Using Contactless Scanners for Quality Inspection

Radomír Mendřický[1, a]

[1]Technical University of Liberec, Department of Manufacturing Systems and Automation, Faculty of Mechanical Engineering, Studentská 2, 461 17 Liberec 1, Czech Republic

Abstract. The article presents the research of use of modern 3D measurement contactless methods for quality inspection in automotive industry production. The experience with measuring functional assemblies and parts of complex shapes as well as advantages of optical measurement methods are shown on practical research example, whose aim was to find effective procedures and methods of obtaining 3-dimensional high-definition models of measured components. The obtained models were then subjected to inspection of their dimensional and shape accuracy, which was performed by means of comparison with the nominal CAD model, as well as to analyses of the assembly functionality by searching or collision situations of the movable parts of this mechanism.

1 Introduction

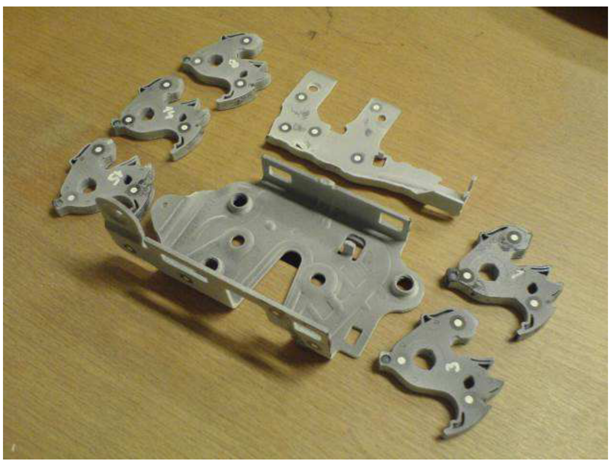
Inspection of the components is currently being performed. Such inspection consists of measuring dimensional and shape accuracy, mostly by means of conventional measurement methods – for example by contact method using coordinate-measuring machine [1]. Although such measurement is very accurate, it offers only constrained amount of discrete information, usually limited to measurement and comparison of prescribed dimensions and tolerances of shape and position according to the drawing. Therefore, an assembly difficulties or collision situations of more complex assemblies and mechanisms may occur despite the fact that a part was inspected by means of the aforementioned method and is usually compliant with the prescribed dimensions.

2 Objective of the Research

The subject matter of our research was to verify and practically apply modern methods of product quality inspection by means of 3D optical and contactless digitisation. The contactless measurement methods are, as the latest research shows, becoming increasingly sophisticated and despite its lower accuracy, these methods provides more objective results than contact measurement methods in most cases. For example: Brajlih (et al.) [2] inspected the possibilities of using ATOS II 3 scanner for complex machined part geometry inspection and concluded that the coordinate-measuring machine is not suitable for parts of certain shapes. He also showed the reachable accuracy of optical scanning method by performing scanning test of gauge blocks and more well-defined geometric shapes.

In our research, we focused on selected parts of car lock with occurrence of problems with noisiness and collision situations of certain movable parts (ratchet wheels) inside the lock. All that despite the fact that the conventional measurement methods of coordinate-measuring machines did not show any specific problems and all key dimensions were within the required tolerance values. Our goal was to perform optical digitisation of these problematic parts and obtain a high-definition point cloud – an STL format model – that will help to perform an allover inspection of the obtained model when fitting on the nominal model.

Figure 1. Car lock parts

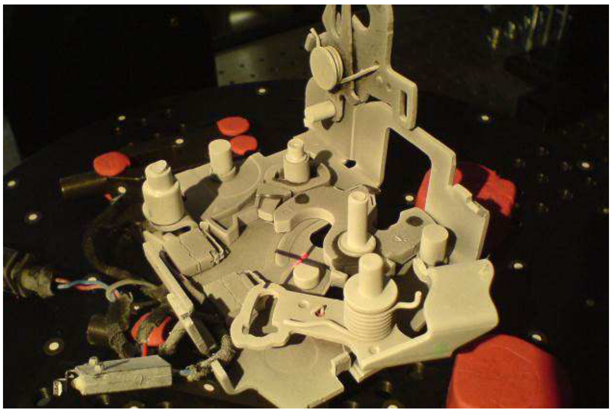


[a] Corresponding author: radomir.mendricky@tul.cz

For the purpose of reaching this goal, the digitisation method by means of a contactless optical 3D scanner was initially used on individual selected parts such as lock sheet-metal bracket, lock rear sheet, ratchet wheels of various sizes, etc. (see Figure 1). Later, the method was applied to more parts such as lock plastic body or individual pins.

In the next phase, the whole lock assembly was digitised with the optical 3D scanner, while the 3D scanning was performed for various position of the ratchet wheels (open state, locked in first position, locked in second position) – (see Figure 2).

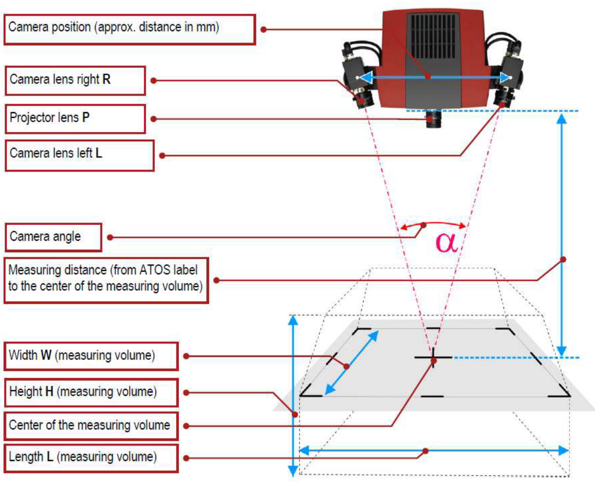
Figure 2. Assembly of the car lock



3 Methods and equipment used:

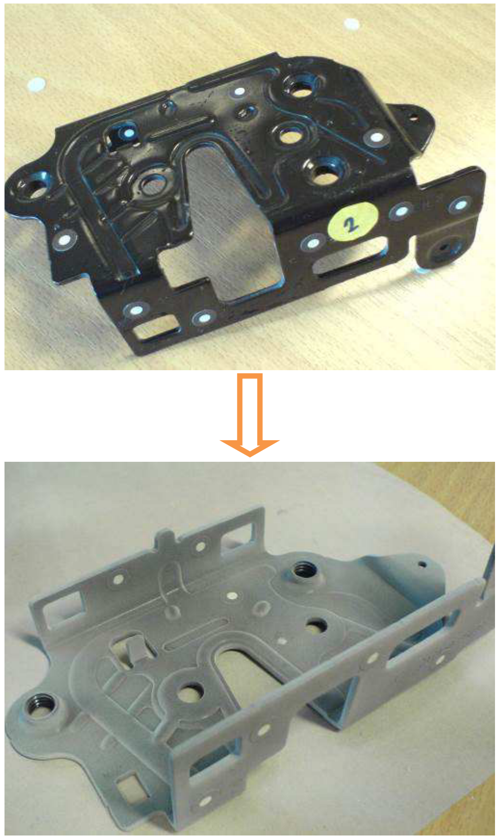
We chose to digitise the parts with optical contactless 3D scanner manufactured by GOM – Atos II 400 (see Figure 3) fitted with lens with measurement volume of 250 x 200 x 200 mm. Before the measurement was initiated, the system was calibrated by means of standardised calibration etalon – „Calibration Panel“ (etalon approved by Decom Prüflabor laboratory).

Figure 3. ATOS optical scanner and the definition of the measurement volume [3]



It was necessary to properly locate so called reference points on the measured part prior to initiation of the 3D scanning process. Those are contrast points and their size is given by the measurement lens used. For the measurement volume of 250 mm, points of nominal diameter of 3 mm were used (see Figure 4 – top). The points are used not only for automatic connection of partial scans to make a whole, but also due to necessity to perform the digitisation from both sides, which requires rotating the part in the process. In order to improve optical surface properties of the model, an anti-reflective chalk coating was applied on the part (see Fig. 4 – bottom). The coating is usually necessary to apply in case of products with poor optical properties in order to prevent undesirable reflections. The problematic materials are often transparent, glossy (machined metal) or even black.

Figure 4. Positioning of the reference points (top), application of anti-reflection coating (bottom)



Both the assembly and individual sub-parts were attached to a GOM rotary table during the scanning process for the purpose of easier manipulation and approximately 30 to 50 scans were performed depending on the surface contours and part complexity (see Fig. 5). These created series of measurements were then connected by means of the reference points and formed a whole, which was used to calculate an optimised polygonal high-resolution polygon mesh (see Fig. 6).

 DOI: 10.1051/matecconf/20178901011

Figure 5. Scanner camera images forming 3D view

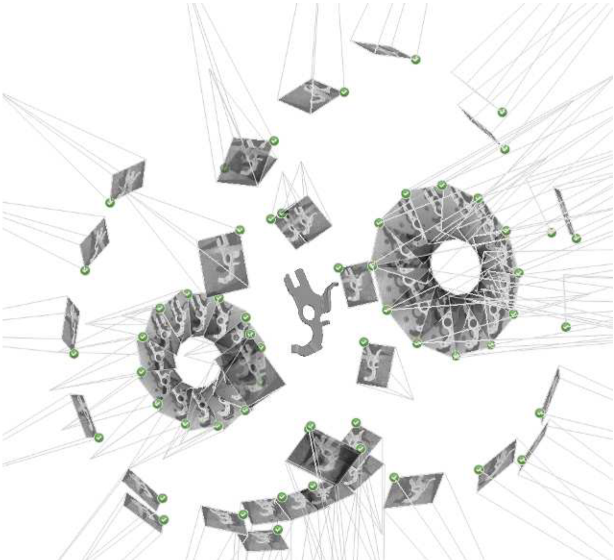
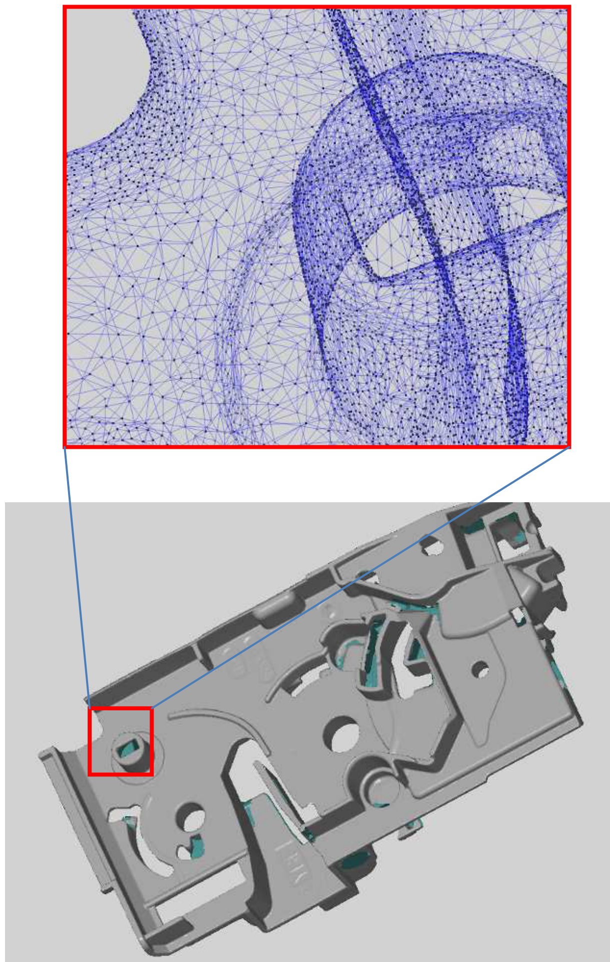


Figure 6. Detail of the polygon mesh



3 Research Results

Models created by means of 3D optical digitisation (see examples in Fig. 7 – scanned assembly model and Fig. 8 – digitised parts after disassembly) may be considered as actual models, while their dimensions and shape correspond to the real parts with accuracy (determined by the scanner manufacturer) – given by the measurement volume – ca. 0.03 mm, which is sufficient accuracy for this type of application.

Figure 7. STL model of the scanned assembly – ratchet wheels in closed position

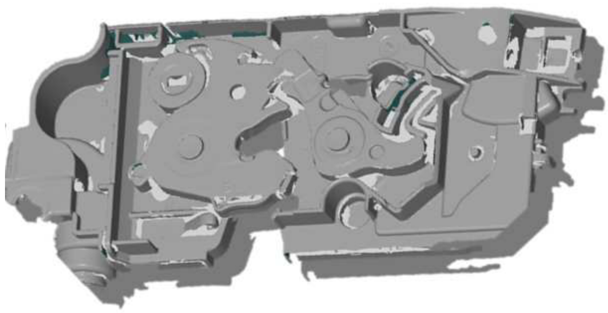
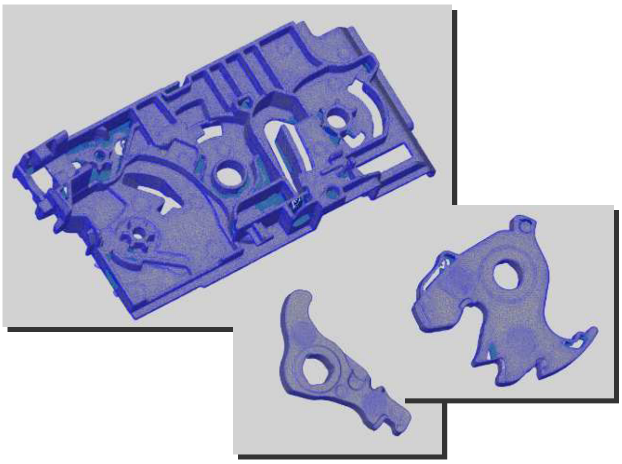
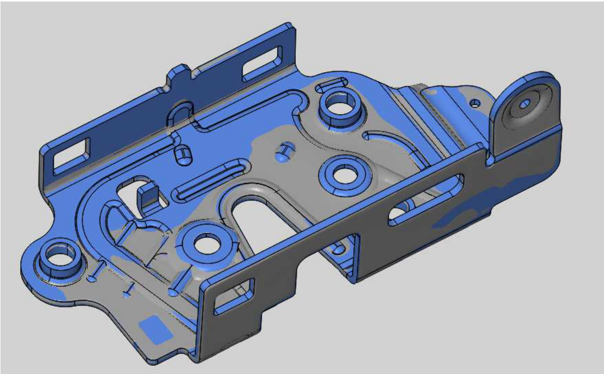


Figure 8. Digitised disassembled parts



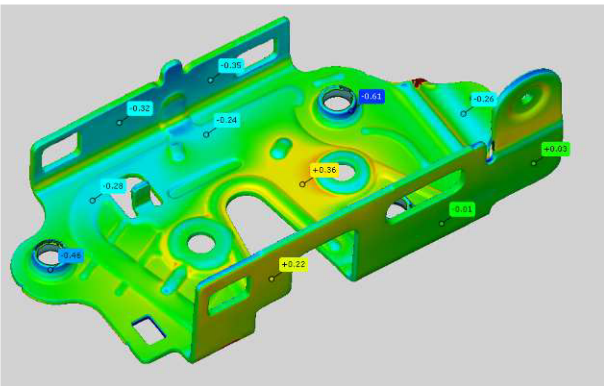
Real products – models in digitised form were subjected to dimensional and shape analysis and helped to find problematic spots in terms of the assembly. The following Figure 9 shows example of fitting an actual model to a nominal model by means of the BestFit method. When using this method, the actual model is transformed in Cartesian coordinate system in respect to the nominal model in a manner, where the total of squared deviations of all measured points on parts (so called point cloud) is as low as possible. This fitting method was used as a primary one for calculation of deviation of the real part (measured) from the nominal one (CAD).

Figure 9. The real model (grey) fitted to the shape of the nominal model (blue) using the BestFit method



The size of normal deviations was represented for all the inspected parts and the whole assembly by so called colour deviation map. Example of colour deviation map for rear sheet is shown in the following Fig. 10. The colours in the picture demonstrate the deformation of the part, where there is too much material (warm shades – e.g. red) or vice versa, where the measured part is negatively deformed in respect of the CAD model (cold shades – e.g. blue). In addition to the allover colour map, inspection cuts may also be created. These cuts are usually created in the most problematic parts. Both, the colour maps and cuts, may be generated for various fitting to the CAD model; except the so called Overall BestFit to shape, it is usually more appropriate to use local fitting of sub-parts (so called Local BestFit) or RPS fitting (Reference Point System), often used in automotive industry.

Figure 10. Normal deviations colour map of the measured part from the CAD model (fitted by means of BestFit method)



4 Summary

For the purpose of car lock quality inspection, a contactless optical method of scanning 3D objects by means of ATOS II 400 optical scanner was designed and successfully used. The models of real parts obtained with this digitisation method were reaching a density of appx. 3,000 points per 1 cm^2, thus allowing performance of analyses with high precision and detail. Creating complex high-definition models of parts contributed to seeking new possibilities of production quality control not only for individual parts, but for functional assemblies as well. Digitised parts transformed to STL format were used for quality inspection when comparing to the CAD nominal template, functionality of the whole assembly, as well as for searching for collision situation of the movable parts of mechanism. The research contributed to solving problems with noisiness of the lock and to improving functional quality of these products. The test also proved that high-tech optical scanning systems may be reliably used even for complex geometry inspection of complex parts and assemblies. Referring to the current and anticipated future development of optical 3D scanning and to the increasing accuracy of these devices, these systems will apparently expand to other fields of inspection as an alternative to conventional measurement methods, thus contributing to increase of productivity and production quality, as well as to increase of product innovation and development speed.

Acknowledgement

The research reported in this paper was supported by targeted support for specific university research within the student grant competition TUL (Project 21010 - Complex optimization of manufacturing systems and processes 2).

References

1. S. T. Chang, W. C. Lin, T. M. Huang, M. Y. Hsu, P. H. Huang, Measurement of Radius of Curvature by Coordinate Measurement Machine, Applied Mechanics and Materials, Vols 284-287, pp. 488-492, (2013)
2. T. Brajlih, et al. Possibilities of Using Three-Dimensional Optical Scanning in Complex Geometrical Inspection. Strojniśki vestnik - Journal of Mechanical Engineering [online]. (2011), roč. 57, č. 11, s. 826-833 [cit. 01/04/2015]. ISSN 00392480. Information on: http://en.sv-jme.eu/data/upload/2011/11/05_2010_152_Brajlih_05.pdf
3. GOM MBH. ATOS Compact Scan: User manual - Hardware. Braunschweig, Germany, (2012)
4. R. Mendřický, Use of Optical Methods for Dimensional Analysis of Multi-Part Moulds. In. Applied Mechanics and Materials, Vol. 474, Trans Tech Publications, Switzerland, (2014), pp 387-392, ISSN 1660-9336
5. S. Zhang, Handbook of 3D Machine Vision: Optical Metrology and Imaging (Series in Optics and Optoelectronics), Publisher: CRC Press, (2013), ISBN: 978-1439872192