INCREASING THE RESOLVING POWER OF INSTRUMENTS FOR MEASURING DIAMETERS USING A ROLLING ROLLER

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INstruments with a rolling roller are used for measuring large diameters of objects (more than 500 mm). The resolving power of these instruments is directly proportional to the resolving power of the roller angle of rotation converter and the measuring time.

The resolving power and rate of measurement can be raised without increasing the resolving power of the roller angle of rotation converter if it is taken into account that the measured object rotates at constant speed.

The functional diagram of such an instrument is given in Fig. 1 and, its time diagram, in Fig. 2.

When measuring roller 1 rotates, the information on its angle of rotation reaches the information input of the first pulse signal counter 5 and input of control block 4 in the form of pulses a from angle of rotation converter 2 which is kinetically linked with roller 1. Pulse b from the counter of the number of revolutions of object 3 also reaches the input of control block 4.

The control block 4 outputs are connected to the control inputs of second 6, third 7, fourth 8, and fifth 9 pulse counters. Pulses from timing generator 11 reach the information inputs of these pulse counters. Outputs of counters 5, 6, 7, 8, and 9 are connected to diameter computer 10, the control input of which, is connected with control block 4.

The operation of control block 4 is so organized that the following information is recorded in the counters during a single or several rotations of the object:

in counter 5 – number of pulses N arrived from angle of rotation converter 2 in a complete rotation of the object;

in counter 6 – number of pulses \( b_1 = t_1 f_g \) corresponding to time \( t_1 \) between start of a complete rotation of the object and arrival of the first pulse from angle of rotation converter 2;

in counter 7 – number of pulses \( c_1 = T_1 f_g \) corresponding to time \( T_1 \) between two pulses from angle of rotation converter 2 at the instant a complete rotation of the object starts;

in counter 8 – number of pulses \( b_2 = t_2 f_g \) corresponding to time \( t_2 \) between the last pulse from angle of rotation converter 2 within the limits of a complete rotation of the object and the end of a complete rotation;

in counter 9 – number of pulses \( c_2 = T_2 f_g \) corresponding to time \( T_2 \) between two pulses from angle of rotation converter 2 at the instant a complete rotation of the object ends, where \( f_g \) is the timing generator 11 frequency.

The perimeter \( P \) of the object can be considered as sum of segments as follows:

\[ P = \ell_1 + L + \ell_2, \]

where \( L \) is the path traversed by the roller in its rotation by angle \( (2\pi/k)(N - 1) \); \( k \) is number of pulses generated by the angle of turn converter in one rotation of the roller; \( \ell_1 \) and \( \ell_2 \) are paths tranversed by the roller in time \( t_1 \) and \( t_2 \).
With linear velocities of rotation of the object $V_1$ and $V_2$ in time intervals $T_1$ and $T_2$ being constant, its diameter can be determined by the formula

$$D = P/n = (d/km)(N-l_1+l_2/T_1+l_2/T_2)$$

or through the contents of the counters

$$D = (d/km)(N-l_1+b_1/L_1)+b_2/L_2.$$

where $d$ is roller diameter; $m$ is the number of rotations of the object used for measuring diameter.

In realizing an instrument based on this principle, instead of the error due to the ultimate resolving power of the converter equal to $\delta_1$(4)

$$\delta_1 \leq 2(d/km),$$

two new components appear in the total composition of the error in measuring the diameter. These are, $\delta_1$, which is the error due to inaccuracy in measuring time intervals $t$ and $T$ and, $\delta_2$, which is the error due to variability of rotational speed in time intervals $T_1$ and $T_2$.

Using the positions of the theory of indirect measurements as applied to methods of digital processing of a signal [3], it is not difficult to show that

$$\delta_1 \leq (kd/m)(d_0+2/c),$$

where $d_0$ is relative instability of the timing generator frequency; $c$ is minimum capacity of the counters which is used for determining time intervals $T_1$ and $T_2$.

For instance, the error $\delta_1$ does not exceed 0.003 mm for $d_0 = 10^{-5}$, $c \geq 10000$ (this is simply realized on today's element base of microelectronics), $d = 60$ mm, $k = 20$ pulses/revolution, and $m = 1$ rotation. This is confirmed by the experimental investigations.

The error $\delta_2$ is caused by radial plays in the measured object, fluctuations in supply voltage, and inaccuracies in making the lathe components, etc. These cause fluctuations in the linear velocity of rotation $V(t)$.

Assuming $V(t) = V_0 + at$, where $V_0 = \pi d/kT$ is initial velocity; $a = \partial V/\partial t$ is acceleration, we get