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A comparative study between photogrammetry and laser technology applied on model turbine blades

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Abstract. The objective of the paper is to apply the reverse engineering in the mechanical field to reconstruct the geometry of two types of model turbine blade: axial blade and Pelton bucket. To generate the point clouds, the geometry of the blades was scanned by laser and digital photogrammetry. The Creaform HandySCAN 700 laser scanner and VXelements software were used to get the point cloud of the blades. For digital photogrammetry the NIKON D610 photo device and Agisoft Photoscan software were used to get the point cloud of the blades. Finally, the point clouds generated were compared in GOM Inspect software to highlight the deviations between them.

1. Introduction

The digital photogrammetry technology is widely used in some particular fields: archaeology, cultural heritage, forensics, biology, full head and body scanning, topography and mapping, arts, geology, ecology [1]. The mechanical domain is not so often approached by photogrammetry technology. Maybe the doubt about the accuracy is one of the possible reasons of this absence. However, we can exemplify some papers which deals with 3D reconstruction of a Francis runner [2], failure analysis and geometry reconstruction of Kaplan runner and blade [3-6], axial blade [7] and Pelton bucket [8]. In [9] Koppel try to answer the question if Agisoft Photoscan software can"*be used for precise reverse engineering issues, like as-built documentations in close range field. Is photogrammetry using PhotoScan an alternative to terrestrial laser scanners* ?" The final conclusion was that "*Compared to a terrestrial laser-scanner (taking the costs of Hard-and Software into account), it is possible to reach similar accuracy results with Agisoft PhotoScan*". In [10] Garcia and others authors utilize the reverse engineering technology to reconstruct the geometry of a small Francis turbine using Laser technology. In [11] Chen-Hua She and Chun-Chi Chang utilize the same reverse engineering technology, but data points of the prototype were measured on a coordinate machine. In [12] Mohaghegh and others authors utilize the reverse engineering technology to reconstruct a turbine blade by digitizing the geometry using an ATOS laser scanner and then the data for each section were extracted using TRITOP software. Then, in [13] the authors use a fitting algorithm to improve and correct the blade geometry. In [14] Zhang and others authors utilize the reverse engineering technology to reconstruct a turbine blade by digitizing using coordinate measuring machine.

The present paper investigates the accuracy achieved through Laser and digital photogrammetry technology on two types of model turbine blade and compares the results at the points cloud level.

2. The Photogrammetry and Laser technology applied on model axial blade

The model of the studied axial blade is presented in Figure 1. The dense cloud with 1,780,197 points of the blade, shown in Figure 2, was obtained with Agisoft Photoscan software through digital photogrammetry [5]. The same axial blade was scanned using laser technology with the Creaform HandySCAN 700 scanner.

Initially, the suction side was scanned (Figure 3), followed by the pressure side (Figure 4). Through the VXelements software, the alignment of the point clouds of the suction and pressure side was made using 3 corresponding points (Figure 5). The whole blade is shown in (Figure 6), the point cloud having 176,820 points. From the VXelements software, the blade was saved as a "stl" file.

Figure 1. The model of the axial blade

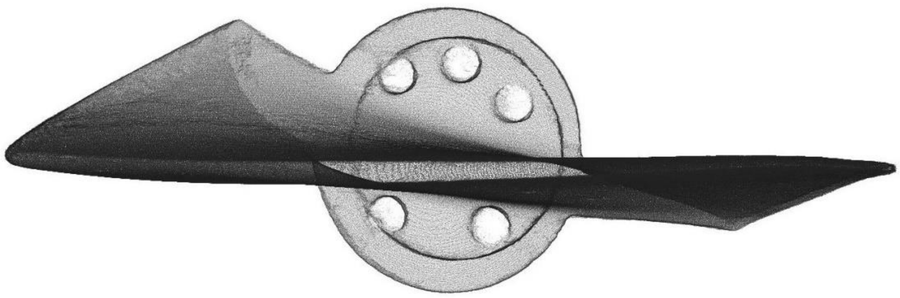

Figure 2. The dense cloud of the axial blade

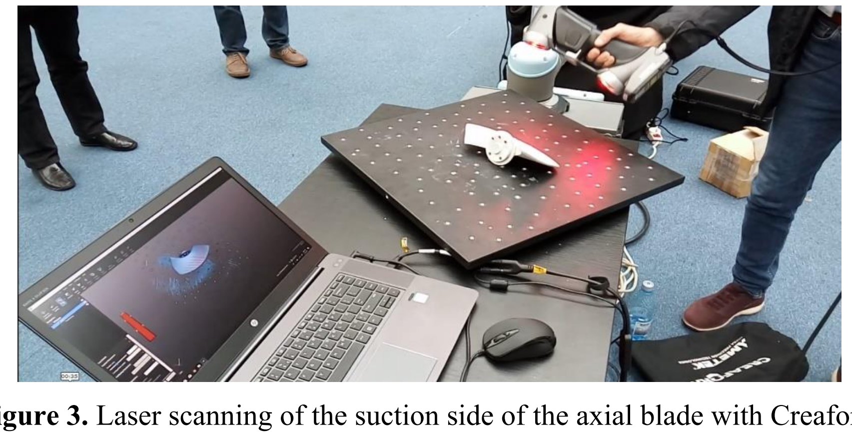

Figure 3. Laser scanning of the suction side of the axial blade with Creaform HandySCAN 700 scanner

Figure 4. Laser scanning of the pressure side of the axial blade with Creaform HandySCAN 700 scanner

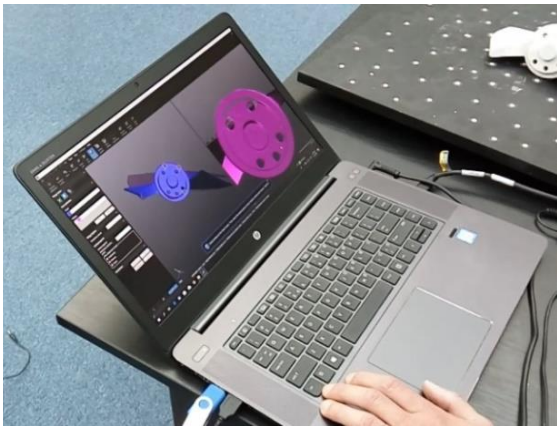

Figure 5. The suction and pressure side alignment of the axial blade in VXelements software

Figure 6. The axial blade reconstructed in VXelements software

Figure 7 shows the point clouds alignment of the blades generated through digital photogrammetry in Agisoft Photoscan software and through laser scanning and VXelements software. The two blades have been aligned based on automatic best-fit alignment of the GOM Inspect software so that their geometry overlaps with minimum deviations. This alignment shows deviations between -0.26 ÷ +0.03 mm, (Figure 8), (Figure 9).

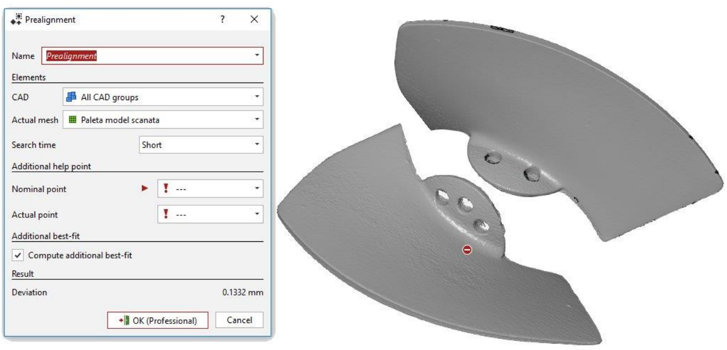

Figure 7. The alignment of the two blades in GOM Inspect software

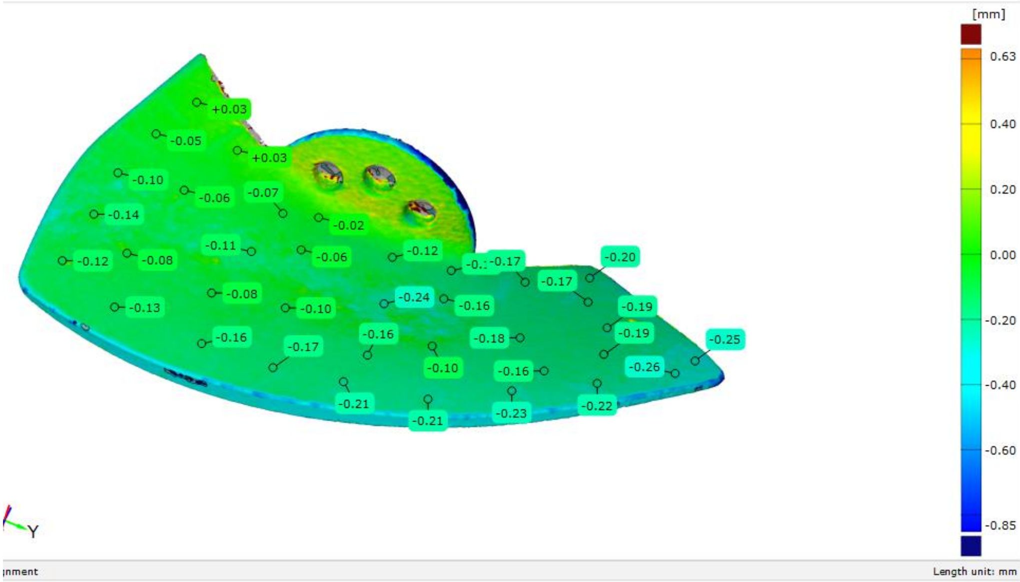

Figure 8. The deviations of the suction side of the blades

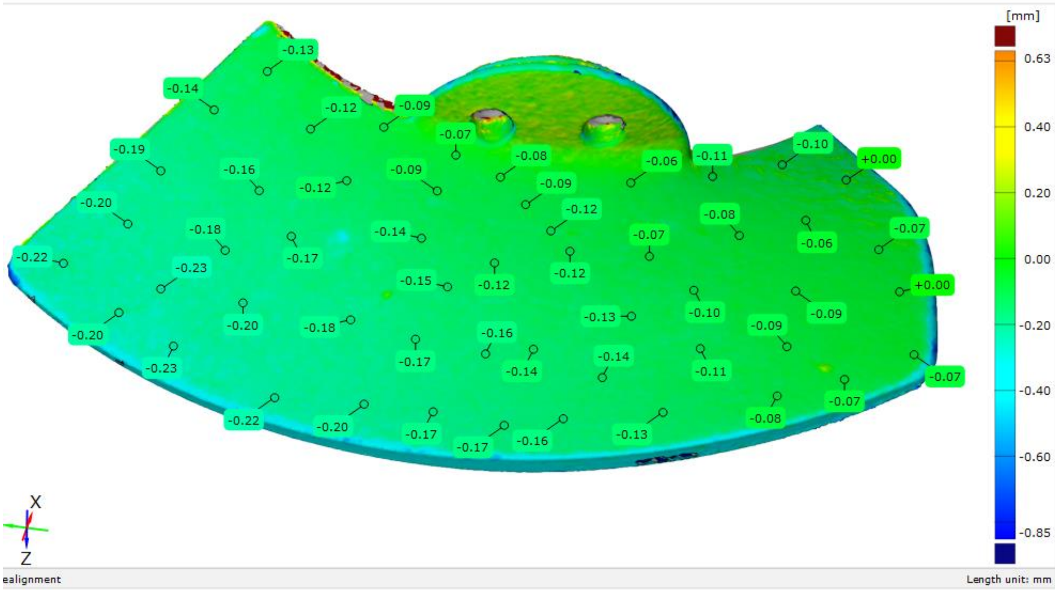

Figure 9. The deviations of the pressure side of the blades

3. The Photogrammetry and Laser technology applied on model Pelton bucket

The model Pelton bucket is presented in Figure 10. The dense cloud with 1,170,227 points of the bucket from (Figure 11) was obtained with Agisoft Photoscan software through digital photogrammetry [6]. The same Pelton bucket was scanned using laser technology with the Creaform HandySCAN 700 scanner.

Initially, the upper side was scanned (Figure 12), followed by the lower side (Figure 13). Through the VXelements software, the alignment of the point clouds of the upper and lower side was made using 3 corresponding points (Figure 14). The whole blade is shown in Figure 15, the point cloud having 277.248 points. From the VXelements software, the Pelton bucket was saved as a "stl" file.

Figure 10. The model of the Pelton bucket

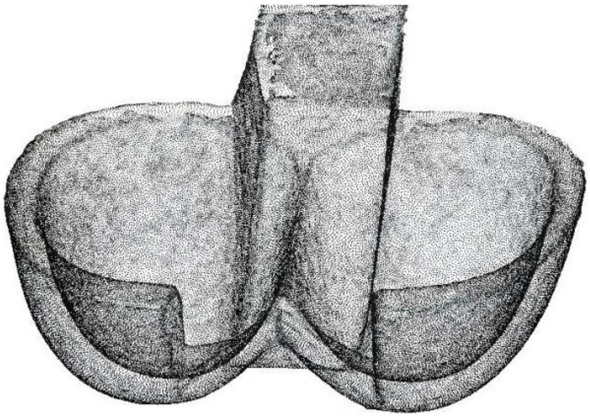

Figure 11. The dense cloud of the Pelton bucket

Figure 12. Laser scanning of the upper side of the Pelton bucket with Creaform HandySCAN 700 scanner

Figure 13. Laser scanning of the lower side of the Pelton bucket with Creaform HandySCAN 700 scanner

Figure 14. The upper and lower side alignment of the Pelton bucket in VXelements software

Figure 15. The Pelton bucket reconstructed in VXelements software

Figure 16 shows the point clouds alignment of the buckets generated through digital photogrammetry in Agisoft Photoscan software and through laser scanning and VXelements software.

The two buckets have been aligned based on automatic best-fit alignment of the GOM Inspect software so that their geometry overlaps with minimum deviations. This alignment shows deviations between -0.37 and +0.17 mm, as shown in (Figure 17) and (Figure 18).

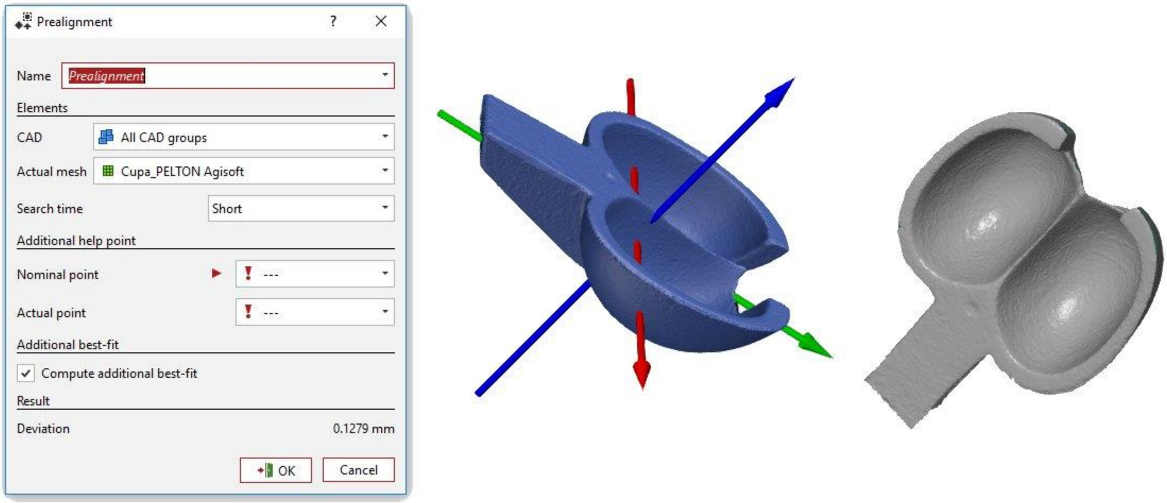

Figure 16. The alignment of the two Pelton bucket in GOM Inspect software

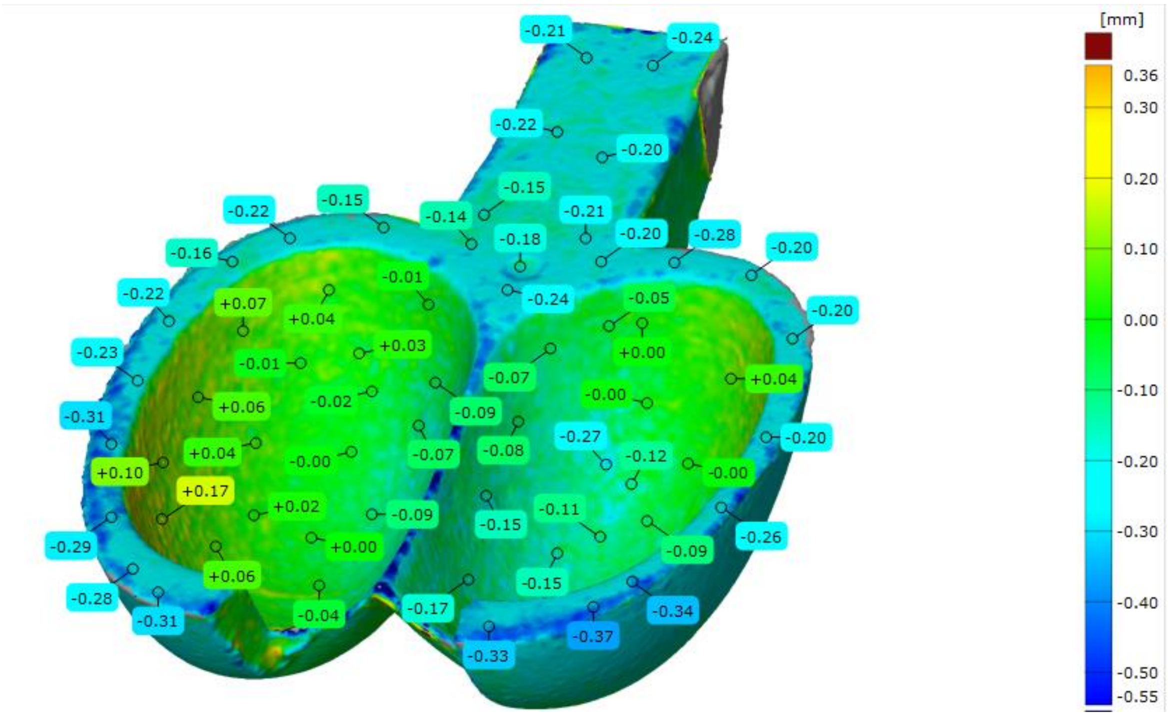

Figure 17. The deviations of the suction side of the buckets

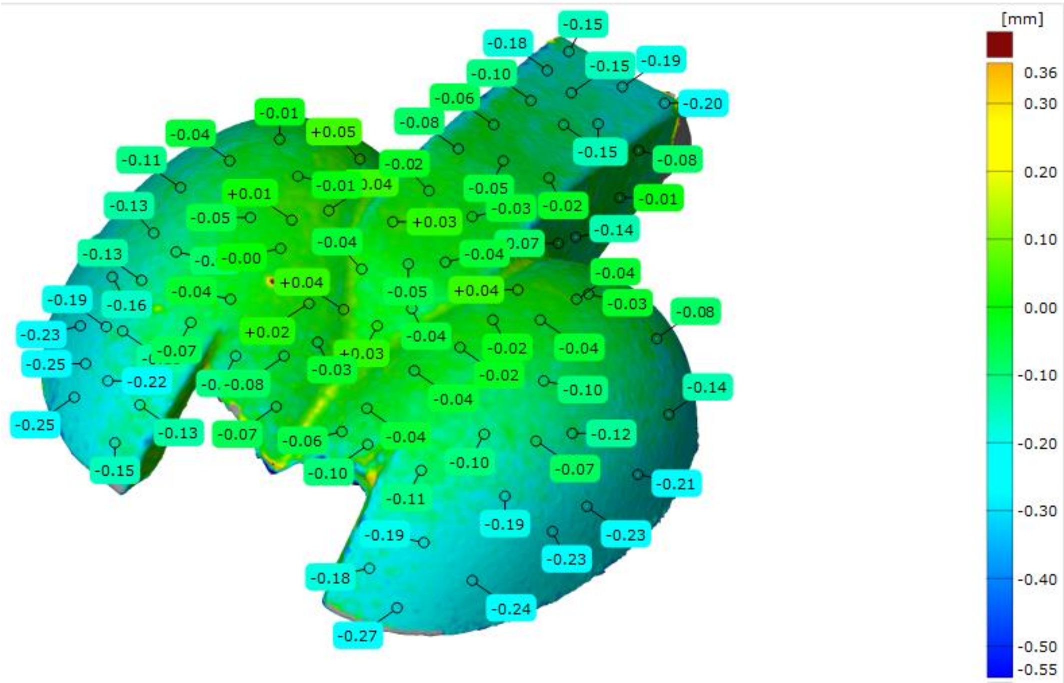

Figure 18. The deviations of the pressure side of the buckets

4. Conclusions

The axial blade and the Pelton bucket were scanned by photogrammetry using NIKON D610 camera and laser technology using the Creaform HandySCAN 700 scanner. The point clouds were generated through Agisoft Photoscan and VXelements software. From the comparison of the axial blades point clouds, deviations fall in the range -0.26 ÷ +0.03 mm, (Fig.8), (Fig. 9).. From the comparison of the buckets point clouds, deviations fall in the range -0.37 ÷ + 0.17 mm, (Figure 17) and (Figure 18).

The main advantage of the photogrammetry technique is the low price of the camera and the Agisoft Photoscan software comparing to a laser scanner and VXelements software. This paper shows the deviations between two technologies applied on two types of model turbine blades, but the real comparison must be made with the geometry of the blades taken from the drawings in order to have a common element for comparison. Each technology includes its own errors on scanning process and later on computer processing. Also, the settings of the applications packages used for reconstruction can have a great influence on accuracy. Using high values of these parameters can improve the point clouds quality and reduce the domain of deviations. However, in the absence of drawings, the deviations provide a numerical indication of their values and can provide a basis for choosing one of these technologies in correlation with their price and accuracy.

Acknowledgments

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