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CMM measurement and measurement quality plan for dimension control

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Abstract: Implementation of a Quality measurement plan is evaluated as an integral part of organization and business goals. A Quality plan has been introduced into the Calypso software process and 118 dimension parameters will be analyzed. A method to define, collect and analyze selected drawing dimension parameters is presented, together with a method for communication within organization. Measurements are conducted with a coordinate measuring machine GAGE MAX 755 Navigator.

Keywords: CMM, measurement, quality, QMP, dimension inspection

INTRODUCTION

Quality measurement plan (QMP) is used for collection of measurement data; they are usually based on 2D or 3D product drawing. Such drawings based on QMP represent a robust procedure that allows an accurate inspection process of products without misinterpretation of critical dimensions. Use of automated measurement systems like coordinate measuring machines allows measurement and control of hundreds of product dimensions that influence the quality, quantity and managing costs [1]. Measurements can accurately describe the status of project process and products. Parts inspected with CMM and direct comparison with computer aided models leave little room for errors. This allows creation of redesigns that facilitate better manufacturability by implementation of drawing/design changes.

QMP requires robust work-holder that allows access to critical dimensions in this paper a total of 118 measurement points or dimensions are investigated. The work-holder has to allow quick and easy positioning and allow repeatability of measurement process where several products of a series are inspected. Fig. 1 shows 3D model of investigated product and relative specially created work-holder. The ratio between distance and starting point has to be considered for its influences on the position tolerance. Furthermore minimum or more points of measurements have to be taken in consideration depending on the measured shape. The more point are used the measurement is more accurate however there comes a point for every shape where redundancy of measurements get involved and the optimal number of measurement points regarding measurement quality can be selected.

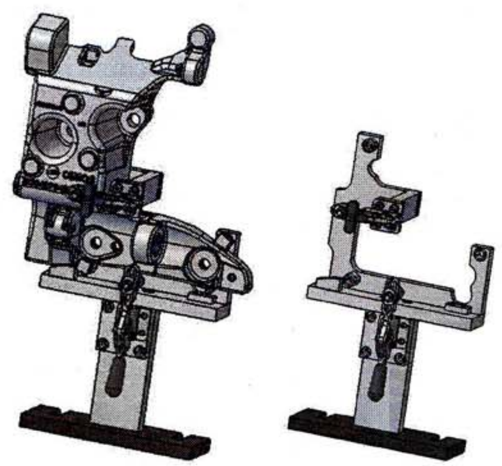

Fig. 1 Special work-holder for alternator carrier

After critical points are controlled the deviations and further analysis of process involved in production of these is analyzed. This is the reengineering methods that allow creation of useful rules that can further reduce measurement uncertainty and possibility of errors.

In this paper investigation of measurement points for an alternator carrier produced with combinations of process of precision casting, boring and milling is conducted. Critical measurement points depend on all mentioned production processes that can greatly influence a production batch. For this investigation ZEISS CMM GageMax 7/5/5 is used with measurement error according to ISO 10360-2 at 20 °C of E = (2.2 + L/300) µm [2]. Measurement plan is used in combination of 3D, 2D product drawing and software Calypso.

SOFTWARE CALYPSO

Software offers selection of tolerances from drawings or CAD models in accordance with the requirements of the work-piece. 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 implementation of specified measuring plan. This method of creating and maintaining measuring plans - Visual Metrology is the basis of CALYPSO's. The selected measuring plans are stored and easily accessible. Fig. 2 shows software display for specific product and four different measurement plans created for analysis of the product and saved by a special code. Fig. 3 shows the product prepared for measurement.

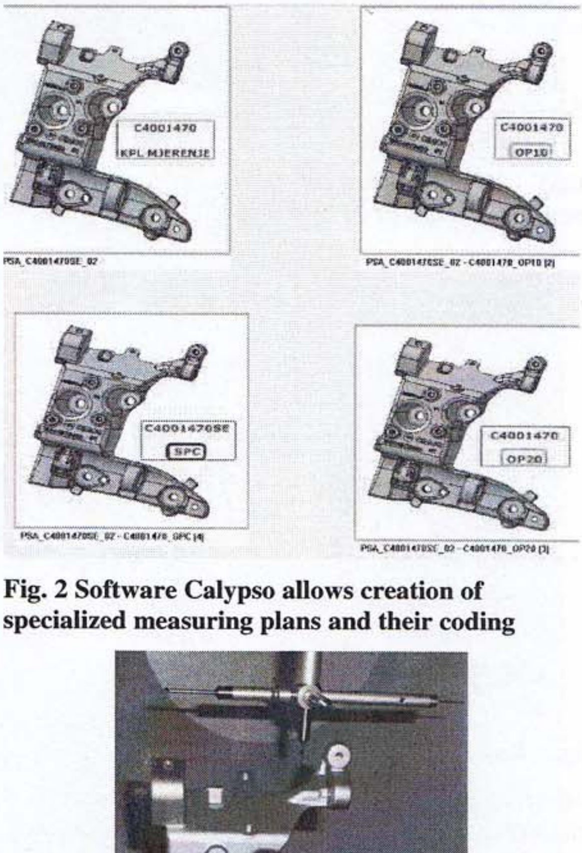

Fig. 2 Software Calypso allows creation of specialized measuring plans and their coding

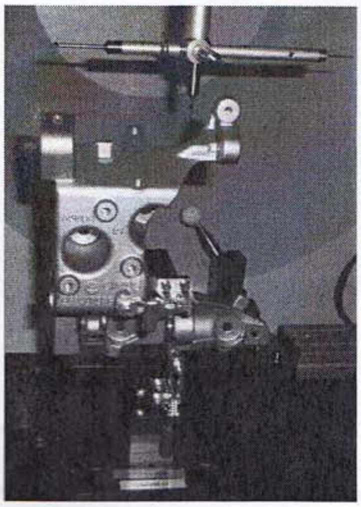

Fig. 3 Product has been pace in work-holder and is prepared for measurement

QUALITY PLAN

In quality plan there are several aspect to consider such as documentation status of the product, name of the product, code of the product and its drawing code, index a number that marks the number for changes on the product, image of the product, status of security and low procedures and administrative data. For measurement purpose 2 plans are created, a plan for control of incoming products and a plan for control of products in the production process. They have similar purpose and their main features are the control characteristics, measurement instruments nomenclature, frequency of control, the specimen load for control and different levels of laboratory control. Levels of laboratory control consist of factory job-shop inspection, factory laboratory inspection, third party with a certified laboratory inspection. Strategy of measurement plan in 3D CMM machines consists of selecting an ideal number and layout of points for control of a specified element [4]. The timetable of measurement cycle depends on the number of points and also the quality of measurement. Ideal cycle that detects dimensional errors depends on shape complexity and specified accuracy in this investigation up to mm^{-3} [3] is used. The number of points creates data that calculates positions, sizes and tolerances from the nominal dimensions. In order to achieve reliable results the gathered data has to be representative for given element. If inadequate number of points or inconsistencies of data distribution is used the possibility of errors is high.

RESULTS

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. Figure 4 presents the boring dimension that is used as a reference for Tab. 1 explanation. Several results are given in Tab. 1. Fig. 5 shows the complexity of investigated dimensions.

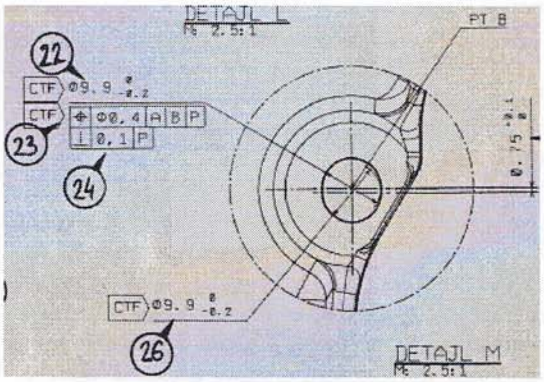

Fig. 4 Detail with the boring dimension Ø $9.9^{-0.2}$

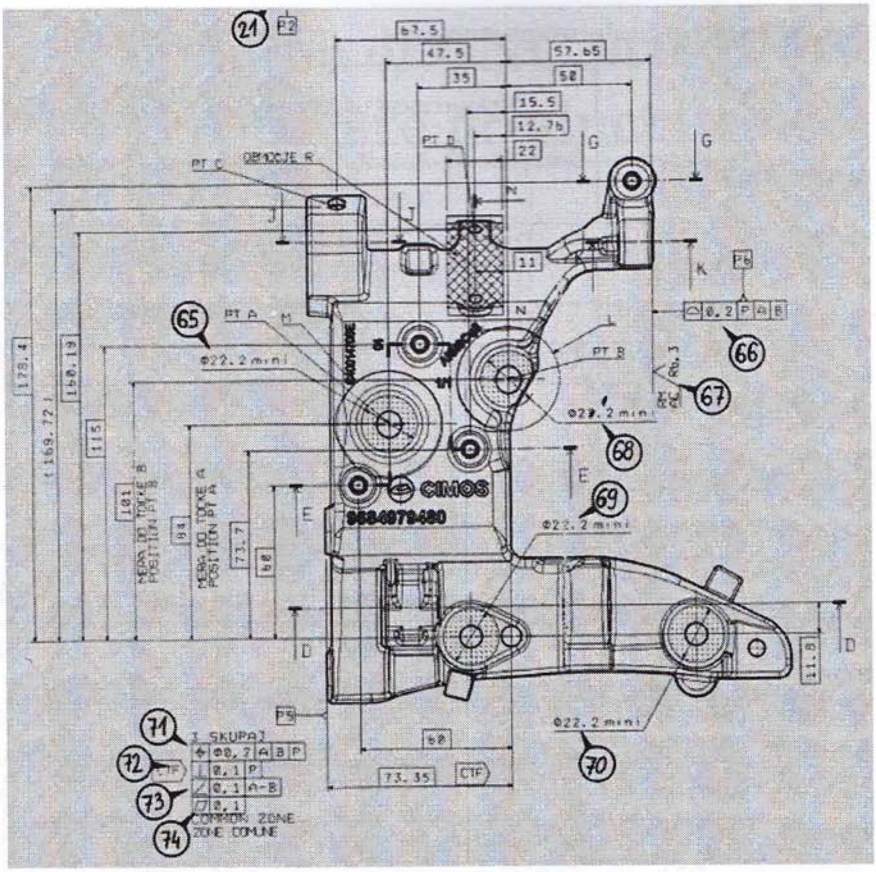

Fig. 5 The complexity of the shape and control dimension of the front view of the product

Example of control for dimension no. 26 indicates boring Ø $9.9^{-0.2}$.

- Mark S denotes functional dimension.
- The number 26 indicates the position of the dimension.
- The letter D indicates the front base of the alternator carrier.
- The measure of 9.7430 mm^{-3} denotes the actual dimension.
- The measure of 9.9000 mm^{-3} nominal value of dimension
- The measure of 0.000 mm^{-3} indicates upper deviation of dimension.
- The measure of - 0.2000 mm^{-3} indicates lover deviation of dimension.
- The measure of - 0.1570 mm^{-3} positive deviation of dimension.

Because the dimension is – 0.1570 < - 0.2000 this means that the dimension is within tolerance boundary condition.

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).

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

For uncertainty calculation of all influential parameter is necessary [5 - 7] and equation (2) is used for its calculation.

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

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. Errors of total uncertainty were analyzed taking in consideration all processing parameters and measurements until this final step. Additional control of bored holes was conducted with comparators, calipers, thread and plug gages. Fig. 6 shows control of Ø $8.22^{+0.02}$ hole comparator standard PSA B11 3110 was used for their control.

Fig. 6 Additional control of boring dimensions

Tab. 1 Several results of conducted measurement

	Measurement uncertainty: 2.2+L/300 mm^{-3} at 20° C					
Names	Description	Actual	Nominal	Utol	Ltol	Dev.
S30	D	9.4545	9.5000	0.0000	-0.2000	-0.0455
S26	D	9.7430	9.9000	0.0000	-0.2000	-0.1570
D38_M	D	8.9520	9.3000	0.0000	-0.7000	-0.3480
D38_L	D	8.9697	9.3000	0.0000	-0.7000	-0.3303
D49_M	GDT Perp			0.1000		0.1283
Reference Length		10.4000				
D49_L	GDT Perp			0.1000		0.0351
Reference Length		11.4000				
INFO_D16	GDT Coa			0.2000		0.1500
Reference Length		19.8810				
INFO_P5_E	AxLength	73.3452	73.3500	0.1000	-0.1000	-0.0048
INFO_P5_E	AxLength	73.3452	73.3500	0.1000	-0.1000	-0.0198
INFO_P5_G	AxLength	73.3452	73.3500	0.1000	-0.1000	-0.0191
D73	GDT Ang			0.1000		0.0318
D74	GDT Flat			0.1000		0.0318
D29	GDT Perp			0.1000		0.0318

CONCLUSION

The investigation has shown the importance of CMM in controlling specific dimensions, points and capability of precise creation for more complex products. Geometrical accuracy of functional dimensions was assured and the used measurement plan has shown its capability in detection of more problematic dimensions and part places prone to errors. Several numerical results have been shown specifically for dimension no. 26 that indicates boring Ø $9.9^{-0.2}$ and can serve as a reference data. The measurement plan was done in accordance with EN2768, EN2768 2, NF EO2 351. The un-dimensioned geometry was done according to 3D model, accuracy. Several standards were followed such as 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. The control was done within job-shop floor in working conditions under the temperature of 20 °C. Measurement strategy observed 118 dimension parameters. Further research will be orientated in reducing the number of measurement points and dimensions while maintaining a satisfactory quality of the product.

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