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Abstract. The 3D digital measurement is commonly used nowadays when parts are with complex geometry, and fast development is required. This comes also from constant technological improvements of devices like 3D scanners. However, the use of them for particular applications needs research that shows the wide range of usability. The purpose of this study has to do with better understanding of the measurement of dimensions, displacements, and deformations of the parts using non-contact techniques, which are elaborated with the case studies for each investigation. Base on the presented research, we see the approach of using the 3D scanning technique for several applications. From a general point of view, we conclude that the use of 3D digital measurement is a useful and flexible methodology for different parts, shown by the presented work. Future research should deal with improvements that are required in terms of the integrated measurement approach.

Keywords: 3D digital measurement, Dimensions, Displacements, Deformations, 3D scanner.

1 Introduction

In recent years, there is a constant need for advanced interaction between physical reality and digital data. This comes mostly from the new need for rethinking of design and new product development in general [1]. New design and manufacturing technologies [2] move the frontiers toward new open ways about the measurement techniques. In this context, several technologies are relevant for this interaction, including reverse engineering [3], additive manufacturing [4], CNC machining, etc. Generally, the inspection process and quality control were a constant requirement from several aspects of industrial part applications. There are several issues that are required, specifically in dimensional inspection, displacement and deformation. In previous, the contact measuring techniques were very obvious for use in different applications. On the other side, non-contact measuring techniques are very common

nowadays [5, 6]. They are flexible both in integration with other systems and also in capturing data from complex geometries.

Due to actual measurement technologies, there is a need to bring this research in a broad context with the importance of more clarifying the relationship and possibilities of 3D digital measurement in different aspects. The purpose of the work has to do with better understanding of new optical techniques for the measurement of dimensions, displacements, and deformations of the parts. The significance of the research stands in presenting the actual work and showing the gap for the integration approach.

The paper will review research works on the subject in Section 2, while in Section 3 the case studies from dimensions, displacements, and deformations of the parts will be presented. Finally, the conclusions will derive the actual situation and further work.

2 Literature Review

Given the aspects of using advanced measuring technologies in different industrial sectors, it is worthy to search from scientific work contributions. There are several important factors which need to be addressed, including scanning factors, the reflection of material and coating, the scanning strategy and reflection, and the shape of the parts.

Gerbino, Del Giudice et al. [7] have investigated some important factors that influence the measured data from the 3D scanner. They can be divided into external and internal. From external can be included, ambient lightening and sensor to surface relative position. From internal, accuracy, and scanner resolution. Those factors were tested in the sheet metal complex part. The accuracy of the process is depended more on the scanner-to part relative orientation, and position of the device.

Mendřický [8] has shown the coating aspects in relation to quality and accuracy of 3D measured parts with different coating thicknesses and has elaborated seven matt coating products, which are used daily for practice. From collected results, the way how to use coating in products, as well as the removal of it, are presented.

Pereira, de Lima e Silva Penz et al. [9] have presented the research that deals with the reflection of the surface of translucent parts during optical scanning. They proposed to use gold, silver, platinum, and carbon for coating and compare them with traditional ones to evaluate the results. From the collected data, the proposed coatings offer higher accuracy and are suggested for 3D scanning.

Koteras, Wieczorowski et al. [10] have treated the impact of optical measurement strategy and its relation with accuracy, especially in big parts. The idea was to test the structure light device to measure the part with dimensions out of the capacity limits. Here several measurement strategies were investigated, while the strengths and weaknesses are concluded.

Cuesta, Alvarez et al. [11] explained the work which deals with both laser scanners and coordinate measuring arms for dimension and tolerance inspection. Related to this, a comparison was made between them. The study shows that is needed to use the right scanning strategy that can cover any surface, and on another side, the use of

statistical analysis with several measurements to complete the feature-based gauge.

Guidi, Malik et al. [12] have used the 3D scanning technology to measure the part with relatively big dimensions and specific geometry, which proves the flexibility of using this technique.

Eastwood, Zhang et al. [13] presented the possibilities for fully automated measuring and inspection of parts using a photogrammetric process. This also comes from the ability to be accessible in parts with complex forms produced by additive manufacturing.

Guerra, De Chiffre et al. [14] have shown the procedure of testing the different 3D scanners technologies including structured light, laser line, and photogrammetry scanner, which are common techniques for inspection in different applications, including additive manufacturing.

Sedlak, Hrusecka et al. [15] have presented the use of reverse engineering technology as the tool to inspect the specific feature of the part and make the data comparison and analysis.

3 Application using Case Studies

In this section, we are focused to explain the applications of 3D digital measurement technology in different aspects including dimensions (section 3.1), displacements (section 3.2), and deformations (section 3.3) of the parts. Today, there are different fields where this technique is applied, especially in parts produced by additive manufacturing [16-18]. Moreover, it is a good way of moving forward in terms of integration using a digital chain between advanced manufacturing technologies and 3D optical devices. The presented case studies are detailed elaborated in [19].

3.1 Dimensions

The most common application of 3D digital measuring techniques among others is related to dimensional check. There are certain aspects why they are used in different cases, especially in part with free forms and complex features. A particular part inspected in geometrical tolerances is presented in Figure 1.

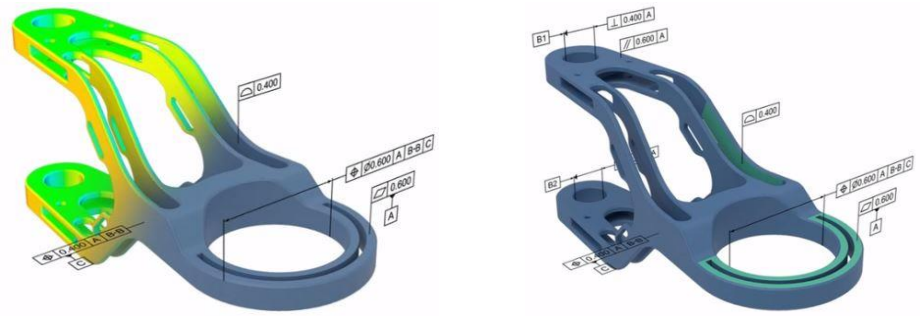

Fig. 1. Inspected part for geometrical tolerances check [19].

3.2 Displacements

In some cases, there are some special requirements related to dynamic measurements of 3D vibration displacement at individual points. This can be shown by the application of 3D digital measurement in the door of the car (Figure 2).

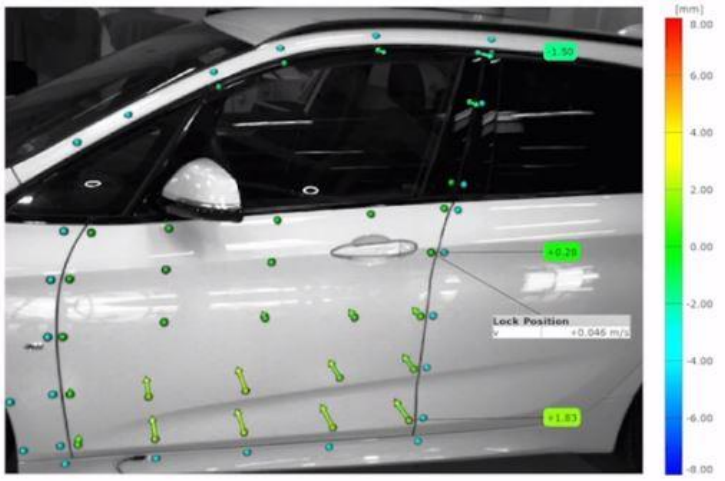

Fig. 2. 3D measuring the door of the car [19].

3.3 Deformations

Another aspect that is very important in terms of measurement is the deformation of the parts. This sends us on different mechanical testing and experiments on deformation. The 3D analysis of deformation of the part (Figure 3) and testing a 3D printed suitcase handle button (Figure 4) are presented below.

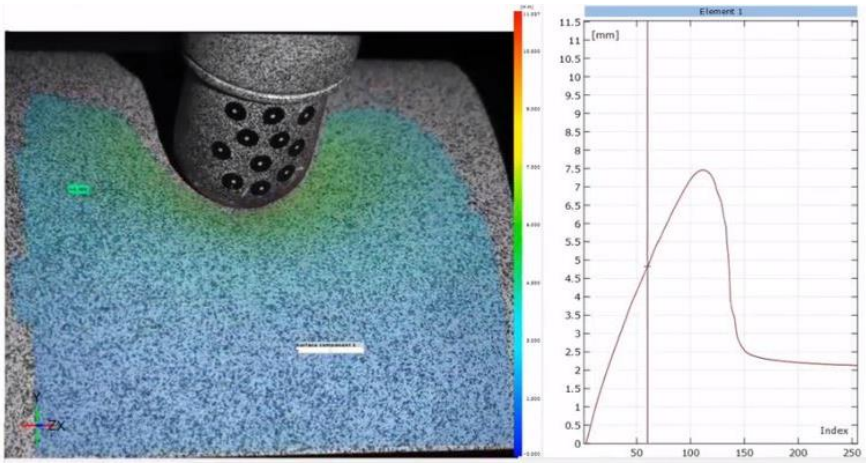

Fig. 3. 3D analysis of deformation of the part [19].

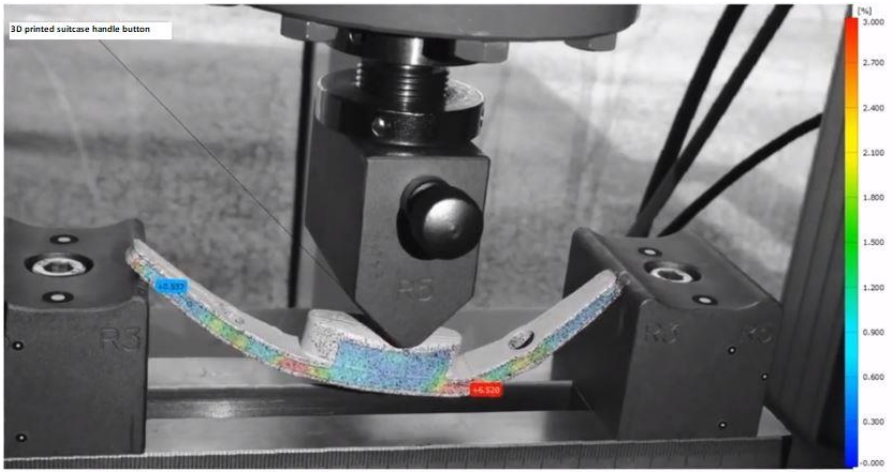

Fig. 4. Testing a 3D printed suitcase handle button [19].

4 Conclusions

In this paper, we tried to show some aspects of new technologies in 3D digital measurement. The literature review was presented in terms of scientific investigation of several important factors that are needed to be known when we use the 3D scanning technique. The practical applications using case studies were presented to show the real application [19]. Based on the presented research we can conclude:

- There is a constant increase of using non-contact optical methodologies for inspection of different parts.
- The importance of several factors during 3D digital measurement are crucial for achieving the accuracy on entire process.
- From case studies we can notice that there is high range of flexibility in 3D scanner devices to deal with different complex shapes of the parts. This was shown during measuring on dimensions, displacements, and deformations of the parts.

From a general point of view, we conclude that the use of 3D digital measurement technology is a useful methodology in different applications.

Further work should deal with improvements that are required in terms of the integrated measurement approach, including advanced manufacturing processes.

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