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[1.] Ján DEKAN, Stanislav MÔCIK

MEASUREMENT OF CIRCULAR INTERPOLATION SPECIFICITY AT MILLING MACHINE

[1.] DEPARTMENT OF MACHINING AND MANUFACTURING TECHNOLOGY, FACULTY OF MECHANICAL ENGINEERING, UNIVERSITY OF ZILINA, SLOVAKIA

ABSTRACT: *This article discusses about the technical diagnostics of the machine tool. Measuring five axial circular interpolations at milling machine using a diagnostic QC 20W Ballbar from Renishaw. The measurement will be evaluate by automatic analyse from Renishaw company, which is one of the original software components.*
KEYWORDS: *circular interpolation, accuracy, errors*

INTRODUCTION

Image of nowadays technological development of machine production is the constant acceleration. This increase in production and parts are increasing demands for quality manufactured products. These are closely linked to the state of machine. For several technical indicators level machine plays an important role of task accuracy. Machining accuracy is affected by a number of uncertainties and variations arising in the carrier system of the machine (elastic and thermal deformation of the supporting bodies, deformations in stationary and mobile connections), the mechanisms for the executive members, in the control system in measuring systems, the tools, plant the workpiece itself. The accuracy of machine tool is determined by its accuracy executive members of the labor movements and their relative position at work. This accuracy can be verified by one of the diagnostic systems, which is presented below.

DIAGNOSTIC SYSTEM QC20W- BALLBAR

It is used to measure the geometric errors of machine tools where the detection of inaccuracies caused by its own control system or units of the motion mechanism. The basis is the exact linear sensor ball ended at both ends (Fig. 1).

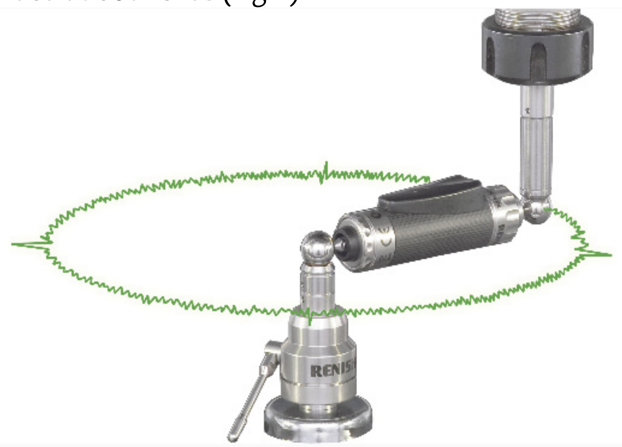

Figure 1. Diagnostic system QC20W (2)

When measuring the balls magnetically clamped to precise magnetic plates. One of them is clamped in the machine spindle and the second magnetically clamped to the machine table. With this arrangement is capable of measuring ballbar even small changes in the programmed radius circularpath.

Subsequently, the machine moves two circular arcs in the direction and opposite direction of the clockwise. Before the scan is carried out starting and ending arc due to stabilization of the task force running the machine tool. Measured data are used to calculate the total value of accuracy in accordance with various international standards or protocols of Renishaw.

Figure 2. Accessories QC20W (1)

Accessories for this diagnostic system (Fig. 2) can be set for testing lathes and testing kit for small radius.

MEASURING OF CIRCULAR INTERPOLATION

It was the measurement of circular interpolation accuracy for machine tools DMG HSC 105 linear. This machine is located in the centre of excellence 5-Axis Machining of Materials Technology Faculty in Trnava. Drawing on it's axis portal milling machine construction.

In Table 1 are some technical specifications of this machine.

Table 1. Technical parameters of maschine

Paths travel	
Axis X	1100 mm
Axis Y	800 mm
Axis Z	600 mm
Axis b	+10° - 110°
Axis c	360°

To measure has not been used extension kit therefore radius of a circle arc was 200 mm. Option is used to extend ballbar 50,150,300 mm (diameter curves 300,500,800 mm).

The test site was in the middle of the desk that is to say that the place is most commonly used. The above evaluation of measurements is using a Renishaw own methodology, which allows automatic diagnosis to 15 specific positioning errors of the machine.

Errors, which were found during the performance measurements, are briefly characterized.

PLANE X-Y

The first measurements took place in the plane of the desk (XY). Control program was created by 180° arc starting and end due to a steady speed of movement of labour and machine units measuring and 360 ° arc in the opposite direction (CCW) and direction (CW) clockwise. Feed rate was 1000mm.min-first In Table 2 are the measured data and Figure 3 shows the shape of circular arcs.

Table 2. Values of positioning errors

Error	Deviation
Perpendicularity	-14,8 µm.m^{-1}
Straightness Y	-1,4 µm
Server belatedly X	▶ -0,7µm
Server belatedly Y	◀ 0 µm
Straightness X	1,1 µm

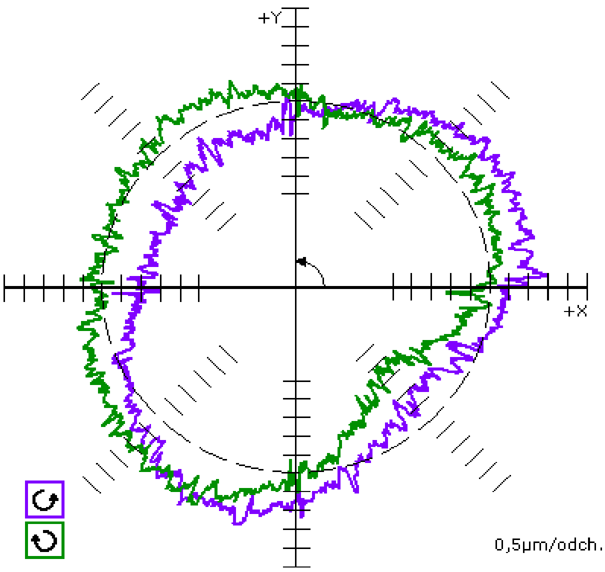

Figure 3. Shape of circular arcs in the plane X-Y

Squareness error

Graf has an oval shape with a deformation of the diagonal. As shown in Figure 4 perpendicularity error value represents the angle between two axes of the plane of the test that is less than 90°. Negative perpendicularity error indicates that the angle between the positive directions of the axis is less than 90°. This angle is greater than 90° when the positive error of perpendicularity.

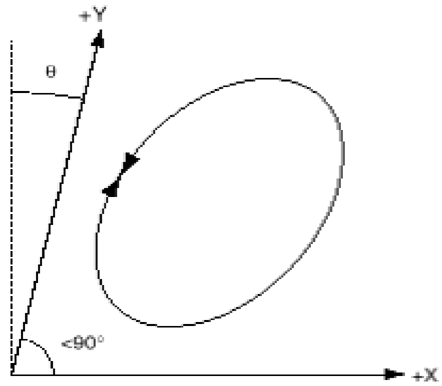

Figure 4. Squareness error (3)

Straightness error

Listened diagnostic software je an arc between the top and seat at the axis in length equal to the diameter of the test circle. On Figure 5 shows the error straight line Y-40µm.

Server belatedly

This is reflected by short peaks starting on the axes. When you move the axis in one direction, and has a turning point and move in the opposite direction, it may instead be continuous turnover to a momentary stop. On figure 6 is an example of reverse peaks at axe X and Y, these peaks define point where (up, down, left, right), are peaks located on an arc.

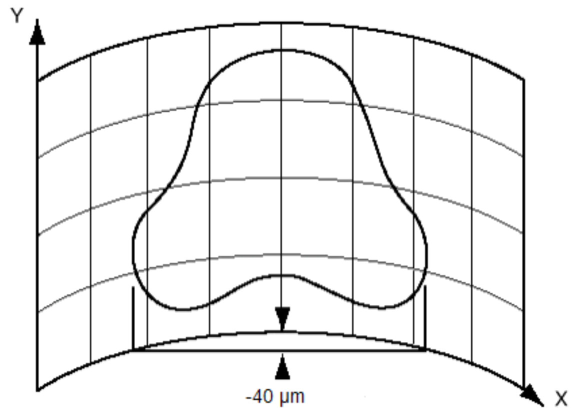

Figure 5. Straightness error (3)

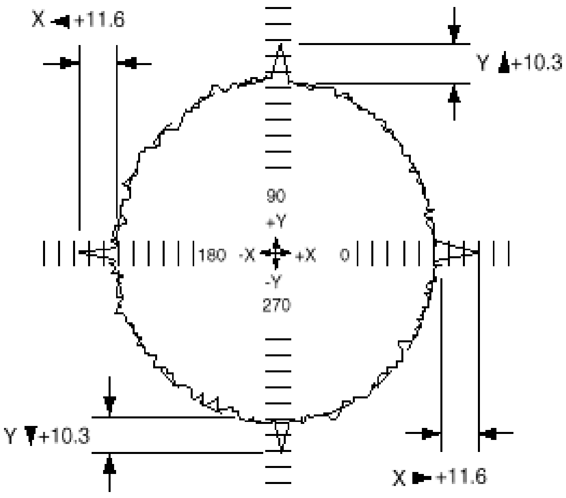

Figure 6. Reverse peaks (3)

PLANE Y-Z

Measurement in the Y-Z plane also took place in two directions. Potential arcs were measured only with size 220° due to collision-free state. The starting and ending arc have size 2° and feed rate was also 1000mm.min. In Table 3 are the measured data and Figure 7 shows the shape of incomplete circular arcs.

Table 3. Values of positioning errors

Error	Deviation
Perpendicularity	-20,3 μm.m^{-1}
Server divergance	0,04 ms
Server belatedly Z	▲0,4 μm
Amplitude of cyclic errorZ	↑0,2 μm ↓0,4 μm
Transverse clearance Z	▲ -0,2 μm ▼ -0,1 μm

Server divergance

Graf has an oval shape with deformation at diagonal (fig. 8) at 45 ° or 135 °. Server divergence happens in case of divergance amplification interpolationed axes. Value is the time in milliseconds indicating overtaking of one servopower axis to the second axis.

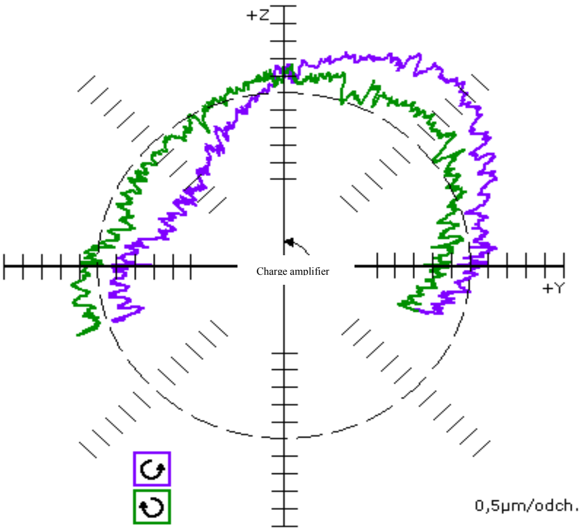

Figure 7. Shape of incomplete circular arcs in the plany Y-Z

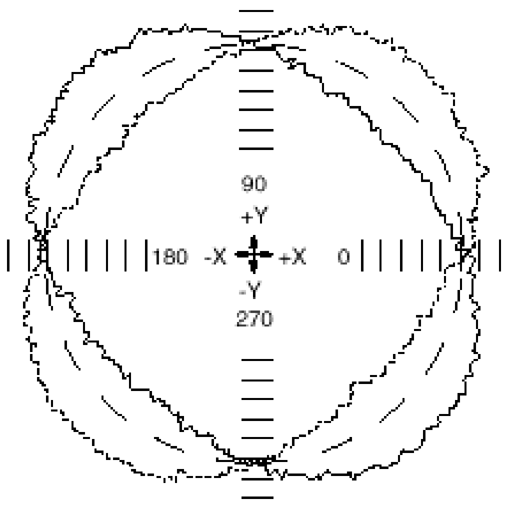

Figure 8. Server divergance (3)

According to table 4 it is possible to determine what is a mutual divergence between the axes.

Table 4. Mutual overtaking of axes

Tested plane	Measured value	Axes
XY	+	*Y foreruns X*
XY	-	*X foreruns Y*
ZX	+	*X foreruns Z*
ZX	-	*Z foreruns X*
YZ	+	*Z foreruns Y*
YZ	-	*Y foreruns Z*

Transverse clearance Z

Is clearance (side) at guideway in the machine. This causes a change in the direction orthogonal movement axes of the machine.

Amplitude of cyclic error

On Figure 9 shows a graph of the cyclic error whose frequency and amplitude of the graph changes. Cyclic error is displayed on this chart, only the Z-axis, where Dz is the wavelength in the axial direction Z. The values are between the amplitude peaks of cyclic errors in the axis of the movement direction indicated by arrow. ↑ determines where increasing positive forward movement in a position to determine positive and ↓downward movement in the reverse position.

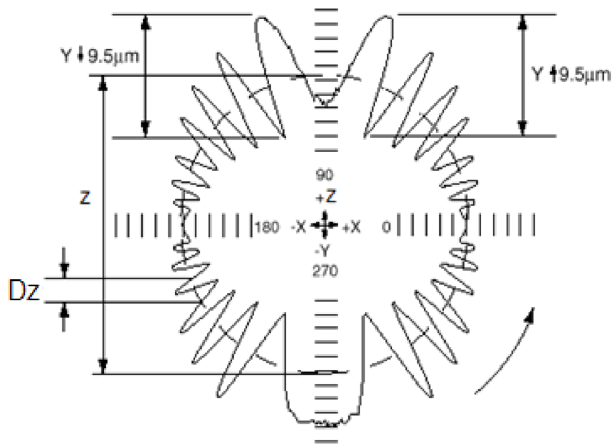

Figure 9. Cyclic error

PLANE Z-X

Measurements of the Z-X plane have the same parameters as in the measurement Y-Z plane. In Table 5 are the measured data and Figure 10 shows the shape of incomplete circular arcs.

Table 5. Values of positioning errors

Error	Deviation
Perpendicularity	4,7 μm.m^{-1}
Transverse clearance Z	▲ 0,4 μm ▼ 0,5 μm
Server belatedly Z	▲0,4 μm
Amplitude of cyclic error Z	↑0,3 μm ↓0,4 μm
Transverse clearance X	► -0,0 μm ◄ -0,3 μm

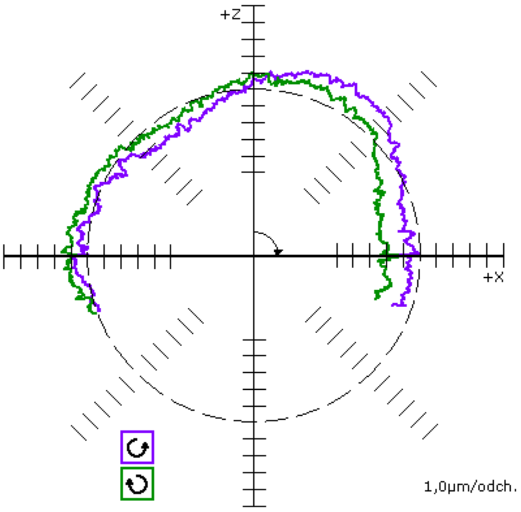

Figure 10. Shape of incomplete circular arcs in the plane Z-X

CONCLUSIONS

The aim of this article was to present diagnostic system QC20-W ballbar from Renishaw and its practical use in measuring the accuracy of circular interpolation five axis of milling machine. Measuring software identifies the type of error (geometric errors, dynamic errors clearance) and sorts them according to seriousness.

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