International Journal of Advance Scientific Research
(ISSN – 2750-1396)
VOLUME 03 ISSUE 10 Pages: 260-269
SJIF IMPACT FACTOR (2021: 5.478) (2022: 5.636) (2023: 6.741)
OCLC – 1368736135

Journal Website: http://sciencebring.com/index.php/ijasr

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Research Article

ANALYSIS OF FACTORS AFFECTING THE MANUFACTURING TECHNOLOGY AND CONSUMPTION OF TOOLS USED IN WIREDRAWING MACHINES

Submission Date: October 20, 2023, **Accepted Date:** October 25, 2023,
Published Date: October 30, 2023
Crossref doi: https://doi.org/10.37547/ijasr-03-10-41

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ABSTRACT

The improvement in the processing of wires made of copper materials in drawing machines is inextricably linked with the use of hard alloys. This leads to a significant increase in the mechanical properties of the device and the stretching performance. Nowadays, stretching is one of the main requirements of wire production to ensure their resistance to corrosion by increasing the hardness of the equipment. In this article, the causes, appearance and ways of eliminating stretching equipment are given.

KEYWORDS

Deformation, hard alloy, roll, elongation, corrosion, construction, defect, performance, tungsten, taper.

INTRODUCTION

In the era of a rapidly growing market economy, the need to focus on improving product quality and increasing competitiveness in manufacturing enterprises is increasing day by day, because, without these main factors, it is impossible to introduce products that meet global requirements and high economic efficiency of production. Taking this into account, the demand for existing technologies and equipment in production increases the quality of products in any production condition, and the production of products that meet export requirements is given great importance. It should be mentioned that the increase in product quality directly leads to an increase in the cost of the product. Reducing the cost of the product and increasing its quality is

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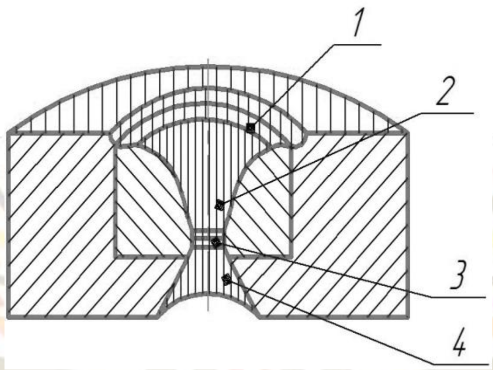
one of the main requirements of the current market economy [1]. Reducing the cost of the product depends on the material properties of the tool used in production, the manufacturing technology, the processing conditions and the correct selection of the structural parameters of the tool.



Picture 1. Die construction.
1- input part, 2- working part, 3- sizing part,
Part 4 of the output

Today, the most popular in the world market of products made of metals are products made of steel and copper wire. One of the most important and labour-intensive stages of production is the wire drawing process. Pulleys used in the drawing process are used as wire drawing tools on drawing machines. The most common materials for the production of stretching tools today are hard alloys based on tungsten carbide [2].

The construction of the tool used for stretching cylindrical wires in drawing machines is presented in Figure 1 [3]. The tool consists of 4 parts.

1. The entrance part serves for correct and proper penetration of the wires and lubrication of the next part.
2. The working part - plastic and elastic deformations take place. Metals are most affected in this part.
3. Sizing part - provides the size and shape of the product.
4. Output part - serves for output.

One of the main factors that directly affect productivity during stretching is the wear and quality of the stretching tool, i.e. the roller. Therefore, the quality of the wires mainly determines the economic indicators of stretching and the characteristics of the wire. Worn or damaged fibres create defects that can cause problems in the stretching process.

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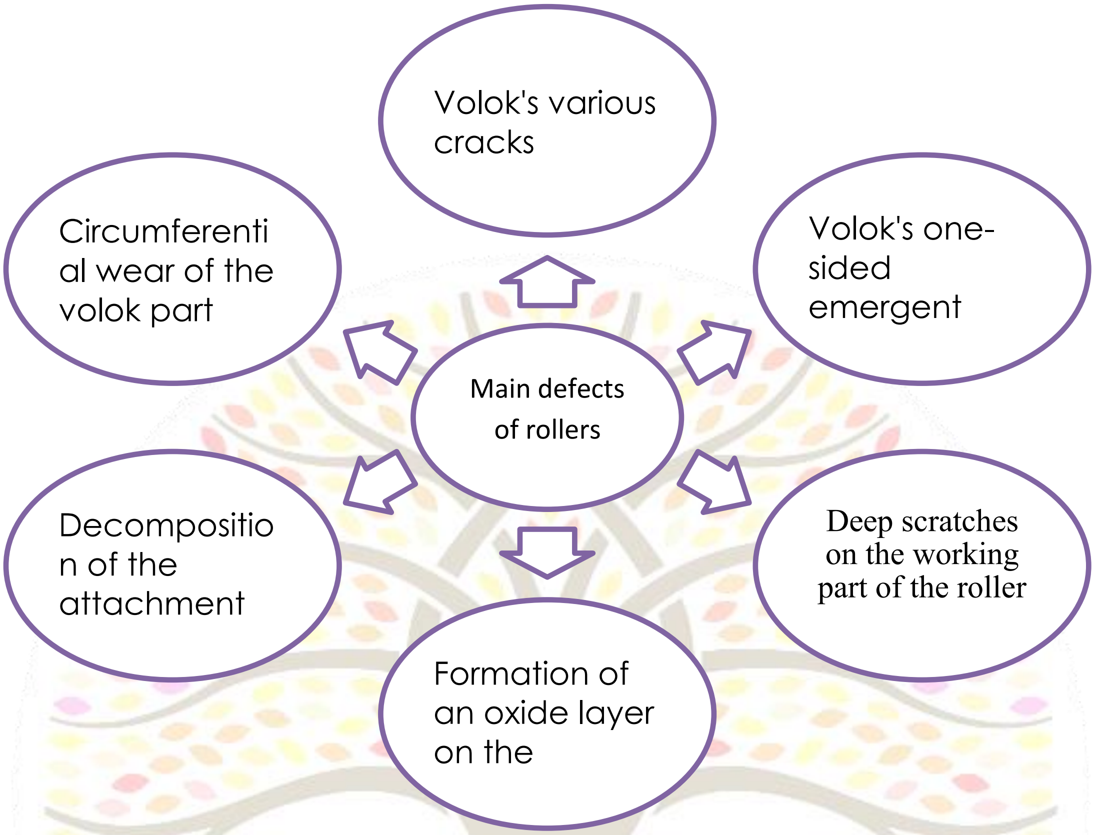

Thus, the fulfilment of the requirements for increasing the processing productivity of the drawing machines, reducing the product cost and ensuring the high quality of the transferred wire is inextricably linked with the problem of the durability of the drawing tools.

The main disadvantages of hard alloy tools used in drawing machines;

1. Cracks;
2. Release of hard alloy attachment;
3. Disintegration of the attachment surface of the hard alloy;
4. Separation of hard alloy elements;
5. Complete separation of hard alloy elements;
6. Deep scratch of hard alloy part;
7. Circumferential wear of the die part;
8. One-sided defect;
9. Cracking of hard alloy material;
10. Formation of an oxide layer on the working surface of the wire, etc.

Materials and methods

Stretching is to prevent premature wear and failure of tools

it is necessary to analyze the reasons for the appearance of defects in the stretching process and the methods of their elimination.

The percentage distribution of the main defects that occur during stretching is shown in Figure 2.

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Crossref doi Google Scholar WorldCat MENDELEY
ISSN-2750-1396

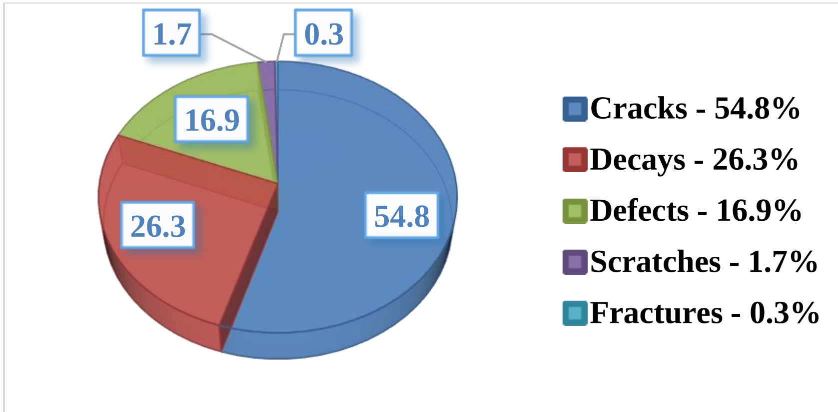

Figure 2. Percentage distribution of the main defects that occur during stretching

Cracks are caused by the failure of crystal lattices of solid alloy materials in the working part of the roller, perpendicular or along its axis. The rollers used in the stretching process are made of very strong materials. This means that they are prone to cracking under the influence of heat and mechanical forces.

Mechanical forces always occur in the direction of stretching and therefore cause only certain types of cracks. Heat gain is less pronounced, so it can cause various types of cracks. Most cracks caused by overheating are usually random in size and orientation. Due to such cracks, stresses appear, and then mechanical forces cause the cracks to grow rapidly. Cracks can occur in the longitudinal direction of the tool and in the transverse direction.

Longitudinal cracks spread through the entire roll. If at least one of these cracks is detected, it can be assumed that there is at least one crack in the roller. Such cracks occur when the force required to deform the wire is greater than the strength of the wire material and its casing. In some cases, it is necessary to redesign the roller or change the compression volume of the deforming workpiece. In addition to the strength of the wire material, the strength of the frame is a very important feature in resisting this type of cracking.

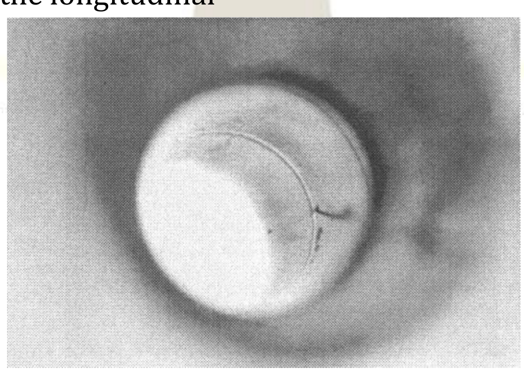

Figure 3. Longitudinal cracks

The boundaries of longitudinal cracks (Fig. 3) are often jagged and have small cracks along their edges. The reasons for the occurrence of longitudinal cracks are as follows:

1. formation of excessive stretching force;
2. deviation of the processed workpiece parameters from the requirements;
3. failure to meet the operating voltage requirements;
4. non-compliance of cooling-lubricating fluids with specified requirements;
5. non-compliance of the actual size diameter of the rollers with the requirements;
6. the presence of defects in the microstructure of the hard alloy;
7. non-compliance of the structural dimensions of the die channel with the requirements.

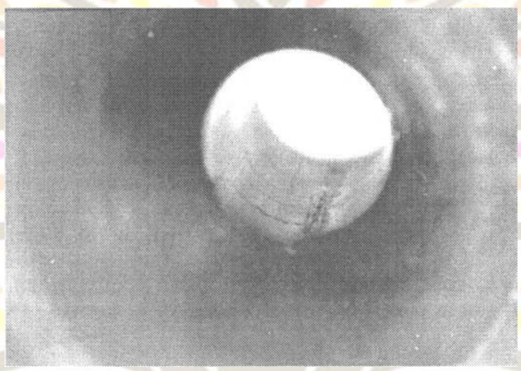

Figure 4. Transverse cracks

Transverse cracks (Fig. 4) are caused by tensile stresses. Due to cracks on the inner surface of the roller, changes in stress values begin, which leads to the erosion of the conical part of the roller. Because such cracks appear on the surface of the inner cone, it is difficult to detect them in the initial stages. If such cracks are not prevented, it can lead to complete failure of the roller. The reasons for the occurrence of transverse cracks are as follows:

1. the service life of the rollers is broken;
2. the presence of a defect in the microstructure of a solid alloy;
3. when there is a defect in the wire (size, when disconnected wires are welded together, etc.).

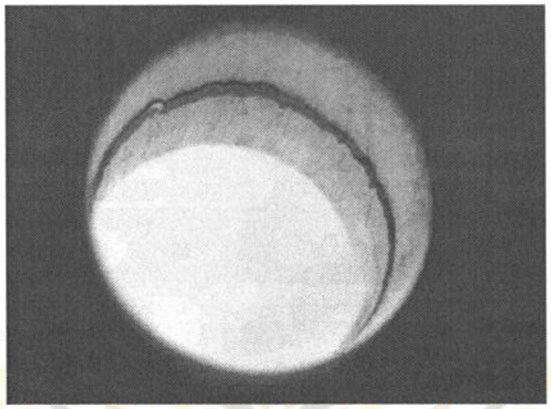

Figure 5. Eating in a circle

Circumferential wear of the roller part (Fig. 5). Usually, corrosion around the working part of the roller is formed in the roller in the early stages of its operation. The reason for the appearance of corrosion is explained by the fact that the voltages that arise when the wire passes through the entrance of the wire are increased to a very high level. Circumferential wear is present in almost every worn die. Its appearance is explained by the presence of a soft cobalt phase and excessive stresses caused by the size and vibrations of the wire entering the coil.

With the appearance of circumferential wear, irregularities in the form of steps with a larger angle appear at the beginning of the contact surface, and the "ring of wear" formed around the circumference causes the penetration of cooling-lubricating fluids into the friction surface prevents.

The reasons for its appearance are as follows:

1. parameters of cooling-lubricating fluids do not meet the requirements;
2. uneven distribution of cobalt content in the solid alloy;
3. geometric dimensions of the working part of the wire mesh do not match the requirements.

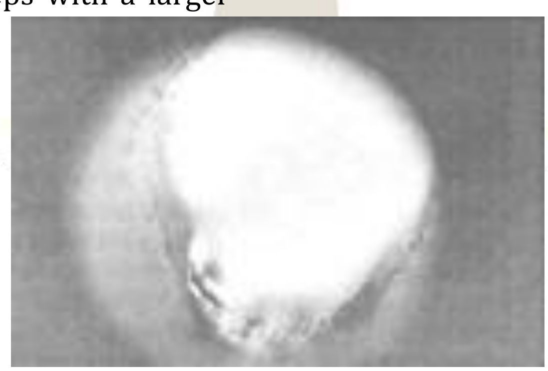

Figure 6. Unilateral defect

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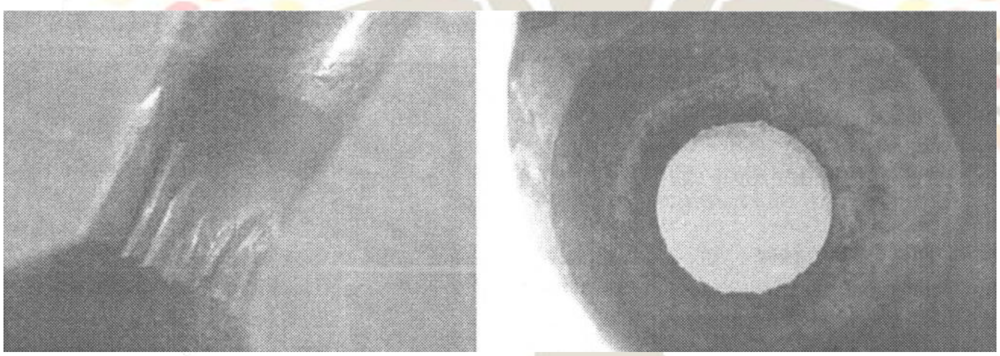
A one-sided surface defect looks like a smooth surface and has a "non-uniform" shape in the cross-section of the central hole and the working cone (Fig. 6). The exact symmetry of the workpiece is lost or broken. This corrosion is determined by the chemical interaction between the wire material and the wire material. Also, since this is a chemical process, additives or elements in the cooling-lubricating fluids can also have an effect. The wear on the rollers looks like a smooth but slightly uneven surface.

Solid carbide tungsten alloys are rarely chemically affected. However, the cobalt binder contained in it can be corroded by chemicals in coolants such as chlorine, fluorine, sulfur and nitrates. The reasons for this eating are as follows:

1. uneven distribution of cobalt content in the solid alloy;
2. symmetrical installation in the case;
3. symmetrical installation of the roller in the tool holder of the stretching machine.

Deep scratch of hard alloy part. Deep scratches extending in the direction of stretching of the wire spread along the entire length of the working area of the wire. Corrosion centres appear mainly in the middle of the working cone and are accompanied by scratching and tearing of the hard alloy (Fig. 6). The causes of deep scratches are as follows;

1. the presence of solid particles in cooling-lubricating fluids;
2. the presence of defects on the surface of the wire.



a b

Figure 6. Scratching. A) – the internal shape of the die; b) – view of the surface from the exit side

Obtaining solid alloys by the powder metallurgy method consists of the following sequential operations:

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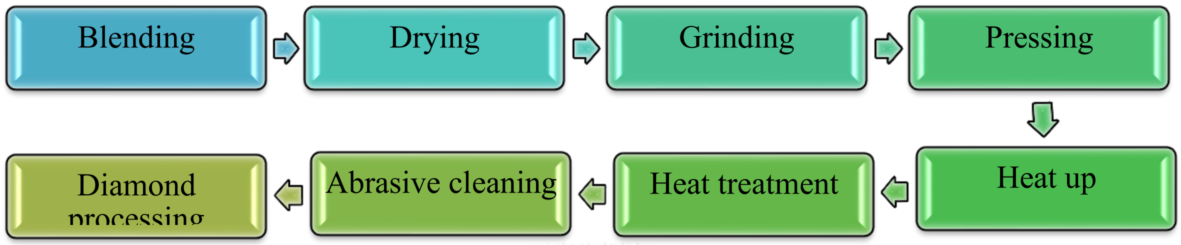

- production of tungsten and cobalt carbide powder oxides by reduction method; grinding and mixing tungsten and cobalt carbide powders in grinding machines to particles from 1 to 2 microns;
- if necessary, pass through a sieve and grind further;
- preparation of powder mixture according to the prepared alloy;
- adding glue and pressing to special stamp moulds corresponding to the shape and size of the product in hydraulic or mechanical presses;
- drying compressed products at a temperature from 80 °C to 130 °C;
- heating the workpieces in a hydrogen atmosphere at 1400-1500 °C. In this, cobalt melts and wets carbide powders, and when cooled, cobalt crystallizes and unites carbide particles. Glue burns at 800-850 °C.
- Carbide cuttings, if necessary, are processed with a diamond tool.
- To increase the eating properties, some types of products are covered with a coating that is resistant to eating [3].

Cobalt and tungsten carbide powders are used as the material of die workpieces for stretching tools. Table 1 below lists the brands and compositional properties of the main hard alloys used for the manufacture of rolls.

An important advantage of single-carbide wires over wires made of other materials is their high corrosion resistance, which makes them suitable for use in large wire drawing environments [4].

Table 1. Brands and structural characteristics of single-carbide hard alloy wheels

Brand	*WC, %*	*Co, %*	*sB, N/mm^2 not less*	*g, g/cm^3*	*HRC not less*
BK3	97	3	980	14.9-15.3	89
BK6	94	6	1180	14.6-15.0	88
BK8	92	8	1270	14.35	87.5
BK10	90	10	1380	14.25	87

RESULTS

Analyzing the brands and compositional properties of single-carbide hard alloy wheels means that with increasing tungsten content, we can see that the hardness of the material increases, but the strength limit of the material decreases.

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Table 2.

No	Sample mass				Eating		
	m_0	m_1	m_2	m_4	Δm_1	Δm_2	Δm_3
1	3,298	3,293	3,288	3,275	0.005	0.01	0.023
2	3,298	3,075	3,065	3,053	0.006	0.016	0.028
3	2,458	2,451	2,449	2,447	0.007	0.009	0.011
4	1,956	1,953	1,947	1,943	0.003	0.009	0.013
5	2,807	2,803	2,801	2,798	0.004	0.006	0.009
6	3,935	3,924	3,917	3,914	0.011	0.021	0.006

CONCLUSIONS

Experiments on increasing the wear resistance of hard alloy rolls show that a 2-fold increase in hardness results in a 1.5 - 2-fold reduction in the wear of the working tool during the stretching process. According to the results of this analysis, the diameter of the wire hole increases more resistance to a wire stretching without significant changes; creates an opportunity to increase the speed of stretching; increase the compression ratio; ensure the geometric dimensions of the stretched wire; achieve long-term operation of the roller without re-control during continuous stretching; it is possible to save the time spent on changing the stretching tool and increase the productivity of the stretching process by taking into account other factors.

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