

CAI MODEL AND DIGITAL FACTORY

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Abstract: *In on-line digital factory, all engineering activities are integrated and simulated before the real production process. "IVA 28" is really good example of digital factory in our industry. This paper presents research, development and implementation of CAI-model, as a basic concept of the digital quality, in the concrete factory "IVA 28" from Obrenovac. Also, this paper presents computer integrated inspection and measurement in the final control of product quality. The slider is specific part that was measured on DEA measuring machine, and PC DMIS is used as software.*

Key words: CAI, metrology, quality, PC DMIS, Digital.

1. INTRODUCTION

Application of computer technologies in the industrial metrology, more specific in coordinate metrology is very important in terms of product quality. Poor product quality is mostly realized in the production phase and it's necessary to pay more attention to quality control. Accordingly, CAI (Computer Aided Inspection) model undoubtedly has a great role where measurement and inspection process are performed on the numerically controlled measuring machine using specialized software.

Factory „IVA 28“ from Obrenovac is engaged in the production of precision parts for machine building industry. Product range is categorized within following groups: sliders, spindle housings, tailstocks and other parts. Tolerance of these parts are very small (a few μm) and is required in the production process to achieve high accuracy production. For quality control of these parts the factory is using coordinate measuring machine "DEA Global Performance" which has the possibility of measuring large and complex parts.

2. MEASURING MACHINE DEA GLOBAL PERFORMANCE WITH SCANNING PROBES

2.1. Basic characteristics of measuring machine

New generation of DEA measuring machines is developed in 200, when the Global line serie is introduced with three new models: Classic, Performance and Advantage. Great flexibility of this measuring machine enables using of Touch-trigger and Scanning probes for measuring complex parts weighing up to 2t. DEA Global Performance is 3D coordinate measuring machine (Fig. 1), with the following technical characteristics [4]:



Fig. 1. DEA Global Performance.

- Stroke $X = 1\ 200$ mm, stroke $Y = 2\ 200$ mm, stroke $Z = 1\ 000$ mm
- Granite table
- Optical measuring system
- Accuracy: $MPE_E = 2.5 + L/333$
- Air bearings
- FB2 control system (3+2 axes control)

2.2. Scanning probes

Along with the measuring machine, factory "Iva 28" is using touch-trigger and scanning probes from renowned Renishaw company. Renishaw motorized probe head PH10MQ is also used, which allows measuring machine to work with five axes.

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Fig. 2. Motorized probe head PH10MQ with scanning probe.

Very significant is the use of Scanning probes which can determine shape defects of given area, besides its measuring position and size. Scanning probe used in the factory is SP25M, with three scanning modules SM25-1, SM25-2, SM25-3 and three stylus holders SH25-1, SH25-2, SH25-3. Renishaw motorized probe head PH10MQ and SP25M with SM25-2 and SH25-2, are shown in Fig. 2 [3].

3. DEVELOPMENT OF CAI MODEL FOR A SLIDER

The first step is the part modeling which defines the nominal form. CAI model is developed for slider, which is built in special-purpose lathe. Slider is modeled in SolidWorks 2007 (Fig. 3).

Integration process CAD-CAI-NUMM (Fig. 4) is accomplished in the first place by modeling of the part, which is in the STEP format and recognizable to software PC DMIS. For inspection process software PC DMIS CAD++, version 4.2 is used, which is a standard programming language for numerically controlled measuring machines.

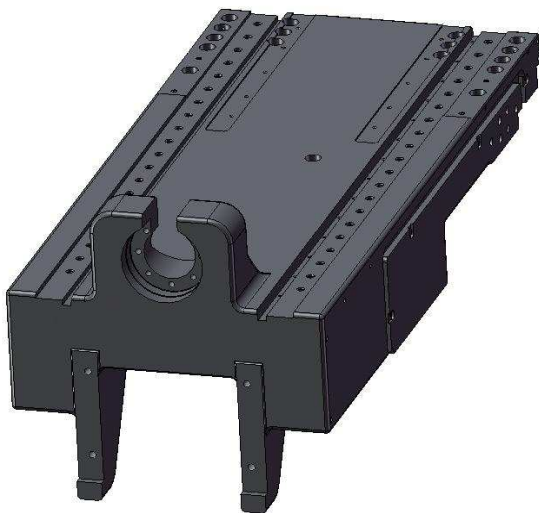


Fig. 3. Slider model in SolidWorks.

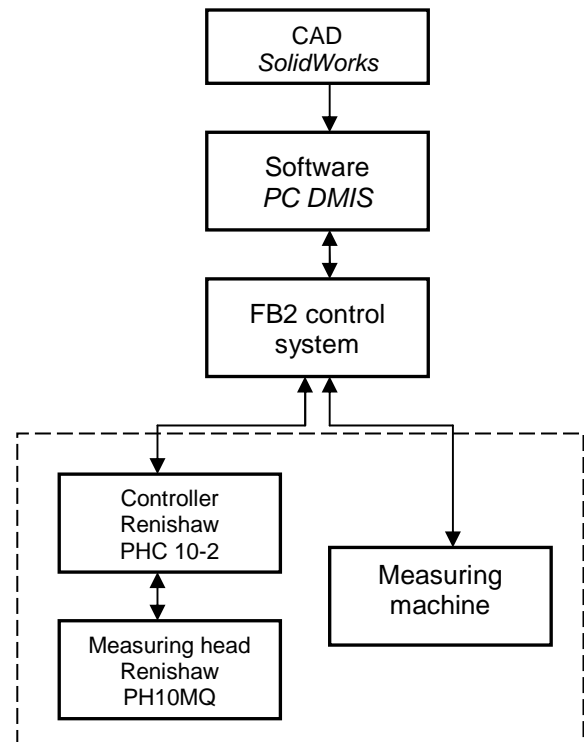


Fig. 4. CAD-CAI-NUMM integration.

Instructions (measuring operations) defined in software PC DMIS are transferred to the control system, which specify the movement of drive system of machine (for movement of linear axes) or probe head (for movement of two axes). Measurement signals represent feedback and measurement results can be processed on a computer [2].

The process of measurement can be conducted in one or more operations, depending on the number of preparations, number of machines, number of positions in which the part is measured. Since only one machine was used in the process of slider control and the part was placed in only one position, the process of measuring was conducted in one measuring operation.

4. MEASURING PROGRAM

The programming of measuring machine implies array of activities which need to be carried out for the specific measuring operation in order to gather all the needed informations for realising the measurement. On basis of these informations, measuring machine is prepared for the start of measuring process and then, in automatic regime, realizes measuring operation or measuring cycle. This leads to measuring report – on the basis of measuring results [1].

4.1. Defining the position of the slider

The measurement program should first define the position of the part on the machine. Due to the large dimensions and weight, the part is placed on the machine without restriction. Placing the slider on its side is conditioned by the paths. Roller guides that require high quality of fabrication are placed on top of these paths. Also, the part is placed longitudinal on the machine so the measuring sensor could easily reach the place where measuring is conducted, in order to avoid collision.

4.2. The choice of the probes

In order to accomplish the measuring operation it is necessary to define the scanning probe. For measuring the slider, measuring head PH10MQ and scanning probe SP25M are used, with scanning module SM25-2 and stylus holder SH25-2. This type of probe has sufficient length of stylus holder which allows measuring of the part without changing the probe. Defining of measuring tools is conducted in the program PC DMIS, in Probe Utilities window (Fig. 5).

4.3. Program measuring report

Program measuring report describes the controlling program through the orders which are written in common language, understandable to the user. Controlling program contains data which defines stylus holders route, stylus holders speed, getting the styli in the right position etc. [1].

Starting point in the program is defining the ground zero and leveling out, which defines the origin of the measuring subject's coordinate system, so the machine has the idea about subject's position and orientation on the machine table. After defining the position of the coordinate system, defining of all the geometrical entities is conducted (lines, planars, circles etc.) which are necessary for later control of shape and position tolerances.

Process of defining geometric entities consists of choosing the optimal number of points which precisely describe the entity, so the measuring process would not take long. It is also necessary to define the referral planars. Figure 6 shows the window from PC DMIS

software. Controlling program is shown on the left side. The right side graphically shows the slider with all the geometrical entities marked.

After the measuring of geometric shapes, determining their mutual relations and relations based on tolerance defined in the drawing is performed. Relations between geometric shapes are inserted by using Feature Control Frame, which is activated by selecting types of tolerance.

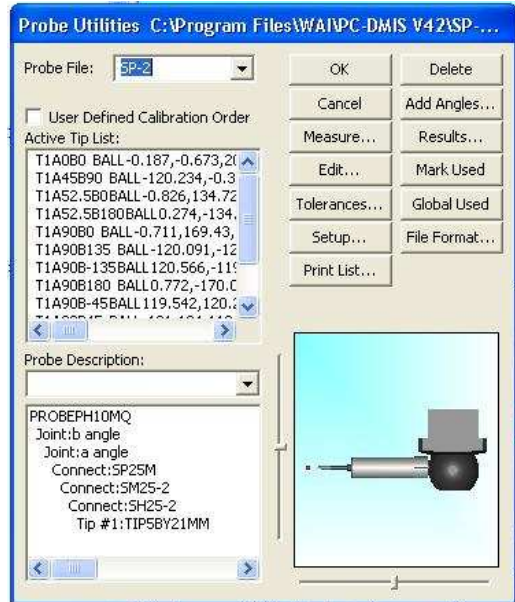
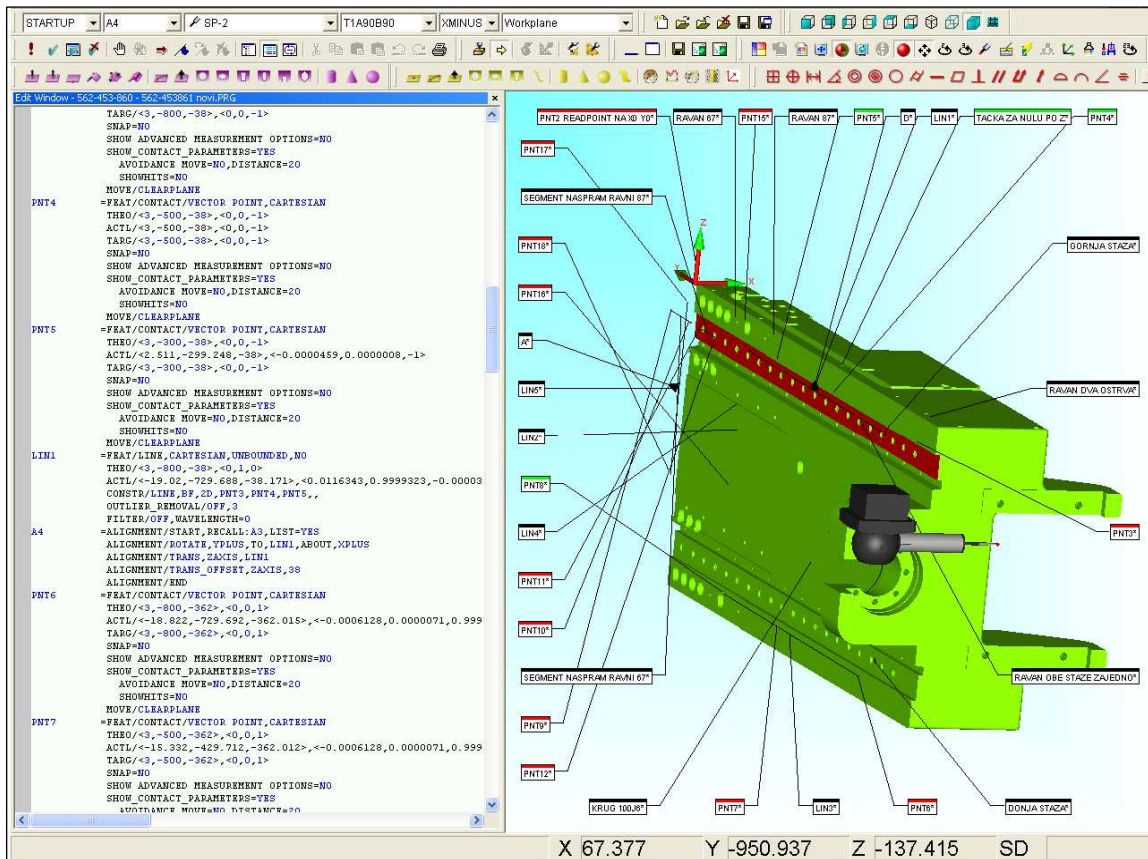


Fig. 5. Scanning probe defined in PC DMIS.



6. Control programme for slider in software PC DMIS.

Fig.

po·dmis		PART NAME : 562-453-861		maj 14, 2009		21:40	
		REV NUMBER : -752		SER NUMBER : 9504		STATS COUNT : 1	
MM		FLAT3 - RAVAN 67 TO THE ORIGIN					
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL	
M	0.000	0.010	0.000	0.006	0.006	0.000	<div style="width: 100%; height: 10px; background-color: green;"></div>
FCFCIRT...		MM <input type="text" value="0.01"/>					
Feature	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL	
KRUG 100J6	0.0000	0.0100		0.0014	0.0014	0.0000	<div style="width: 100%; height: 10px; background-color: green;"></div>
MM		LOC1 - KRUG 100J6					
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL	
D	100.000	0.016	0.006	99.995	-0.005	0.000	<div style="width: 100%; height: 10px; background-color: green;"></div>

Fig. 7. Report obtained by measuring slider.

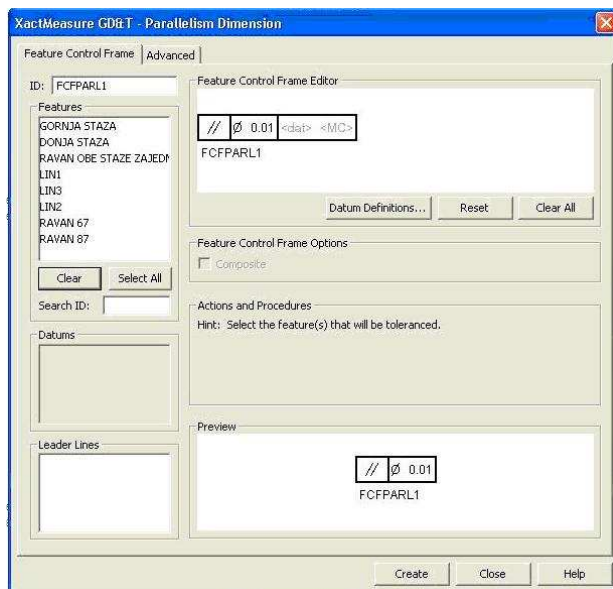


Fig. 8. Window *Feature Control Frame* for defining tolerance.

Figure 8 shows input values such as tolerance for parallelism required geometric shape.

Feedback in the form of a report is obtained after the end of the measurement process and slider control. Report contains name of the part, serial number, control date and all types of demanded tolerances presented in detail. Along with the label of tolerance, nominal value of the measure (NOMINAL), upper and lower tolerance (+TOL, -TOL), actual value of measure (MEAS), deviation from the nominal value of the actual measure (DEV) and also the value exceeding the actual measure in relation to the permitted (OUTTOL) are defined. One part of

the report, obtained after measuring the slider is shown on Fig. 7. Report shows that the measuring values are within allowed limit. Fulfillment of tolerance field is colored green. If some measures exceed the allowed value, the part is submitted to finishing until the set value is reached.

Additional control of the slider is done by placing the roller guides via comparator. Slider paths on top of which roller guides are placed must have high accuracy in terms of parallelism and flatness.

5. CONCLUSION

The basic elements of production metrology are numerically controlled measuring machines. Implementation of the measuring machine and the software requires high costs, but also provides many benefits and savings in time.

"IVA 28" is an example of digital factory in Serbian industry, where with CAI model manages to maintain product quality at a high level. Also, efficient and fast measurement of parts using CAI model allows that all customer requirements be met, both in terms of quality and in time of delivery.

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