Journal of KONES Powertrain and Transport, Vol. 21, No. 2 2014

ISSN: 1231-4005
e-ISSN: 2354-0133
ICID: 1133862
DOI: 10.5604/12314005.1133862

ANALYSIS OF DIMENSIONAL ACCURACY OF BLADE OF AIRCRAFT ENGINE USING A COORDINATE MEASURING MACHINE

Grzegorz Budzik, Krzysztof Kubiak, Małgorzata Zaborniak
Łukasz Przeszłowski, Tomasz Dziubek

Rzeszow University of Technology
Faculty of Mechanical Engineering and Aeronautic
Powstańców Warszawy Av. 8, 35-959 Rzeszow, Poland
e-mail: gbudzik@prz.edu.pl, krkub@prz.edu.pl
mzab@prz.edu.pl, tdziubek@prz.edu.pl

Rafał Cygan, Mirosław Tutak

WSK PZL-Rzeszow" S.A.
Hetmańska Street 120, 35-959 Rzeszow, Poland
e-mail: rafal.cygan@wskrz.com

Hubert Matysiak

Research Centre Functional Materials
Warsaw University of Technology
Wołoska Street 141, 02-507 Warszawa, Poland
e-mail: hmatysiak@inmat.pw.edu.pl

Abstract

Technological process of aircraft engine turbine blades requires control of blade geometric parameters. Innovation technologies for measurement of aircraft engine turbine blades are based on coordinate numerical machines – measurement process is based on processing of numerical data obtained by measurement using coordinate measuring machines. The paper presents the opportunity of analysis of dimensional accuracy of aircraft engine turbine blades measurements using coordinate measuring machine (CMM).

Coordinate measuring machine allows specifying full methodology for designation of complex dimensions of physical objects (blade of aircraft engine) and transforming them into a computer program space of coordinate measuring devices.

Presented paper includes capabilities of device used in the study to improve the measurement process and blades geometry analysis in the technological and economical aspects. Another issue described in the paper is impact of measurement performance in automatic mode on the quality of performance – the numerical model of geometry, from the standpoint of accuracy and number of collected data points in time.

Measurements using a coordinate measuring machine are among the most accurate methods of measuring. The paper includes an analysis of conditions related to the measurement works, such as the process of preparing the model, measurement equipment and data processing capacity. As the result, methodology of (CMM) measurements of aircraft engine turbine blades will be presented.

Keywords: *aircraft engines turbine blades, optical measurements, coordinate measuring technique*

1. Introduction

Analysis of accuracy of aircraft engines turbine blades at various stages of technological process requires control of geometric parameters using coordinate measuring methods (CMM) [1].

Development of coordinate measuring methods is associated with development of computer-based CAD/CAE [2-5]. Measurement process is based on computing of measurement data, so that it is possible to determine dimensions of measured object in three-dimensional numerical space. Measurement procedures are based on determination of coordinates of the measured points. Currently, rapid development contact measurement methods using coordinate data processing can be noted [6-8]. These methods allow performing measurements with high accuracy, significant decrease of measuring time.

2. Coordinate measuring machine

Coordinate measuring machine allows performing measurements of the surface objects with complex shapes, such as blades of aircraft engines. Work stand of the measurement system shown in Fig. 1.

Acceleration of the coordinate measuring machine measurement process is possible due to use of hardware and software automation. Hardware automation is based on measured object mount in holder with additional rotary axes or non-contact measuring head. For CMM it is also possible to install the measuring head or measuring probe in machine magazine. A solution significantly accelerates the measurement process.

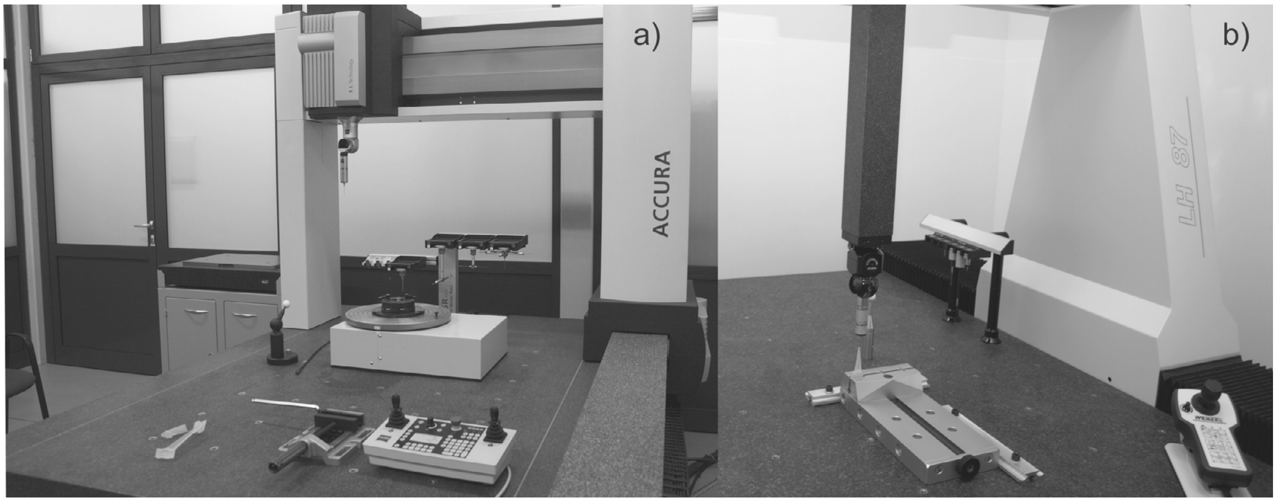

Fig. 1. Coordinate measuring machine: a) ZEISS ACCURA, b) WENZEL LH 87

3. Object and coordinate measuring machine

Tests were carried out on a specially RP manufacturing blade model. The 3D-CAD test model system of coordinates was joined with the midpoint of the blade surface. Such a system of coordinates was a basis for a precise identification of the model in the software space of the coordinate measuring machine. The bottom part of the blade constitutes a fixing element that enables a fast and accurate positioning of the model for measurement.

Before the measurements, calibration of the CMM system is needed. Before performing an actual measurement, it is also needed to prepare automation equipment. The real geometric accuracy has been determined by direct measurements of blade prototypes utilizing the coordinate measuring machine WENZEL LH 87 (Fig. 1) equipped with the scanning head Renishaw. The blade is divided into sections illustrating the cross-sectional (Fig. 2).

4. Analysis of measurements results

The measurement results of the most accurate RP – SLA blade models have been presented graphically in the form of measurement protocols (Fig. 3). A 3D protocol shows the deviation values graphically as a deviation vector of proper direction. Additionally (2D – protocol), in selected measurement points, there are tables showing detailed values of deviation in the x, y axes from the CAD nominal model.

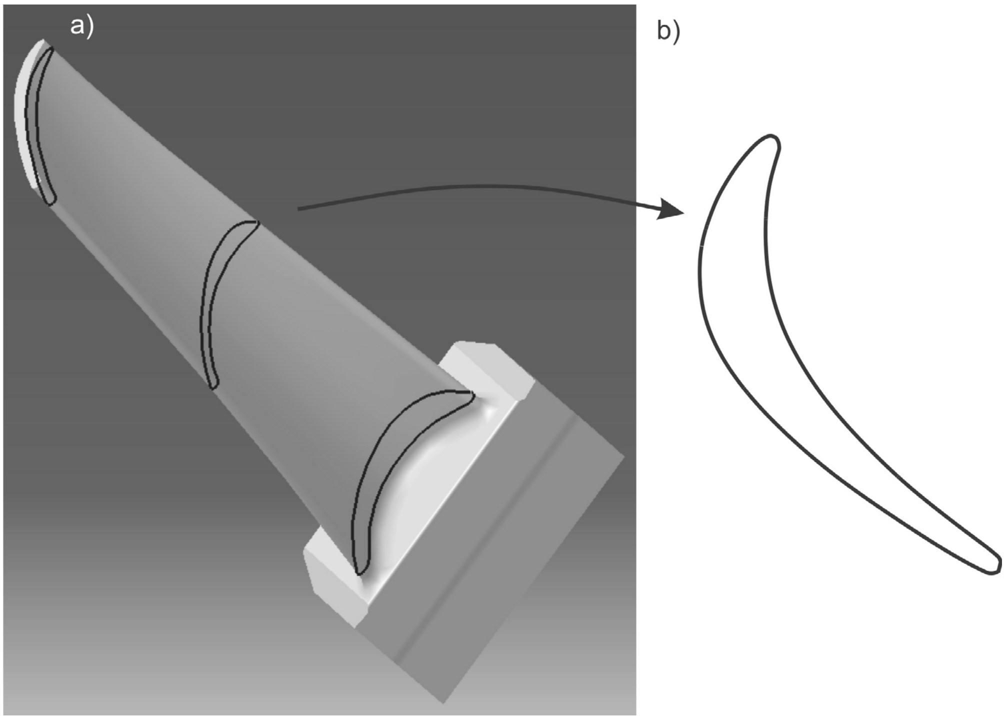

Fig. 2. The way of measure process CMM: a) blade profile, b) one section line of profile

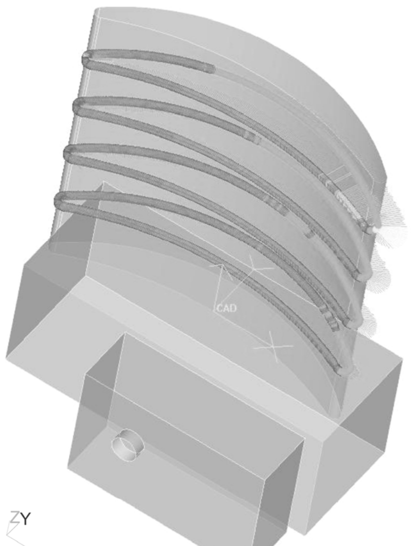

Fig. 3. Blade measurement protocol – 3D space Metromec WENZEL

Software allows subsequent performance of the accuracy analysis of the obtained measured element with respect to the nominal model. It allows analysing whole element what gives a complete picture of the accuracy of its implementation. In addition, coordinate measuring system offers the possibility of using different CAD model adjustments systems: based on the geometrical elements.

With respect to the nominal profile, deviations of all individual measuring points are calculated. The concentration of collected points is relatively large and deviations are visualized as a colour map. Complex analysis of the measured blade has been performed and presented in Fig. 4.

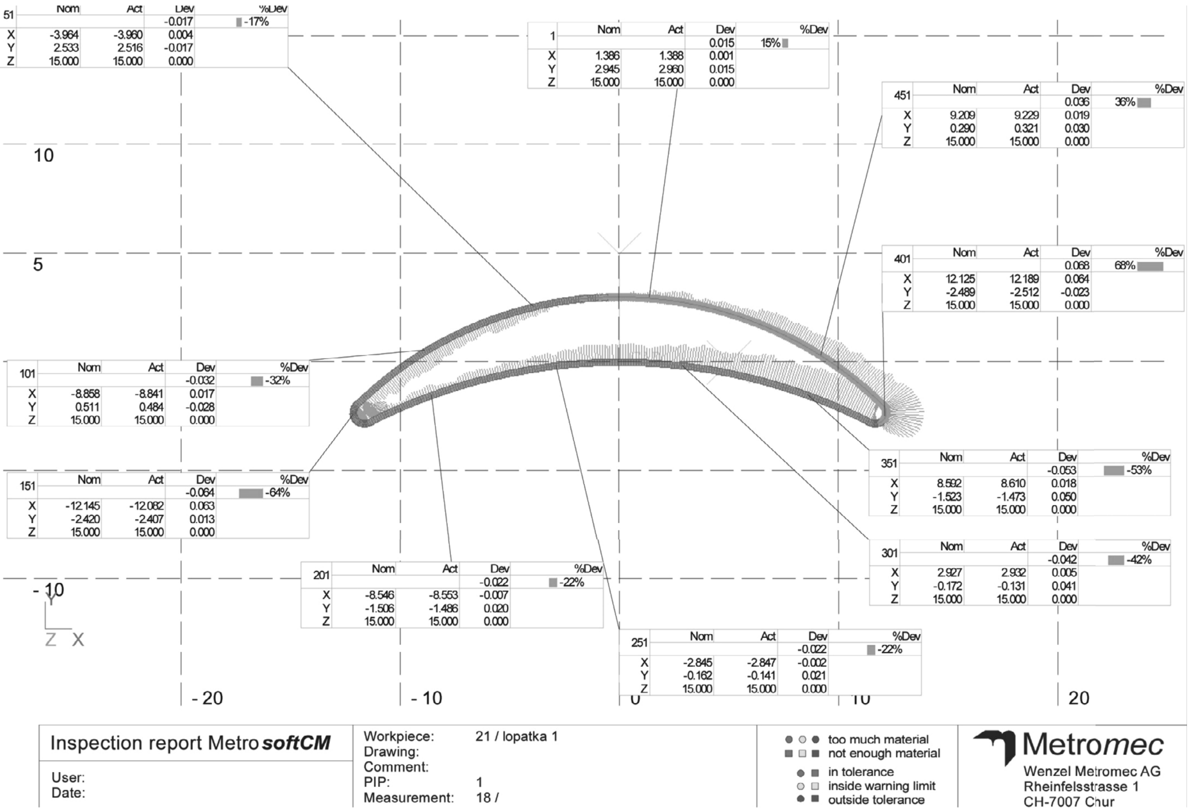

Fig. 4. RP – SLA blade measurement protocol – Metromec WENZEL

After such an analysis, inspection points and dimensions are defined and included in the measurement plan. Critical areas can be specified and documented for further analysis. Coordinate Measure Machine software (Blade Pro – ZEISS) allow additionally detailed analysis of the deviations of outline profile for selected values: profile twist, profile edge thickness, maximum profile thickness, profile chord line, profile centroid, profile mean line, profile edge circles, profile edge points. For example, profile mean line is the ends of the profile edge – with circle created (Fig. 5).

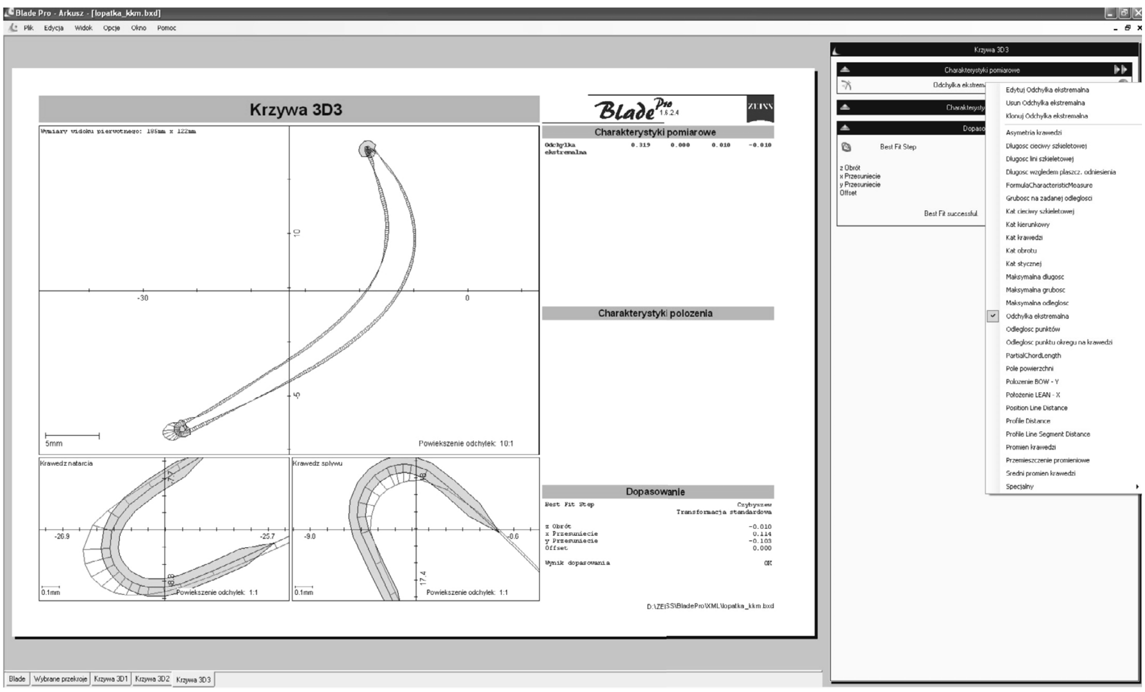

Fig. 5. Detailed analysis of the deviations of outline profile for selected values

6. Conclusions

Geometric accuracy is one of the fundamental parameters determining the quality of the product and the opportunity to work in a team element machine. Analysis of the geometric parameters of the product should be conducted in a way to produce a product that meets specified by the manufacturer assumptions dimensionally shaped. Coordinate measuring methods based on computer systems are a tool to verify the accuracy of product at certain stages of the process. One of the main advantages is the ability to coordinate the methods of measurements of complex internal and external geometries. This is particularly important in the manufacture of prototypes of aircraft engine turbine blades. The article presents an analysis of methods for measuring the geometry of the blades of aircraft engines in terms of theoretical and practical.

Measurements of aircraft engine blades and their automation using coordinate measurements method and system allows significant acceleration of the measurement process. The automation does not eliminate the need for adequate preparation for the measurement model.

Acknowledgement

Financial support of Structural Funds in the Operational Programme – Innovative Economy (IE OP) financed from the European Regional Development Fund – Project "Modern material technologies in aerospace industry," No POIG.0101.02-00-015/08 is gratefully acknowledged.

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