



Automatic measuring workplace

Ing. Dana Kubátová¹

¹Faculty of Mechanical Engineering; University of West Bohemia in Pilsen; 306 14 Plzeň; Czech Republic.

E-mail: kubatova@kto.zcu.cz

Surface integrity is gaining unprecedented importance and some areas of metrology are also very intensively developing along with it. Controlling also plays a big part in conjunction with 3D measurement. This article describes the possibilities of combining the requirement for 100% inspection of parts with automated measurement in the automotive industry with 3D measurement using the Equator system from Renishaw. Further, the article describes the essential characteristics of the device and its placement options in the workspace. The main theme deals with possibilities of processing the measured data gained in automatic mode.

Key words: Data Processing, Equator, Measuring unit

1 Introduction

Surface integrity nowadays is gaining unprecedented importance. This concept, however, has a different meaning for different people. Considering surface in terms of metrology only a limited number of parameters are evaluated. The company Astro Kovo Plzeň monitors geometric parameters, tolerances of form and position. There are a number of options for checking these parameters. One option is to manually check according to predefined procedures. Another, pioneering variant uses a 3D measuring device (CMM). This is the option chosen by Astro Kovo Plzeň.

Astro Kovo Plzeň is a Czech company located in Třemošná near Pilsen (CZE). It was founded in 1994. The company now employs over 50 staff in three shifts. Its activities are focused on automated processing of metals. It specializes in co-operation according to documentation supplied by customers. The company is equipped with high performance turning centers to produce daily series of thousands of pieces of products, mainly for the automotive industry.

In the days before automation of measuring the company was forced to invest a lot of time in 100% control of the parts that automotive customers typically require. Until 2012 Astro-Kovo Plzeň used manual measurement for 100% inspection of parts. In 2012 it transferred to automated control of parts using the Equator 3D measuring device from Renishaw.[1]

Astro-Kovo Plzeň is the only company in the Czech Republic to use this device for controlling production. Modifying the Renishaw Equator to achieve the required level of control measurements and data processing was the combined work of Miss Kubátová and Mr. Melichar from the University of West Bohemia in Pilsen and Mr. Hamouz with Mr. Holub of Astro-Kovo Plzeň s.r.o. Implementation of new software enabled the device to provide the required level of work with the data obtained in the automatic mode. Until the final completion of the SW, none of the basic programs supplied with the device allowed statistic evaluation. Nowadays, however, it is necessary to use the maximum capabilities of any device available to a company, and therefore a team of experts was established to solve this issue.

2 Measuring device

Why Equator? When selecting, assessing and comparing devices, Equator excelled especially in measurement flexibility, user friendliness, measurement per unit of time and, last but not least, the ability to work in automatic mode, for which the device is very well prepared. It outshone its competitors in 3D measuring with its unique design, based on parallel kinematics.

It replaces the need for current measurement and has 100% control within the entire volume of parts production, limited both in terms of number of pieces at a time and in terms of shape complexity. After measuring parts, the instrument can evaluate whether the measured piece is good or bad and display outputs on the control PC. The basic principle of the measurement process is based on a comparing inspection- a comparison of the measured part to the "golden" part. The "golden" part is the one that is made as a model for mastering, i.e. with the initial setup of parameters before or during the measurement of temperature change, achieving limit of number of checked items, or the expiry of the time limit, the setting, etc. [2]

1.1 Placement of the device

A great advantage of the device is that it does not require maintenance of constant climatic conditions. The device can be placed in an air-conditioned space enclosed by a fence in a metrology lab, or it can work in a space without air-conditioning directly in the production hall where the temperature is constantly changing. Our test device is placed in a measuring box with air conditioning directly in the production hall. This placement simplifies parts handling and reduces the time needed for it.

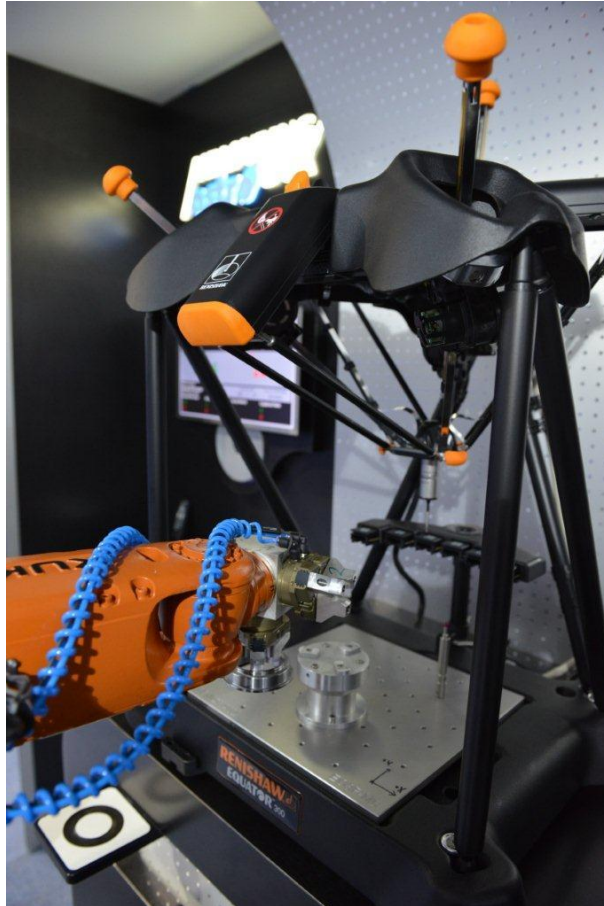


Fig. 1 Equator measuring device [9]
Obr. 1 Měřicí přístroj Equatro [9]

2.1 Measuring box

The measuring box (AstroBox) is a fully automated measuring station for non-stop measuring without being influenced by the human factor. The box is excellently designed and is admired by all customers. When using the products, the required 100% inspection of all parts is ensured.

Its circle of potential users, and thus the possibility of wider applications of the device, is increased by its ability to control not only metal parts, but also parts made of plastics, ceramics, etc.

AstroBox is equipped with a number of features that are unique and help to simplify and accelerate work. It includes a remote control with a touch screen mounted on the outside of the box, which makes it easier to program the robotic arm and a lit display at the top of the box which indicates whether the parts are within tolerance or not.

The box is also designed for the safety of the operator. A shutoff switch is located on the entrance door to the AstroBox, which turns off all devices running when the door is opened. Furthermore, the manual override is located directly above the basic control panel, and there is also one of the most important controls, the central stop button and the switch between automatic and manual mode. The advantage of the modularity of the box is the possibility of using multiple boxes for different measuring devices in various configurations. One form of AstroBox is shown in Figure 2. [6]

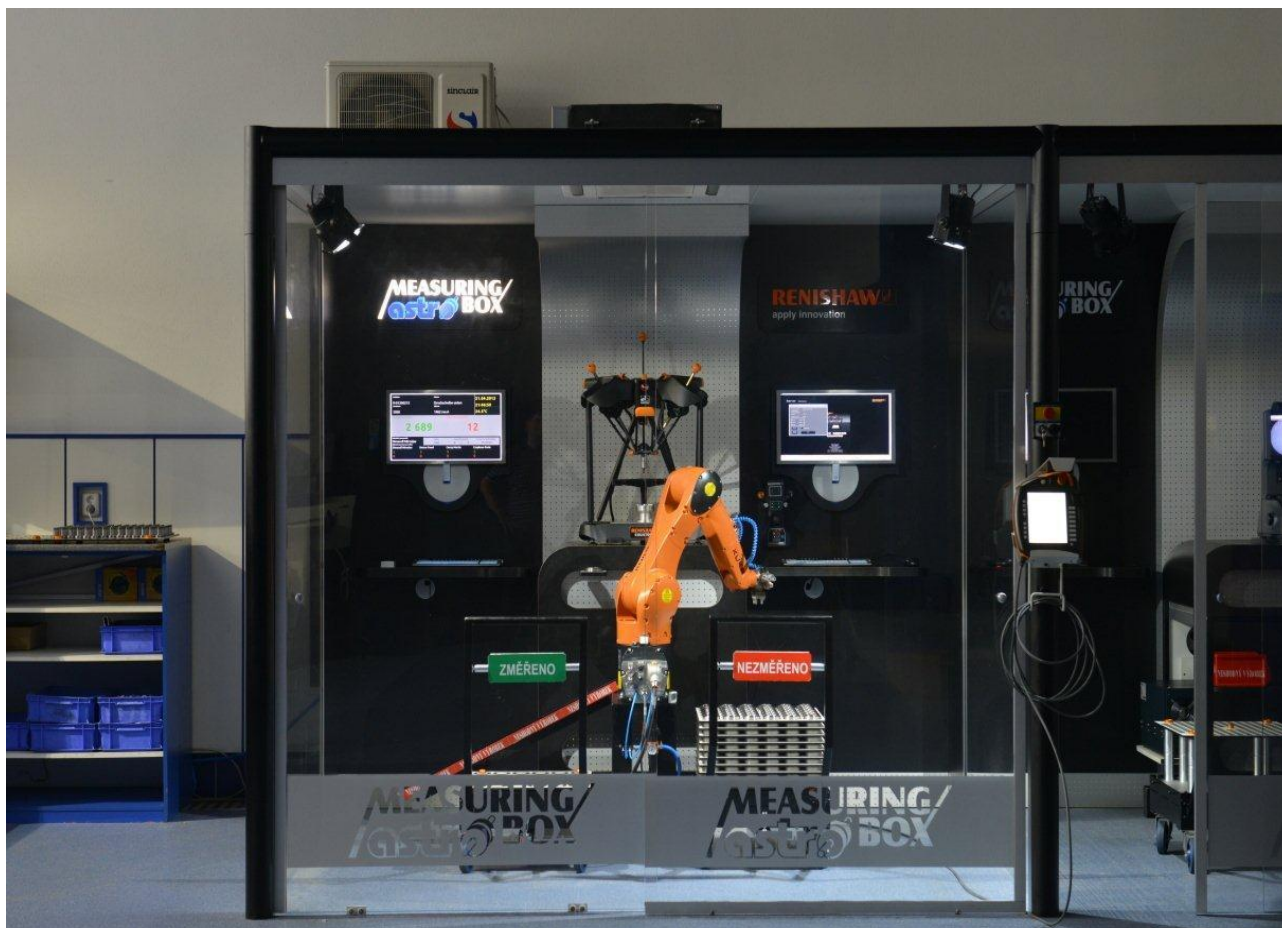


Fig. 2 AstroBox [9]
Obr. 2 AstroBox

3 Data analysis in the automatic mode

Direct processing of the measured data from the parts manipulated by the robot is not possible using the software supplied by Renishaw. The device can only evaluate whether the part is within tolerance or out of tolerance. This is set at the factory. In Astro-Kovo Plzeň s.r.o. the display data are stored in a PDF file. This file format can be very difficult to process further and so the company has decided to concentrate on this problem. The main benefit is the possibility of future development and improved competitiveness in the market, especially in the automotive industry.

3.1 Data processing program

The first step in the design of the program was to change the format of the stored data. Instead of PDF, which is pre-defined by the manufacturer, CSV format was selected. In this format, the data can be converted to any other program and thus change the format of the data.

MS Excel was selected for working with the data as it allows processing of large amounts of data, because several parameters are measured hundreds of times for each type of part. When storing the data obtained from the measurements we expect to use one xxx.CSV file for one type of part. The processing of the data is performed after loading in MS Excel.

Working with the program for data processing is simple. After the initial startup of the data processing program we receive a form as shown in Figure 3. It is a pre-prepared, blank table to retrieve data, through which the user opens a form by which the entire data processing is carried out.

The user form in Figure 4 is used for simple and centralized control of the entire data processing, using macros, which are hidden under most of the buttons that are on the user form.

Fig. 3 Custom form for controlling data processing
Obr. 3 Uživatelský formulář pro ovládání zpracování dat

In first step we must start MS Excel, and then must be data record into the program. This is one of the generated CSV files. This is done with the button marked, load data. Under this is concealed a macro which, using commands hidden in it, converts the data into a CSV file, shown in figure 4. Additionally, this macro contains commands for the evaluation of individual items measured in terms of the number of parts in tolerance and out of tolerance and for finding and writing critical values.

After running the entire macro, a user form returns to the screen which is filled with the information gathered during the initial load data, see Figure 4. We now have data in the program and partially pre-processed for further processing.

| J14 | | INTOL | | | | | | | | | |
|---------------|----------|-------|-------------|-----------------|------------|-----------|-----------|-----------|-----------|----------|-----------|
| měřený rozměr | | | | A | | B | | C | | D | |
| | | | | 059105329A | | D24 - D16 | | D30 - D28 | | D - D27 | |
| | | | | 20 25 | | 16 17 | | -28 -27 | | | |
| datum | čas | směň | dělník | v/mimo toleranc | číslo dílu | parametr | tolerance | parametr | tolerance | parametr | tolerance |
| 24.11.2013 | 16:12:31 | Ranni | Honza Novak | Mimo toleranci | 059105329A | 24.05 | OUTOL | 16.043 | OUTOL | -27.989 | INTOL |
| 24.11.2013 | 16:20:34 | Ranni | Honza Novak | Mimo toleranci | 059105329A | 24.05 | OUTOL | 16.043 | OUTOL | -27.99 | INTOL |
| 24.11.2013 | 16:21:26 | Ranni | Honza Novak | V toleranci | 059105329A | 24.025 | INTOL | 16.005 | INTOL | -28.02 | INTOL |
| 24.11.2013 | 16:21:55 | Ranni | Honza Novak | Mimo toleranci | 059105329A | 24.027 | INTOL | 16.001 | OUTOL | -28.015 | INTOL |
| 25.11.2013 | 16:22:39 | Ranni | Honza Novak | V toleranci | 059105329A | 99999 | INTOL | 16.006 | INTOL | -28.023 | INTOL |
| 25.11.2013 | 16:25:25 | Ranni | Honza Novak | V toleranci | 059105329A | 24.028 | INTOL | 16.014 | INTOL | -28 | INTOL |
| 25.11.2013 | 16:27:27 | Ranni | Honza Novak | Mimo toleranci | 059105329A | 24.026 | INTOL | 16 | OUTOL | -28.025 | INTOL |
| 24.11.2013 | 16:28:01 | Ranni | Honza Novak | V toleranci | 059105329A | 24.028 | INTOL | 16.002 | INTOL | -28.017 | INTOL |
| 24.11.2013 | 16:28:45 | Ranni | Honza Novak | V toleranci | 059105329A | 24.029 | INTOL | 16.002 | INTOL | -28.017 | INTOL |
| 24.11.2013 | 16:29:30 | Ranni | Honza Novak | V toleranci | 059105329A | 24.027 | INTOL | 16.001 | INTOL | -28.025 | INTOL |
| 27.11.2013 | 16:30:14 | Ranni | Honza Novak | V toleranci | 059105329A | 24.028 | INTOL | 16.001 | INTOL | -28.02 | INTOL |
| 27.11.2013 | 16:30:58 | Ranni | Honza Novak | V toleranci | 059105329A | 24.03 | INTOL | 16.001 | INTOL | -28.018 | INTOL |
| 27.11.2013 | 16:31:44 | Ranni | Honza Novak | V toleranci | 059105329A | 24.028 | INTOL | 16.001 | INTOL | -28.019 | INTOL |
| 24.11.2013 | 16:32:27 | Ranni | Honza Novak | V toleranci | 059105329A | 24.029 | INTOL | 16.002 | INTOL | -28.02 | INTOL |

Fig. 4 The form of the data after transfer using a macro
Obr. 4 Podoba dat po převodu pomocí makra

The second step is to select a date (Figure 5 marked with the letter A) which filters the data. This filtered data is processed further.

The actual processing is performed only after checking the buttons below the corresponding parameters (in Figure 5, marked with the letter B). Again, the processing is done by macros hidden below the buttons with these commands.

Fig. 5 The completed form ready for further processing
 Obr. 5 Vyplnění formulář připravený pro další zpracování dat

3.2 Data processing outputs

The output from the data processing is a report page that is filled directly from the user form and using the protocol button. When clicked it opens another form over the original user form, which is used to fill the report page header and additional information which is necessary for evaluating the data, and to definitely identify reports from measurements. The form is shown in Figure 6. After completing the form, the information is in the appropriate position in the report header, see Figure 7. The company supplies this form to its customers to demonstrate control measurement.

Fig. 6 User form for additional information in the log
 Obr. 6 Uživatelský formulář na doplnění informací do protokolu


| | | | | | | | | | | | | | | | | |
|-----------------------------------------------------------------------------------|------|-------|--------|-------------------------------|---|---|---|---|--------------------|---|---|---|---|----|-----|--|
|  | | | | <h1>REPORT PAGE</h1> | | | | | page: | | | | | | | |
| | | | | | | | | | Protocol number: : | | | | | | | |
| Address of the contractor: | | | | Drawing number: | | | | | | | | | | | | |
| | | | | The drawing name : | | | | | | | | | | | | |
| | | | | Date of Change: | | | | | | | | | | | | |
| | | | | Number changes: | | | | | | | | | | | | |
| | | | | Order number : | | | | | | | | | | | | |
| Address of recipient: | | | | Checked by: | | | | | | | | | | | | |
| | | | | Contact controller: | | | | | | | | | | | | |
| | | | | Date of inspection: | | | | | | | | | | | | |
| | | | | Critical value: | | | | | | | | | | | | |
| | | | | Values in the tolerance: | | | | | | | | | | | | |
| | | | | Values outside the tolerance: | | | | | | | | | | | | |
| č.p. | name | apper | botton | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | OK | NOK | |
| 1 | | | | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | |

Fig. 7 Report Page
Obr. 7 Report Page

Information that must be specified in the form are:

- critical value
- assessment of the number of parts in tolerance and out of tolerance
- values of indices C_p and C_{pk}
- Measurement protocol for the first 5 values from the set day

Additional data which is required, but not with every measurement report, is the distribution of parts in the tolerance field, i.e. a histogram, the course of the process, and all this can be evaluated by researchers, shifts, series, batches, etc. Everything in its final form is shown in the measurement protocol, which is issued every day. Once created, again using a macro, an email is sent to the person in charge. Data in the report is displayed by selecting the check boxes on a user form after the initial launch of the program for data processing.

4 Conclusion

The current business environment is characterized by the extreme pressure on guaranteeing product quality. Manufacturers in the automotive industry, where our company is placed, are pushed to a maximum of 5ppm out of tolerance, which is very difficult to achieve and maintain, but it is possible. As Mr. Dušek, owner and CEO of Astro Kovo Plzeň says, "It is important to know that bad parts will always be produced, but that they must never reach the customer!"

AstroBox originally allowed only simple sorting of products within statistical sampling into good and bad pieces. That in itself was sufficient progress and streamlined the control process. The aim of the research was originally to prepare a machine interface for a deeper analysis of the results. In the next step it was necessary to connect the control module software for statistical treatment of the development of advanced applications and quality management tools. For the near future we plan to replace the Microsoft interface by a Linux or web-based interface. This should allow advanced remote management of AstroBox including complex diagnostics of the controlled manufacturing process.

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Abstract**Artilec:** Automatické měřicí pracoviště**Authors:** Ing. Dana Kubátová**Workplace:** Fakulta strojní, Západočeská univerzita v Plzni, 306 14 Plzeň. Česká republika.
E-mail: kubatova@kto.zcu.cz**Keywords:** Měřicí přístroje, Equator, AstroBox, zpracování dat

Metrologie se v současné době rozvíjí velmi intenzivně, a proto vědci na Západočeské univerzitě v Plzni ve spolupráci s Astro-Kovo Plzeň vyvinuli progresivní měřicí přístroje "Astro-box", který umožňuje vysoce pokročilé automatické měření dílů vyrobených v hromadné a sériové výrobě.

Tento článek popisuje "Astro-box", v reálných výrobních podmínkách. Hlavní část článku se zabývá přenosem velkých objemů dat získaných v automatickém režimu měření. Tyto data mohou být použity na místě pro základní binární analýzy, nebo se mohou předávat pomocí softwaru do protokolů tvořících komplexní statistické analýzy často požadované v automobilovém průmyslu.

Použití automatického měřicího boxu a automatického zpracování dat je výhodné nejen při dokladování dodržení předepsaných výrobních tolerancí, šetří značné množství finančních nákladů, ale i umožňuje udržení firmy krok před konkurencí. Přínos je největší při kontrolování dílů i při jejich vyhodnocování a tvoření dokladů o jejich kontrole. Sice počáteční náklady na pořízení boxu jsou vyšší než za použití klasických metod ruční kontroly dílů, ale veškeré náklady spojené s lidskou prací a následným zpracováním dat se po nedlouhé době činnosti zařízení vrátí z důvodu odstranění nutnosti právě lidského faktoru při jeho činnosti.

