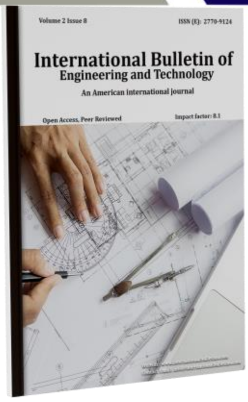

ANALYSIS OF THE EXPERIMENTAL RESULTS OBTAINED IN THE COORDINATE MEASURING MACHINE

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Annotation. Modern tools of coordinate measurement and calculation systems allow us to automate the process of measuring parts of complex shape. It also helps us to eliminate problems in the production process and learn about problems that may arise in the future.

The experiment was conducted at the joint enterprise "Uz Auto Austem" in Andijan city, Andijan region. The object of the experiment is a three-coordinate measuring machine, in the course of the experiment, we measured the disks produced for several different cars and checked the obtained results.

Key words: coordinate measuring machines (CMM), automotive industry, coordinate measuring methods, X, Y, Z coordinates, laboratory test equipment, testing, analysis, quality assurance, warranty period.

In order to conduct test experiments on coordinate measuring machines, we should first pay attention to how accurately the measuring machine is measuring. For this, we need to use a sphere with a diameter of 15.876 mm, that is, our standard, which we always check before measuring.

Fig 1. A snapshot of the process of measuring the standard to be checked before starting the measurement.

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In the picture below, we can see the machine-measured coordinates of the standard:

UZ AUTO AUSTEM	ИМЯ ДЕТАЛИ: СФЕРА		April 01, 2022	8:12 AM
	НОМЕР РЕДАКЦИИ:	ПОРЯДК. НОМЕР:	СТАТИСТ. СЧЕТЧИК: 1	

РАЗМ. LOC1=ПОЛОЖЕНИЕ СФЕРА SPH1 UNITS=MM

ОСЬ	НОМИНАЛ	ИЗМЕР.	+ В. О.	– Н. О.	ОТКЛ	

РАЗМ. LOC2= ПОЛОЖЕНИЕ СФЕРА SPH4 UNITS=MM

ОСЬ	НОМИНАЛ	ИЗМЕР.	+ В. О.	– Н. О.	ОТКЛ	
D	15.876	15.875	0.050	0.050	-0.001	----#----
X	0.000	-0.002	0.050	0.050	-0.002	----#----
Y	0.000	0.001	0.050	0.050	0.001	----#----

РАЗМ. LOC3= ПОЛОЖЕНИЕ СФЕРА SPH5 UNITS=MM

ОСЬ	НОМИНАЛ	ИЗМЕР.	+ В. О.	– Н. О.	ОТКЛ	
D	15.876	15.874	0.050	0.050	-0.002	----#----
X	0.000	0.001	0.050	0.050	0.001	----#----
Y	0.000	0.002	0.050	0.050	0.002	----#----

РАЗМ. LOC4= ПОЛОЖЕНИЕ СФЕРА SPH6 UNITS=MM

ОСЬ	НОМИНАЛ	ИЗМЕР.	+ В. О.	– Н. О.	ОТКЛ	
D	15.876	15.877	0.050	0.050	0.001	----#----
X	0.000	0.002	0.050	0.050	0.002	----#----
Y	0.000	0.001	0.050	0.050	0.001	----#----

РАЗМ. LOC5= ПОЛОЖЕНИЕ СФЕРА SPH7 UNITS=MM

ОСЬ	НОМИНАЛ	ИЗМЕР.	+ В. О.	– Н. О.	ОТКЛ	
D	15.876	15.878	0.050	0.050	0.002	----#----
X	0.000	0.002	0.050	0.050	0.002	----#----
Y	0.000	0.003	0.050	0.050	0.003	----#----

Figure 2. Results of the standard of the coordinate measuring machine.

Coordinate measuring machines (CMMs) are used in almost any field that requires accurate dimensional inspection of manufactured parts. In today's competitive environment, manufacturers require CMMs to be accurate, reliable, fast, cost-effective and have maximum flexibility in their work environment.

The maximum permissible error of the CMM indicator for measurement

EMPE, L is a term that many CMM users know. This is a term that determines the accuracy of measuring the length of their CMM. EMPE is defined as the extreme value of the error of the SME indicator for measuring the size of EL allowed by the specifications, regulations, etc. for the SME. The maximum permissible error of the CMM indicator EL, MPE for the measurement error is shown in one of three forms:

a) *EL, MPE = ± minimal (A + L / K) va B* (see Figure 3a);

b) *EL, MPE = ± (A + L / K)* (see Figure 3b); or

c) *EL, MPE = ± B* (see Figure 3c);

here,

A is a positive constant expressed in micrometers and provided by the manufacturer;

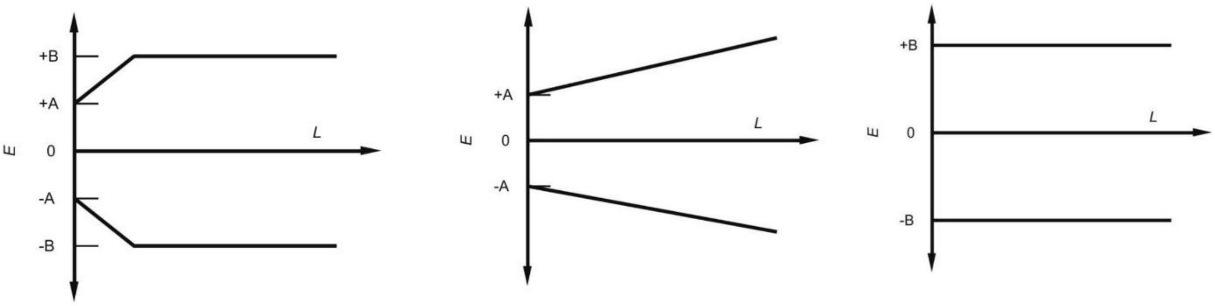
K is a dimensionless positive constant supplied by the manufacturer;

L - measurement size, in millimeters; and

B is the maximum allowable EMPE, L error in micrometers as stated by the manufacturer.

These expressions are valid for the orientation of the location of the material standard of any size in the CMM measurement volume.

Measurements must be made using the three axes of the machine, and these expressions are valid for any position and orientation of the material standard in the working envelope of the CMM.



a b c

Fig 3. The specified maximum SME error

EL, MPE, the maximum permissible length measurement error, is newly defined as the new length measurement error, EL, the maximum value allowed by the specifications. Part 2 of ISO 10360 specifies L = 0 mm and L = 150 mm (standard values).

It should be noted that when test measurements reveal errors, the maximum permissible error (MPE) is used, as opposed to the maximum permissible limit (MPL) specification, so testing the MPE specification requires the use of calibrated artifacts.

Operating conditions

When conducting acceptance testing, the SME should be managed using the procedures provided in the manufacturer's user manual.

Specific directions of working conditions that must be followed, for example:

- car start-up / warm-up cycles;
- stylus system configuration;
- cleaning procedures for the stylus tip;
- check the qualification of the system;
- thermal stability of the sensing system before calibration;
- weight of stylus system and/or sensing system; and
- location, type, number of thermal sensors.

Calculation of results

The specified value can be corrected taking into account systematic errors, if the SME has additional devices or software for this purpose. If the environmental conditions used for the test are recommended by the manufacturer, then there is no manual correction, the specified values can be manually performed by the user.

Analysis of research results and recommendations

The results of test experiments on the accuracy of measuring light car details (in the example of a disk) on a three-coordinate measuring machine.

Dopusk is an interval in which the actual dimensions of workable details lie. It is always a positive quantity.

"Posadka" refers to the joining of two details. According to the size of the hole and the shaft, the posadka is divided into harmful (slotted) or productive (tense) posadkas.

We carried out the measurement accuracy of light car details on a three-coordinate measuring machine on the example of a car disc and got some results.

Fig 4. The measurement process of the light car disc part on the coordinate measuring machine.

In the process of measuring the disc shown in the picture above on a coordinate measuring machine, we looked at how correctly the disc was pressed and how well it was produced for each car disc.

Fig 5. In the picture above, the standard dimensions of the disc placement.

UZ AUTO AUSTEM	ИМЯ ДЕТАЛИ: M-300 14		March 15, 2022	5:53 PM
	НОМЕР РЕДАКЦИИ: LOT 22.03.15A/13	ПОРЯДК. НОМЕР: 22.C.0542	СТАТИСТ. СЧЕТЧИК: 1	

Текущая температура : X=22.137 Y=18.983 Z=22.431 P=20.483

Температурная компенсация ВЫКЛ.

РАЗМ. LOC1=ПОЛОЖЕНИЕ ТОЧКА PNT3 UNITS=MM

ОСЬ	НОМИНАЛ	ИЗМЕР.	+ В. О.	– Н. О.	ОТКЛ
Z	-43.500	-43.173	0.500	0.500	0.327

РАЗМ. LOC2= ПОЛОЖЕНИЕ ТОЧКА PNT6 UNITS=MM

ОСЬ	НОМИНАЛ	ИЗМЕР.	+ В. О.	– Н. О.	ОТКЛ
Z	-43.500	-43.635	0.500	0.500	-0.135

РАЗМ. LOC3= ПОЛОЖЕНИЕ ТОЧКА PNT9 UNITS=MM

ОСЬ	НОМИНАЛ	ИЗМЕР.	+ В. О.	– Н. О.	ОТКЛ
Z	-43.500	-43.637	0.500	0.500	-0.137

РАЗМ. LOC4= ПОЛОЖЕНИЕ ТОЧКА PNT12 UNITS=MM

ОСЬ	НОМИНАЛ	ИЗМЕР.	+ В. О.	– Н. О.	ОТКЛ
Z	-43.500	-43.518	0.500	0.500	-0.018

Fig 6. M-300 i.e. the result obtained on the coordinate measuring machine of the Spark car disc.

UZ AUTO AUSTEM	ИМЯ ДЕТАЛИ: T-250 15			April 08, 2022	6:50 PM
	НОМЕР РЕДАКЦИИ: 22.04.02.A	ПОРЯДК. НОМЕР: 22.D.0771		СТАТИСТ. СЧЕТЧИК: 1	

Текущая температура : X=21.911 Y=21.279 Z=21.987 P=21.84
Температурная компенсация ВЫКЛ.

РАЗМ. LOC1=ПОЛОЖЕНИЕ ТОЧКА PNT3 UNITS=MM

ОСЬ	НОМИНАЛ	ИЗМЕР.	+ В. О.	– Н. О.	ОТКЛ
Z	-45.000	-44.630	1.000	1.000	0.370

РАЗМ. LOC2= ПОЛОЖЕНИЕ ТОЧКА PNT6 UNITS=MM

ОСЬ	НОМИНАЛ	ИЗМЕР.	+ В. О.	– Н. О.	ОТКЛ
Z	-45.000	-44.756	1.000	1.000	0.244

РАЗМ. LOC3= ПОЛОЖЕНИЕ ТОЧКА PNT9 UNITS=MM

ОСЬ	НОМИНАЛ	ИЗМЕР.	+ В. О.	– Н. О.	ОТКЛ
Z	-45.000	-44.212	1.000	1.000	-0.212

РАЗМ. LOC4= ПОЛОЖЕНИЕ ТОЧКА PNT12 UNITS=MM

ОСЬ	НОМИНАЛ	ИЗМЕР.	+ В. О.	– Н. О.	ОТКЛ
Z	-45.000	-44.904	1.000	1.000	0.096

Fig 7. The result of the T-250 i.e. Aveo drive on the coordinate measuring machine.

UZ AUTO AUSTEM	ИМЯ ДЕТАЛИ: GSV-EM 14x5.5J 95040743		April 13, 2022	8:36 PM
	НОМЕР РЕДАКЦИИ: LOT 22.03.15A/13	ПОРЯДК. НОМЕР: 22.C.0542	СТАТИСТ. СЧЕТЧИК: 1	

Текущая температура : X=22.78 Y=21.695 Z=22.953 P=22.502
Температурная компенсация ВЫКЛ.

РАЗМ. LOC1=ПОЛОЖЕНИЕ ТОЧКА PNT3 UNITS=MM

ОСЬ	НОМИНАЛ	ИЗМЕР.	+ В. О.	– Н. О.	ОТКЛ
Z	-39.500	-38.995	0.500	0.500	0.005

РАЗМ. LOC2= ПОЛОЖЕНИЕ ТОЧКА PNT6 UNITS=MM

ОСЬ	НОМИНАЛ	ИЗМЕР.	+ В. О.	– Н. О.	ОТКЛ
Z	-39.500	-38.661	0.500	0.500	0.339

РАЗМ. LOC3= ПОЛОЖЕНИЕ ТОЧКА PNT9 UNITS=MM

ОСЬ	НОМИНАЛ	ИЗМЕР.	+ В. О.	– Н. О.	ОТКЛ
Z	-39.500	-38.988	0.500	0.500	0.012

РАЗМ. LOC4= ПОЛОЖЕНИЕ ТОЧКА PNT12 UNITS=MM

ОСЬ	НОМИНАЛ	ИЗМЕР.	+ В. О.	– Н. О.	ОТКЛ
Z	-39.500	-38.773	0.500	0.500	0.227

Fig 8. GSV-EM, i.e. the result obtained on the coordinate measuring machine of the Cobalt car disc.

In order to get the results we measured, the base, i.e. 0 point for the measured car wheel, is selected and 4 points manually, the 0 points we selected are entered into the coordinate measuring machine. After that, 4 points of the car tire mounting part are manually inserted into the measuring machine at an angle of 90 degrees, and then the results are obtained.

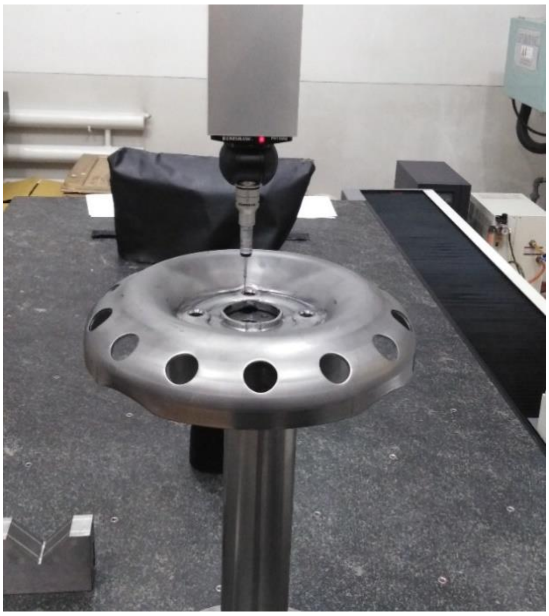


Fig 9. GSV-EM 14, i.e. Cobalt light car disc part measurement process on coordinate measuring machine.

Analysis of results obtained in experiments

According to the results obtained in the experiments, as we have seen, the coordinate measuring machine from the daily work in the disc production process of M-300 (Spark), T-250 (Aveo), J 200 (Jentra), GSV-EM (Cobalt) cars we looked at the results. If we pay close attention to the pictures, the results are produced without any problems within the permissible errors. In some cases, if the measurement result exceeds the permissible error in any part of these tables, that error is marked with red color and displayed on the computer screen. We understand from this that the part being produced is defective and the production line needs to be adjusted.

There have been significant improvements in measuring systems to meet the changing demands of the market. This rapid change and development of measurement technology was primarily driven by the accuracy and precision requirements of the aviation, automotive, and other manufacturing industries. Coordinate measuring machines (CMMs) with different technologies and configurations have been effectively meeting the needs of customers for more than ten years. Although today's SMEs are more than able to meet the rapid and increasing demands of customers, SMEs have a lot of room for improvement and development. As a result of the globalization of production, various complex products have been manufactured and mechanical components have been miniaturized. Micro/nano-scale 3D measurement technology is still disruptive for industries. Therefore, it is necessary to investigate a system that is accurate and precise enough to deal with the complexity of parts and products in the micro and nano range.

As precision and accuracy requirements increase from the aerospace, automotive, medical, die and die, semiconductor, electronics, shipbuilding and other manufacturing industries, it is imperative to create machines capable of new procedures and complex measurements. CMM is considered transparent in the inspection industry due to its high accuracy and repeatability of measurement results. At the same time, the CMM should provide the necessary and reliable information about the dimensions and tolerances of the parts. Evaluating the performance of CMM's and identifying the uncertainty associated with measurement results is essential to maintain reliability as well as repeatability of CMM's results.

According to the results, in the process of measuring the disc on the coordinate measuring machine, we looked at how correctly the disc was pressed and how well it was produced for each car disc. According to the results obtained in the experiments, as we have seen, the coordinate measuring machine from the daily work in the disc production process of M-300 (Spark), T-250 (Aveo), J 200 (Jentra), GSV-EM (Cobalt) cars we looked at the results. The results are produced without any problems within the permissible errors. In some cases, if the measurement result exceeds the permissible error in any part of these tables, that error is marked with red color and displayed on the computer screen. We understand from this that the part being produced is defective and the production line needs to be adjusted.

Conclusion

The role of coordinate measuring machines

CMMs are ideal for the following conditions:

• Short lead times - we may be producing hundreds or even thousands of parts, but production control is not sufficient to justify the cost of tooling.

• Multiple properties - Both if we have a number of properties

dimensional and geometric - CMM is a tool for management that makes management easy and economical.

• Flexibility - Because we can choose the program of the CMM system, we can do short-term work and measure several properties.

• High unit cost - Because recycling or waste transportation is expensive, CMM systems significantly increase the production of acceptable parts.

• Production stoppage - When a part needs to be inspected and moved before the next part can be processed, a machining center can save the manufacturer more money than it would save by reducing time.

All CMMs have three orthogonal axes (X, Y and Z) operating in a 3D coordinate system. Each axis has a dimension used to indicate the position or position of the system in space. Machines read data from a sensing device programmed by the operator or using computer numerical control (CNC). They then use this information to calculate the desired distance measurements (dimensions), geometric shapes (features), and the relative position of these shapes (processing features).

The introduction of CMMs has made quality assurance more efficient, accurate and flexible. These advantages come from programming and automation that completely eliminates operator error. Machines can be configured to perform repetitive measurement tasks automatically without the need to reprogram each time. They can also eliminate the need to have different measuring tools for individual jobs, as one CMM can be programmed to handle any measurement task.

Coordinate measuring machines (CMMs) are extremely powerful metrological tools: they allow us to find coordinates of points of three-dimensional structures, which simultaneously combine both dimensions and orthogonal relationships.

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