POLISH ACADEMY OF SCIENCES - COMMITTEE OF MATERIALS SCIENCE
SILESIAN UNIVERSITY OF TECHNOLOGY OF GLIWICE
INSTITUTE OF ENGINEERING MATERIALS AND BIOMATERIALS
ASSOCIATION OF ALUMNI OF SILESIAN UNIVERSITY OF TECHNOLOGY

Conference Proceedings

12th INTERNATIONAL SCIENTIFIC CONFERENCE
ACHIEVEMENTS IN MECHANICAL & MATERIALS ENGINEERING

Manufacturing of industrial tools for sheet-metal forming by Use of Reverse Engineering

I. Pahole, I. Drstvensek, J. Balic, M. Mikulan

Faculty of Mechanical Engineering,
Smetanova 17, SI-2000 Maribor, Slovenia

Manufacturing sheet metal forming tools usually requires a lot of subsequent manual corrections in the tool testing phase. The reason is in insufficient command of the forming process, which mathematical formulations are usually incomplete due to simplification reasons. The new, corrected shape of the forming tool therefore deviates from the planed shape what represents a problem for repairing or manufacturing a substitutional tool, respectively. By the use of reverse engineering it is possible to gather the actual geometrical data of the corrected shape of the forming tool. These data can be recorded into the tool's technical documentation and thus preserving the actual shape of the forming tool. Besides up-to-date archiving of the tool's shape can the gathered data of deviation of the actual (needed) form from planed (required) form be used as a fundament of the knowledgebase for use in intelligent forming tool planning methods.

1. INTRODUCTION

Nowadays toolmakers encounter constant changes and novelties from their environment. Industrial tools are becoming biger and more complex and quality standards are getting more and more demanding. On the other hand market demands less expensive tools made in shorter time as ever before. Toolmakers are therefore forced to invest into personnel education and to introduce new manufacturing procedures to reduce costs and time-to-market. One of these procedures is reverse engineering. It can be defined as a process, which converts a real physical model into a virtual mathematical one. Reverse engineering is intended for general use in cases where only a physical model is available, which needs to be reproduced, reconstructed, measured, etc [3].

2. DEVELOPMENT OF AN INDUSTRIAL TOOL

Characteristically, toolmakers construct and produce practically only prototypes. As a rule not the two industrials tools are equal, and very seldom they are similar. Number of pieces is usually one, what means that orders are projects, planed, coordinated and controlled by the rules of project management. Thus the development of an industrial tool starts with market's demands analysis that is followed by construction, manufacture and takeover by a customer.

All the steps of the project are written to the development scheme what enables the coworkers in the project to effectively change, check, verify and validate single steps of the project [4]. Industrial tool manufacture consists of:

- Preparation of technical documentation,
- Machining and manual processing, mounting of elements,
- Testing,
- Changing,
- Final take over.

3. METHODS FOR TESTING AN INDUSTRIAL TOOL

Testing is the last phase of industrial tool's production process. It is done by making a test piece, observing its surface and measuring it according to the prescribed measuring protocol. In the case of deep drawing tools a graphometric analysis can be used to analyse plasticity deformations [2].

Correct operation of industrial tool is regularly checked during its development. Special simulation software is used to check the functionality of the tool and to eliminate most of errors in the early phase of tool's development. Thus higher costs of later modifications and corrections can be avoided.

The test pieces are visually checked against cracks and wrinkles and measured according to demanded dimensions of the finished product. The industrial tool is also checked against cracks and wear-out. If the measured dimensions meet the demanded ones and both the tool and the piece are in a suitable condition, the tool is exposed to the last test.

4. ADAPTATION AND REPAIRING OF INDUSTRIAL

Adaptation and repairing are usual procedures in the development of an industrial tool. There are two possible reasons for that:

- Funkcional unsuitability (creasing, tearing, etc.)
- Dimensional unsuitability of the test piece.

Corrective measures usually relate to:

- Geometrical shape of the tool
- Quality of the tool's surface,
- Sheet metal's holders,
- Cut of the raw part,
- Cutting relaxations,
- Lubrication,
- Speed of the forming process.

Suitable countermeasures and their size is defined after the test pieces are observed and measured. If the deviations are small enough the corrections are performed manually. In cases of larger deviations the tool is repeatedly machined. Usual procedures include welding and milling on CNC machines or only additional milling and cleaning of certain parts of the tool on CNC machines. In the worst cases some elements of the tool have to be made again from the scratch. It is obvious that such corrections cost a lot of time and money.

5. CAPTURING GEOMETRICAL DATA OF CORRECTED INDUSTRIAL TOOL

Reverse engineering proves to be a tool of choice where a real object needs to be converted into a numerical (virtual) model. The reverse engineering procedure comprises of:

- 3D digitalization (scanning) of an object,
- Processing of the computer model of the scanned object.

Scanning is usually made by the use of special digitizer that captures clouds of points form the object's surface. Processing of these clouds provides a user with a useful CAD model that can be further processed using the usual CAD tools (Boolean algebra, etc.)

To prove the use of reverse engineering in the field of tool making industry an experiment has been made on the real, existing industrial tool in a working environment of the tool making workshop. The goal of the experiment was to substantiate the use of optical 3D scanning of the industrial tool in the testing phase. A photogrametric digitiser that captures a picture through a CCD camera was used for capturing the shape of the tool. Accuracy of the captured model depends on the size of the object, the quality of lenses, and the wavelength of the light[5].

Advantages of optical digitalization are following:

- Very fast process of digitalization,
- The System is practically unconstrained by the size of the object,
- The system can be easily carried around,
- Achieving of accuracy down to a few μm.

Process of digitalization consists of several phases:

- Preparation of surface (figure 1),
- Preparation of digitizer,
- Digitalization,
- Processing of gathered data.

Surface of the tool was thoroughly cleaned and coated with a nonreflecting coating. Special labels – reference points were afterwards glued to prepared surface.

The digitizer was equipped with suitable lenses according to the size of the scanned object and calibrated. Several scans of the object were made during the digitalization process. The scans are combined into a three-dimensional numerical model and written into a STL file. The file can be transferred into a suitable CAD package where it can be compared to the original model of the industrial tool or further processed in order to gather the data for tool making knowledge base. Several levels of sensitivity can be used in the comparing procedure (0,2; 0,5; 3 and 4mm, for example). The analysis of the compared data can provide the user with positions and sizes of geometrical changes of the shape of the industrial tool. Differently coloured fields represent a scale of the geometrical deviation from the referential (basic) shape of the tool. The sensitivity of comparing is chosen according to the size of the geometrical deviation (figure 2).

Results of the comparison are used as information about the location and the size of corrections carried out on the industrial tool's surface. They will be of great help in a case when a spare part will be needed due to wear out or failure reasons. The spare part can than already at the beginning be machined to these new, digitized dimensions what diminishes the correction costs and time in the testing phase.

Figure 1: Preparation of tool [1]

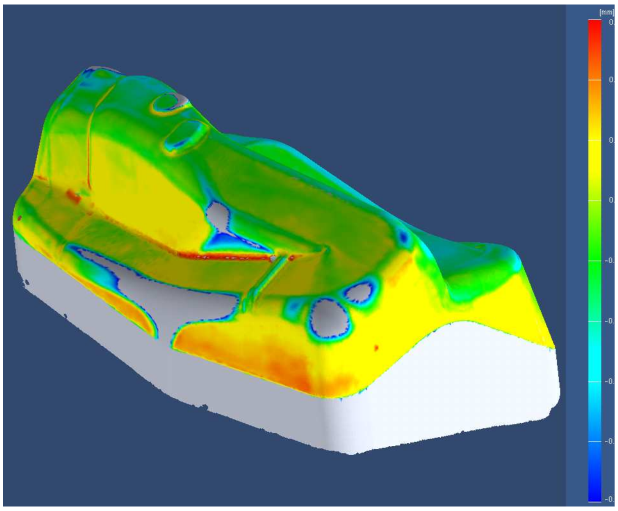

Figure 2: Comparison of scanned with the original model (sensitivity 0,2mm) [1]

6. CONCLUSION

Modern digitalization systems made the digitalization process simple and user friendly. Belonging software on the other hand enables optional treatment and modification of gathered data. They can serve as a powerful tool for repairing and modifying the worn out tool.
Described research indicates the possibility of capturing and evaluating physical properties in spatial forming of sheet metal. With gathered and suitably treated data a knowledge base can be constructed, which can be used as a support tool for projecting new industrial tools.

REFERENCES

1. M. Mikulan, Reverse engineering in manufacturing of sheet metal formig tools, Fakulteta za strojništvo, Maribor, (2003)
2. I. Pahole, Forming tools, Fakulteta za strojništvo Maribor, (1999)
3. T. Herbertson, Reverse engineering, K. Kuzman (ed.), 4th International Conference on Industrial Tool, Bled, pp. 419-422, Tecos Celje, (2003)
4. Poslovnik kakovosti in varovanja okolja - razvoj novega orodja, Emo orodjarna d.o.o, Celje, (2000)
5. Quality Control and 3D-Digitizing using Photogrametry and Fringe Projection, Tecos, Celje, (2002)