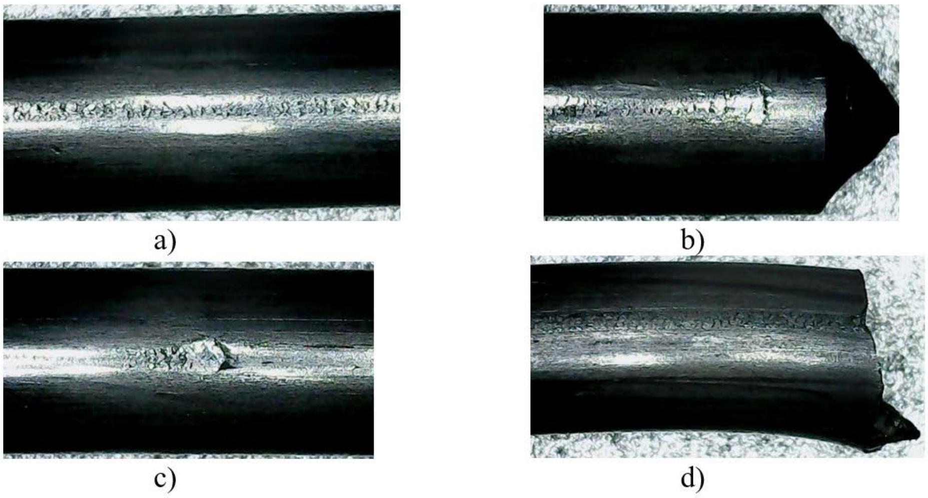


Figure 3: Samples for the study: a - The general nature of the flaws on the samples; b - The view of the flows at the place of the break on one of the samples; c - A flaw 75 *mm* from the place of the break on the sample; d- Flaws on the response sample

In the process of preparing samples for microstructural analysis, tears in the form of "crow's feet" were found in the metal structure. Figure 4 shows these tears on the untreated surface.

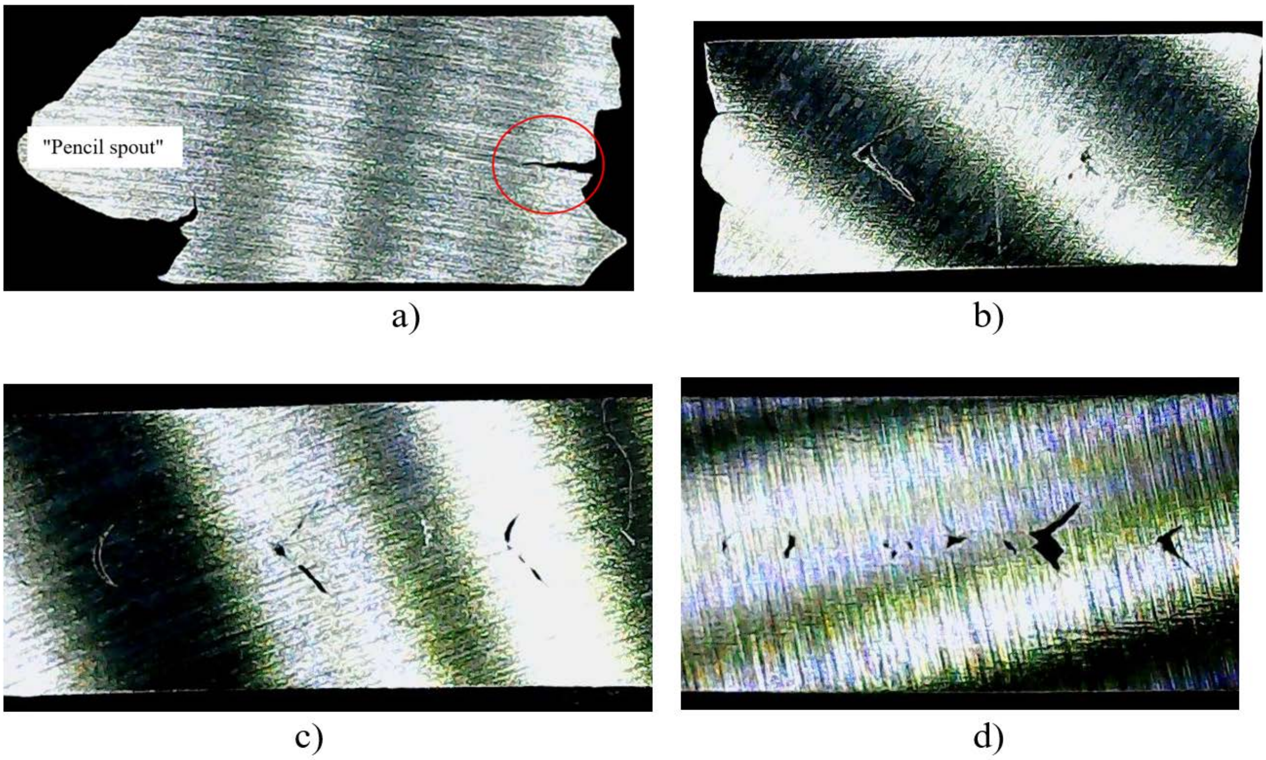
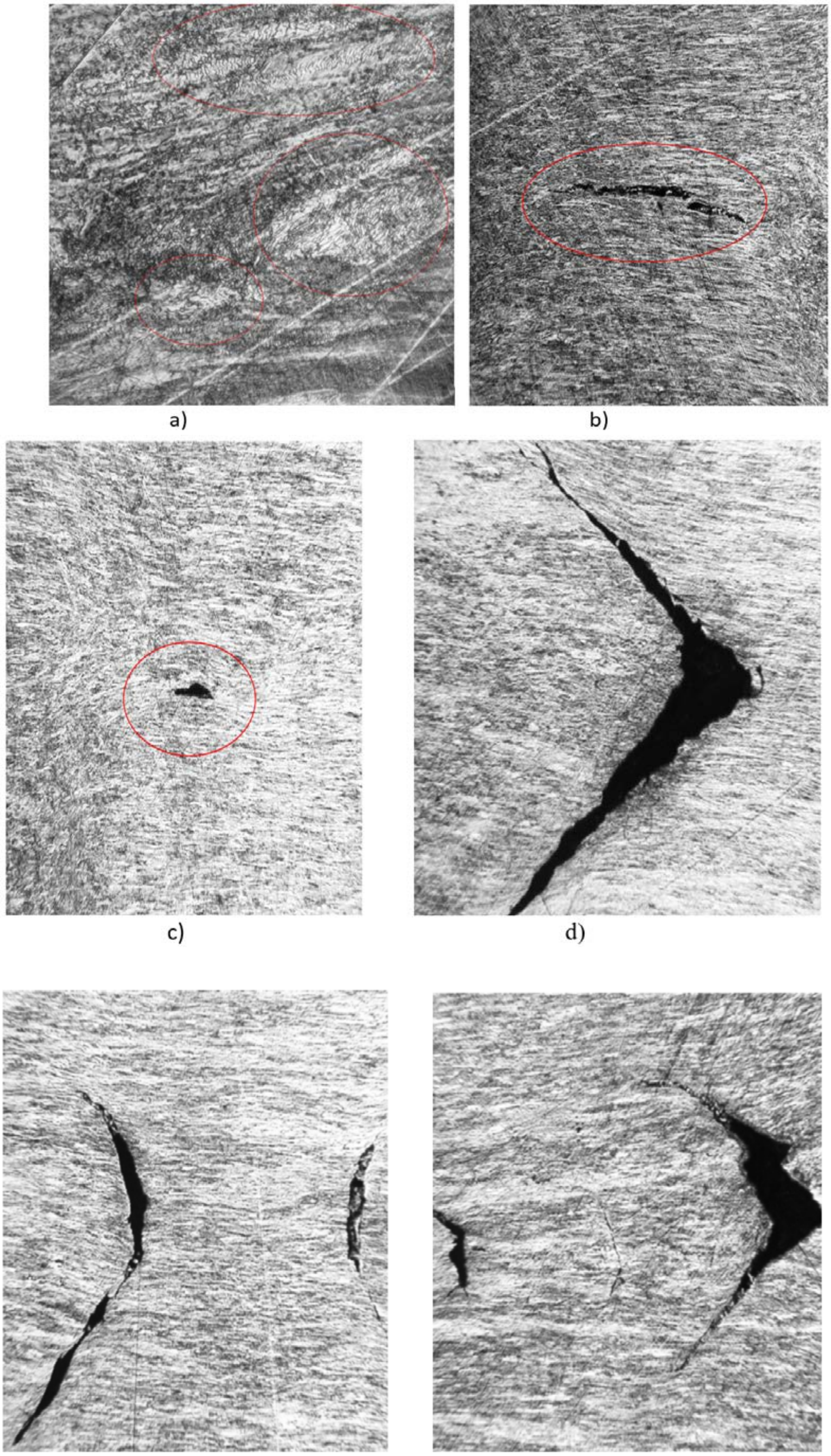


Figure 4: a - "Pencil spout" (red ovals are highlighted in cracks in the metal); b - A view of "crow's feet" at a distance of 75 *mm* from the breakage point (from the spout of the "pencil"); c - A view of "crow's feet" from the opposite end of the sample from the breakage point (sample with the spout of the "pencil"); d- A view of "crow's feet" and cavities from the opposite end of the second sample from the breakage point

Microstructural analysis showed that when drawing the wire section where the tears occurred, there is a sufficiently large grain of perlite (see Fig.5).



a) b) c) d) e) f)

Figure 5: Microstructural analysis with a 50-fold increase

a - the microstructure of steel on a wire (red ovals highlight areas with large-lamellar pearlite); b - the microstructure of steel in the area of the formed inner cavities; c - a longitudinal tear near the «pencil» nose; d - longitudinal strain within 5 *mm* from the tip of the "pencil"; e - one of the characteristic tears of the "crow's feet"; f - "crow's feet" from the opposite end of the sample with a "pencil" tip

Microstructural analysis on an Altami MET 1C microscope showed that during the production of wires where tears occurred, there is a rather large pearlite grain (see Fig. 5, a), which provoked the appearance of tears in the thickness of the metal.

4 CONCLUSIONS

The reason for the formation of tears was a violation of the heat treatment technology in the wire patenting line, namely hardening, as a result, large-lamellar perlite formed in the steel structure, and this, in turn, led to the destruction of the wire.

5 RESULTS

1. In the process of visual inspection, it was revealed that there is a defect in the form of "diversity" on the surfaces of the samples.
2. Under a digital microscope Altami MET 1C, additional flaws, and two longitudinal scratches were found on the surfaces of the samples, spreading along the entire length of the samples.
3. During the study of the internal structure of the samples in the thickness of the metal, tears were revealed, one of which destroyed the wire.
4. In the production of reinforcing rope, the total compression of steel is 81.7%, but when examined with a microscope, the plates of large-lamellar perlite are visible (see Fig. 5).
5. Large-lamellar perlite in the steel structure indicates a violation of the heat treatment regime in the production of wire for the manufacture of a rope.

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