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DEFINING THE GEOMETRICAL ACCURASY OF INSTRUMENTAL DATUM SURFACES OF CNC LATHES *

The quality of instrumental datum surfaces is important for assuring the requirements to the machined parts and longevity of the cutting tools. The real conditions of the instrumental datum surfaces are different from the theoretical ones due to the inaccuracies during their production, due to their exploitation, and as a result of their damage after collisions. Suggested is a method for evaluating the real position of the datum surfaces and a methodology for their definition.

Key words: *Turning tools, Setup of CNC Lathes, CNC accuracy.*

Under the conditions of high-variety production a significant portion of the preparatory time is devoted to setting up of the instrumental equipment due to the requirements of their positioning along the X and Y axes in order to provide normal cutting process and ensuring the quality of the product [1; 2, p. 5, 16]. Setting up is connected with multiple measurement cycles; the most significant problems occur during set up of tools for machining holes: drills (especially with indexable inserts), reamers and others. In many cases it is necessary to disassemble and re-assemble the cutting tools and their tool holders in search of their best angular position. Quite often the results of poor set up become visible only after machining of the parts and measuring the deviation of the machined dimension or mutual position of the surfaces, often leading to scrapping the parts [4, p. 34]. If it is impossible to achieve the required position of the tool and to correct the non-parallelism of the axes of the spindle and the cutting tool it is necessary position the cutting tool in a different pocket of the turret. In some cases the only option is to control the position of the turret which requires the involvement of specialists, loss of several hours due to multiple measurement cycles, and checking and/or re-set up of already set-up cutting tools. The problem is exacerbated when for the machining of the part are required several hole-making cutting tools. All this leads to increased preparatory time of the equipment which, in case of high-variety production and depending on the batch size can be comparable or even higher than the actual machining time. If the positional errors of the datum surfaces are known in advance then it would be possible to select the ones with the least error which would lead to a minimised set-up time [2; 3, p. 834].

Further in the paper are investigated the central cylindrical instrumental datum surfaces (tool holders) because using cutting tools installed in them are connected to bigger difficulties during ensuring their positional accuracy relative to the spindle rotation axis.

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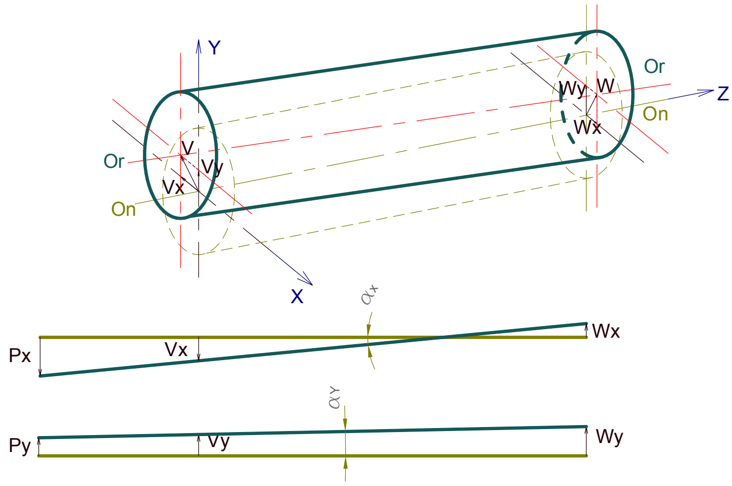

Fig. 1. Position of cylindrical tool holder

The nominal position of cylindrical tool holders is such that their axis O_n-O_n (nominal axis) coincides with the spindle rotation axis (Fig. 1). In reality, however, due to machining errors, wear, and inadequate control of the turret the real position of the axis of the instrumental datum surfaces is different from the nominal one: O_r-O_r (real axis). This leads to inaccurate positioning of the cutting tool and to the problems described above.

For describing the position of the axis are used vectors, connecting the nominal and real centres of the two end sections of the instrumental datum: at the front this is vector $\vec{V}$, and at the end– $\vec{W}$. Their projections on the axes X and Y are $\vec{V}_X$, $\vec{W}_X$, $\vec{V}_Y$ and $\vec{W}_Y$, respectively. In the figure are shown the real positions of the axis in both directions and the angle between it and the spindle rotation axis – α_X and α_Y, respectively. Under these conditions the dimension forming point of the tool is displaced relative to the spindle rotation axis in two directions by $\vec{P}_X$ and $\vec{P}_Y$. The direction of the vectors shows the direction of the displacement of the axis of the instrumental datum surface. The positive directions are accepted to be along the positive directions of the corresponding axes.

In order to define the actual position of the axis of the instrumental datum surfaces it is necessary to define its deviation from the spindle rotation axis. For this, using a controlling bar installed in the datum surfaces under investigation, the deviations in the X and Y directions are measured in the positive and negative directions, respectively, in two sections using the following methodology:

- installing the controlling bar into the cleaned datum surfaces;
- installing the measuring device: micrometric dial calliper or sensor for measuring linear displacements into a stand fixed to the spindle so that its tip is perpendicular to the cylindrical surface of the bar;
- measuring the distance between the two controlled sections (I and II) and between the face of the turret and section I;
- moving the measuring device to section I in the direction of +X;
- setting the measuring device to zero;
- three measurements and entering the data for this section along the axes +X, -X, +Y, -Y, respectively;
- moving the measuring device to section II without setting it to zero;
- measuring similar data in section II;
- analysis of the data;
- analysis in relation to the condition of the position and its usability;
- measuring the instrumental datum surfaces in the next turret position;
- if necessary re-setting the position of the turret;
- the measurements are repeated after disassembly and re-assembly of the turret.

Suggested is an algorithm for defining the geometrical accuracy of the cylindrical instrumental datum surfaces of CNC lathes; it is presented in Fig. 2.

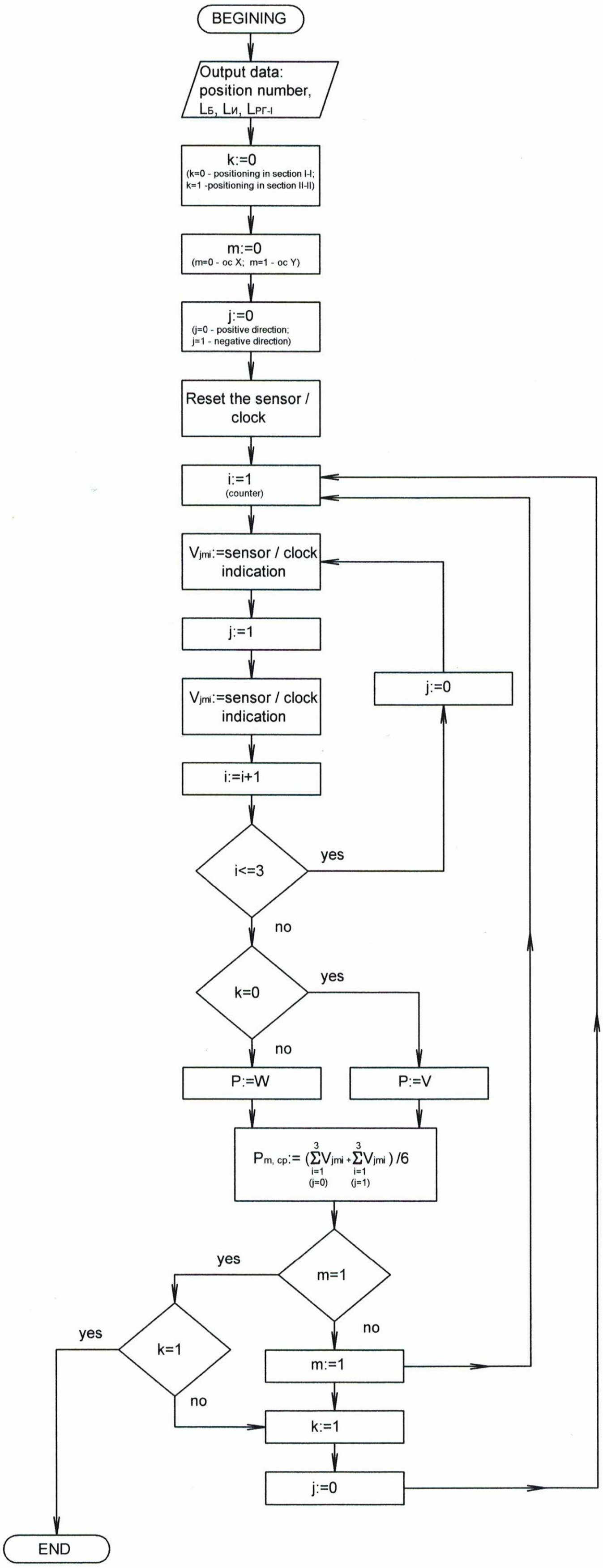

Fig. 2. Algorithm for defining the geometrical accuracy of the cylindrical instrumental datum surfaces of CNC lathes

In order to decrease the preparatory time it is suggested the construction of the equipment for controlling of the real position of the datum surfaces of cylindrical tool holders in CNC lathe turrets (Fig. 3). The controlling equipment consists of a measuring bar 1 installed in the measuring datum surfaces of the turret 5 with the help of conical bushings 4 and 6. Thus with the help of the bushings and the nuts stretching them 3 and 7 are ensured gapless assembly and copying the position of the cylindrical datum surfaces. Fixture is realised with the help of facially positioned relative to the nuts holes.

The measurements are performed by a stand and micrometric dial calliper (or sensor) 2 fixed to the machine tool. It is recommended that the measuring equipment has high accuracy with minimum accuracy 1μm or 0.1μm. Inspections are performed in two sections (I and II) along the directions of axes X and Y in the positive and negative directions, respectively which coincide with the positive and negative directions of the axes of the machine tool. For each axis and point three measurements are taken in order to minimise measurement errors. The two sections are at a distance L_B relative to each other (Fig. 4). Section I is at distance L_{TUR} from the face of the turret. The measured deviations are averaged and using them the real position of the axis of the datum surfaces in space are defined. It is done by finding the angles α_X and α_Y between the axis of the datum surface and the spindle rotation axis.

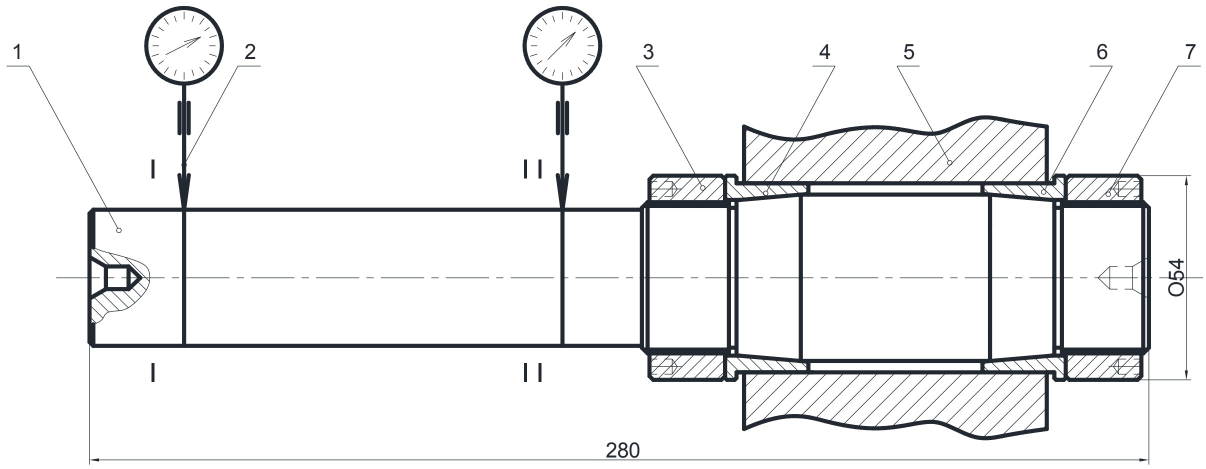

Fig. 3 Equipment for controlling of the real position of the datum surfaces of cylindrical tool holders

With the help of trigonometric relations it is also possible to find the intersection point between the axis of the datum surface and the spindle rotation axis. This would allow calculating the deviation of the dimension defining point of the tool in the position of the turret as a function of its length. It is also possible to define the deviations in two separate sections of the tool corresponding to the length of the machined hole which is important for dimensional tools like reamers.

In order to create technological documentation, reducing the number of measuring cycles and measuring errors electronic spreadsheets in Windows are created in MS Excel. It is necessary to enter (see Fig. 4) the following: the number of the controlled pocket (position), base length L_B – the distance between the two controlled sections in mm, distance L_{TUR} from the face of the turret to section I in mm, the measured deviations along the axes ±X and ±Y in two sections, and the length of the tool L_T that will be installed in this pocket. In order to reduce the measuring errors each measurement is performed three times in each position and the values are recorded.

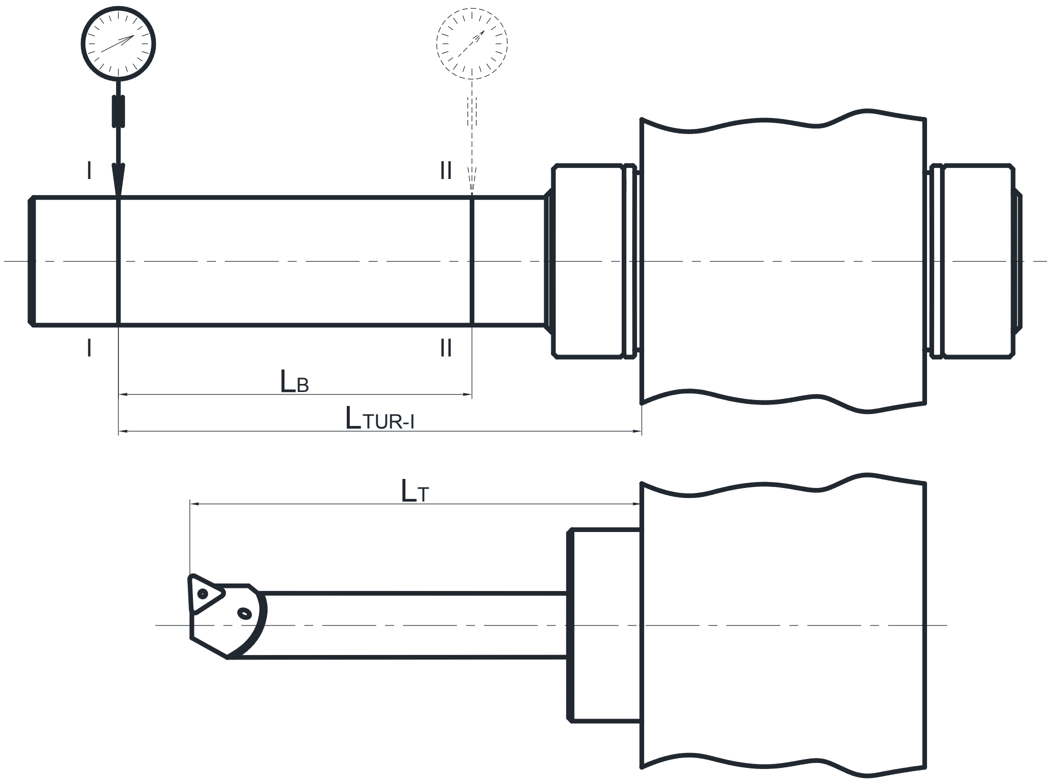

Fig. 4. Scheme of measurement

The vectors $\vec{V}_{X,middle}$, $\vec{W}_{X,middle}$, $\vec{V}_{Y,middle}$ and $\vec{W}_{Y,middle}$ are defined after which as mean square value the vector sums are defined in each section:

$$\vec{V} = \sqrt{\vec{V}^2_{X,middle} + \vec{V}^2_{Y,middle}}$$

$$\vec{W} = \sqrt{\vec{W}^2_{X,middle} + \vec{W}^2_{Y,middle}}$$

Then the angles between the axis of the datum surface and spindle rotation axis along the directions X and Y are defined:

$$\alpha_X = a\tan(V_{X,middle} - W_{X,middle}) / L$$

$$\alpha_Y = a\tan(V_{Y,middle} - W_{Y,middle}) / L$$

Using these values the deviations P_X and P_Y of the dimension-defining point of the cutting tool along the axes X and Y and the total deviation P are defined in μm.

It is important to note that after performing the initial measurements the only value to be entered is the length of the cutting tool relative to the face of the turret up to the dimension-forming point of the tool.

In cases where the machine tool is capable of being programmed parametrically and a sensor measuring linear displacements of a three-coordinate touch probe is used it is possible to feed the measured data directly to the machine tool where they are stored, analysed, and results are obtained for each pocket of the turret.

The existence of data for the accuracy of each instrumental pocket of the turret enables the correct selection of the pocket before setting up the cutting tool. It enables selecting the correct pockets (positions) for each cutting tool. For example, cutting tools for finishing operations can be placed in pockets with lower positional errors. The reduction in the preparation time leads to the decrease of the technological unit cost.

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ОПРЕДЕЛЕНИЕ ГЕОМЕТРИЧЕСКОЙ ТОЧНОСТИ ИНСТРУМЕНТАЛЬНЫХ БАЗИСНЫХ ПОВЕРХНОСТЕЙ ТОКАРНЫХ СТАНКОВ С ЧПУ

Качество инструментальных поверхностей материала важно для обеспечения требований к обрабатываемым деталям и долговечности режущих инструментов. Реальные условия инструментальных поверхностей материала отличаются от теоретических из-за неточностей при их изготовлении, из-за их эксплуатации, а также в результате их повреждения после столкновений. Предложены метод оценки реального положения опорных поверхностей и методика их определения.

Ключевые слова: *токарный инструмент, наладка токарных станков с ЧПУ, точность ЧПУ.*