

## METHODS OF MEASUREMENT OF CYLINDRICAL GEAR AIR, GEAR WITH STANDARD SOFTWARE CMM

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### **Abstract**

*Air gears must meet high performance criteria for accuracy; therefore, quality control is necessary for their production. CMM Software determines the capabilities and scope of the measuring machines. Measuring machines equipped with specialized software for the measurement of the gears are commercially available. An example might be a company offering Wenzel TGEAR XY software. This specialized software for the measurement of gears allows fully automatic measurement of the contour deviation (involute), line tooth pitch, and radial run out, tooth flank topography.*

*If you do not have a special software to measure the gear, you require a measurement process based on 3D CAD model of the gear. It is necessary in this case, the preparation of a strategy based on measurements of 3D CAD model and load points or paths with the CAD model. The results of the measurement refer to the CAD model treating it as the nominal model. Item will present the methodology of measurement of cylindrical gears using a standard CMM software. Cylindrical gears can be measured through non-contacting or contacting methods – measuring point or scanning.*

*The choice of measurement method should be carried out taking into account the accuracy of gear and taking into account the capabilities of the system and measurement needs. An important advantage of the measurement using the gears multipurpose measuring software is that it is possible to measure any geometry of the wheels in relation to the CAD model. Using this measurement strategy avoids the need to purchase additional software, the measuring machine and its setup. You should only choose a method of analysis that will be carried out directly in the environment-measuring machine, or will be made in the CAD system based on the geometry acquired during the measurement with respect to the virtual model. In the second case, export is needed in the appropriate format measurement data to CAD software.*

**Keywords:** *gear, cylindrical gear, aircraft gearbox, coordinates measuring technique*

### **1. Introduction**

The usage of coordinate measuring methods in accordance with CAD/CAM methods in the making process of the aircraft gearbox is to modify the process of designing the construction and technology of the transmission production. The air gear must meet the high standards of manufacturing accuracy; therefore, the control of accuracy is necessary in their production [1, 8].

The effectiveness of the measuring process depends not only on the equipment accuracy of the measuring tool but also on the knowledge and skills of the operator himself. Geometrical features of the gear have a big influence on their measuring results. The development of the measuring process must be planned taking into consideration the production accuracy of the gear, the kind of the gear measured and technology that was used. Choice of the measuring strategies allows the measuring time to be shortened with the simultaneous conservation or even enhancement of the measuring results accuracy.

Currently used measuring tools include a very universal range of usage. The programs of coordinate measuring machines enable the measure of regular geometrical elements, possibility of stating the relations between those elements and also include procedures of stating typical shape deviation or position.

## 2. Methodology of gear measurements in the universal CMM software.

The roll gear of the aircraft gearbox can be measured with the clearance or contact methods – the point measurement of the scanning measurement. The choice of the measuring method is in accordance with the precision of the gear construction and also with the possibilities of the system and measuring needs. The time needed to conduct and analyse the results is an extra factor influencing the choice of the method. If a specific software to measure gears isn't in use, one needs to prepare the process of the measurement based on 3D-CAD gear model. The measurement results are referred to CAD model, being treated as a nominal model. In the methodology treated this way, both analyses of profile tolerance, tooth trace and also analysis of gear side surface, at the same time the necessity of additional purchase of the measuring machine software and its remaking are avoided [4, 8]. The methodology of roll gear air flanking transmission measurements has been elaborated with the usage of coordinate measuring machine Wenzel LH87 and also with the usage of standard software Microsoft CM 3.8 (Fig. 1).

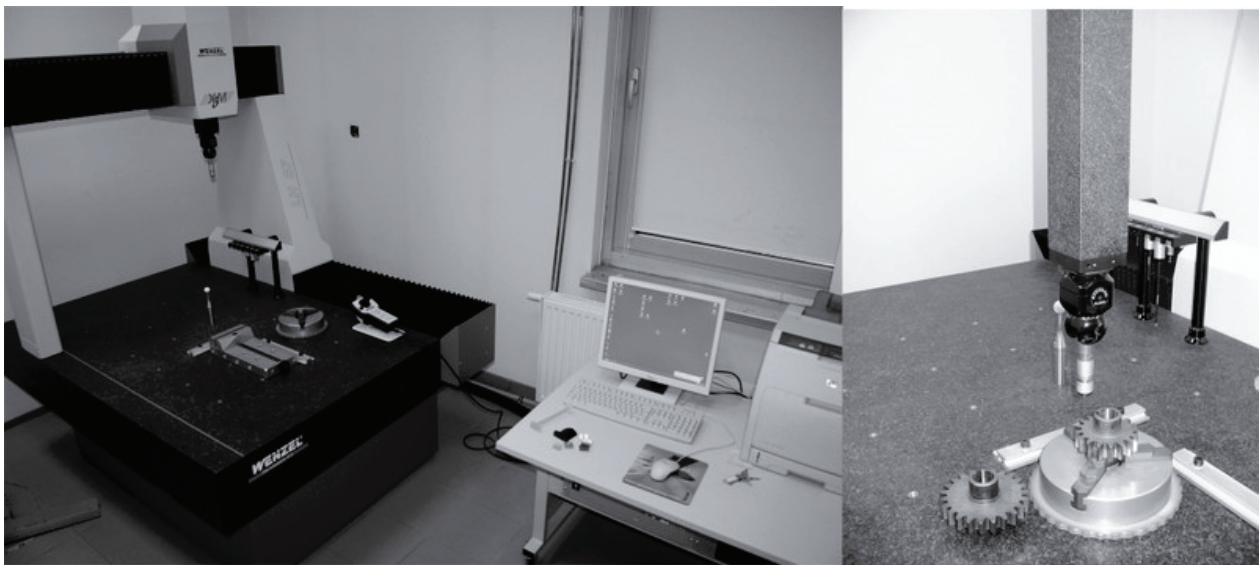


Fig. 1. a) Measuring laboratory with coordinate measuring machine Wenzel LH87 b) cylindrical gear measurement on CMM

The method of gear measurement by comparing real surface with 3-D CAD model is becoming a standard in coordinate technology. During the measurements conduction the strategy taken should be related to constructional and technological specification of the measured gears. The analyses of the measurements results has been conducted directly in the measuring machine environment (Fig. 2), and in CAD system based on geometry received during the measurement related to the virtual model.

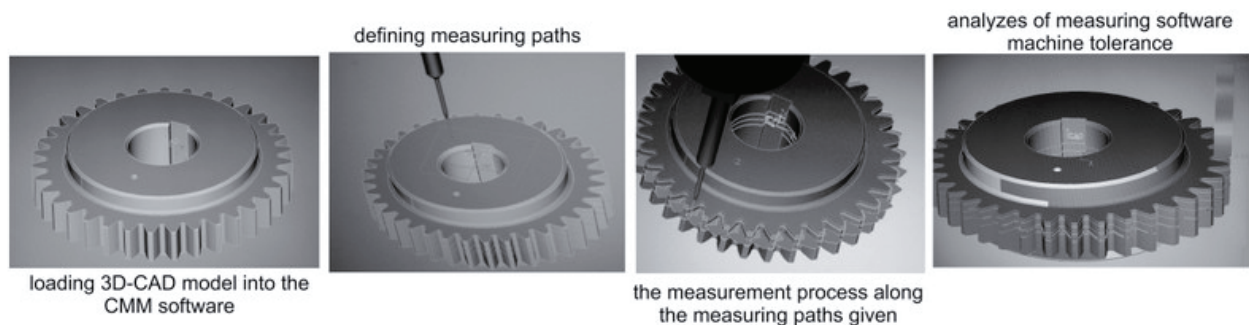


Fig. 2. Gear measurement related to the virtual model with the usage of coordinate measuring machine



The first stage of work in integrated systems CAD/CMM is the import of data in the given formats of loading into the measuring system of coordinate measuring machine. The imported file CAD must be loaded as a rated surface. Because of the fact that the model 3D-CAD has its own coordinate system, its transfer to the coordinate system of the measured gear defined in the dimensional space was necessary. It was also necessary to prepare measuring strategies based on model 3D-CAD. Regular geometrical elements are often loaded directly from model 3D-CAD, and the measuring paths are generated for those elements in an automatic manner. Conducting the gear measurement profile in Metrosoft software, one had to load the nominal points from CAD model. They were generated by cutting the gear with the surface in a given surface of coordinate system. While generating the measuring intersections one should state the cutting surface in coordinate system and the cutting distance. The analysis of the results was conducted with the usage of coordinate measuring machine software related to the nominal model 3D-CAD. The measuring results given as measuring protocols have been stated: the analysis of gear profile (Fig. 3) the analysis of tooth line tolerance (Fig. 4).

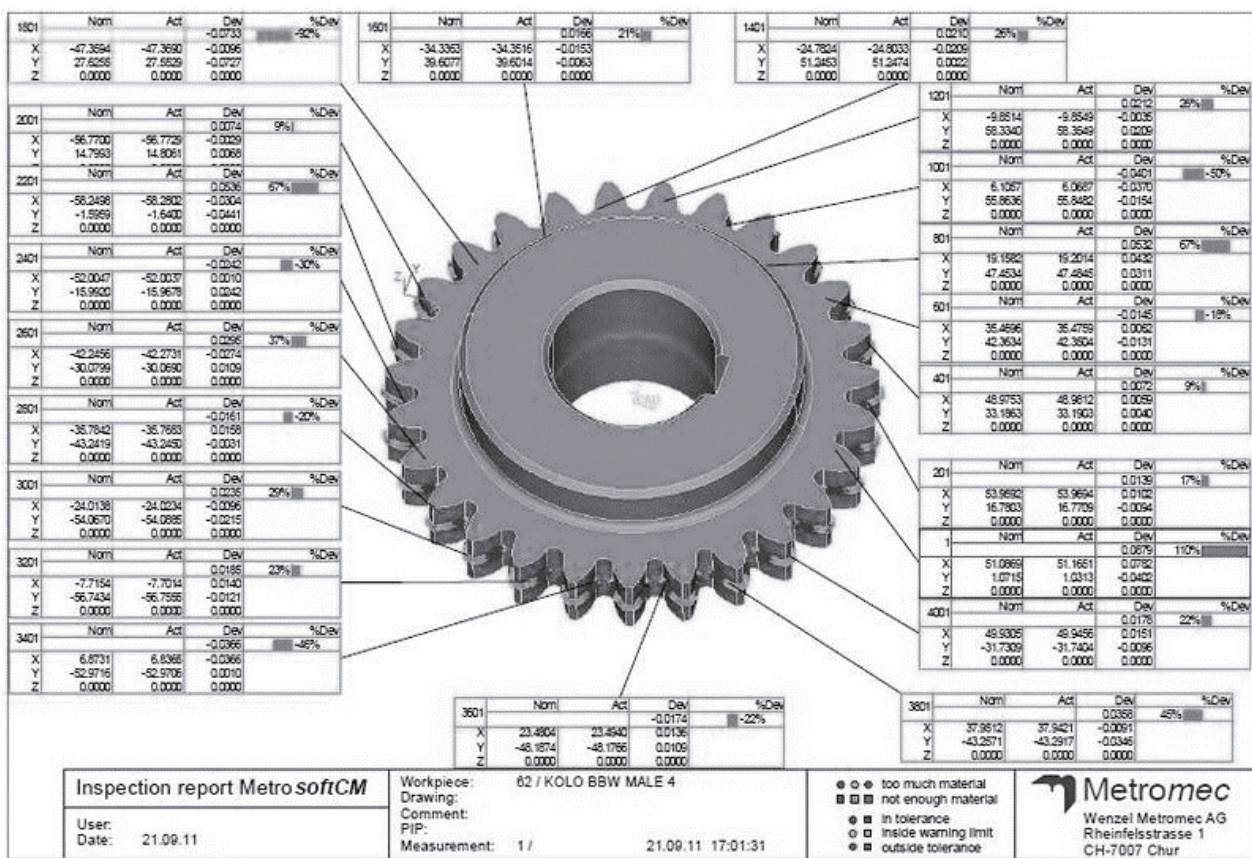


Fig. 3. Analysis of gear profile tolerance – measuring protocol

It was not always necessary to measure the whole gear, it was often enough to conduct measurements and analyses of only those geometrical elements that were sufficient to precise shape and geometrical analysis, for example tooth line. Resulting from the measurement conducted the coordinates of points X, Y, Z were received. The measurement results given were loaded in a format enabling the import to CAD system. As an example, putting a roll gear to analysis ( $z=27$ ,  $m=4$ ) in order to state wheel cutting tolerance related to nominal model 3D-CAD, pitch circle was provided and piercing points with tooth lines were stated, based on this, measuring scale was conducted (Fig. 5). Scale out of tolerance is a difference between the measured scale and related to it the theoretical scale in the head surface, defined in a circle, whose middle is the circle axis.



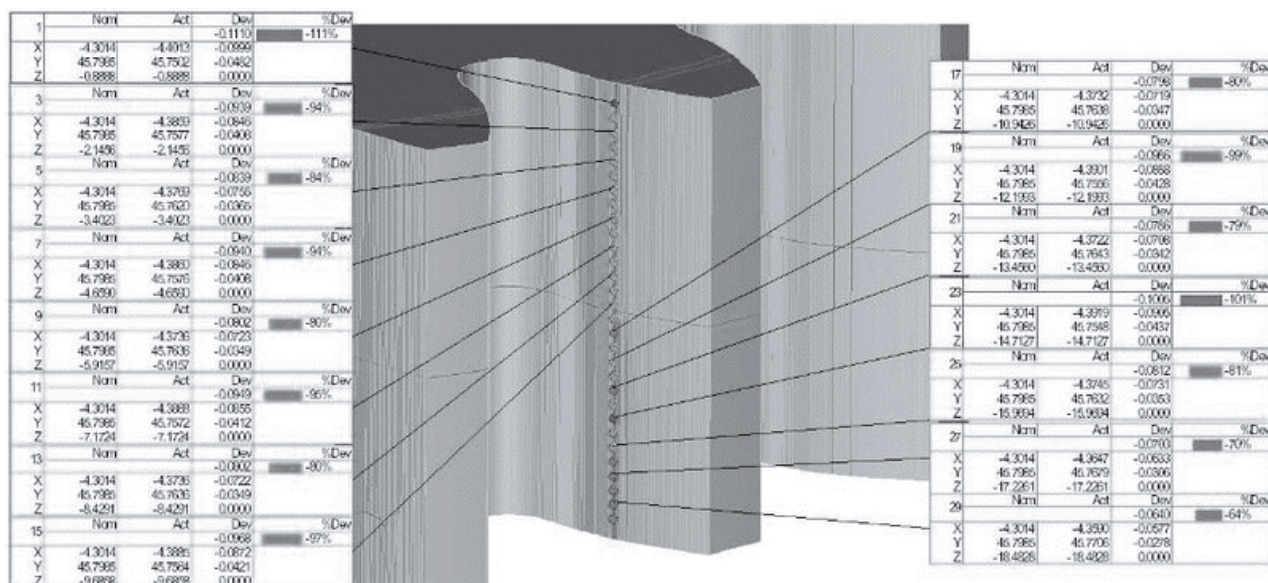


Fig.4. Analysis of tooth helix tolerance

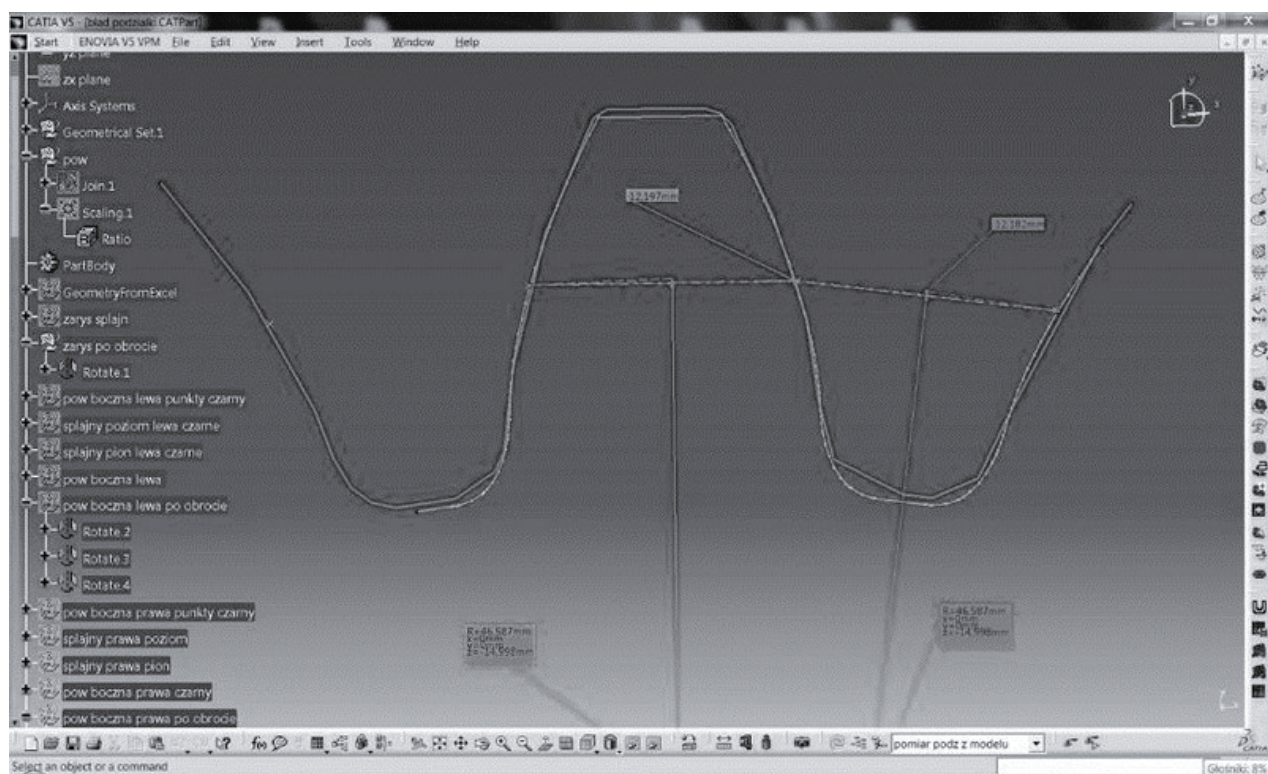


Fig. 5. The example of single pitch deviations gear  $z=27$ ,  $m=4$

Based on the roller method of measurement, the analyses of gear beating were conducted. The model 3D-CAD of the gear was the datum feature. Instead of rollers, circles with diameters related to the measuring rollers were introduced. The status of roller middles could be stated, relating to the circle rotation axis and on this basis, lack of tolerance was stated.

The surface model of a gear makes it possible to conduct measurement or shape precision analysis, at the same time eliminating the necessity of using an expert measuring software. Precise analyses of tooth profile tolerance were conducted and defined in frontal cross-section (Fig. 6).

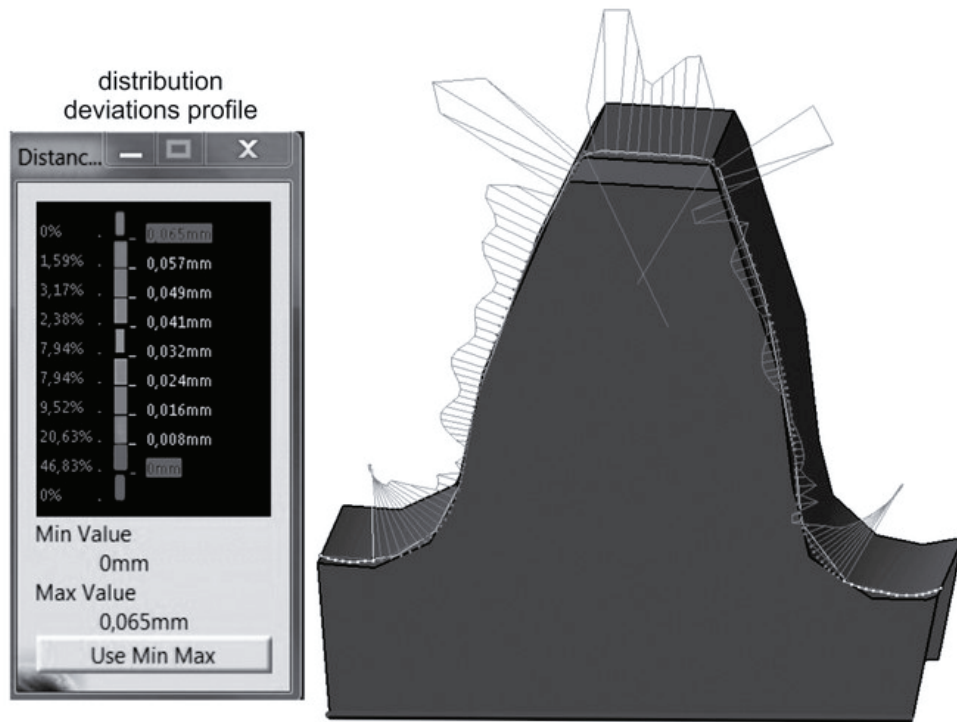


Fig. 6. The analysis of profile tolerance conducted in CAD environment

The topography of the tooth side was also analysed. The topographical control of the gear tooth side was conducted in an analogical way as in the case of profile control or tooth line. The difference was about producing the surface of tooth side based on measurement data instead of the curves themselves. The analysis of tooth side surface tolerance is presented in particular measuring net knots or as the topographical map of side surface tolerance.

Figure 7 presents topographical net of the gear side including numerical values of tolerance, measured in particular net knots. The unevenness of surface is the dominating characteristic feature. Side surface tolerance (maximum 0.07, minimum 0.035) is characterized by its uneven spread, increasing at the base of the tooth and decreasing gradually when approaching its peak.

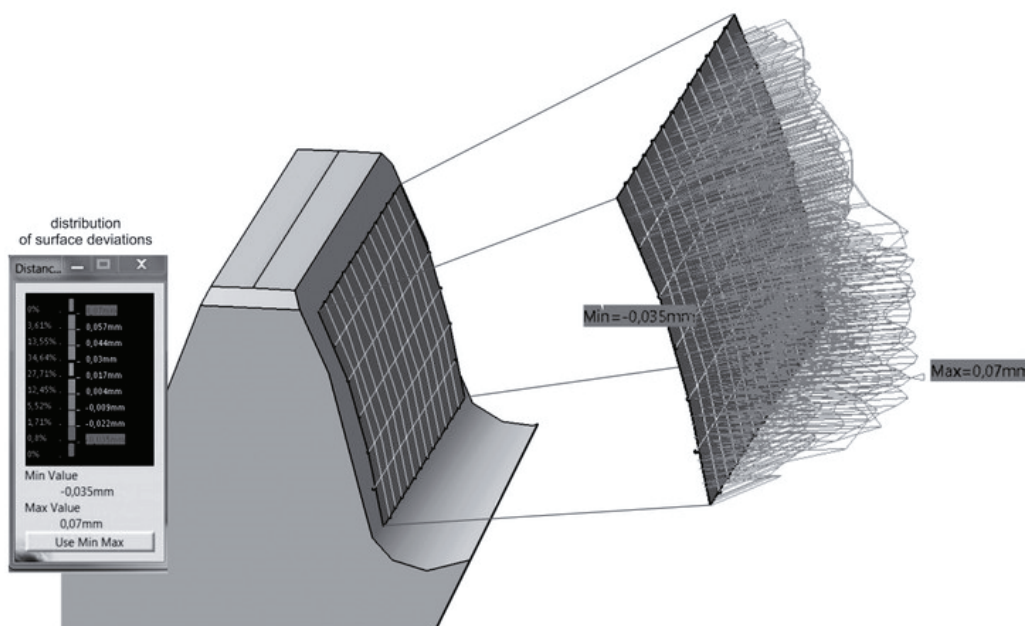


Fig. 7. Analysis of side surface tolerance conducted in CAD environment



### 3. Conclusions

Coordinate measuring systems are widely used in many technical domains. Most of commercial measuring programs are universal software and depending on the users' needs, other expert measuring packets (e.g. to measure gears or blade) are added [1, 4, 8].

One of basic advantages with computerized contribution measuring methods is the possibility of conducting measurements in relation to nominal model 3D-CAD in various stages of producing process. This is particularly important in production of air flanking transmission gears. Based on the models 3D-CAD received in the conducting process, it is possible to measure characteristic geometrical values describing a gear both with defining its tolerance. The value of standard suspense resulting from measuring repetitiveness for example for the tooth line was 0.002 mm.

### 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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