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ACCURACY DETERMINING OF PLASTIC FORMING TOOLS WITH USING OF COORDINATE MEASURING MACHINE

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Abstract: *In the article, the possibility of application of Coordinate Measuring Machine in the plastic forming tools manufacturing process has been discussed. The application contains also cooperation of CMM system with CAD/CAM. The example of measurement of the forging matrix for valve elements has been presented. The practical aspects of CMM application in the projecting and manufacturing processes has been discussed, too.*
Keywords: *plastic forming, CAD/CAM, CMM*

1. INTRODUCTION

To meet customer's demands on quality of final products made by hot plastic forming (especially dimensional and surface conditions), it is necessary to follow strictly the projected accuracy during the manufacturing of the matrixes and their replaced parts, and the forming stamps. That leads to the question of reliable check of those tools to verify their compatibility with the requirements imposed by the constructor. It must be emphasized that both mechanical and electrolytic machining causes many factors affecting accuracy of the manufactured tools. To mention some of them: wear and tear of machining tools, forces that push tools away from the matrix being under machining, vibrations caused by the work of holder-tool system, inhomogeneous structure of the material, and inappropriate basing and preparing works. Those factors take place especially in case of matrixes and forming electrodes (for further electrolytic machining) manufactured by boring and milling technology. Facing the mentioned problems, the certain factory in Poznan which main products were die forging out of steel or brass, decided to buy a Coordinate Measuring Machine and to include it into a process of projecting and manufacturing of forging tools. In many cases it was the only way of verification of free surfaces, impossible or very difficult to verify by conventional methods. The measured object was compared to the ideal model projected in CAD system.

2. COOPERATION OF THE CAD/CAM SYSTEMS WITH CMM DURING THE MANUFATURING OF PLASTIC FORMING TOOLS

The important element of computer aided process is full compatibility and integration of

all parts of system. The full conformity of data record and exchange enables to fulfill the technical requirements of project. One of the examples of such cooperation between the CAD/CAM systems is a module converting 3-D model prepared in system Autodesk Inventor into the program EdgeCAM. This is performed directly through original file format, without translators, which ensure the maximum accuracy of the generated tool path. As a result, the technological sequence will precisely reproduce the projected shape of the matrix. The data import from systems CAD to CMM is performed with universal formats like VDA, IGES, STEP or ACIS. In the mentioned above factory, during control of the forging matrix tools most often ACIS format was chosen (files of *.sat, *.sab, *.sax type). It was because of ability to keep 3-D structure of object, unlike e.g. IGES format which may transform the "solid" object into surface. The restrictions on the free choose of data record format are caused also by the recordability of the CAD software. In fact, one deals with certain software modules installed in CMM, enabling data readout and conversion into its own system.

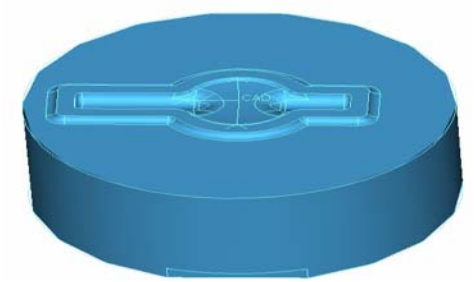
Other important issue of the matrix projecting process was correlation of the machining and measuring bases even when the virtual model of matrix has been created in the CAD system. The "zero point" (center of the coordinate system) is placed usually in the intersection point between the symmetry axis of the solid, and its highest plane. Moreover, when the matrix is cylindrical, additional machining bases are done in order to enable the orientation of axis. Therefore there is no need of further correction of the model placed in systems CAD and CMM, because the solid is placed in 3-D space in the same way in all three systems. This way the error caused by re-orientation will never occur.

However, the main problem remains how to base a physical model in the milling center space, and in the CMM's space. The preparation to milling and boring process must be performed most carefully and precisely, using the electronic positioning sensors, and above all, the operators of machining center must strictly cooperate with operators of CMM, in order to use the very same technological bases proposed by constructor. This way the measurement is more reliable, because the base is no more related to the machined surface, which are to be measured and whose deviations from nominal values is to be determined.

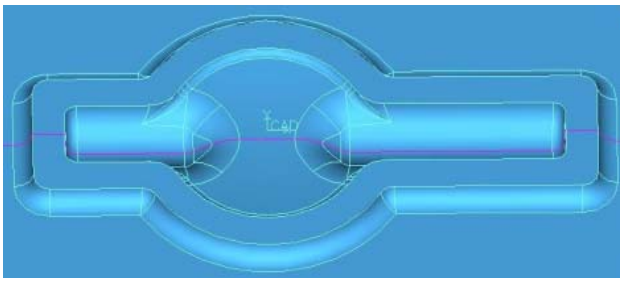
3. EXAMPLE OF THE FORGING MATRIX MEASUREMENT

In order to verify the accuracy of the matrix for hot forging of valve detail, the use Coordinate Measuring Machine was unavoidable. The matrix contained free surfaces, therefore the CMM measurement supplied the most precise results to the milling and boring center operator, which display the run of the machining process. Before measurement, the 3-D matrix model has been created and inputted into the software of the measuring machine Metrosoft 3.5 with module SURF 3D. The "zero point" and bases have been taken from CAD system and repeated according to the procedure performed by the milling and boring center operator. In measurement the contact pulse probe made by Renishaw was used, to collect on the matrix surface characteristic points to be compared with the CAD model.

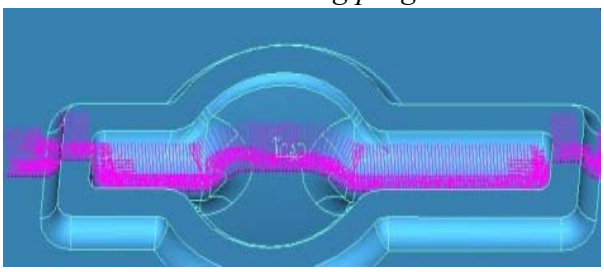
First of all, the intersection of the 3-D matrix model with the plane containing its symmetry axis was made. It resulted with the curve corresponding with the sampling path. Next, the number of sampling points was determined, as well as acceptable value of deviation from the nominal (in case of matrixes it is usually ± 0.05 mm. The results of measurement with calculated deviation will be displayed in the measurement window. The process of the deviations determination for the points placed in the certain curve, is shown in the Fig. 1.



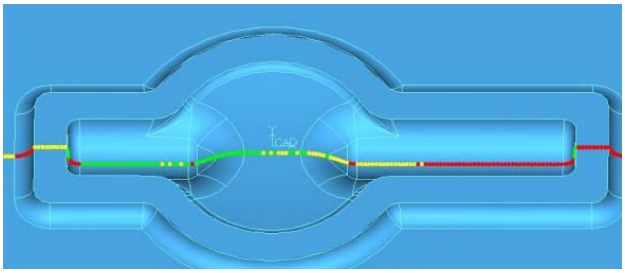
a) Display of the CAD matrix model imported to the measuring program



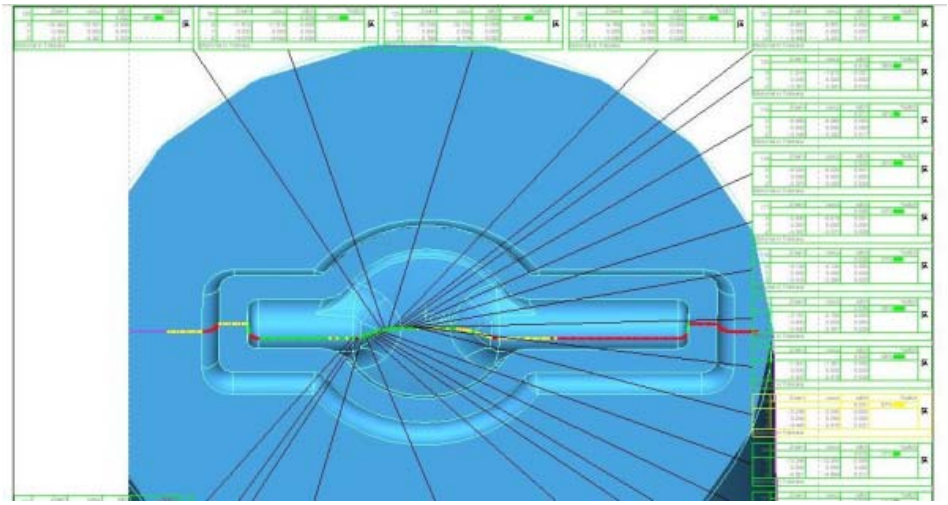
b) View of the curve created on the matrix



c) Draw of the matrix with the curve and the vectors of coming probe



d) Collected measuring points in the curve



e) The example of the measuring report with nominal and actual points

Fig. 1. Stages of control points determination on the certain curve in the matrix

The other way of matrix verification was through the measurement of the free surfaces. Different views show the measuring path and vectors of coming probe, so that would represent the maximal area. Like in the previous method, the values of the dimensional deviation have been restricted. In order to present the results clearly, the measuring points within the tolerance were marked with other color than those exceeding the acceptable boundaries. This way the "map" was created, showing the dimensional distribution in the certain planes of the matrix surface. Such analysis enabled to find out the places which must undergo additional machining or polishing, and to point the places where the machining tool got blunt or went under repulsion forces. In the fig. 2 the result of the matrix free surfaces measurement is presented.

The last stage of the matrix accuracy check was the measurement of the edge between the surfaces. In the discussed case, it was the upper, outer surface of the die impression.

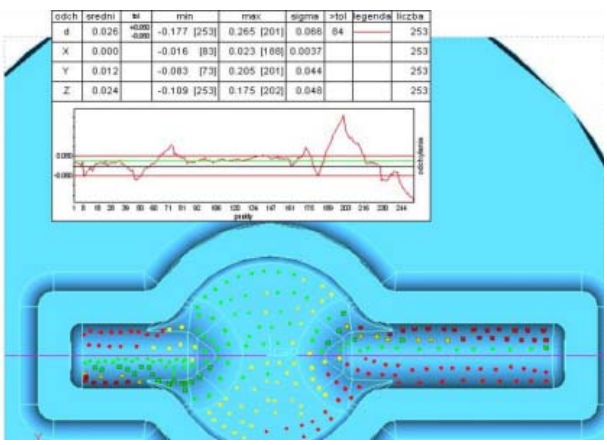


Fig. 2. The statistics of the measured points on the matrix free surfaces

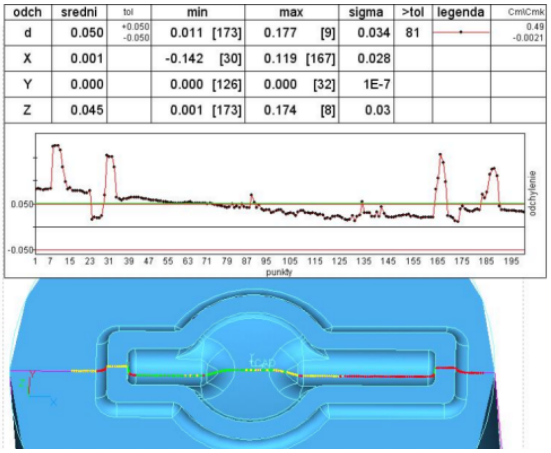


Fig. 3. Statistics of the points measured in the curve

4. CONCLUSIONS

In the certain factory given here as an example, the accuracy of matrix produced for hot forging was found very important. Any deviation from the project requirements causes the defective final products, namely valves. If the problem would be recognized before the run of the forging process, the matrix could be corrected or replaced without costs of defective final products. To achieve this kind of savings, one needs to introduce the Coordinate Measuring Machine into the process of manufacturing of forging die or matrix. The role of the CMM is not merely measurement, it may also provide the information to constructor and technology operator on the project itself. The results of the measurement may be inputted into the CAD system and become the base for the other matrix construction. It is also noteworthy, that the advances of the CMM may be fully exploited in the tool manufacturing process only when the close team cooperation is reached between the constructor, technologist and operators of machining center and CMM. This way the errors may be eliminated out of whole process of projecting and manufacturing of tools, which results with higher quality of final products.

5. LITERATURE

[1] Gawlik J., Juras B., Karbowski K., Wójcik A., Koncepcja oceny dokładności powierzchni swobodnych w systemie inżynierii odwrotnej, Metrologia w technice wytwarzania, Politechnika krakowska, Kraków 2003.

[2] Gawlik J., Wójcik A., Modelowanie i ocena dokładności powierzchni swobodnych w systemie WMP CAD CAM. Prace Naukowe Instytutu Technologii i Automatyzacji Politechniki Wrocławskiej, Nr 84, Kraków 2003.

[3] Kędzierski Tomasz, Mądry Lukasz, The method of workpiece exactitude evaluation on the basis cad model by means of coordinate measuring machine, Scientific Bulletin of North University of Baia Mare, serie C, vol. XVIII, pp. 155 - 160, Baia Mare (Romania), ISSN 1224-3264.

[4] Weckenmann A., Killmaier T., Weprom – code for the automated process chain from produc development to inspection, Zeszyty naukowe, Akademia Techniczno - Humanistyczna w Bielsku – Białej, Budowa i Ekslopatacja Maszyn, Konferencje, Nr 3 (2002).

[5] www. wenzel cmm.com.