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SHAPING AND RELIEVING OF MILLING CUTTERS BY THE ANODE-MECHANICAL METHOD

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/Figures are appended./

Cutting and grinding of tools by the anode-mechanical method is already being practiced at a number of plants. However, because of the lack of experience in working interrupted surfaces by the anode-mechanical method, concern has arisen as to the possibility that working on the cutting edge of a tool where the greatest current intensity is concentrated might destroy the cutting edge.

Experimental work was done on a milling machine having a converted spindle (see Figure 1). The new spindle has current pick-up rings and is adapted for securing the tool (i.e., the disk-cathode) to it.

The attachment for rotating the cutters (see Figure 2) is set according to the number of teeth; for achieving a spiral movement of the cutters a rocking device secured by a spring to a stationary support has been used. The milling cutter to be shaped and a profile cam are installed on the same shaft to assure movement according to the required profile. Rotation of the cutter is accomplished by hand through a pilot wheel. Profile disks of steel and cuprite are used for the tool-cathode. All other apparatus and the emulsion are the same as those used in conventional anode-mechanical cutting and grinding.

Profile templets and micrometers were used as checking tools in conducting the experimental work.

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As a result of experiments in shaping flat models, it was established that maximum metal removal takes place at 18 volts, 40 amperes. Correct shape and finish of the recess being worked is achieved at 14-16 volts, 15-20 amperes. When the volt-ampere conditions used in grinding and finishing are lowered, wear on the disk-cathode is negligible and the width of the recess differs only slightly from the thickness of the disk-cathode.

Experiments in shaping convex and concave disks almost completely confirmed the results of the first test. They further demonstrated the possibility of obtaining sufficient precision and surface quality when working on rotating work pieces.

After completing work on models, experimental work was conducted on profile mill blanks. Structural steel was used for the mill and cuprite for the disk-cathode.

An attachment with a master form was used for conducting the experiment. The disk-cathode was notched for better entrance of the emulsion (see Figure 3).

When operating with the master form attachment the impacts of the disk-cathode against the mill blank were observed. At the moment of impact, an intensive sparking took place in the electrode gap; at the same time the current intensity increased sharply to 50-80 amperes, while the voltage dropped approximately 15-20 percent below the voltage of the idling generator. Current impulses gave intensive metal ejection and a rough surface was obtained on the work piece, although there was no evidence of wear on the disk-cathode.

This experiment established the fact that interrupted anode-mechanical shaping of a work piece is fully possible and that the electrokinematic system used was satisfactory for the conducting of experimental work.

In the course of further work, it became necessary to arrange for smooth rotation of the work piece and its impactless contact with the disk-cathode.

In the direct-current circuit, the installation of a ballast rheostat is desirable to prevent excessive sparking under the current impulses.

For an experiment in the shaping of high-speed steel, a 60-millimeter mill of that material was selected. The disk-cathode tool had a diameter of 51.30 millimeters. During the experiment the profiles of the cutter and the disk-cathode were checked for clearance by means of profile-mating templates. A clearance of 0.02-0.03 millimeter was observed. The surface of the miller which had been worked answered the finish requirements of classes $\nabla\nabla 4$ and $\nabla\nabla 5$. The disk-cathode, when checked with a micrometer, showed no apparent wear.

The same experiment was conducted on a concave mill. The results were analogous to those indicated above.

From these experiments the following conclusions can be drawn:

1. The profiling and relieving of blades on high-speed-steel profile mills by the anode-mechanical method is fully possible.

2. Precision of profile within ranges of existing tolerances can be achieved.

3. Surface finishes answering to Groups II-III under GOST 2789-45 and 2940-45 are obtainable.

4. Anode-mechanical working of profile mills is economically expedient. Machining time on a 50-60-millimeter 12-blade mill is 10 minutes.

50X1-HUM

5. The recommended electrical conditions are 10-18 volts, 5-60 amperes.

Working characteristics at a number of time points during the process should be described. At the moment of contact between the work and the disk-cathode, a shower of sparks is ejected from the electrode gap both in the direction of disk rotation and in the opposite direction. During the initial moment the current suddenly increases to 80-100 amperes, then falls to 10-20 amperes, and finally to zero as the master form separates the work from the disk-cathode. The voltage falls rapidly as the current is rising, and then comes up to its minimal value, i.e., 2-3 volts below that of the idling generator (for electrical machines [sic]).

During final finishing, a small amount of weak yellowish sparks is ejected at the moment of contact between the work and the disk-cathode. The current rises to 20-30 amperes, thereafter dropping suddenly to 5-7 amperes and then to zero as the work leaves the disk-cathode. At the same time the voltage decreases 3-4 volts and then rises to its rated value for the operating speed of the generator.

The greater the rake angle of the back of the tooth, the slower must be the rotation of the mill. The rate of rotation should be somewhere between 20-50 revolutions per minute.

Shaping and relieving milling cutters equipped with metal-ceramic hard-alloy blades includes the operations of deep roughing, grinding, and finishing. The first operation of roughing the cylindrical part of the mill and relieving are performed with a smooth cylindrical disk. In the second operation the curved part of the mill profile is worked and relieved with a shaping disk. In the third operation the final profile of the tooth is worked and the mill is relieved until the required surface finish is obtained.

At the moment of contact between the tooth of the mill and the disk-cathode, current impulses reaching 60-80 amperes occurred, while the voltage fell off 5-8 volts. The metal-ceramic blade was destroyed by so powerful a current; to correct this situation, the amperage was reduced.

The surface finish, dimensional accuracy, and other characteristics obtained were almost exactly the same as those achieved in working mills of high-speed steel.

The following conclusions can be drawn from the experiments conducted:

1. Mills having metal-ceramic hard-alloy blades can be shaped and relieved by the anode-mechanical method; however, as shaping under large allowances (i.e., relieving the body of the mill) is an operation of low productivity, it is necessary to supplement this phase of the operation by mechanical methods. Final shaping and relieving of mills by the anode-mechanical method is a simple and productive operation, while working with abrasives is extremely difficult.

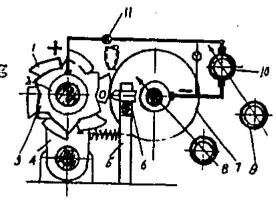
2. The anode-mechanical process assures the necessary dimensional accuracy, surface finish, and economic expediency. A cuprite disk-cathode should be used for the tool.

3. The recommended electrical regime is 10-16 volts, 5-40 amperes.

In shaping and relieving mills anode-mechanically, the following conditions are recommended: peripheral speed of the disk-cathode, 4-8 meters per second; rate of mill rotation, 5-10 revolutions per minute during grinding and 20-40 revolutions per minute during finishing.

Shaping and relieving of profile mills having hard-alloy blades opens new possibilities for the introduction of high-speed profile milling.

1. Mill
2. Current pick-up ring
3. Master form
4. Pendulum
5. Support
6. Master form pawl



7. Disk-cathode
8. Electric motor spindle
9. Electric motor generator
10. Generator
11. Emulsion nozzle

Figure 1

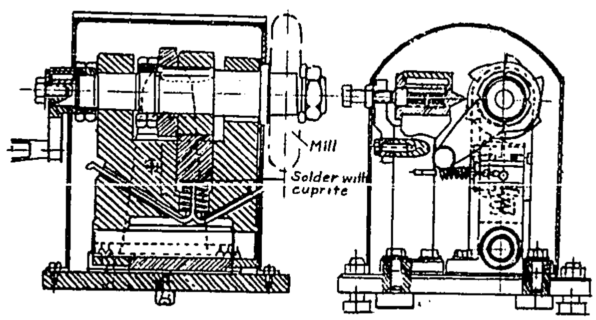


Figure 2

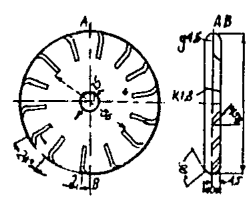


Figure 3

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