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Scheme of Manufacturing the Seamless Carbide End-Milling Cutters and Elimination of Blank Curvature

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ABSTRACT: The greatest difficulty in the technological process of cutters manufacturing was caused by the production of blanks-columns with a given surface straightness. There is necessary to increase the allowance for machining due to the curvature of the surface of the rods. The study of the dependence of the curvature of the resulting parts on the curvature of the blanks was carried out

KEYWORDS: carbide end mill, extrusion, pressing, sintering, powder material, billet-column, rod curvature, rod shrinkage

1. INTRODUCTION

Technology of manufacturing the seamless carbide end-milling cutters includes production of blank, machining of blank and machining of products.

I. Preparation stage. Production of the blank consists of several stages:

-shaping of blanks of an axial tool can be done by pressing or by extrusion.

-extrusion is a more productive and more technologically advanced method of obtaining blanks. At the modern production of Uzbekistan, the technology of extrusion for metals is at the stage of development.

-pressing can be divided into several stages:

At the first stage, material (powder) is poured into the mold. The length of the obtained blanks is regulated by the amount of material in the mold [1, 2].

The second stage is characterized by the fact that with an increase in pressure caused by an increase in the resistance of particles to movement, most of them occupy a stable position

The third stage is characterized by a gradual weakening of the plastic deformation of the particles and the occurrence of fracture deformation. Crushing of the powder particles can take place at this stage.

- Sintering of blanks.

Sintering of powder materials is a heat treatment of loosely poured powder or pressed blanks at a temperature of 0.7-0.9 absolute melting temperature of the powder metal, in this case the temperature of cobalt [3].

2. Stage of machining of blanks of carbide cutters:

- rough grinding of external surfaces;
- semi-finishing grinding;
- grinding of ends;
- processing of chamfers;
- finishing grinding

3. Stage of machining of products:

- grinding of constructive elements of end-mill.

4. Stage of deposition.

5. Stage of testing.

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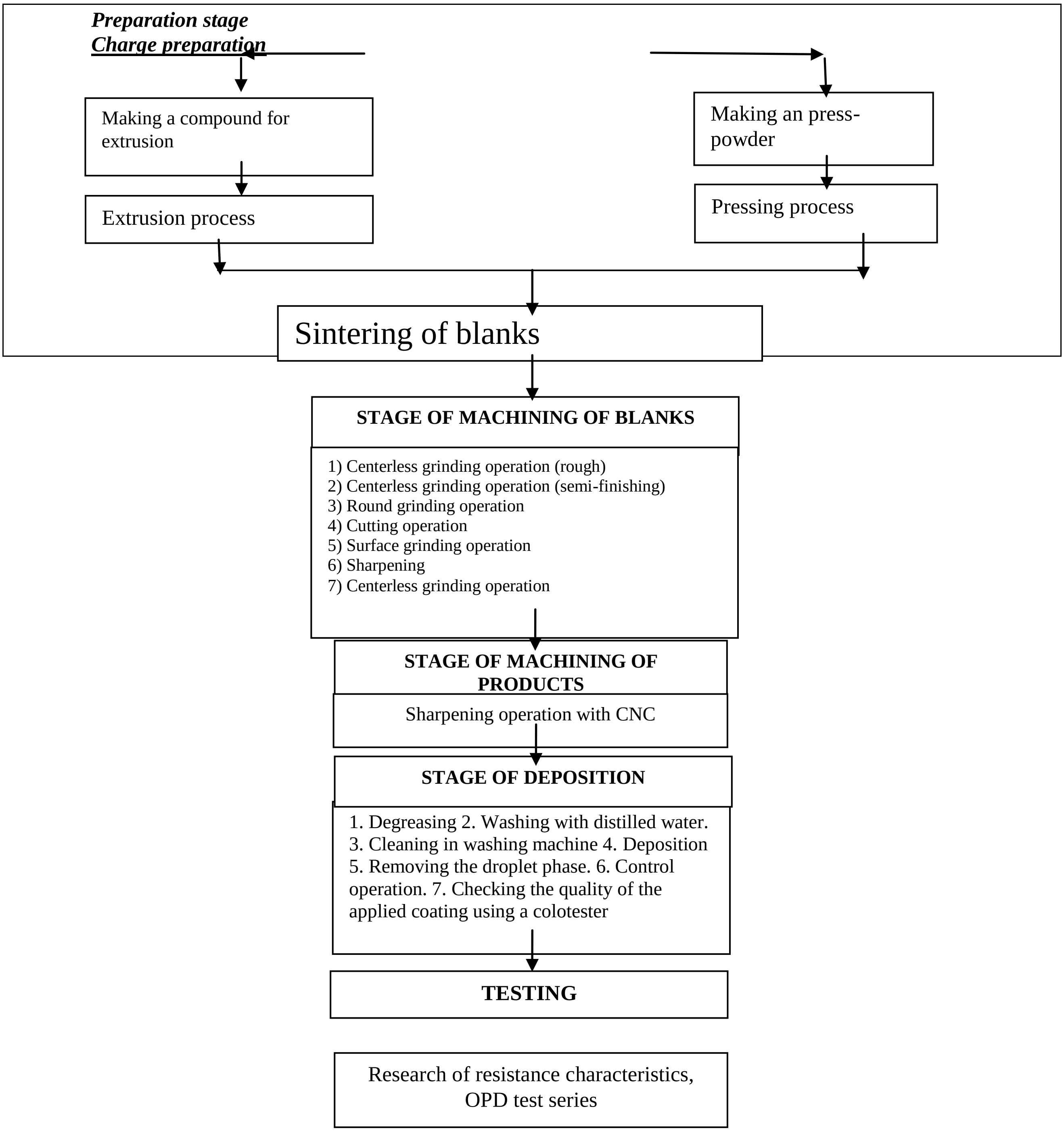

II. MATERIALS AND METHODS

Study of the dependence of the curvature of the obtained parts depending on the curvature of the blanks was carried out. The rods were ground on centerless grinding machines. Recommended ranges of cutting conditions have been experimentally identified.

For comparative tests, blanks of Ø5, 6, 8, 10, 12 mm, L = 300mm were taken.

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The rods are made of VHS11 grade alloys - submicron hard alloys, which designed specifically for the manufacture of end-mills that require high strength and wear resistance of the cutting edge.

Table 1
Material characteristics

Characteristics	**Material**
	VHS11
alloy composition,% mass	WC8 – 44.2; WC8(72h) – 31.3; WC8(144h) – 13.4; WCnano – 0.5; CO – 10.0; CrC2 – 0.6
density, g/cm3	14.43
grain size of solid phase, micron	0.6 – 0.8
coercive force, Oersted	187
bending strength, MPa	≥ 3300
hardness on Rockwell, HRA	90.5
crack resistance, MPa*m (1/2)	12.0 – 15.0

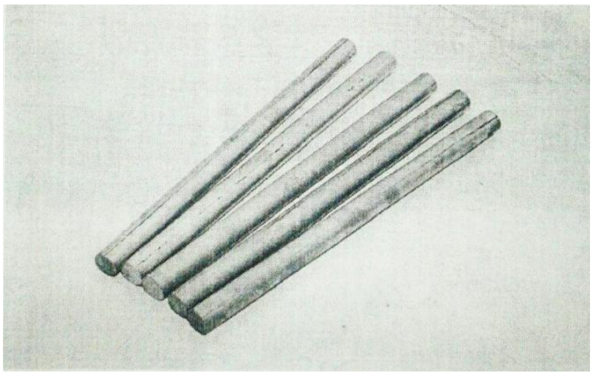

Fig. 2. Blanks after sintering

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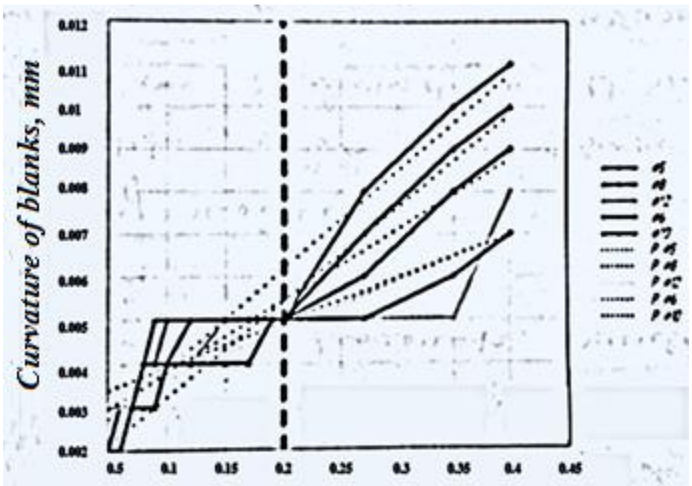

Fig. 3. Graph of dependences of the residual curvature of the rods on curvature of the blank

The greatest difficulty was caused by the manufacture of rods with diameters up to 5 mm. since it was necessary to technologically provide a deviation from straightness of 5 microns. During sintering, the plasticizer is removed and the rods shrink. Some of the rods are warped during sintering. After sintering, the curvature of the rods is checked using a dial indicator. Next, the rods are sorted into groups by diameter and curvature. The purpose of this and the previous operation is to avoid breakage of the rods during grinding on the pass due to their curvature and large allowance.

To obtain stable dimensions on the product, it is necessary to stabilize the temperature regime of the semiautomatic device before work by turning on the machine at idle speed for at least 30 minutes.

From the graphs in Fig. 2 and Fig. 3 we can see that in the end, only with the curvature of the blanks less than 0.2 mm, it is possible to provide the required straightness value for rods of any diameters. Rods large in diameter can also have a greater curvature, but in this case during processing, large shock loads occur, which lead to intense destruction of the grinding wheel. The empirical dependences of the residual curvature of the rods on the curvature of the blanks are obtained.

The curvature of the blanks after sintering was measured using a set of probes.

After final machining, the residual curvature of the rods is measured using a tripod and a dial indicator 1 MIG-1 type.

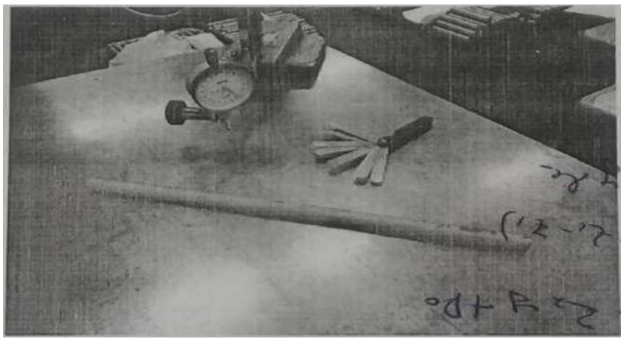

Fig. 4. Measuring the curvature of blanks

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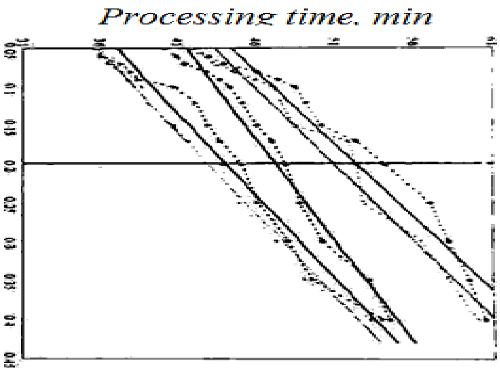
The curvature of the blanks significantly increases the machining time. This is because of the need to reduce the allowance removed per pass and to increase the number of spark-out passes. The graph shows the dependence of the processing time on the curvature of the blanks.

In some cases, the time increases by one and a half. From the tests carried out, the optimal processing time for carbide rods was revealed.



Curvature of the blanks, mm

Fig. 6. Graph of dependences of processing time on curvature of the blanks.

III.RESULTS AND DISCUSSIONS

The tabular data were approximated by the least squares method with a polynomial of degree 1, while the regress function was used for the polynomials. The interpolation function is built using the standard inter function.

Example of approximation for rod 5.

$$y1 := \begin{pmatrix} 41.95 \\ 42.95 \\ 43.94 \\ 46.03 \\ 47.38 \\ 48.43 \\ 49.13 \\ 50.18 \\ 52.32 \\ 54.13 \\ 56.95 \\ 58.12 \\ 59.45 \\ 60.45 \end{pmatrix} \quad x := \begin{pmatrix} 0.05 \\ 0.06 \\ 0.07 \\ 0.08 \\ 0.09 \\ 0.1 \\ 0.12 \\ 0.15 \\ 0.17 \\ 0.2 \\ 0.25 \\ 0.3 \\ 0.35 \\ 0.4 \end{pmatrix}$$

$$R1 \begin{pmatrix} 3 \\ 3 \\ 1 \\ 41.791 \\ 52.861 \end{pmatrix}$$

Analysis of reason for the deviation of blanks from straightness is carried out. It was found that the curvature of the blanks significantly depended on curvature of substrates on which the blanks are sintered in vacuum-

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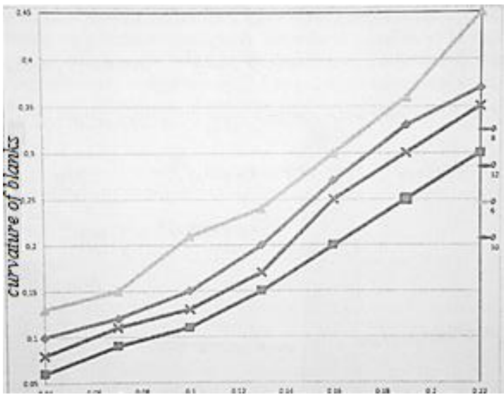
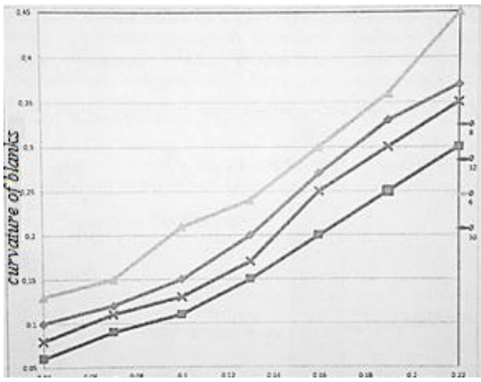
compression furnaces. Initially, the substrates were multi-site and were manufactured according to the following KTM.296229.028 drawing. Attrition of substrates was not controlled and could reach up to 0.1 mm



Deviation from the flatness of the tooling surface, mm

Fig. 7. Graph of dependences of curvature of blank on deviation from the flatness of the stand



Deviation from the flatness of the tooling surface, mm

Fig. 8 Graph of dependences of curvature of blanks on 0.1 deviation of the flatness of the substrate

Graph shows the dependences of curvature of the rods on deviation of substrates from straightness, from which it can be seen that the curvature of the substrates should not exceed 10 ... 20 microns. We proposed to change the design of substrate. The first drawing shows the old structure, the second a new one. The requirement for the straightness of the reference surfaces is sharply increased.

Nevertheless, practice has shown that the curvature of the rods does not always depend only on the curvature of the substrates. Two reasons have been established, on which it could happened. Firstly, due to insufficient rigidity of the tooling, which was deformed when it was installed in the assembly before being put into the oven? Secondly, due to the dragging of the tooling at a high sintering temperature. It was proposed to increase the rigidity of the tooling. Structure that is more rigid is shown in the third drawing. Because of the use of new equipment, it was possible to reduce the curvature of the rods to 0.1 mm. After sintering, rods are tested to determine their physical-mechanical characteristics (Appendix 1).

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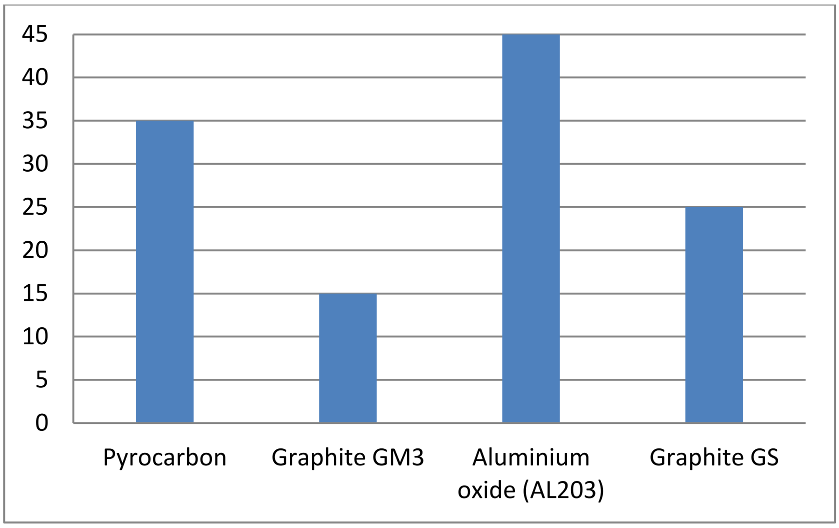

Fig. 9. Graph of dependences of tool life on material.

IV. CONCLUSION

The attrition of tooling occurs quickly due to the high sintering temperature and shrinkage of the rods (makes 20% and more). The tooling, the curvature of which became more critical, was considered attired. Research of service life of the tooling was carried out depending on type of used graphite. It can be seen from the diagram that the tooling made of graphite G5 shows the best resistance. However, it is expensive, and GM3 was recommended. The tooling can be protected from attrition by using various covering. Such studies were carried out with the deposition of aluminum oxide. They showed good efficiency, but the covering turned out to be short-lived. It is planned to carry out a study with the application of covering, for example, pyrocarbon, which has better adhesion with graphite.

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