UNIVERSAL ACTIVE MONITORING INSTRUMENT
FOR PLANE-CUTTING MILLS

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UDC 531.714.2 : 621.924.2

The measurement of the dimensions of parts being machined on plane-cutting mills occurs under the following specific conditions. The machined surface in the majority of cases is discontinuous, with the extent of lands and cuts in the surface varying from several millimeters to several meters. This surface is moved under a measuring tip at a rate from 1 to 50 m/min, with the rate possibly changing during the course of a single machining cycle. The time of passage of a projection of a part (or a groove in the surface) under the measuring tip is from 0.005 to 30 sec.

Machined parts are moved either in one direction or back-and-forth and are situated in an arbitrary manner on the table of the mill.

Instruments of well-known types [1] — those having wide measuring tips, measuring certain parts with sequential stopping of the measuring tip, and having damping of the measuring tip or the output signal — do not satisfy requirements arising in connection with the conditions mentioned.

The Bureau of Interchangeability has developed a universal instrument [2] permitting elimination of the effects of the above-mentioned factors on the measurement process. The instrument is equipped with a friction braking mechanism holding the measuring lever in a position corresponding to the greatest dimension of the monitored part, and a locking (interrogating) device recording the signal (dimension) in a readout-command device.

Figure 1 shows the instrument schematic. The instrument's measuring lever 1 is hinged with strip 4 held from translation by means of spring 20, lever 2 and heels 3 and 5. Spring 20 is regulated such that in the absence of a part under the measuring tip 22 lever 1 is not lowered. If the height of a part is greater than the distance of the tip 22 to the plate, lever 1 is lowered, and after sliding of strip 4 between heels 3 and 5 remains in a position corresponding to the dimension of the part.

For repeated measurement a pneumatic arrester 19 is provided. On delivery of compressed air from a programming device (command apparatus 14) the arrester rod deflects lever 2; strip 4 is freed and measuring lever 1 under the action of spring 21 is let down. The upper end of lever 1 serves as a gate of measuring nozzle 7. The instrument indications are determined by the gap S between gate 6 and nozzle 7.

During machining compressed air under constant pressure $H = \text{const}$ is applied to the input nozzle 17 and flows into gap S. The measuring pressure $h$ developing in the chamber between the input 17 and the measuring 7 nozzles then depends on the size of gap S delivered through interlocking valve 8 to the readout-command device 9.

The instrument operating cycle is controlled with the aid of command apparatus 14. The command apparatus consists of an electric motor 13 on the shaft of which are mounted two cams 11 and 12 and two control nozzles 10 and 15. Air to the control nozzles is applied through input nozzles 16 and 18.

During machining of parts on the mill a discontinuous surface is moved under tip 22. The shaft of command apparatus 14 rotates at a constant speed and for each shaft rotation two sequential commands are generated to control instrument operation. First cam 12 closes nozzle 15, the pressure under arrester membrane 19 rises, and the arrester rod moves and moves out lever 2, freeing strip 4. Measuring lever 1, under action of spring 21, sets down on the machined surface or into a groove. After a set time nozzle 15 opens, arrester 19 returns to its initial position, and spring 20 and lever 2 brake measuring lever 1. If measuring tip 22 goes down onto the machined surface, lever
1 is fixed in this position. If measuring tip 22 goes down into a groove of the surface, then during its motion a land of the part raises it. After a given time control nozzle 10 opens, the pressure under membrane valve 8 falls, and as a result of valve operation the measuring chamber is connected with readout device 9, which records the dimension of the machined parts. The measurement cycle is repeated for each turn of the shaft of command apparatus 14.

Figure 2 shows a cyclogram of instrument operation. The cycle begins with closure of control nozzle 15 (see Fig. 1), operating arrester 19 and braking the measuring lever. After braking the lever can be raised by projections of the parts, before which interlock valve 8 operates.

The time $T$ of one measurement cycle is

$$T = 2t_1 + t_2 + t_3 + 2t_4 + t_5 + t_6,$$

where $t_1$ is the time to operate and lower the arrester; $t_2$ is the time of the free state of the measuring lever; $t_3$ is the lever lift time; $t_4$ is the valve switchover and closing time; $t_5$ is the open state time; $t_6$ is the interval between the connection of arrester 19 and valve 8.

For plane cutting the magnitude of $T$ is most affected by the component $t_3$, which is approximately equal to $0.9T$. For time $t_3$ at least one part must pass under the instrument's measuring tip. Therefore $t_3$ should be greater than the time of passage of the largest surface discontinuity (for least table speed) under the instrument's measuring tip.

An increase of $t_3$ and $T$ affords an increase of instrument life.

In order to lower the machining error during time $t_3$, at the final stage (for example, during pull-through) minimum margin should be removed. Pull-through on plane-cutting mills having a vertical spindle and continuous feed is accomplished with 3-5 turns (passes) of the table for a time interval of no less than 10-15 sec. For these mills $T$ is taken equal to 6-8 sec. For mills having a horizontal spindle and periodic feed the pull-through time is a order greater and $T$ is 15-20 sec. These cycles satisfy the majority of cases encountered in practical machining on plane-cutting mills.

In the design shown for the mechanism the instability of the recording of the position of the measuring lever does not exceed 0.8 $\mu$ for multiple measurements.

The described principle was used to develop the BV-4066K instrument, which has the following technical characteristics: measurement limit from the table surface 400 mm; measurement limit along the scale 0.24 mm; scale division 0.002 mm; greatest tolerance of machined parts 1.2 mm; speed of translation of monitored parts.