

Safronov I. O., Kozlovsky D. O., Brynza M. B., Potapov A. M.

Yuzhnoye, State-owned Design Office named after M. K. Yangel. Ukraine, Dnipro

## METHODS OF CONTROL OUTPUT GEOMETRICAL PARAMETERS WITH COORDINATE MEASURING MACHINES

*This article outlines ways to control the geometric characteristics of objects using CMM. Considered the possibility of the work of the coordinate measuring machine type "hand" and a laser tracker. Shows the drawings of the equipment used, measurement objects and visualized models of the measured parts. Particular attention is paid to the processing of the results. [dx.doi.org/10.29010/085.10]*

Keywords: coordinate measuring machine (CMM); mathematical model; measurement; protocol; result.

### Introduction

Coordinate measuring machine – a device for measuring the geometric characteristics of the object. In this article, two types of CMM will be considered:

- Articulated arm type [1];
- Laser range finders with volumetric scanning (Laser Tracker) [2].



Fig. 1

The indispensable requirements for measuring machines are the accuracy and speed of measurements, adaptability to the conditions of real production, ease of training of personnel and operation of the CMM.

Mobile coordinate measuring machines, in contrast to stationary and portal CMM, have universal capabilities, autonomy, ease of operation and training to work with them.

We consider the capabilities of a hand-type CMM using the example of a mobile coordinate-measuring complex with a contact FARO Edge Scan Arm 2.7 m laser probe (manufactured by FARO Technologies Inc, Switzerland).

Coordinate-measuring complex FARO is a universal means of controlling linear dimensions, relative position and shape of products. The principle of operation consists in measuring the movements of the probe with respect to the measured part in a given coordinate system. A hand CMM is installed either next to the product to be controlled, or directly onto it, if the design of the product allows. Using the computer, FARO automatically conducts:

- coordination of machine bases and parts;
- touch point compensation for the probe;
- processing of measurement results (error, tolerance);
- calculation of the error of an individual measurement.

Defined characteristics: diameters, mutual arrangement of holes, deviations, angles, linear and positional dimensions.

Specifications:

- measuring range – 2.7 m;
- repeatability of a point – 29 microns;
- linear measurement error – 41 microns;

The possibilities of a laser tracker will be considered on the example of a portable coordinate measuring machine FARO Laser Tracker Vantage E (manufactured by "FARO Technologies Inc.", Switzerland)



Fig. 2

FARO Laser Vantage E is a unique mobile coordinate measuring machine that allows you to perform extremely accurate measurements, optimize production processes and implement measurement solutions more quickly, simply and accurately than ever before.

Vantage E is the most accurate laser tracker available to solve measurement problems, in which the angular error of the device is the dominant component of the error. The device is very functional, has a significant measuring range (range up to 25 meters), low weight up to 13.4 kg.

Benefits:

- mobility
- autonomous battery life
- wireless connection
- measurements of large objects up to 50 m from one placement
- high accuracy of measurements from 9 microns
- compensation of the error from weather conditions (built-in weather station)

We use PowerINSPECT as software. PowerINSPECT has successfully implemented sophisticated calculation algorithms that make it easy to take measurements, process data and create reports. The advantages of this software:

Combination of 3D data

In PowerINSPECT, methods for combining 3D data are implemented for both prismatic parts and surfaces of arbitrary shape. When combined with a CAD-model, it is possible to bind to surfaces, faces and vertices in any of their combinations. If the measured part

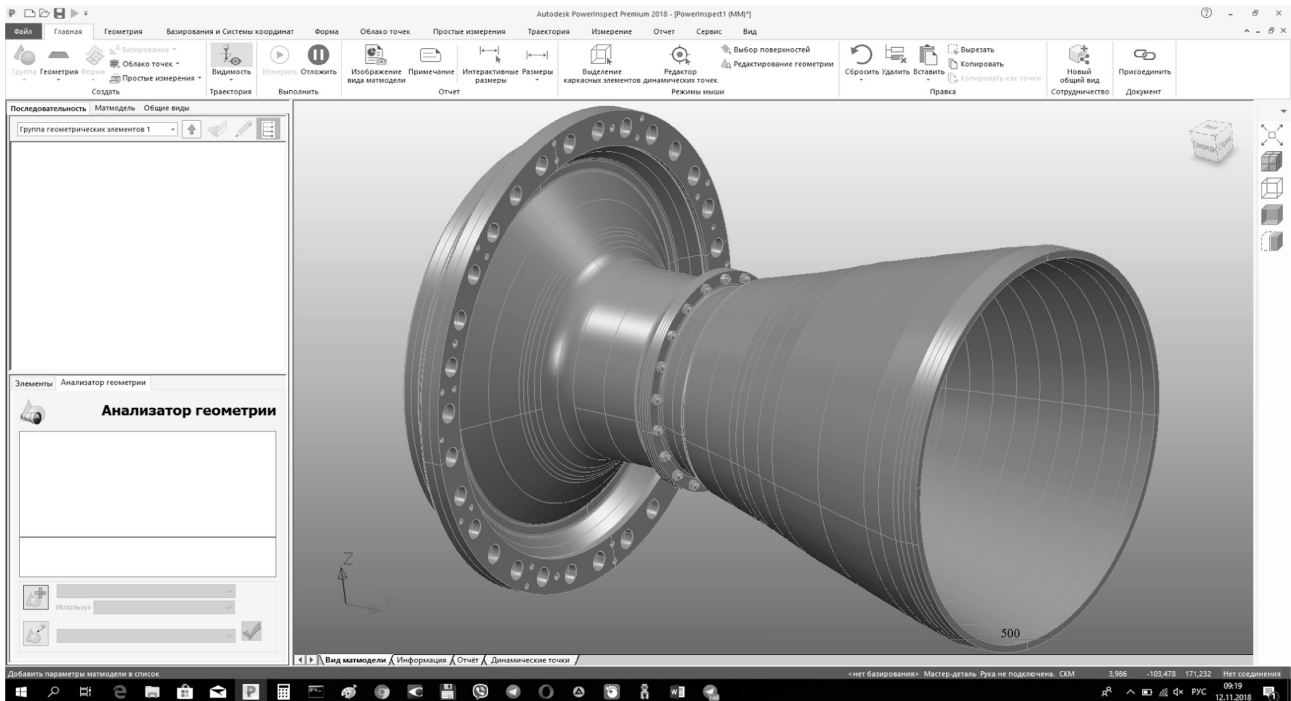


Fig. 3

does not contain elements for precise basing, PowerINSPECT allows you to perform the combination using various fit strategies.

Clear graphic presentation of information

The immediate display of the calculated errors and deviations directly on the theoretical 3D model in the form of intuitive text-color schemes allows the user to perform measurements in an interactive mode. Measurement results are documented in the form of automatically generated reports that are understandable to technicians who do not have special knowledge in metrology.

Automatic report generation

An automatic report containing all the necessary information about the measurements taken is instantly generated with a single mouse click. The user can indicate any possible problems with additional graphic and text comments.

Customizable scripts and algorithms

PowerINSPECT allows you to create custom scripts to perform specific actions and customize the algorithm of the program. For example, a CAD system may itself interrupt the sequence of measurements when the specified error is exceeded or automatically generate a report after successful completion of all measurements.

Control of cross-section accuracy

Control programs for non-destructive control of the cross-section of the part are generated automati-

cally based on the CAD model and the selected section plane. The interactive PowerINSPECT user interface makes it easy to define the boundaries of a desired section of the cross section.

Creating reports

PowerINSPECT allows you to quickly create readable, detailed reports containing all the necessary information about the measurements taken. The measurements can be almost instantly documented with one click of the mouse in the form of a short summary or detailed report consisting of text, tables and explanatory images.

Creating reports with one click

Any PowerINSPECT CAI system window with the image of an 3D model with an error coding color scheme can be formatted and documented in one report form. This is the fastest way to attract attention to problem areas of the product.

Quick analysis of measurement results

The display of measurement results using intuitive color coding schemes allows you to instantly make evaluation conclusions.

Automatic creation of tags with comments

To improve ease of use and clarity of perception of measurement results, the CAI system automatically creates and distributes tags with comments on the program window. If necessary, labels can be placed in the most critical places manually.

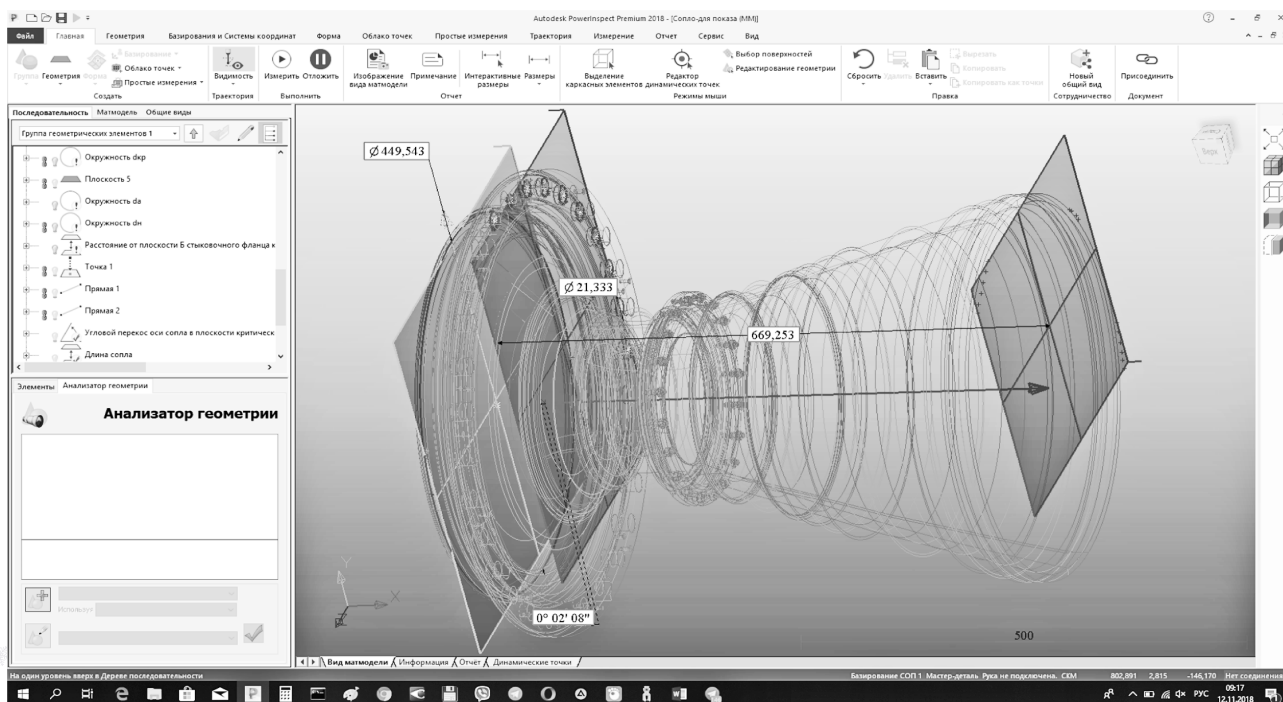


Fig. 4



Fig. 5

#### Customizable report templates

PowerINSPECT allows you to customize the template of the generated reports in accordance with the requirements of users. The template may include information about the customer's company and its logo. The default template is further automatically used by the CAI system when generating reports.

The main advantage of FARO coordinate measuring machines compared to traditional ones is their mobility. All equipment is packed in special cases that have wheels and is easily transported to the place of control. All measurements are made in real time, i.e. the user immediately sees on the computer screen both a virtual image of the measured element and its geometric characteristics.

For increased mobility, we recommend using a laptop. Thanks to special temperature sensors, the FARO coordinate measuring machine monitors the ambient temperature in real time and amends the measurement result. This allows the equipment to be used in harsh workshop conditions. The equipment can be installed both near the product and on it. For this special magnetic and vacuum plates, massive and mobile tripods are used.

The accuracy of coordinate measuring machines (CMM) depends on the temperature conditions of the environment in which the machine operates. Temperature fluctuations, acting on the scale, the structural elements of the machine and the measured objects, cause their expansion, contraction and, in some cases, non-linear distortions. Although the distortions caused by thermal fluctuations are compensated in one way or another, they can lead to significant measurement uncertainty, especially in the case of measurements in workshops where it is difficult to control the temperature. In the context of the continuous trend of transferring measurement control tasks from temperature controlled metrology laboratories to plant premises, understanding how temperature affects the accuracy of a CMM becomes more important than ever before.

#### **Conclusion**

The use of CMM in conjunction with the CAI-system makes it possible to control the geometrical parameters of the product at all stages of manufac-

turing, which will improve the quality of manufactured products. It also gives the opportunity to check the tooling for compliance with design documentation.

#### References

- [1] FARO Skan Arm Edge User Manual.
- [2] FARO Laser Tracker Vantage. User Manual.

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*Сафронов И. О., Козловский Д. О., Брынза М. Б., Потапов А. М.*

Государственное предприятие «Конструкторское бюро «Южное»» им. М. К. Янгеля. Украина, г. Днепр

#### МЕТОДЫ КОНТРОЛЯ ВЫХОДНЫХ ГЕОМЕТРИЧЕСКИХ ПАРАМЕТРОВ С ПОМОЩЬЮ КООРДИНАТНО-ИЗМЕРИТЕЛЬНЫХ МАШИН

*Изложены способы контроля геометрических характеристик объектов с помощью КИМ. Рассмотрены возможности работы координатно-измерительной машины типа «рука» и лазерного трекера. Указаны рисунки используемого оборудования, объектов измерений и визуализированных моделей измеряемых деталей. Особое внимание уделено процессу обработки полученных результатов. [dx.doi.org/10.29010/085.10]*

*Ключевые слова:* координатно-измерительная машина (КИМ); математическая модель; замер; протокол; результат.

#### Литература

- [1] FARO Skan Arm Edge. Руководство пользователя.
- [2] FARO Laser Tracker Vantage. Руководство пользователя.