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Application of optical scanning for measurements of castings and cores

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Abstract

In the paper application of non destructive method for dimensional control of elements in initial phase of car manufacturing, at Volkswagen Poznań foundry was presented. VW foundry in Poznań is responsible of series production of chill and dies castings made of light alloys using contemporary technologies. Castings have a complex shape: they are die castings of housings for steering columns and gravity chill castings of cylinder heads, for which cores are manufactured using both hot box and cold box method. Manufacturing capabilities of VW foundry in Poznań reach 26.000 tons of aluminum castings per year. Optical system ATOS at Volkswagen Poznań foundry is used to digitize object and determination of all dimensions and shapes of inspected object. This technology is applied in car industry, reverse engineering, quality analysis and control and to solve many similar tasks. System is based on triangulation: sensor head projects different fringes patterns onto a measured object while scanner observes their trajectories using two cameras. Basing on optical transform equations a processing unit automatically and with a great accuracy calculates 3D coordinates for every pixel of camera. Depending on camera resolution as an effect of such a scan we obtain a cloud of up to 4 million points for every single measurement. In the paper examples of dimensional analysis regarding castings and cores were presented.

Keywords: Product Development, Quality Management, Scanning

1. Introduction

Dynamics of development regarding innovative applications of manufacturing technologies is - within the last years - growing rapidly. Respecting still more and more sophisticated customer requirements as far as quality of purchased products and price a need to implement integrated processes for measurements and control fulfilling these wishes without production time and price pressure emerges. Competitiveness puts it even further to minimize manufacturing prices and use fast, effective and non destructive measurement and control systems. In the paper some practical aspects of non destructive method for dimensional control of elements in initial phase of car manufacturing, at Volkswagen Poznań foundry was presented. It was explored for some time already and proved to be an effective and fast way of goods inspection. As working principle is purely optical this technique can be used for castings and cores without a risk of destroying measurement device or workpiece.

2. Activity of VW Poznań foundry

Volkswagen Poznań was established in 1993 as a joint venture between VW AG and Polish utility car manufacturer Tarpan FSR Polmo. In these premises T4 Transporter as well as Skoda Favorit and Felicia were assembled. In 1996 the factory became a 100% daughter company of Volkswagen being a thirty fifth production plant within the concern. There are three plants composing Volkswagen Poznań: car body construction division, assembly division and paint shop located in Poznań - Antoninek, production of welded assemblies, assembly of cockpits, production of special car bodies as well as logistics center and suppliers center located in Swarzędz, and foundry located in Poznań.

Foundry is than one of Volkswagen Poznań Sp. z o.o. plants that that was created in 1996. At the beginning it had an auxiliary function for foundry in Hannover. In the middle of 1996 the plant was moved to area hired from Hipolit Cegielski Poznań factory, and in 1999 series production of chill and die castings made of light alloys was started. From 2009 foundry at VW Poznań organization and competence wise is situated in the structure of Volkswagen AG Component Foundry. General view of entrance of main foundry building was presented on figure 1.

Fig. 1. Foundry at VW Poznan - general view

There are two production halls with total area of approx. 50,000 square meters in the factory area. The production capacities of the casting plant are approx. 26,000 tones of aluminum castings per year. Here, with the use of modern technologies, castings with very complex shapes and meeting the highest quality requirements are produced. These are: die castings for steering column housings and gravity chill castings for cylinder heads, the cores for which are manufactured using both the Hot-Box method and, since 2008, Cold-Box method. Example of the product manufactured in Poznan is shown on the Fig. 2.

Fig. 2. Example of casting made at VW Poznań foundry

The plant manufactures sand cores both in Cold-Box and Hot-Box technologies. At present it also performs tests in the production of unorganic technology, which - apart from its multiple technical advantages - is also environmental friendly. While the sand cores are indispensable for shaping the internal spaces of the cylinder head, its external surfaces are modeled by the mould, which is the chill. After casting and cooling the cylinder head, the cores are removed by shaking process. The cores manufactured using the Cold-Box method require special technology of shaking, in which after the stage of typical hammering the cylinder head is put into simultaneous vibration and rotation, thus enabling the sand to get out of each channel and space of the cylinder head.

3. Measurement system ATOS GOM

Optical measurement system ATOS used in VW Poznań for digitization of objects, measures the whole shape of a workpiece. This technology is used in car industry, reverse engineering, applications connected with quality analysis and control (first part inspection, assembly, manufacturing and optimization of tools, production monitoring, supplies control etc.) [1]. The main merits of that technology are:

- scanning and visualization of the whole workpiece in 3D and its comparison with CAD data,
- fast measurement process in comparison to traditional measurement systems with touch probe, e.g. tactile coordinate measuring machines,
- high resolution and accuracy, very often much better than requirements for particular applications,
- mobility of systems enabling for easy measurements of workpieces at different divisions of a plant.

ATOS is based on triangulation principle [2]: sensor head projects different fringes patterns onto a measured object while scanner observes their trajectories using two cameras (fig. 3). Basing on optical transform equations a processing unit automatically and with a great accuracy calculates 3D coordinates for every pixel of camera. Depending on camera resolution as an effect of such a scan we obtain a cloud of up to 4 million points for every single measurement.

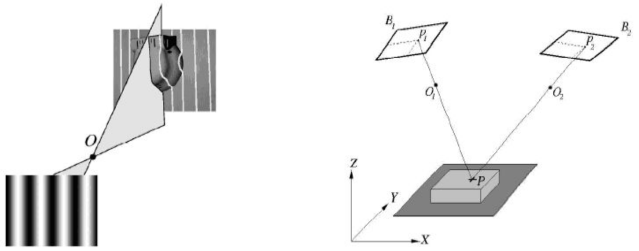


Fig. 3. Fringes projection and triangulation

Geometrical configuration of the system and objectives distortion parameters is calibrated using photogrammetric method. During measurements operator can position scanner head on a stand in front of a measured workpiece and any further additional fastening technology is not necessary (fig. 4). Markers used on a workpiece or in its surroundings are used as reference points.

For bigger objects like for instance big forming tools, reference points are put directly onto an object. Before scanning process they are measured with photogrammetric system TRITOP [3,4]. For that purpose object is analyzed from various angles by means of a special digital camera. TRITOP allows for creation of a reference data set of practically unlimited size. For example, it is possible while measuring with TRITOP objects with 4 meters nominal dimensions to reach accuracy on the level of hundreds of millimeter.

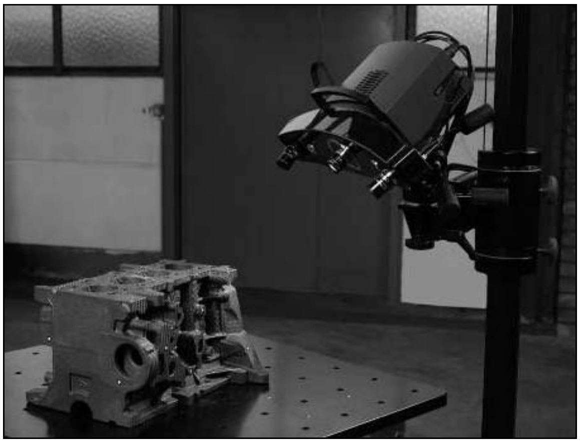
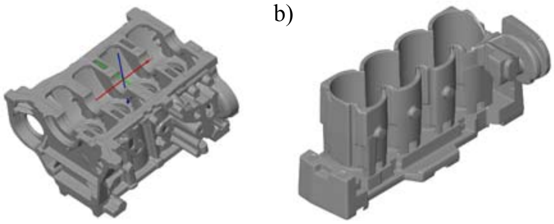


Fig. 4. Working with ATOS scanner

Analysis and inspection of sheet metal workpieces by means of ATOS system ensures a great potential for optimization of products and production procedures, particularly for car industry and its suppliers [5]. Elements are scanned, and obtained measurement data are fitted onto CAD model. Data matching is made basing on characteristic points, like: holes, areas or points on edges, for which specifications are included in RPS system. Specifications are either taken directly from drawings or from CAD files. Figure 5a presents measurement data obtained with ATOS for engine casing, while figure 5b shows respective data for a core. After fitting data deviations of all single measurement points are calculated in reference to nominal shape. As the density of collected points is very high deviations can be visualized as a color plot. That kind of presentation enables for a fast and accurate analysis of inspected object. Color plot of deviations is particularly useful to analyze workpieces during their manufacturing trials. first part inspection, for measurements after production and also for process verification.

a) b)



Rys. 5. A picture of an engine block (a) and core (b) obtained with ATOS [courtesy of GOM]

While repeating measurement tasks are concerned as well as when the same or similar workpieces are measured in big amounts, a necessity of fast inspection and time reduction becomes still more crucial. This is usually connected with automation of actions taken during measurement and auxiliary processes. In such applications a control unit of ATOS system can handle industrial robots and rotary tables. Installation of ATOS head on a typical industrial robot is very straightforward, what was shown on fig. 6. Robot typically works in learning mode: during first run its measurement positions are set manually, and than a user friendly interface in ATOS software enables to memorize trajectory of head and to include it into measurement procedure. From that moment it can be repeated any number of times without any further interactions. The whole system can be also programmed off line with easy-to-use tools to present and simulate behavior of the system.

Fig. 6. ATOS head on robot arm

4. Typical measurement applications from VW Poznań foundry

Volkswagen Poznań uses optical system ATOS GOM for two purposes: inspection of car bodies [6] and analysis of casting processes. In foundry of VW Poznań ATOS GOM is used since 2007 for example for statistical quality control of sand cores (fig. 7, 8). It is also a very useful device while checking wear conditions regarding foundry tools (chills and boxes) are concerned. This is executed by means of comparison of actual shape with CAD model (fig. 9). Basing on detected deviations from nominal dimensions it is possible to correct tools to obtain their proper shapes after repair corresponding to nominal values and thus allowing production of workpieces according to drawings and specifications. Scanning of reflective surfaces (metallic, ground, polished etc.) requires their initial preparation to get appropriate and not distorted signal. To do this surface is coated with sprayed chalk powder what significantly reduces or even eliminates all the glosses.

As it was mentioned before, the number of points obtained during measurement enables to create a color plot and meaningful visualization of deviations. Colors and tolerance limits are freely selectable by user. Still, in most cases deviations are shown in a way similar to physical maps, known from geography. Thus, negative deviations (real points below nominal data) are marked with blue color, the bigger is deviation the darker gets the shade. In contrary, positive deviations (real points above nominal data) are marked with green, yellow, and finally red colors, each of them with a number of shades. This visualization enables an operator to concentrate only on the greatest deviations, that are the most important and clearly seen, where the biggest risk of reject takes place. It is also a very user friendly way of description being time saving in industrial environment particularly comparing with tactile coordinate measurements.

Fig. 7. Measurement result of core at inlet core of cylinder head

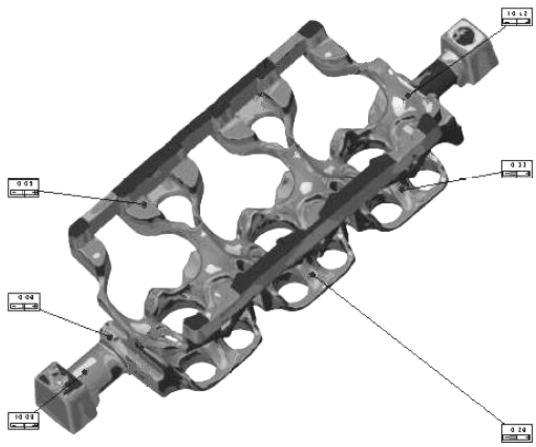


Fig. 8. Measurement result of core at water core of cylinder head

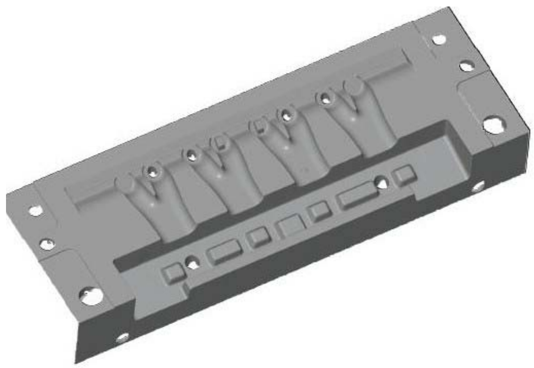


Fig. 9. Tool image after measurement with ATOS GOM

Application of ATOS GOM system for foundry tasks at VW Poznań showed how useful it can be in every day's life. The most basic advantage of the system is short measurement and reporting time (already mentioned before) including different presentation options. Depending on complexity of measured part it can vary from below twenty to fifty minutes. Particularly in series production time plays a very important role, as reaction time after when improper dimensions are found can be very short. This in turn has a great influence on overall quality of manufactured elements, reduces costs of rejects giving a manufacturer a more convenient financial situation and decreasing risk of including a wrong workpiece as a good one and sending it to a customer. This philosophy is compliant with a principle of creating "small quality circles", i.e. fast and effective elimination of process distortions.

Another advantage of ATOS GOM system is a possibility of comparison of results from different time periods by matching them and fitting on one plot. This function allows comparing workpieces within groups - cores, castings or tools. In case when there are many elements of the same kind in series manufacturing, they can be easily compared to assess wear and - with acquiring more and more experience - their life time can be predicted. This is another benefit in series production enabling for better planning of tools repair and regeneration.

In January 2010 in Quality Assurance Division of foundry at VW Poznań under Mirco Wöllenstein leadership new project group started to work aiming to create a concept of core measurement automation by means of ATOS GOM system. Positive effect and output of these works will be a next level in core production inspection and will enable further stability of casting processes.

5. Conclusions

In the paper application of optical scanner in Volkswagen Poznań foundry was presented. The scope of plant activities of was shown with examples of castings and cores manufactured there. Working principle and general application of optical scanner was described. Some typical workpieces from VW foundry were discussed. Optical scanner proved to be a very useful measuring device, enabling for fast comparison of data collected from elements with CAD data. For sand cores the fact that it is not tactile is crucial application wise. Some future ideas with automation of measurement process using robot were also presented.

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