INVESTIGATION OF AN A QUALLITY MEASUREMENT PLAN FOR AN ALTERNATOR CARRIER ON A CMM MACHINE

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ABSTRACT: Investigation of alternator carrier was conducted by measuring the functional positions on the coordinate measuring machine GAGE MAX 755 Navigator. The CMM machine was used in combination with Calypso software that was used for implementation of the measurement plan. The acquisition of measurement results was made and concrete analysis and conclusions were given. The work holder was designed and prepared for necessary measurement procedure. Measurement strategy included evaluation of 106 dimension parameters.

1. INTRODUCTION

The need for better precision has led to the development of more modern type machines (CMM), which can keep the pace with industry advances in achieving more precise dimensions. Coordinate measuring machines (CMM) machines are highly accurate, they contain a measuring head with the touch probe and with computer aid the tentacle touches a certain number of points to reconstruct the sampled surface for reverse engineering or verify dimensions and feature characteristics. Analysis of statistical data is often conducted in order to maintain 99 % possibility of acceptance with satisfactory process capability index and methods of process shifting for sensed accuracy of 0,1 μm and boundary failure of measuring in micrometric proportion [1]. In particular, with the aim of accuracy optimization, the sample density and its interaction with the probe configuration play the main character; on the other hand, in order to enhance the reproducibility of the measurement process, the iterative alignment is a real cost-effective tool able to improve this variable, with high effectiveness [2]. As for any other measuring equipment the uncertainty of CMM measurements must be reported together with the measured values. The spectrum of workpieces has been greatly increased and the work pieces have become geometrically more demanding and complicated, requiring a greater accuracy. In such a production control means are known to occupy from 30 % to 100 % of production time. In modern manufacturing production the quality assurance depends increasingly on the characteristics of CMM. Their use is not limited to the control of standard geometry, but they are also able to measure some special elements such as gears, camshafts, scanning of irregular shapes and many other elements that make the traditional technology required a separate special control devices or machines. In this paper investigation of alternator carrier dimensions is conducted on CMM GageMax 7/5/5. Quality assurance was usually performed with manual control method by using statistical methods. Manual control in most cases lasts longer and requires a precise and tedious work. A lot of times there exists the need to separate control of the workpiece from the processing machines, which in this case, cause delays and bottlenecks in production planning. The introduction of coordinate measuring machines (CMM) has caused great changes in all the production changes in production activities and also in the quality control.

2. SELECTION OF MEASUREMENT MACHINE

The quality of production doesn't depend only on the quality of machinery and tools used for processing, but also on the control method for these products. Important criterions for selection of CMM are the dimensions of the machine, number of touch probes, the shape of measurement head and he used software. CMM measurement uncertainty and are prescribed in the standard ISO 10360-2 is in force since 1994, which specifies two types of uncertainties in length and volumetric probing. When selecting the CMM based on the criteria of uncertainty the size of the measuring range for the length dependence and uncertainty must be taken into account. Larger area of tolerance at larger distances may pose a greater problem of measuring than small-scale measurements at a small distance. Table 1 presents aspect of ratio between the distance and starting position.

Table 1. Ratio between the distance and starting position.

Position tolerance	**Distance from the starting point.**		
	10	**100**	**300**
0.005 mm	0.25+L/1000		
0.010 mm	0.5+L/900	0.4+L/1000	
0.015 mm	0.7+L/500	0.6+L/600	0.4+L/1000
0.020 mm	1.0+L/400	0.8+L/500	0.6+L/750
0.030 mm	1.5+L/250	1.2+L/350	0.8+L/450
0.050mm	2.5+L/200	2.2+L/300	1.6+L/350
0.070 mm	3.5+L/200	3.0+L/200	2.5+L/300
0.100 mm	5.0+L/150	4.3+L/150	3.5+L/200

0.200 mm	10+L/100	9.0+L/100	7.0+L/100

Example: Bore with a position tolerance 0.050 mm and the distance from the starting point is 100 mm the CMM of necessary uncertainty is calculated with (1).

$$E = \frac{2.2 + L}{300} \qquad (1).$$

Equation (1) gives the possibility of uncertainty calculation on all distances L. For uncertainty calculation of all influential parameter is necessary and equation (2) is used for its calculation.

$$u_{proc} = \sqrt{\left(\frac{\mathrm{MPE}_E}{a}\right)^2 + u_{rep}^2} \qquad (2).$$

Where (MPE_E/a) is the maximum permissible error with an adequate probability density function applied (rectangular for instance); u_{rep} is the reproducibility of the measurement obtained from three different replications over the same experiment.

In this paper investigation of alternator carrier was conducted with CMM GageMax 7/5/5. Basic configuration of used measuring machine GageMax 7/5/5 navigator is as follows:

- ZEISS CMM – coordinate measuring machine,
- Measuring of distance X = 750 mm Y = 500 mm Z = 500 mm,
- TVA-Length of measuring error ,
- Temperature Variable Accuracy : MPE E TVA = (2,2 +0,05 ° * dT) + L / (300-5 * dT) µm, dT with ... deviation from 20 ° C and L length in mm,

Measuring error according to ISO 10360-2:
at 20 °C: MPE E = (2.2 + L/300) µm,
at 22 °C: MPE E = (2.3 + L/290) µm,
at 28 °C: MPE E = (2.6 + L/260) µm,
at 35 °C: MPE E = (3.0 + L/225) µm,
at 40 °C: MPE E = (3.2 + L/200) µm.
MPE_THP = 3.3 µm u 50 sec, MPE P = 2.2 µm.

In the figure 1 placement of alternator carrier can be seen.

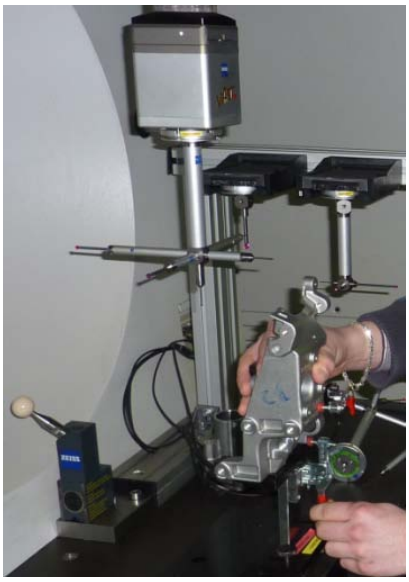

Figure 1. Selected measuring head and placement of product in the work-holder.

With its good thermal stability GageMax operates in a range between 15 °C and 32 °C (max. up to 40 °C). In other words, this is the temperature at which they can rely on very accurate results. Only Carl Zeiss defines accuracy as a function of temperature (TVA = Variable Temperature Accuracy), which allows to calculate the accuracy GageMax and at any temperature. It is a vital factor for highly precise measurements. Measuring machines that operate in the middle of the production facility must be better protected. It must be almost completely protected against dust, oil, and vibration and temperature changes. For this reason the whole of the measuring technique is protected in a 3D frame. This frame is placed on the base of the machine and protects the sensitive components of the coordinate measuring machine from the environmental impact. Guides are made from a solid, thermally stable carbon fiber. The additional screen is sensitive to touch and it is also protected from dust and moisture. Measuring machine must be placed in the middle of the facility and must offer optimal flexibility without disturbing the production process. Job-shop position must have nominal temperatures from 18 - 28 °C GageMax CMM is designed to offer unrestricted access from three sides. Despite its compact design GageMax is surprisingly roomy for measuring volume.

3. SOFTWARE CALYPSO

Investigation of alternator carrier was conducted with the use of the Calypso software. It is important that input design of the computer to be able to accept all orders of operator over NC program specifically designed for the measuring application.

Calypso software has the following characteristics:

- software with CAD core for all prismatic core measurements,
- software is easy to use because process is based on examination schedule,
- complete graphics support including tasks visualization and input data,
- small affinity to errors due to the tendency of automatic identification elements and automatically generate routes,
- timing and optimization considering to the variable of focus,
- variable report of results from the simple integration of related graphics,
- multimedia support for documenting parts of the clamping and probe configuration for the run of CNC.

Software offers selection of tolerances from drawings or CAD models in accordance with the requirements of the workpiece. Elements for the measurement that have to be evaluated can be specifically selected. Integrated assistant offers an ergonomic and intuitive approach that allows the selection of necessary references and fast integration of specified measuring plan. This method of creating and maintaining measuring plans - Visual Metrology is the basis of CALYPSO's. Benefits are that conduction of measuring plan is done without programming in single line. The selected measuring plans are stored and easily accessible.

4. FUNCTIONAL COORDINATES

Functional coordinates are dimensions that are very important for proper utilization of the product. Functional dimensions are used to calculate the required tolerances for the location, perpendicular, concentricity, flatness and holes. Dimensions that have been marked as a draft functional are indicated with the label CTF. The figure 2 shows 7 functional dimensions, while total investigated number consisted of 106 dimension parameters.

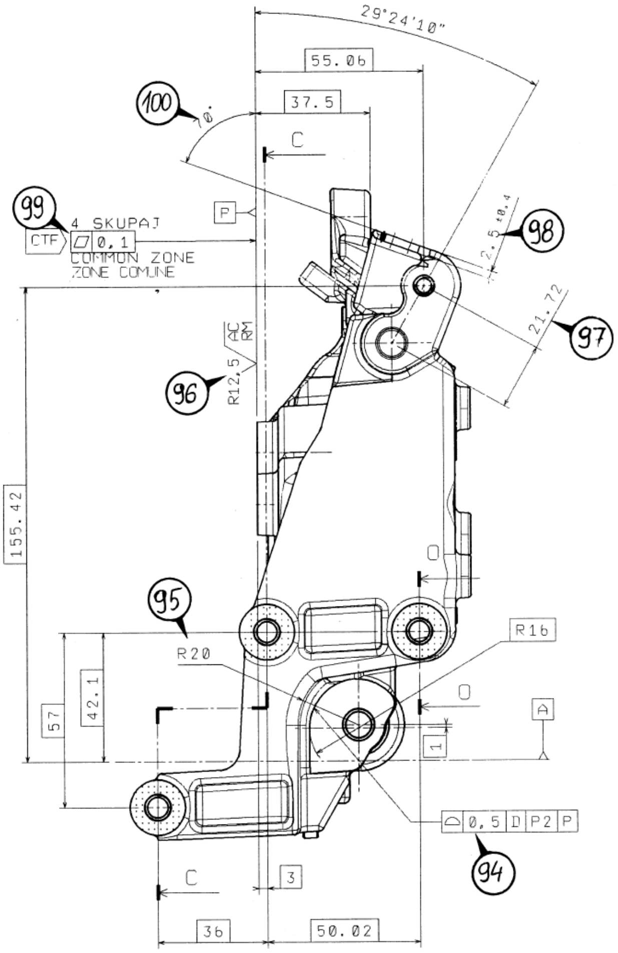

Figure 2. Alternator carrier front view and relative functional dimensions.

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5. QM PLAN

For quality measurement plan the Software Calypso and CMM machine have to be coordinated. The setup requires activation of software, preparation of navigation, selection and control of touch probe. The touch probe is selected depending on its performance and capability to complete the measuring in one cycle. Order of using the probe is specified depending on the measurement plan and adequately each probe is calibrated. The contact probing system of a Coordinate Measuring Machine is characterized by evaluating a large number of measurements on the surface of a very precise sphere of known diameter. The required quality of the master spheres is determined by the intended application. The standard high quality balls used for general commercial calibration are A.F.B.M.A.-grade five [3]. This quality meets the requirements of the ANSI-B89.4.1-1997 Specification for Evaluating C.M.M. Performance. This is an instrument quality ball with a sphericity of 127 nm. The total surface texture of grade 5 balls is held to less than 10 nm Ra. When calibrating high-end commercial machines and super accurate laboratory measuring machines, grade 2.5 master spheres are used. The required 63.5 nm sphericity of these master spheres is right at the limit of commercial measuring ability. The total surface texture on these spheres, approaches 5 nm. The control is executed with the touch probe that revolves around the quality ball in xy, xz and yz axes. The results are corrected with measuring software and the measuring of intended product can start [4, 5]. In our case the object from the front side overlaps on two locations. This is mainly at the bottom of the object. On the back the object overlaps in three places (locating points), usually beside the functional dimensions where the largest measurement accuracy is necessary. Figure 3 represents front view of locating and clamping positions for the alternator carrier.

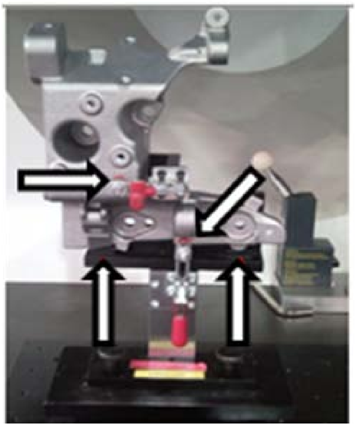

Figure 3. Arrows represent locating elements and clamping, product must be constricted in all directions of fredom

If an insufficient number or inappropriate distributed data is used the possibility of obtaining unreliable results is very large. On the other hand increasing the number of points means an increase of the measurement program which would mean increasing the cost of quality. For this reason it is necessary to determine the number and distribution points to obtain reliable results.

Adherence to given instructions given in some cases may not be sufficient. There exists a great variation in dimensions of measuring elements, processing technologies, surface condition, material, probe systems, the required accuracy and other parameters that influence the choice of proper measurement strategies. The key is understanding the characteristics of each element accessible in the selection of measurement strategies. For this reason, the strategy of calibration and the method of calculation may be useful guidelines to help reduce measuring uncertainty. The investigation CMM hardware performance and determination of the machine variables contribution to measurement uncertainty was also taken in consideration for QM plan.

In our investigation three different forms for QM plan were determinated to be necessary:

- Home page QM plan - product image, product name, code, index products.
- QM plan - a description of testing - performance testing, MPO, frequency, pattern, level.
- Addition QM plan - sketch the characteristics of the test.

6. ANALYS OF THE RESULTS

At the end of the measurements we obtained the results of combined with other data useful for interpreting the QM plan. First part of the report provides information on the codes work, timekeepers, time measurements, pieces of tags, and the CMM machine all necessary for calculation of total uncertainty.

The unspecified tolerances were monitored according to EN2768, EN2768 2, NF EO2 351. The undimensioned geometry was done according to 3D model, accuracy. Several standards were followed PSA B11 3110 for threads, PSA A32 4250 for unspecified tolerances for HPDC parts, PSA A1 2260 for product marking, PSA B20 0110 for product supplies, PSA B20 0250 for materials subjected to regulations, DEX ISO 1302 for geometrical product specifications.

Dimensions were investigated from S1 to S99 and evaluation was given. The dimensions out of tolerances were addressed and recommendations for their improvement given. A significant variation in mean measurement error was produced and it was associated to machine squareness errors.

Example of control for dimension no. 99 indicates the evenness:

- Mark S denotes functional dimension.
- The number 45 indicates the position of the dimension.
- The letter D indicates the front base of the alternator carrier.
- The measure of 0.1000 denotes the upper deviation of investigated dimension.
- The measure of 0.0461 indicates positive deviation from the nominal dimension.
- Since 0.0461 <0.1000 this means that the dimension is within the limits of specified tolerance.

The number of dimensions is in the draft given in figure 2. Some results are given in table 2.

Table 2. Some measurements results.

	Measurement uncertainty: 2.2+L/300 mm^{-3} at 20° C					
Names	Description	Actual	Nominal	Utol	Ltol	Dev.
S99	GDT Flat			0.1000		0.0461
S25	D	10.0697	9.9000	0.0000	-0.2000	0.1697
S40	D	8.0332	8.0300	0.0200	0.0000	0.0032
S39	GDT Perp			0.0500		0.0062
Ref. Lenght		10.4000	8.2200			
S45	D	8.2296		0.1000	0.0000	0.0096
S46	GDT po2d					0.0344
	Anglet	-77.7190				
	Z	-15.9963	-16.0000			0.0037
	X	73.4832	73.5000			-0.0168
S47	GDT Perp			0.0500		0.0131
Ref. lenght		9.0000				

7. CONCLUSION

The investigation was conducted in order to assure geometrical accuracy of functional dimensions. A concrete measurement plan was created and executed. The complete numerical results are provided for dimension no. 99, which can serve as reference data. Proposed measurement quality plan fallowed prescribed norms and indentified critical dimensions. The method proved its reliability to indicate the measurement uncertainty as control was done within job-shop floor in working conditions under the temperature of 20 °C. Measurement strategy observed 106 dimension parameters. Statistical probability of error used for the production process of 95 % was satisfied as the errors were within 2σ value range.

8. REFERENCES

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