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COORDINATE MEASURING MACHINE APPLICATION FOR MACHINE TOOL CORRECTION

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Abstract − Coordinate measuring machines in various branches of industry within last years became very common. Measuring machines can be used e.g. for direct determination of correction values for machine tools in production cycle. In the paper a description of closed loop of machine tool and coordinate measuring machine was given. Thus CMM generates a correction file with data including crankshaft geometry. Position of crankshaft during measurements was analyzed and holder for crankshaft was designed and made. Probe pins configuration was prepared and measuring program was elaborated. As a result even a non-skilled operator can easily prepare a floppy with correction file.

Keywords: CMM, measuring strategy, machine tools correction

1. INTRODUCTION

Coordinate measuring machines in various branches of industry within last years became an ordinary sign of every days life [1]. Their common application comprises not only quality control of incoming goods, measurements of workpieces in production and checking of finished products. CMMs can be also used for direct determination of correction values for machine tools in production cycle. In most cases it is connected with start of manufacturing process after retooling or at the beginning of shift. To do it properly it is of course necessary to apply appropriate measuring device with right measuring uncertainty, after properly performed calibration [2], and moreover equipped with software that enables for something more than just pure output of dimensions [3]. An ideal situation comes with software, that would be written in open form, with possibility to apply existing commands but also to create new ones, extending measuring capabilities of the machine itself. CMM that we used in our work had just such software installed – Quindos, so the only one allowing for that kind of activity and most probably the best that we could expect. Another important aspect when using CMM for such an application is an operator with appropriate level of education and creativity, who is ready to think wider and go far beyond traditional applications.

Nearly every truck is equipped with pneumatic braking system. A very crucial part of such a system is a compressor, that is a source of compressed air – medium used for energy and control. Compressors for supply of pneumatic braking systems are piston-crank ones powered by a combustion engine by means of belt drive or gears. Both piston compressors as well as turbocompressors work in trucks in very difficult, one can even say extremum conditions, because of mechanical and thermal load of their particular elements. Among parts of such compressors there are casings and crankshafts manufactured by POLMO. Very high quality demands stated by car manufacturers and resulting from necessity of ensurance of work for such compressors without any problems within main review period (1÷2 mln km of run) cause a requirement for precise, accurate and repeatable manufacture of such elements and groups. It is possible to fulfill such requirements only by detailed process parameters monitoring by means of accurate measuring devices and by using proper, reliable and fast measuring methods giving possibly quick (immediate) information regarding danger of trespassing previously defined values.

FOS POLMO Łódź is one of the top Polish companies in the field of car elements manufacturing. It is a well known and acknowledged supplier of parts and systems for leading customers from European Union manufacturing very responsible truck elements. History of this company goes back to 1908 and is closely related to metal, aviation and automotive branch of industry. It is already a tradition of POLMO to manufacture motorcycle and car parts, like engines, carburators, fuel pumps, compressors and pneumatic braking systems. At present the main production activity of POLMO is manufacturing of parts and accessories for mechanical vehicles and its engines, in particular piston air compressors, parts and assembly groups for compressors, as well as parts and groups for pneumatic braking systems. Customers of the factory are manufacturers of the above mentioned elements and service organisations or just regular people using trucks. POLMO production is based on three main customers, who practically totally shares European Union market of pneumatic braking systems and turbocompressors.

This paper is a presentation of one part of activity within a framework of aimed project: Implementation of New Technology for Geometrical Features Measurements of Compressors and Turbocompressors Elements, that is being run together by Poznań University of Technology and FOS POLMO Łódź, co-financed by Committee of Scientific Research included in the meantime into Ministry of Science and Information changed recently into Ministry of Education and Science.

2. DESCRIPTION OF PROBLEM

One of the customers of POLMO gave its suppliers very strict rules regarding start of serial production. They are based on cycle analyze of manufactured workpiece and – if it is necessary – implementing related correction values. It concerns both: geometrical dimensions (e.g. diameters) and form deviations (e.g. roundness deviations). Measurements concern a family of crankshafts for compressors used in braking systems. The view of typical example of such a crankshaft was shown on figure 1. The crankshaft can have one or two cranks, depending on particular application and customer.

Fig.1. Example of crankshaft.

At the customer's site the measurements are made on special device that is specialized just for this purpose – to measure solely crankshafts. We, i.e. Poznan University of Technology and FOS POLMO, decided to solve this problem basing only on measuring devices that are already installed in factory without any new investments. Thus a coordinate measuring machine PMM by Leitz with Quindos software was taken for these measurements (fig.2).

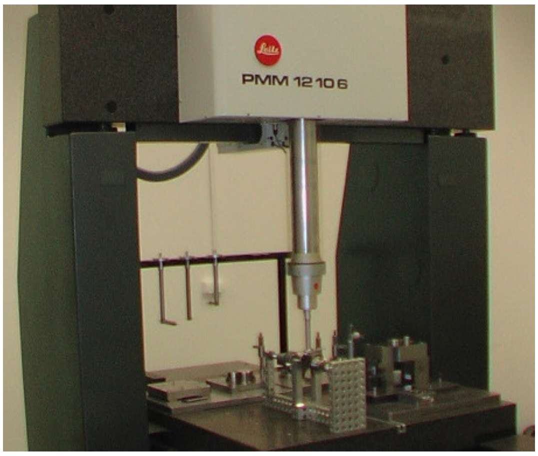


Fig.2. CMM used for crankshaft scanning.

Crankshaft manufacturing technology at FOS POLMO is based on initial and final machining of blank – a forging shown on fig. 3.

Fig. 3. Blank for crankshaft manufacturing.

The most important issue of the whole machining is grinding on a special machine dedicated solely for crankshafts (fig. 4). This operation is done in one holding as a final machining for bearing pins, crank pins and cone.

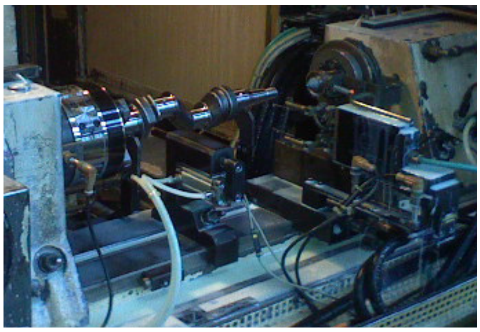


Fig. 4. Crankshaft on grinding machine.

The grinding machine can correct dimensions basing on measurements of a workpiece. It is further equipped with an own system to determine diameters used when positioning a blank on a machine tool. After every change in production caused by e.g. tool change, the first crankshaft is taken to a

CMM for measurements. Dimensions are checked and a correction file with roundness values for main and crank pins is generated. That file – to fulfill grinder and customer requirements - contains 2 columns and in principle is a table of values regarding angle and radius respectively. According to the customer wish radius values are output every 0,1 degree on pin perimeter.

3. WORKING ALGORITHM

The measuring task was divided into a number of stages, connected with each other.

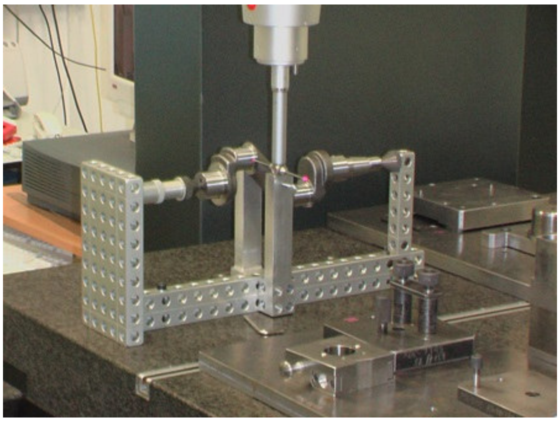


Fig.5. Crankshaft holder for measurements.

First it was necessary to design a holder for workpiece, that from one side would ensure manufacturing bases and convenient access to all surfaces to be measured, and from another point of view causing no noise or distortion in measuring procedure and no loss of accuracy. Designing this holder it was necessary to take a decision whether the workpiece in measuring position would be horizontal or vertical. After a thorough investigation we found out that horizontal position is better (fig.5).

Vertical position caused micro bending of workpiece not noticeable in horizontal position with proper fastening.

Second element was proper configuration of probe pins, to get as good accuracy of performed analysis as possible. This configuration must also allow for measurement of the whole cylindrical part for main bearings and for crank pins. This task was connected with workpiece orientation during measurement. For vertical position perpendicular pins would have to be longer what could possibly cause higher uncertainty. Configuration of probe pins was depicted on fig. 6.

Fig. 6. Probe pins configuration.

The third stage is elaboration of measurement program including its all components, that would provide obtaining results compliant with reality and customer and manufacturer expectations. Writing a proper measurement procedure started with special, very precise calibration routine regarding probe pins configuration [4].

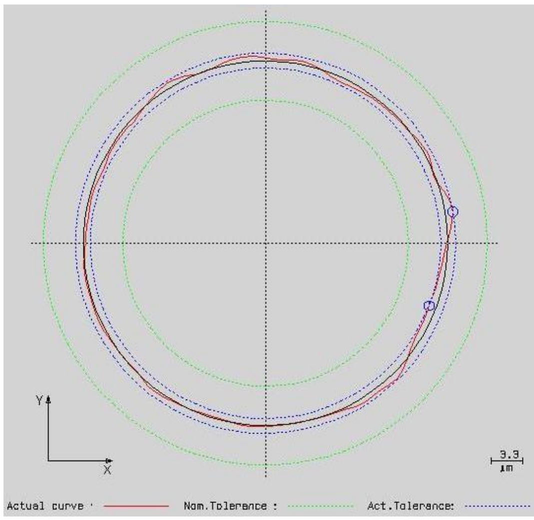


Fig.7. Example of roundness chart.

After scanning of one half of shaft with one pin, and second half of shaft with another one it may happen that in total chart of roundness both scans will not close each other, causing a small step. Accurate calibration procedure can eliminate this phenomenon and in final chart a place where two scans were connected is invisible (fig.7). The whole procedure comprised measurements of diameters and form deviations.

Our last task was to generate a file in a format that would be accepted and understood by a grinding machine. Because correction in its assumption should be made once at every shift, the correction file should be transported by a floppy disk. Still a possibility was left for the future, that this could be made using a computer network. The whole procedure had to be prepared in a command form, that could be fast and easily executed by even a non-skilled operator, not having advanced knowledge in coordinate metrology or computer technology.

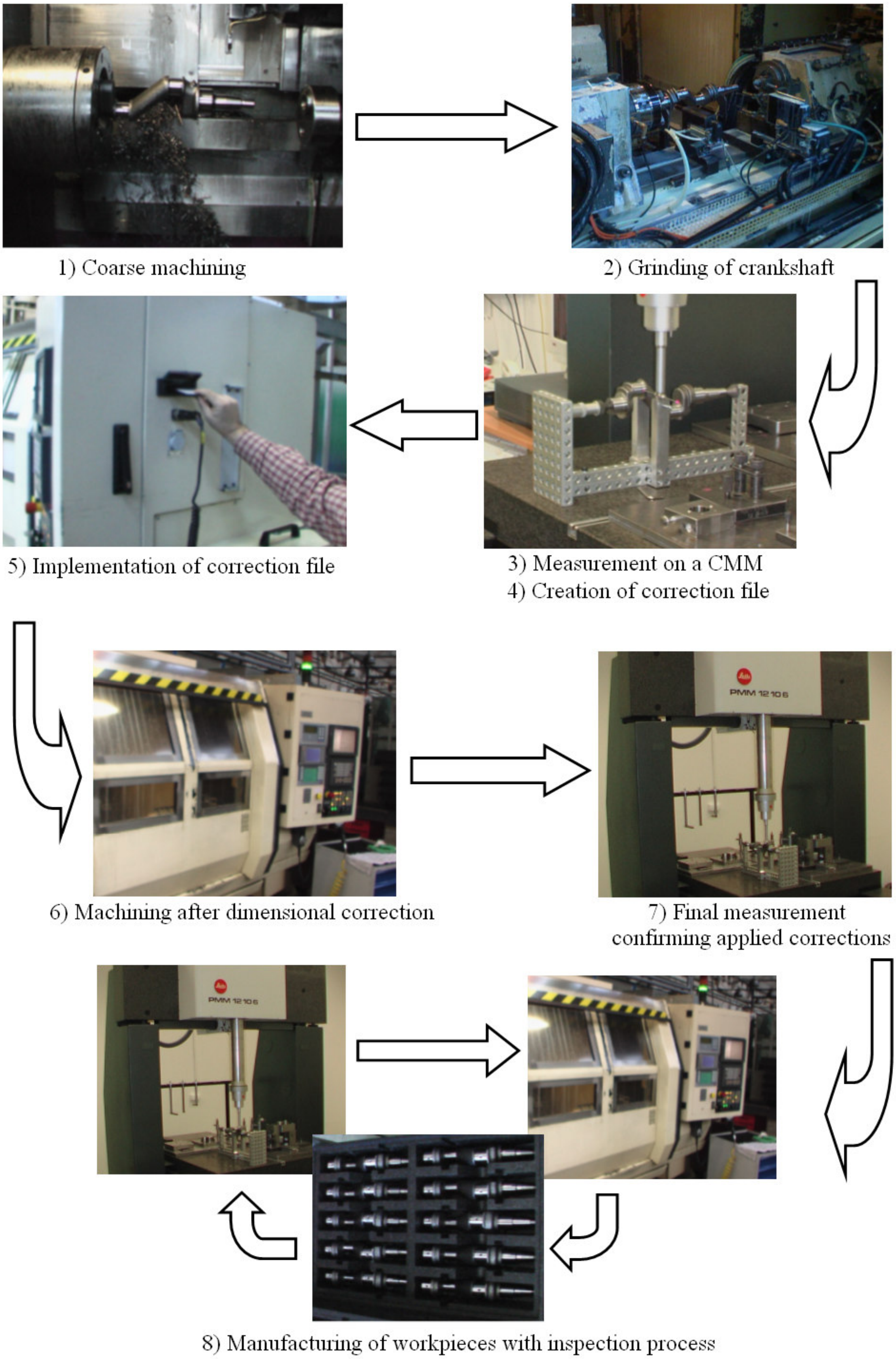
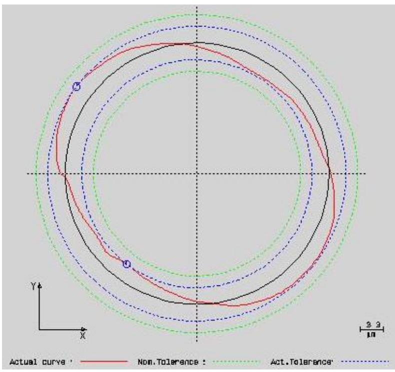


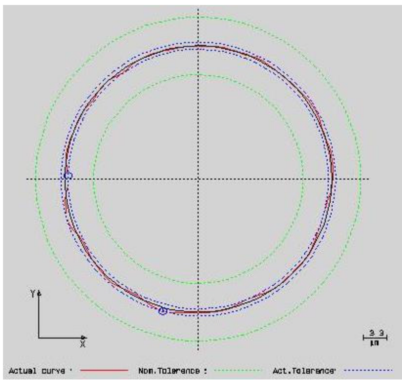
Fig. 8. Working algorithm after application of corrections for machine tool done by means of a CMM.

4. THE RESULTS OF CONDUCTED WORKS

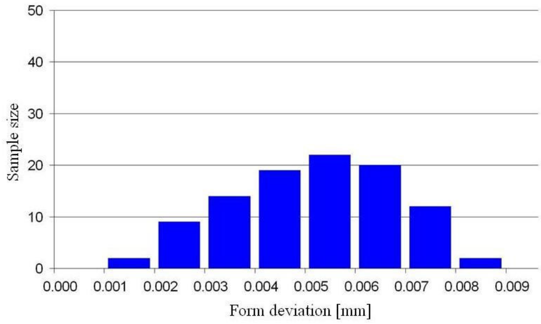
The aim of conducted works was to create a possibility to generate a correction file for machine tool settings by a CMM software. After preparing suitable procedures versatile experiments were performed. As a result of that a solution of the measuring task was obtained: a correction file was properly generated, reading it into control system of machine tool was fully successful. A series of measurements without correction was performed on machined crankshaft. A correction file for every workpiece was generated, and than new machining with responsible correction file the workpiece was performed. A significant improvement of the obtained results visible in reduction of form deviation was observed. Then a repeatability test was performed: basing on first machined crankshaft a correction file was generated and a test batch of workpieces was executed. This action was compatible with planned production routine. All crankshafts made this way were measured, and the obtained values confirmed process stability as well as positive effects of performed activities.



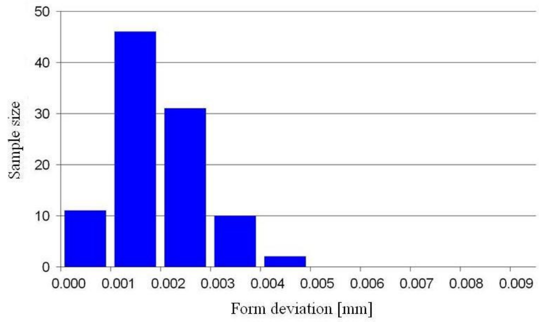
a) form obtained before correction



b) form obtained after correction
Fig. 9. Influence of correction file on form error of crankshaft.



a) values obtained before correction



b) values obtained after correction
Fig. 10. Spread of results for form error of crankshaft.

As it was shown on figures 9 and 10 a generated correction file clearly influences on positive effects obtained after machining, i.e. lower values of form error. Additionally thus performed correction of machine settings decreases range of obtained values enabling for a more precise assembly of groups. It is a direct input to better functioning of particular elements working in a compressor.

5. CONCLUSIONS

In the paper a description of closed loop of machine tool and coordinate measuring machine was given. Thus CMM generates a correction file with data including crankshaft geometry. Position of crankshaft during measurements was analyzed and holder for crankshaft was designed and made. Probe pins configuration was prepared and measuring program was elaborated. As a result even a non-skilled operator can easily prepare a floppy with correction file.

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