STUDY ON THE SOLVING A CHAIN OF DIMENSIONS FOR THE MILLING MACHINES

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ABSTRACT: The works shows a possibility of solving the chains of dimensions on the basis of the statistic methods of calculus. The dimensions chains determining the parallelism of the axle of the mill- holding shaft of the horizontal milling machine to the flat surface for directing the device where both the fastening and orientation of the semiproduct are carried out.

KEYWORDS: milling machines, chain, dimensions, statistic method

1. Introduction.

The most commonly used types of milling machine are vertical and horizontal millers, vertical and horizontal referring to the plane of cutter's axe of rotation. Vertical axis is usually called face milling and horizontal milling is termed peripheral or slab milling, fig.1and fig.2, [5].

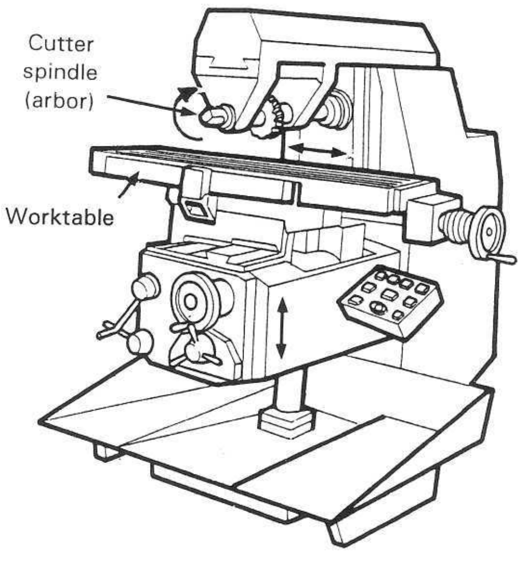

Figure 1. Milling machine – spindle horizontal.

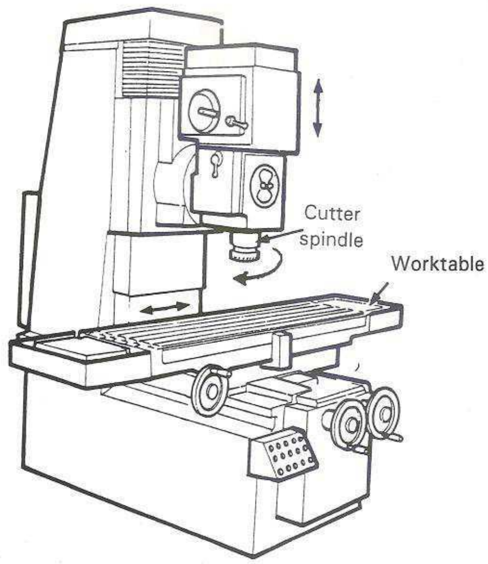

Figure 2. Milling machine – spindle vertical.

They shall analyze the solution of the dimensions chain determining the parallelism of the mill-holding shaft of the horizontal milling to the flat surface for directing the device where both the fastening and orientation of the semi-product are carried out, fig.3.

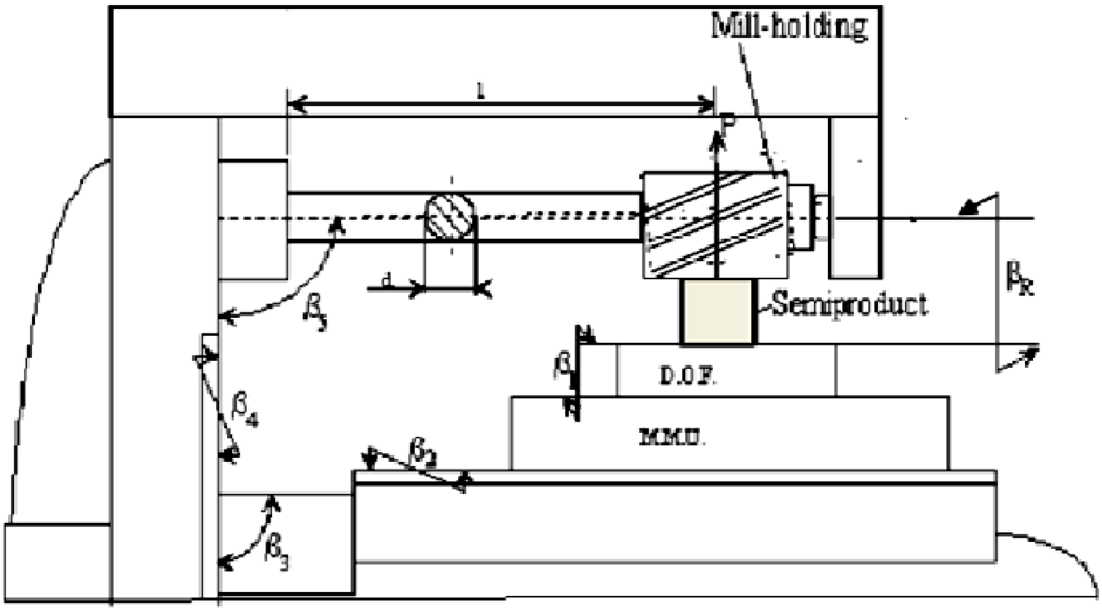

Figure 3.The chain of dimensions for milling machine – spindle horizontal.

The elements composing the chain of dimensions are the following:

β_1 - is the parallelism error of the orientation surface of the device designed for orientating and fastening the semi-product to the table of the machine-tool;

β_2 - non-straighteness of the guides of the machine table to the column;

β_3 - perpendicularity of the machine table to the column;

β_4 - non-straighteness of the guides of the bed;

β_5 - perpendicularity of the mill-holding mandrel to the machine column;

β_R - resultant element of the chain of dimensions.

The parallelism between the axle of the mill-holding mandrel and the plan orientating surface of the device, the resultant element of the chain of dimensions, shall be within a certain limit, so that, from the working operation shan't result rejected parts.

2. Solving the dimensions chain

Once the resultant element β_R is determined the parallelism of the surface A_1 and A_2 the part on the part width L_p or on a length taken as referential $L_{ref} = 300mm$, fig.3 [6]:

$A_{p1} = L_p \tan\beta_R$ deviation from parallelism reported to the part width.

In order to continue the calculation of each factor it is necessary to set a repartition for each factor. In this case we shall take the normal repartition for all the elements making up the dimensions chain. The calculus may be carried out as follows.

The dispersion of the elements $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ shall be [2]:

$$\sigma_{\beta_1} = \sqrt{\frac{T_1^2}{36}}, \quad \sigma_{\beta_2} = \sqrt{\frac{T_{21}^2}{36}}, \quad \sigma_{\beta_3} = \sqrt{\frac{T_3^2}{36}},$$

$$\sigma_{\beta_4} = \sqrt{\frac{T_4^2}{36}}, \quad \sigma_{\beta_5} = \sqrt{\frac{T_5^2}{36}}, \qquad (1)$$

The dispersion of the resultant element shall be calculated [4]:

$$\sigma_{\beta_R}^2 = \left(\frac{\partial\beta_R}{\partial\beta_1}\right)^2 \cdot \sigma_{\beta_1}^2 + \left(\frac{\partial\beta_R}{\partial\beta_2}\right)^2 \cdot \sigma_{\beta_2}^2 + \left(\frac{\partial\beta_R}{\partial\beta_3}\right)^2 \cdot \sigma_{\beta_3}^2 + + \left(\frac{\partial\beta_R}{\partial\beta_4}\right)^2 \cdot \sigma_{\beta_4}^2 + \left(\frac{\partial\beta_R}{\partial\beta_5}\right)^2 \cdot \sigma_{\beta_5}^2 \qquad (2)$$

Afterwards the standard deviation may be calculated and by this the tolerance of the
resultant element shall be determined, taking, for example, a field of $\pm 3\sigma$:

$$T_{\beta_R}^S = \pm 3\sigma_{\beta_R} = 6\sigma_{\beta_R} \qquad (3)$$

According to the proposed statistical method of calculus the reduction factor of the tolerance shall be calculated together with the tolerance increasing factor of the primary elements [3]:

$$r = \frac{T_{\beta_R}^S}{T_{\beta_R}^A} \qquad (4)$$

The new tolerance of the primary elements shall be then calculated by the relationships $T_n = m \cdot T_v$ and afterwards the testing calculus of the dimensions chain shall be made with the new provided tolerances.

Case study

For the above case the following practical example shall be taken:

A material type OLC 60 with $R_m = 75 daN/mm^2$ shall be worked by a cylindrical helicoidally mill with drill featuring itself by: d=80mm, t=B=80mm, z=14, reinforced by little plates with metallic carbides, P10.

The parameters of the cutting regime are the following: advance on tooth $S_d = 0{,}05 mm/tooth$, contact length $t_1 = 15mm$, $v_{as} = 90 m/min$.

The cutting force P = 650daN, and a force variation of ±20daN shall be taken.

The length in bracket of the mill-holding mandrel is l=300±3mm.

Mandrel diameter $d = 30_0^{+0,1}$ mm.

Mandrel elasticity module:

E=210000 N/mm^2.

The part width is $L_p = 15$ mm.

The primary elements have the nominal values: $\beta_1 = 0^0$, $\beta_2 = 0^0$, $\beta_4 = 0^0$, $\beta_5 = 90^0$

and tolerances reported to a reference length $L_{ref} = 300mm$:

$$T_{\beta_1} = T_{\beta_2} = \frac{0.008mm}{300mm}; \quad T_{\beta_3} = T_{\beta_4} = \frac{0.028mm}{300mm};$$

$$T_{\beta_5} = \frac{0.008mm}{300mm};$$

The minimum and maximum method:

The tolerance of the resulted element is:

$$T_{\beta_R} = T_{\beta_1} + T_{\beta_2} + T_{\beta_3} + T_{\beta_4} + T_{\beta_5} + T_{\beta_6};$$

$$T_{\beta_R} = \frac{0.080mm}{300mm}.$$

The statistical method:

Both the dispersions and square average deviations for the primary elements β_1, β_2, β_3, β_4, β_5 shall be calculated by using the relationship (1):

$$\sigma_{\beta_1} = \sigma_{\beta 2} = 13.333 \times 10^{-4} mm;$$

$$\sigma_{\beta_3} = \sigma_{\beta 4} = 46.666 \times 10^{-4} mm;$$

$$\sigma_{\beta 5} = 30,000 \times 10^{-4} mm;$$

The dispersion of the resultant element shall be determined by the relationship (2):

$$\sigma^2_{\beta_R} = 0.561096 \times 10^{-4} mm; \qquad \sigma^R_{\beta} = 0.00749mm$$

Afterward, taking a risk ratio of 0.27% the tolerance of the resultant element shall be calculated by using the relationship (3):

$$T^S_{\beta_R} = \pm 3\sigma_{\beta_R} = 6\sigma_{\beta_R} = 0,044mm / 300mm.$$

Taking into account the symmetrically distributed deviations the resultant element has the nominal value and the limit deviations like this:

$$\beta_R = 0 \pm 0,022mm$$

According to the proposed statistical method of calculus of the reducing tolerance factor of the resultant element end of the increasing tolerance factor of the primary elements they get:

$$r = \frac{T^S_{\beta_R}}{T^A_{\beta_R}}, \quad m = \frac{1}{r},$$

respectively: r=0,55

that means: m=1.81

The statistical calculus shows that is possible the variations (tolerances) of the primary elements of the chain be higher with approx. 45% and to get the same deviation from the parallelism when working the semi-product.

3. Conclusions

The calculus of the tolerance of the resultant element of the dimensions chain through the agency of the statistical method shall result in a less value that the value got by applying the minimum and maximum.

It is possible the primary elements of the chain have higher tolerances, the statistical calculus shows that is possible the variations (tolerances) of the primary elements of the chain be higher with approx. 45%, so that the value of the tolerance of the resultant element got by the new tolerances through the agency of the calculus by the statistical method be approximately equal to the tolerance of the resultant element, tolerance got through the agency of the minimum and maximum method under the conditions of the initial tolerances.

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