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A CRITERION FOR SELECTING CHARACTERISTIC DIMENSIONS OF A ROLLER VEE BLOCK

Key words

Shape errors, roller vee block, optimum criterion.

Summary

This article presents the results of analysis of cylindrical object centre displacements when the object is turning, supported in a roller vee block. These displacements result from the interaction between the element measured and permanent points of support. Limit values of these displacements were determined as well as the tolerance range of displacements expressed in the characteristic dimensions of the measuring system and the measured value of roundness deviation. Additionally, optimum selection criteria were defined for measuring system parameters from the point of view of the displacement range minimum.

Introduction

A typical method of basing cylindrical objects, particularly objects of large dimensions, consists in placing them in roller vee blocks. This method of mounting enables objects to be freely turned during the measurements of shape deviations and axis position.

For measurements to be accurate it is important to adequately select characteristic dimensions of elements making up the measuring system. The turn in a vee block causes displacement of an object supported in it. The displacement depends on the tolerance and limit dimensions, and the characteristic dimensions forming a measuring system. For a roller vee block, the characteristic dimensions are as follows: the diameter of the object measured, the spacing of rollers' axes, and the roller diameter. The optimum criteria should be used while selecting these dimensions. One criterion concerns defining the effect of the tolerance of characteristic dimensions on the limit values of the position and tolerance range of measured object centre displacements [1, 2]. The other criterion is connected with a displacement resulting from the interaction between the measured element and its permanent points of support.

The optimum criterion resulting from the interaction of the measured element with the permanent points of support.

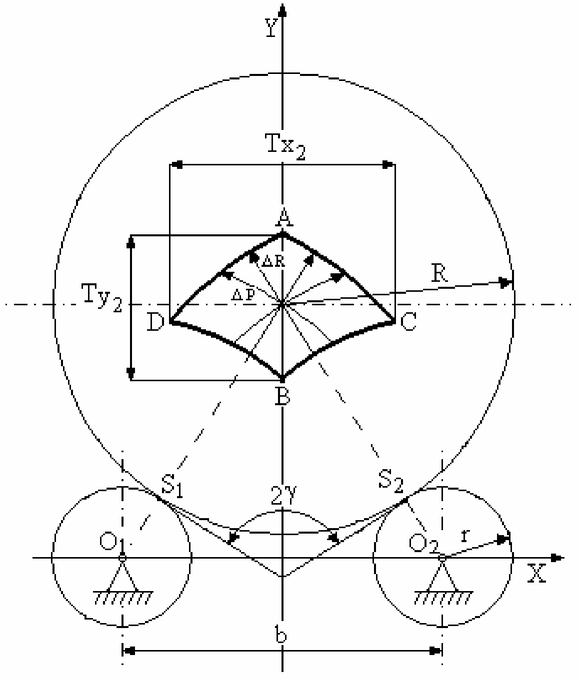

Fig. 1. Characteristic dimensions of a roller vee block with the object centre displacement range resulting from the interaction of the measured element with the permanent points of support

According to the diagram presented in Fig. 1, the displacement range of the centre of an object supported in a roller vee block, resulting from the interaction of the measured element with the permanent points of support for an assumed value of shape deviation ΔR, has a shape of a figure the limits of which T_{x2} and T_{y2} can be described by the following relations:

$$\mathrm{T}_{x2} = \frac{4(R+r)\cdot \Delta R}{b} \tag{1}$$

$$\mathrm{T}_{y2} = \sqrt{[(R+r)+\Delta R)]^2} - \sqrt{[(R+r)-\Delta R]^2 - \left(\frac{b}{2}\right)^2} \tag{2}$$

where:

- R – radius of the measured object,
- r – roller radius,
- b – spacing between roller axes ($2\,r \le b \le 2\,(r + R)$),
- ΔR – roundness deviation.

The area of this surface has been determined by integrating the equations of circles restricting this area in the 0–x_c interval. Mathematically, the surface area can be presented like this:

$$P = \left[\left(x+\frac{b}{2}\right)\sqrt{(R+r+\Delta R)^2 - \left(x+\frac{b}{2}\right)^2} + (R+r+\Delta R)^2 \arcsin\frac{\left(x+\frac{b}{2}\right)}{(R+r+\Delta R)}\right]\Bigg|_{x=0}^{x=x_c}$$

$$-\left[\left(x+\frac{b}{2}\right)\sqrt{(R+r-\Delta R)^2 - \left(x-\frac{b}{2}\right)^2} + (R+r-\Delta R)^2 \arcsin\frac{\left(x-\frac{b}{2}\right)}{(R+r-\Delta R)}\right]\Bigg|_{x=0}^{x=x_c} \tag{3}$$

where $x_c = \dfrac{2(R+r)\cdot \Delta R}{b}$

By presenting the relation (3) in a relative form of the dimension r with the assumption that $R = \alpha r$, $b = r\,(2 + c\,\alpha)$, where $0 \le c < 2$, at the same time $x_c = \dfrac{2(\alpha+1)\cdot \Delta R}{2 + c\cdot\alpha}$, we can express the magnitude of object centre displacement range, resulting from the measured element—permanent support point interaction, as a function involving characteristic parameters of the vee block. This relationship can be presented in diagrams of the 3D coordinate system ($P = f(c, \alpha)$).

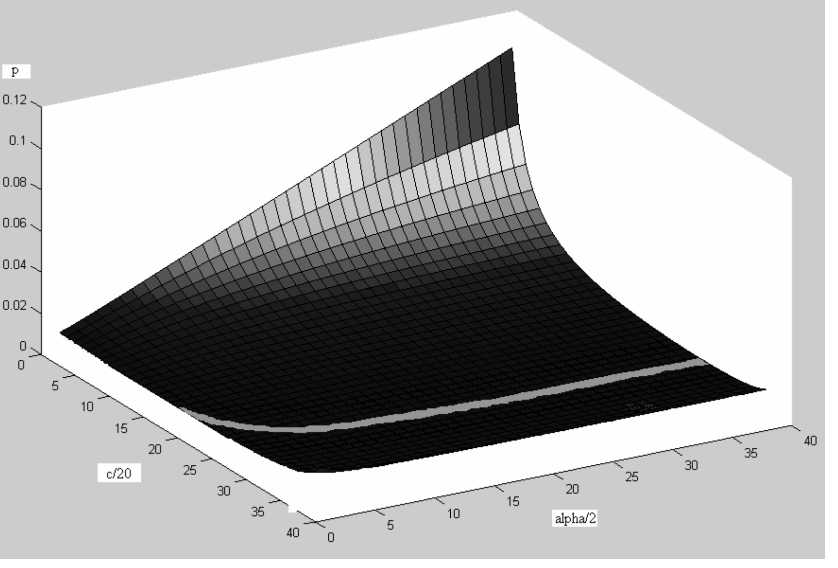

Fig. 2. The effect of the parameters c and α on the tolerance range P of object centre displacements resulting from the measured element—permanent support point interaction

Figure 2 presents an example of how parameters c and α affect the value of the tolerance range of the object centre for specific values of r and ΔR (in the case considered here $r = 10$, while $\Delta R = 0.05$). Analysis of the function described by relation (3) performed in the Matlab environment allowed the determination of the function minimum that, regardless of r and ΔR, lies along the curve located on a plane parallel to the plane c-α, marked in Figure 2 by a bold continuous line. The angle of the vee block γ (dependent on parameters R, r, b), for points lying on the analysed curve changes from 44°36' to 45°21'; the best approximation of the equation of the curve created by these points is as follows:

$$c = \frac{1{,}4142 \cdot (\alpha + 1) - 2}{\alpha} \tag{4}$$

The values of parameter c, calculated from this relation for specific values α, correspond to the systems of characteristic dimensions forming the vee block with angle $\gamma = 45°$. Therefore, this angle can be regarded as the optimum (similarly for a vee block formed by two planes), if we consider the criterion of the minimum displacement range of the object centre in the context of the interaction of the measured element with the permanent points of support.

Conclusions

The results of investigations and given functional relationships may constitute a basis for selecting optimum characteristic dimensions forming a vee block from the viewpoint of the criterion of the minimum of object centre displacement range, displacements being a result of an interaction of the measured element and permanent support points.

The shape and limit dimensions of the displacement range depend on characteristic dimensions that form a measuring system and on the value of shape deviation. The parameter *c* has a significant influence on the size of tolerance range, consequently on the spacing of centre lines of the rollers that make up a vee block.

References

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Słowa kluczowe

Błędy kształtu, pryzma rolkowa, kryterium optymalizacji.

Streszczenie

W artykule przedstawiono wyniki analizy przemieszczeń środka przedmiotu cylindrycznego bazowanego w pryzmie rolkowej podczas jego obrotu, wynikające ze współpracy mierzony element–stałe punkty podparcia. Wyznaczono graniczne wartości tych przemieszczeń oraz pole tolerancji przemieszczeń wyrażonych za pomocą wymiarów charakterystycznych układu pomiarowego oraz wartości mierzonej odchyłki okrągłości. Wyznaczono też optymalne kryteria doboru parametrów układu pomiarowego z punktu widzenia minimum pola przemieszczeń.