Miroslav CÍSAR[1], Ivan ZAJAČKO[2]

Opiekun naukowy: Ivan KURIC

# PROCESSING OF DATA FROM MEASUREMENTS WITH RENISHAW BALLBAR

**Summary:** The article presents methods of data processing for measurements with Renishaw Ballbar QC20-W using software developed at Department of Automation and Production Systems Faculty of Mechanical Engineering.

**Keywords:** Ballbar, data processing, CNC machine tool

# PRZETWARZANIE DANYCH Z POMIARÓW PRZEPROWADZANYCH Z ZASTOSOWANIEM RENISHAW BALLBAR

**Streszczenie:** W artykule omówiono metodę przetwarzania danych uzyskiwanych z pomiarów przeprowadzanych z zastosowaniem Renishaw Ballbar QC20-W używając oprogramowania napisanego w Katedrze Automatyzacji i Systemów Produkcji na Wydziale Mechanicznym.

**Słowa kluczowe:** Ballbar, przetwarzanie danych, obrabiarki typu CNC

## 1. Measurement of machine tool geometrical errors

Overall performance of machine tool, as complex mechatronic system, is affected by condition of its subsystems and individual parts in terms of production quality and its sustainability. Condition of machine tool is not constant over the time and it is developing according to various factors such as its initial state, occupancy, load level, qualification of operation staff, quality of maintenance and much more. It is clear that maintenance is essential for machine tool to sustain its condition in limits to allow production. Effective maintenance requires knowledge about real current state of machine tool. Such information can be obtained from various sources such as machine tool operators (part of total productive maintenance), monitoring of production parameters or as result of technical diagnostics.
Machine tool diagnostics as important part of proper machine tool maintenance is intended to reveal machine tool errors and inaccuracies whether existing or emerging

[1] Department of Automation and Production Systems Faculty of Mechanical Engineering, University of Zilina, miroslav.cisar@fstroj.uniza.sk
[2] Department of Automation and Production Systems Faculty of Mechanical Engineering, University of Zilina, ivan.kuric@fstroj.uniza.sk

ones. It includes many different procedures based on various physical phenomena and detecting various parameters of overall condition of machine tool. Contemporary methods of machine tool diagnostics commonly use state of the art devices and technologies in order to ensure quality, reliability and informative value of information acquired by diagnostic procedures.

Machining precision is affected by a number of uncertainties and variations arising in the carrier system of the machine (elastic and thermal deformation of the machine tool body, the contact deformation in moving and static parts), in individual drives, control system, measuring system, tool and workpiece itself. The accuracy of machine tool is determined by drives (spindles, slides, tables...), and their relative position during machining. Machining accuracy along with manufacturability determine the productivity, quality and efficiency of production. Among the many indicators of the technical level of machine tools has given priority to their work accuracy.

Some methods of machine tool diagnostics are described in ISO 230 norms that consist of ten parts with common title. "Test code for machine tools".

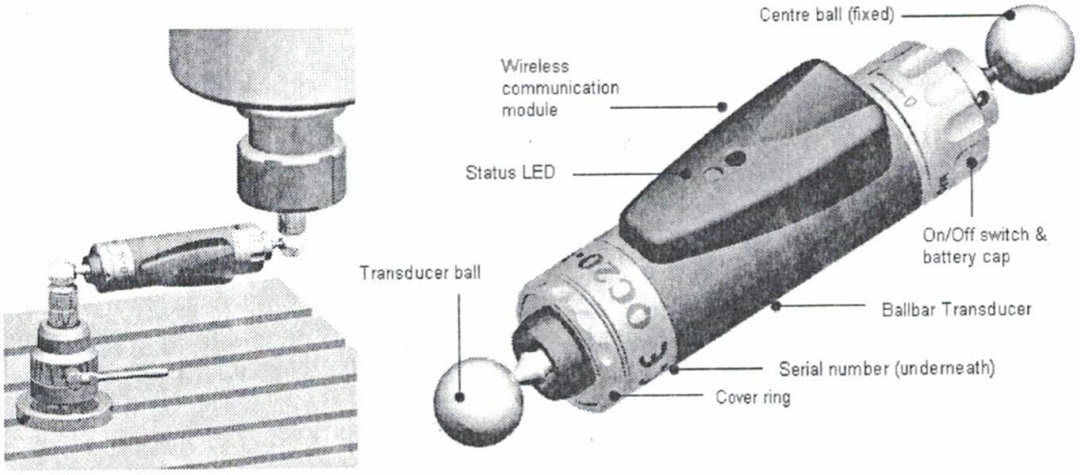


*Figure 1. Renishaw Ballbar QC20-W*

One of the devices described in these set of norms, namely ISO 230.4, is Ballbar device which uses analysis of tool path during circular interpolation to measure and evaluate its precision, faults and errors. The Renishaw Ballbar (Figure) is a linear displacement sensor. It is designed to perform a simple, rapid check of a CNC machine tool's positioning performance according to various internationals standards. Such test involves moving tool by circular arc or circle with radius defined by Ballbar assembled length. Small deviations in the radius of this movement are measured by a transducer in the ballbar and captured by the software. From the data supplied (via a PC interface) the systems software automatically detects and diagnoses range of machine geometry deviations, and motion errors.

The Ballbar measures any deviations in the circle radius during the test. The shape of the Ballbar plot indicates the major sources of machine error. Powerful software gives automatic analysis and diagnosis of specific machine error characteristics. Each error is ranked according to its significance to overall machine accuracy. Overall machine accuracy is graded with a value for circularity and positional tolerance.

The Renishaw QC20 Ballbar and its software are used to measure geometric errors present in a CNC machine tool and detect inaccuracies due machine tool state. Errors are measured by instructing the machine tool to 'Perform a Test' which will instruct it

to scribe a circular arc or circle. Small deviations in the radius of this movement are measured by a transducer and captured by t SEMENETS he software. The resultant data is then plotted on the screen, to reveal how well the machine performed the test. By analyzing graph shape we are able to recognize following machine tool errors: backlash, cyclic error, lateral play, master-slave changeover, offset change, plot rotation, positional tolerance, radius change, reversal spikes, scaling error, servo mismatch, spiral error, squareness, slick slip, tri-lobe (straightness), and vibrations.

## 2. Measurement records and its conversion

Despite the fact that the Renishaw Ballbar system was designed to be used to measure of geometrical errors of conventional CNC machine tools with Cartesian kinematic structure, it is possible to use it to perform measurement on virtually any numerically controlled device capable of perform circular, or at least semicircular, movement with radius same as the Ballbar assembled length. However, the software is currently capable of evaluation only errors based on conventional Cartesian mechanics.
Recently, at the Department of Automation and Production Systems Faculty of Mechanical Engineering, University of Zilina, a lot of effort was put into utilization o Ballbar measurement system to be used with different numerically controlled machines such as machine tools with parallel kinematics, common industrial robots and industrial robots with parallel kinematics. Such devices require different approach not only to measurement data analysis but also to measurement itself.
The Renishaw Ballbar uses the software with the same name. The software is essential part of the Ballbar measuring system and it is responsible for communication with the device, its calibration, setting of measurement conditions, generating of NC programs for some of the machine tool control systems, and mainly capturing data and analyzing measurement. It would be ineffective to create own software for all these purposes therefor we decided to use standard software for the measurement preparation and calibration of device and use its outputs to perform further analysis on various machine tools and other research tasks.

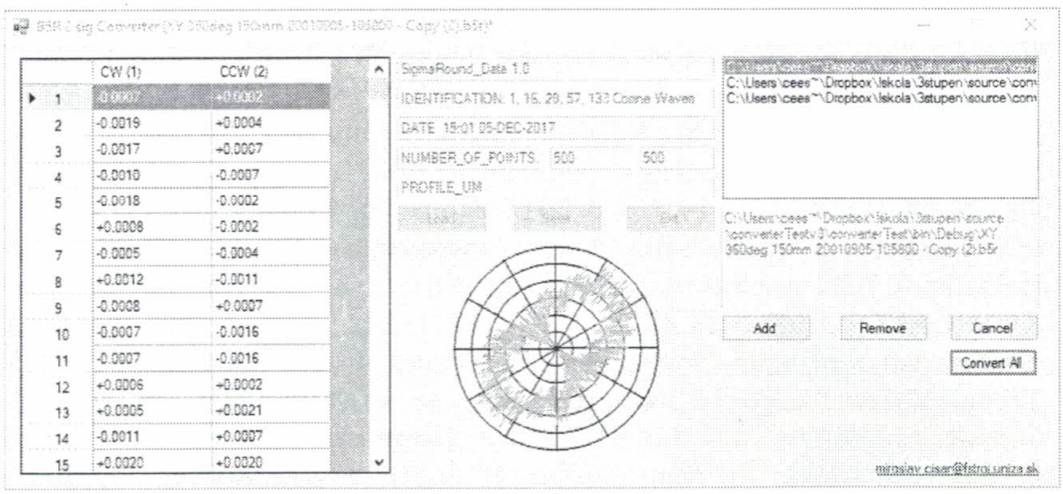


*Figure 2. B5R 2 SIG converter*

The measurement is recorded to file with *.b5r extension which is formatted according to XML standard what allows relative simple data acquisition using

common software components. The file contains a lot more data than it is necessary for analysis as it also store data from run-in and run-out movements, results of analysis, measurement conditions and more.
Therefor we decided to design and create own software "B5R 2 SIG converter" (Figure) capable of filtering and converting of B5R files to different format more suitable to be processed with other software. Compared to its previous version (Converte test), the B5R2SIG is capable of batch conversion as the research usually requires data acquisition from significant amount of measurements. The software also shows simple polar diagraph of currently loaded measurement for fast check of data consistency and data that will be saved to file header if the *.sig format (SigmaRound compatible file) is selected. Other option is to save measurement data to *.txt (plain text) file.

**Acknowledgement:** This article was made under the support of APVV project – APVV-16-0283 Research and development of multi-criteria diagnosis of production machinery and equipment based on the implementation of artificial intelligence methods.

## Conclusion

This article highlights importance of machine tool diagnostics, especially diagnostics based on analyzing of positioning performance using Renishaw Ballbar QC20-W This approach allows to analyze measurement results with other various tools such as Matlab or Microsoft excel in our case. These tools allow us to utilize already very useful measurement device to be used on various numerically controlled devices as was verified especially with industrial robots, machine tools and manipulators with parallel kinematics.

## REFERENCES

1. MAJDA P.: The Influence of Geometric Errors Compensation of a CNC Machine Tool on the Accuracy of Movement with Circular Interpolation. Advances in Manufacturing Science and Technology, vol. 36, No. 2, 2012, 59-67. Publisher Elsevier
2. NAKAZAWA H., ITO K.: Measurement System of Contouring Accuracy on NC Machine Tools. Bull. Japan Soc. Prec. Eng., 12, 4: 189, 1978. Publisher Elsevier
3. SAPIETOVA A., SAGA M., NOVAK P.: Multi-software Platform for Solving of Multibody Systems Synthesis. Communication - Scientific Letters of the University of Zilina, vol.14, No. 3, 2012, Zilina, pp. 43- 48, ISSN 1335-4205
4. ISERMANN. R.: Fault-Diagnosis Applications, Springier-Verlag Berlin Heidelberg, 2011
5. KUMIČÁKOVA D., TLACH V., CÍSAR M.: Testing the performance characteristics of manipulating industrial robots. In Transactions of the VŠB - Technical University of Ostrava: mechanical series, 2016, vol.62, no.1, pp.39-50
6. CÍSAR M., ZAJAČKO I., KURIC I.: Diagnostics based on poositioning performance during circular motion. In Inżynier XXI wieku: Projektujemy przyszłość, ISBN 978-83-65182-51-7, pp. 536-542
7. QC20-W wireless ballbar system description and specifications. (2013) [online] Available on Internet: www.renishaw.com/media/pdf/en/bc37e3f237284417baa57889d207cf97.pdf