Annals of DAAAM for 2012 & Proceedings of the 23rd International DAAAM Symposium, Volume 23, No.1, ISSN 2304-1382
ISBN 978-3-901509-91-9, CDROM version, Ed. B. Katalinic, Published by DAAAM International, Vienna, Austria, EU, 2012
Make Harmony between Technology and Nature, and Your Mind will Fly Free as a Bird
Annals & Proceedings of DAAAM International 2012

RAPIDTECHNOLOGY IN INDUSTRIAL FITTING

TOMASIAK, J[acek]

Abstract: *The paper describes a general concept of using a 3D scanner in production conditions, as an alternative to inspection and test devices. The tested object was a body of HCVB6 high-pressure valve. The input from the test object is a cloud of points acquired from the scanning of the valve body and a virtual 3D model. Comparing the virtual model with the factual itemprovided conditions to perform control and measurement analysis. The paper contains measurement results of the valve body obtained with Atos scanner manufactured by GOM company and "GOM Inspect" software. The concept of 3D scanning in production conditionsshows the advantages and disadvantages of the control and measurement process.*
Keywords: *3D scanning, reverse engineering, virtual prototyping, rapid inspection*

1. INTRODUCTION

The success of today's business largely depends on rapid development of computer technologies and software used in the production engineering. Currently, most of the engineering work is computer-aided and it's hard to imagine the implementation of a new product without preparing a three-dimensional model and photorealistic visualization. At the same time, every company wants to have its innovative products implemented as quickly as possible, ensuring high quality, cost-efficiency and compliance with binding standards. Therefore, in industries we may observe an increasing trend to use RapidTechnologies of manufacturing prototypes. Currently, the Rapid Technologies are used in almost all industries, especially in applications where high quality is required, and where designed models have complex shapes. Rapid-Technologiesinclude: Virtual Prototyping, Rapid Prototyping, Rapid Manufacturing, Rapid Tooling, Reverse Engineering, Rapid Inspection

The process of virtual prototyping consists in constructing a 3D model, followed by the kinematic, dynamic and strength tests on the designed model. A virtual model may be also a base for constructing next variants or create series of models. In the end, the virtual model is sent to CAM software, which performs a virtual machining process on CNC machine, selects the tools and equipment, and optimizes the machining process. A different technology is theReverse Engineering, which uses the real physical item to create itsdigital 3D model, which can be modified and used to manufacture items using Rapid Manufacturing technology.

At present widely measurement techniques adopted in the industry are based on using measuring machines adapted for specific production systems. This technology requires applying specialist devices, of measuring conditions what extended the lead time of the measurement. Thanks to new solutions of the computing and optoelectronic we have the possibility of using scanning heads which are recording image with digital cameras in the measurement technique and let conduct analysis of these images. Using of scanners 3 D to the measurement technique is combining advantages of measuring machine with advantages of optical measurements [1].

For the purpose of this paper, authors presented Rapid-Inspection technology used for the production of industrial valves, on the example of the body of HCVB6 DN25 PN250 valve, manufactured in FabrykaArmaturyPrzemysłowej (Factory of Industrial Fittings) in Bodzanow.

2. RAPID INSPECTION TECHNOLOGY IN INDUSTRIAL FITTINGS

The effectiveness of rapid-technologies depends on the manufacturing quality of the prototype. Therefore, to assess the quality of a manufactured product, it is suggested to use Rapid Inspection technology as an alternativein the control and measurement process. Rapid Inspection technology consists in quick checking the conformity of parameters of an actual item (first of all shape and surfaces) with its virtual 3D CAD model (Fig.1). The analysis of the shape and size is performed byprecise 3D surface scanning of the item. The scanning process of the real item providesa digital record, whichis close to the original surface.

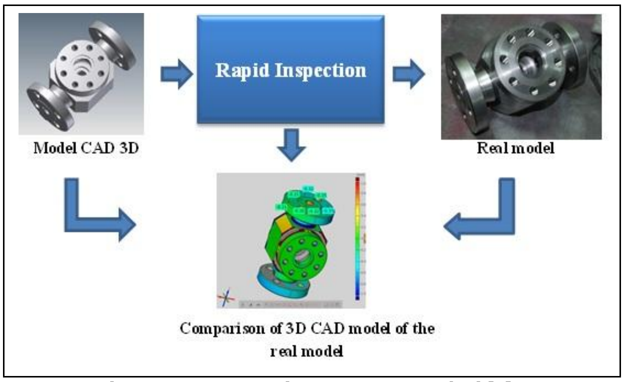

Fig. 1. Rapid Inspection – control-measurement method [2]

2.1 Virtual prototyping

In order to examine the valve body, first a parametric 3D model (Fig. 2) was made, which is a virtual model for later assessment of the actual item.

Parametric features of 3D model mean that any change in parameters (size, node) will cause an automatic corresponding change of the entire model, including its documentation. A Parametric model is a mathematical model which is defined by numbers or functions. The mathematical models include[3]:

- decision variables
- structural parameters
- criteria of optimizationandlimits

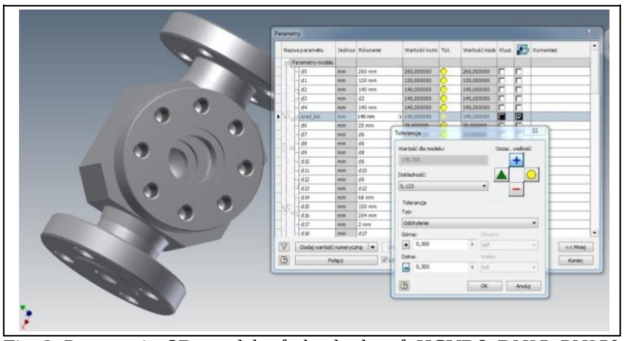

Fig. 2. Parametric 3D model of the body of HCVB6 DN25 PN250 valve

To prepare the valve model, the decision variables were used, which are adjusted in the design process along with parameters describing the structure which do not change in the design process. The optimization criterion wasthe maximum value of flow and valve wall thickness. Additional criteria optimization which was used for the reduction in production costs they presented at the article [4]. All parameters were described in a worksheet and then exported to Autodesk Inventor software.

Constructing virtual 3D models also enables designers to carry out a number of strength tests that affect the model geometry, material type, etc. For the model of the valve body described here, a safety factor analysis was performed applying the nominal pressure (Fig. 3).

An advantage of constructing virtual 3D models is the ability to define not only the geometric and topological structure of the modelled item, but also defining other non-geometric features necessary to design the process of its manufacturing, e.g. tolerances, surface parametersthread parameters, teethparameters etc.[5]. Parametric 3D model is also the base for developing the engineering process using CAM software, which generate NC code for numerically controlled machines.

In the next step, the machining process was designed for the valve body, using CAD/CAM system. Imported 3D model of the valve body was used for the automatic recognition of Manufacturing Features. Then a rough and shaping machining was designed, using *Profiling* strategies. Simulations of the machining process were performed and if no collision was indicated by a completed simulation, a control program was generated for the postprocessor of DMG DMU200P milling machine (Fig. 4).

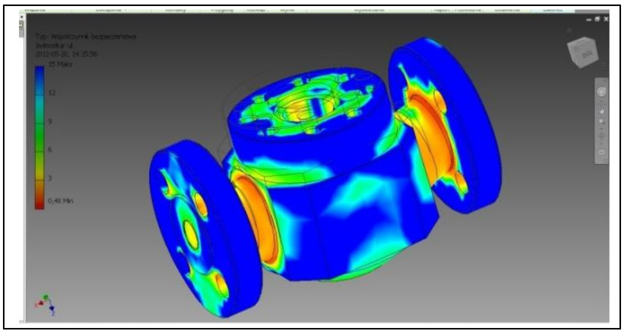

Fig. 3. Strength analysis, using MES method

Thanks to the use of these tools, preparing the documentation and control program is relatively short. Moreover all requirements are met and full control of the user over highly automated design activities is ensured.

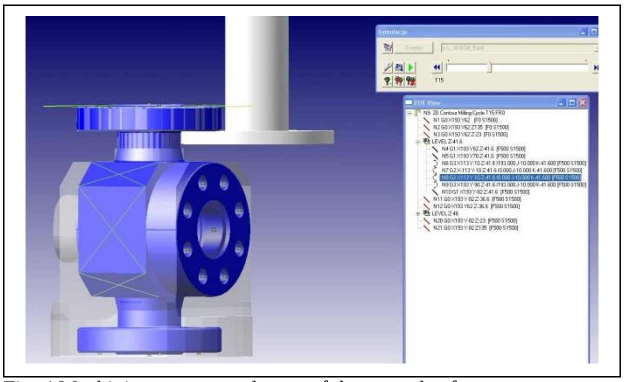

Fig. 4.Machining process anda part of the control software

2.2 Rapid Inspection

Rapid Inspection technology was used to inspect the body of HCVB6 DN25 PN250 valve, whose production wasstarted in FabricArmaturyPrzemysłowej (Factory of Industrial Fittings) in Bodzanow, Poland.

To obtain 3D model of the valve body, ATOS Compact Scan 2M scanner of GOM company was used with the following parameters table 1.

Parametr	Wartość
Camera Pixels	2 x 2 000 000
Measuring Area	35 x 30 - 1000 x 750 mm²
Point Spacing	0.021 - 0.615 mm
Working Distance	450 - 1200 mm
Sensor Dimensions	340 mm x 130 mm x 230 mm
Weight	ca. 4 kg
Sensor Controller	integrated
Cable Length	up to 30m
Sensor Positioning	lightweight tripod or sensor stand
Part Positioning	manual or automatic rotation table
Image Processing Computer	portable or desktop
Operating System	Windows 7
Software	data capture, processing and complete inspection
Ambient lighting	low sensitivity to environment lighting conditions
Environmental vibrations	unaffected due to GOMs dynamic referencing system
Operating Temperature	5 - 40°C, non condensing
Power Supply	90 - 230 V AV

Tab. 1. Parameters scanner Atos by GOM

Rapid Inspection process was performer in the following stages:

- scanning the real item
- importing CAD 3D model
- overlayingthe scanned model on CAD 3D model
- comparing overlaid models and analysing

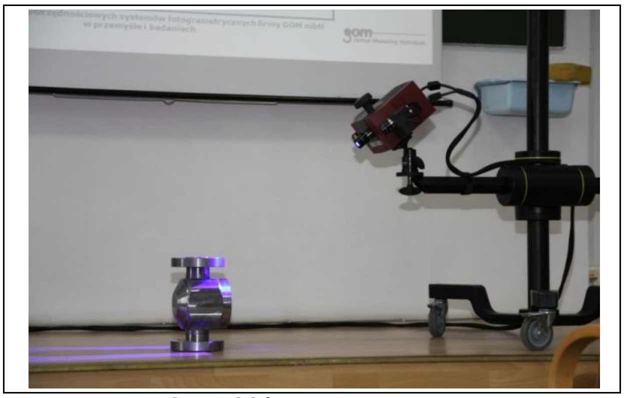
Fig. 5. Preparing valve model for scanning

The scanning process was preceded by calibration of the instrument, and preliminary preparation of the product surface, which involved cleaning and attaching markers (Fig. 5). Due to the fact that during the calibration the valve body showed too much glare, the valve body was coated with a chalk spray.

The process of 3D scanning consisted in reproducing the shape of the real valve, followed by recording it in digital form. The projector of the scanner projecteda set of fringes of known density onto the tested item. Straight lines underwent distortion corresponding to the size of deformations on the item surface and the image was captured by camera matrices (Fig. 6). Using the input data (light structure, image captured by the camera, its calibration parameters, the angle between the direction of projection, and the direction of reading), and mathematical equations, the location ofevery camera pixel was calculated. The result of a single measurement is a cloud of points and their number is directly dependent on the resolution of the cameras used.

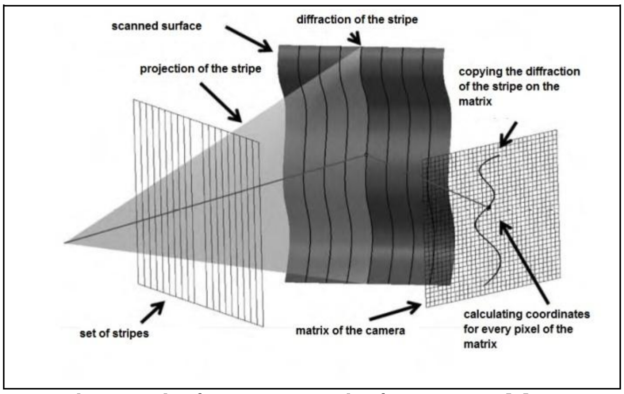

Fig. 6. The principle of 3D scanning with a fringe scanner [6]

Then, GOMInspect v7.5 software was used to compare models. To complete this activity, CAD 3D model was imported to the scanned actual item. At a later stage it was necessary to adjust two models, because the measured coordinate system did not cover the reference system of CAD 3D model (Fig.7).

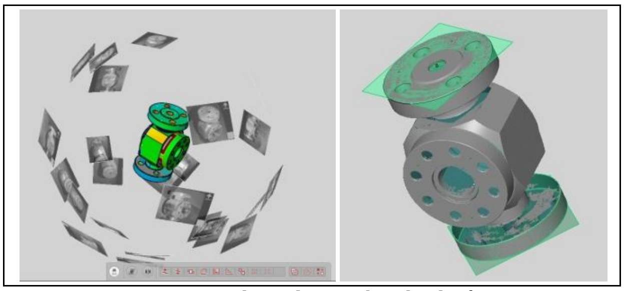
Fig. 7. Scanning stages and overlaying the cloud of points onto 3D model

After overlaying the cloud of obtained points on the 3D model, missing parts of the surface were visible in hardly accessible areas. These missing parts resulted from methodological limitations - primarily from the need to scan manually some hardly accessible fragments such as cavities, pipe-shaped fragments, gaps, but thanks to repeated calculations carried out for triangles that did not meet the defined requirements, the deficiencies in the model were minimized (Fig. 8).

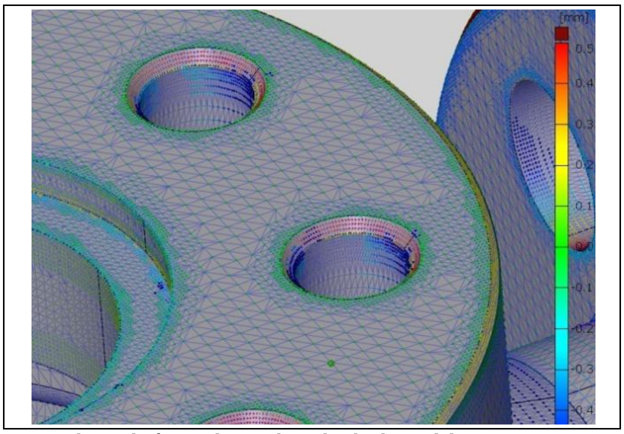
Fig. 8. The grid of triangles on the valve body model

The control-measurementprocess for the real item included, among others, checking compliance of geometrical dimensions (e.g. opening diameters), radiuses, edgesetc. Its results are presented in the graphicalreport (Fig. 9).

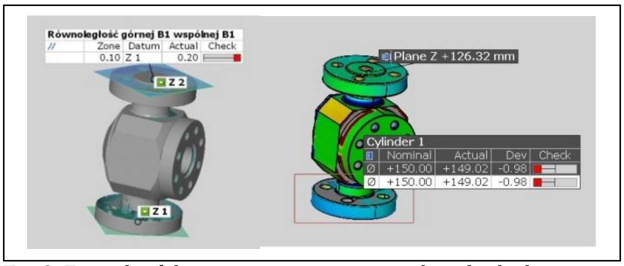

Fig. 9. Example of the measurement process on the valve body

Completed analysis revealed significant differences in measured dimension between the CAD 3D model and the real, scanned item. Substantial differences were visible between the upper and lower flange of the valve body (Fig. 10). The difference was also present in the diameter of both flanges and in the surface parallelism. Additionally the measurement revealed a lack of concentricity of openings in both flanges. Too large differences were revealed on one side of the upper flange neck that enforced further, detailed analysis.

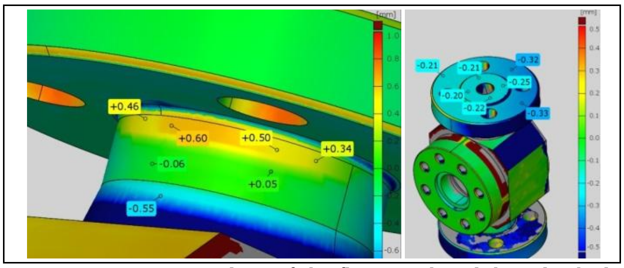

Fig. 10. Measurement analysis of the flange neck and the valve body neck

The measurement analysis revealed that during the machining process of the valve body – when using a single-point fixing – the machining forces were too. This was particularly evident during machining theflange neck using a disc cutter. Optimization of the machining process assumedperforming the largest possible number of operations withsingle-point fixing of the workpiece. It turned out that this method of mounting together with the workpiece of such dimensions is not a proper solution (Fig. 11).

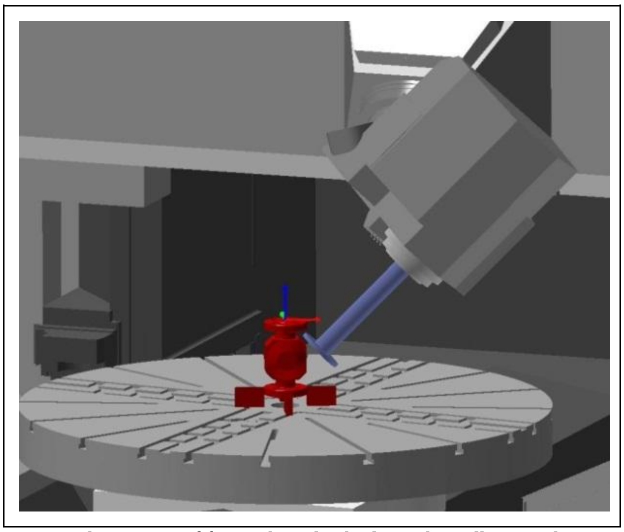
Fig. 11. The manner of fixing the valve body on the milling machine

Rapid Inspection technology used in production conditions may help to quickly determine the dimensional errors and make appropriate adjustments to cutting and fixing methods. As it is important to introduce products to the market as soon as possible, we may state that using traditional measurement techniques the process of measuring and detecting errors would be much more time consuming. The scanning results were also used for computer simulation in CAD/CAM systems to eliminate errors in the machining process. During the measurement process, it was particularly difficult to analyse internal surfaces due to the limited range of the scanner -therefore the results of the analysis were limited to external surfaces. During the scanning process it must be remembered thatlight reflecting on the machined workpieceadversely affects the quality of the scanned image of the surface.

One of the advantages of the scanning process is the option of its automation. Using the rotary table of a machine, or spindle, we may integrate 3D scanner with a machine tool and carry out monitoring and control process. This method has many advantages as it reduces the measurement time and provides reliable results.

3. CONCLUSION

Using Rapid Inspection technique enables users to detect errors in machining process already at the stage of creating a prototype. This allows us to quickly correct errors and perform proper machining process.

Undoubtedly, the biggest advantage of this method is reducing the total time of product measuring process, performed in the production environment. The process of preparing and scanning took about one hour. Performed analysis provided a lot of information on the machined surfaces and the course of the machining process. With this method, errors were removed and subsequent valve bodies were manufactured correctly.

Presented example proves that Rapid Inspection technology is a very important and necessary elements that complements both control and measuring processes. It allows users to quickly check the correctness of the prototype, and the analysis of measuring and control results facilitates correct selection of applied production processes and used materials. In addition, it prevents recurrence of errors and is one of the key factors affecting the optimization of the structure.

4. REFERENCES

[1] Mc Cann D.: Mobile metrology. Cutting Tool Engineering, no. 10/2008, s. 60-63

[2] Oczos, K.& Cena, I. (2008), Rapid Inspection – measurement/control methods duly harmonized with rapid-technology processes, *Mechanik*, No. 3,pp.165-174

[3] Jaskulski, A. (2008), Selected results of analysis of 3D tools advisability and effectiveness in small production plant, *Przeglad Mechaniczny*, No. 7-8, pp. 30-33

[4] Chwastyk P., Kołosowski M.: Choice of Variant of Manufacturing Processwith Estimation of Cost Production. Annals of DAAAM for 2011 & Proceedingsof the 22nd International DAAAM Symposium, ISBN 978-3-901509-83-4, ISSN1726-9679, pp. 511, Editor B. Katalinic, Published by DAAAM International,Vienna, Austria, 2011

[5] Nikiel, G. (2011),Parametric solid body modeling method for use in the computer aided design and manufacture, *Mechanik*, No. 11, pp. 908-911

[6] Kowalski, M. & Paszkiewicz, R. & Kuczko, W. & Wichniarek, R. & Zawadzki, P. (2011), Automationofthethree-dimensional scanning process basedon data obtained from the photogrammetric measurement. *Postepy Nauki I Techniki*, Vol., No.7, pp.109-119, ISSN 2080-4075