Research Article

Development of Dimensional Measurement Methods with a 3D Measuring Device without Using a Checking Fixture

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(First received October 26, 2022 and in final form December 18, 2022)

Reference: Özgüven, C. I. Development of Dimensional Measurement Methods with a 3D Measuring Device without Using a Checking Fixture. The European Journal of Research and Development,2(4), 24–32.

Abstract

Present time's cutting edge sheet metal forming capabilities have created opportunity to the manufacturing of automobile parts that have complex geometries. An equipment that defined as a fixture is needed in order to obtain quality status of parts which had high deformation strain before welding joint process. Fixtures are time and budget consuming equipment. Automobile sheet metal parts can be measured by 3D measurement devices. In this study, dimensional quality of parts is assessed and compared either fixture or fixtureless by methods of virtual fixing and metrology.

Keywords: *Metrology, Checking Fixture, Virtual Fixing*

1. Introduction

Today's automotive industry, companies produce extraordinary designed cars in order to reach out wide range customer profiles Weckenmann, et al, 2015). Despite the high developments on forming of sheet metal technology, components are produced under high strain stress and forces which lead the components to become different from desired shape and quality (Weckenmann & Weickmann, 2006). Therefore, a checking fixture is needed to establish a reliable fixation in order to understand their quality status. Checking fixtures are evolved from three main stages which are very time consuming and laboring such as design, manufacturing and verification (Camelio, et al.,2004). In case of any delay or mistake of manufacturing of checking fixtures may lead a delay which is a not desired, on a feedback for produced components.

On the other hand, optical measuring devices can be used as auxiliary elements at this point (Weckenmann, et al, 2005). These systems allow users to determine the quality status in short time by comparing the CAD model with the data that is created from the produced parts via laser censors (Weckenmann & Weickmann, 2006). Already produced sheet metal parts are inspected in checking fixtures by 3D measuring machines. However, in order to be a source for future projects and contribute the literature, in this study it is aimed to create the most accurate quality color maps of the parts via virtual fixturing tools without a control fixture with an optical measuring device (Jaramillo, et al.,2011). In addition, its studied that virtual fixation may reduce the costs.

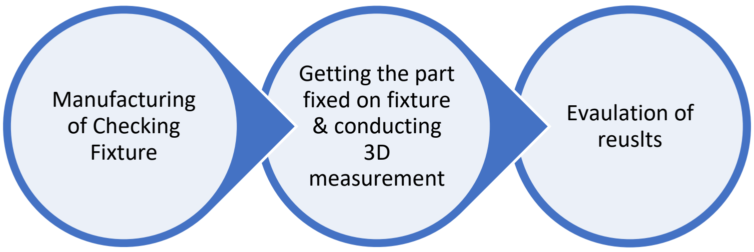


Figure 1a: 3D Measurement with a fixture

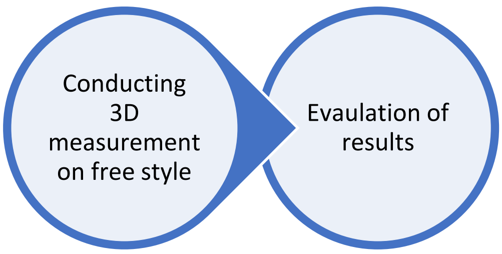


Figure 1b: 3D Measurement without a fixture

2. Materials and Methods

The part which has reference number 57***-F40** (Fig. 2) which is floor reinforcement part has been chosen as candidate specimen. Its considered that the thickness is 1.6mm of main part is enough to obtain reliable 3D measurement and fixation without having a deflection.

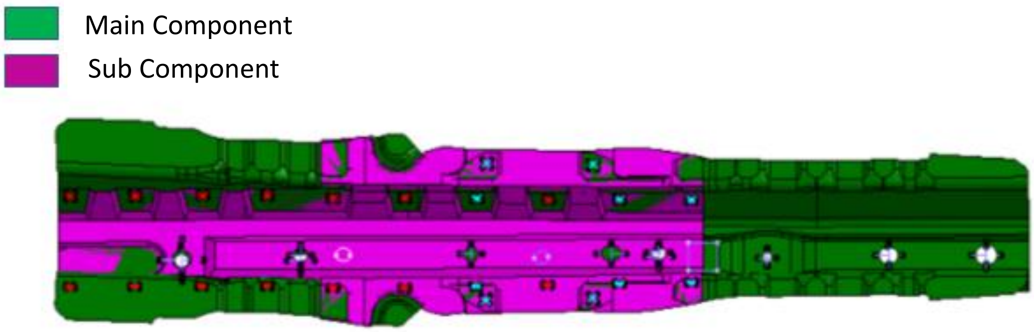


Figure 2: CAD View of Specimen

Initially the cloud data has been created via laser measurement device on the free flat surface. In order to define objects on cloud data mesh work has been conducted (Fig. 3) then model data created (Fig. 4). Because of the freestyle scanning, model data's position is different from original CAD data's position therefore both data were matched by coarse alignment (Fig. 5).

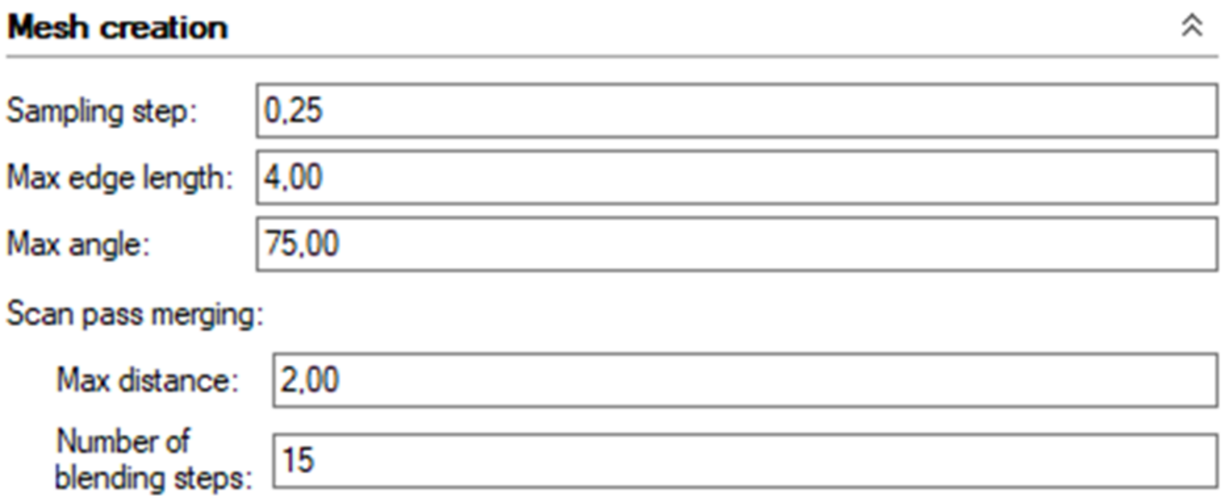


Figure 3: Mesh Parameters

Figure 4: Positions of CAD & model before coarse alignment in 3D space

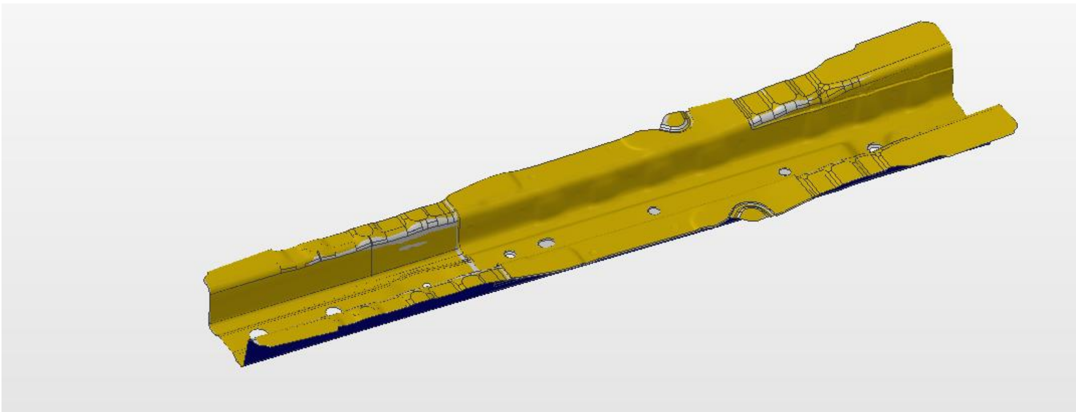


Figure 5: The view of two data after coarse alignment

In this method, quality of the sheet metal part is evaluated by conducting 3D virtual fixation as it is on checking fixture. In project and mass production phases in the sector, pins, locators and clamps are used to lock 6 degrees of freedom of part in order to make reliable measurement. Degrees of freedom is related to object's move or turn motion in coordinate system (Fig. 6). This conditioning logic has been used in this virtual fixation study.

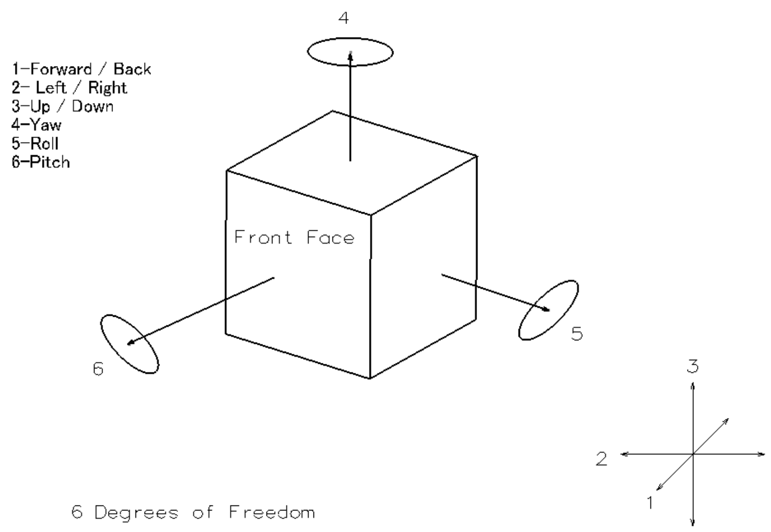


Figure 6: Degrees of Freedom

Datum information has been applied from technical drawing (Figure 7). First of all, Datum I pin is plugged in to lock motion on XY plane. Then datum II pin is plugged in to prevent rotation on Y axis. Lastly, Z axis which is vertical to the XY plane is locked from four surface locations. In figure 8 and 9 datum locations are shown in detail of A and B.

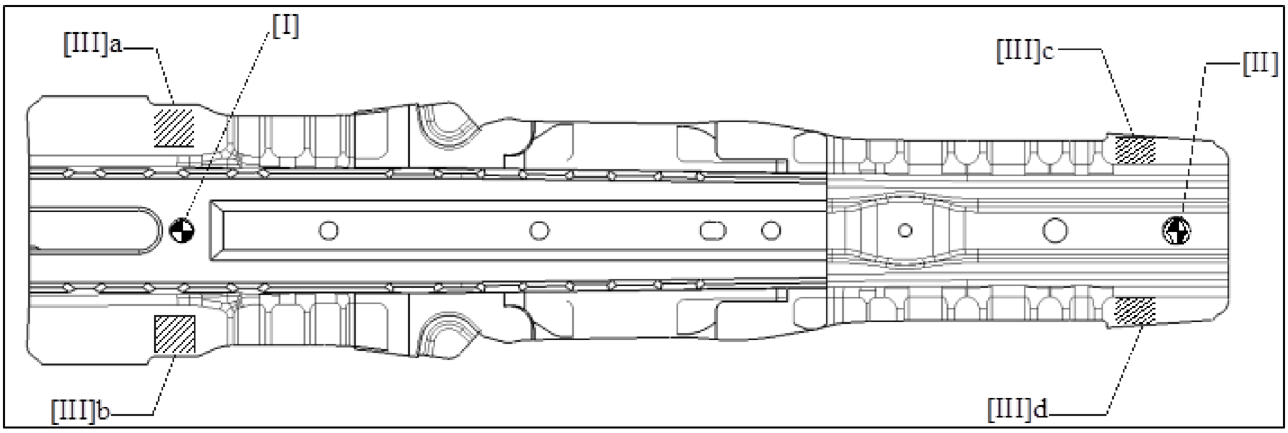


Figure 7: Datum Locations of Specimen in Technical Drawing

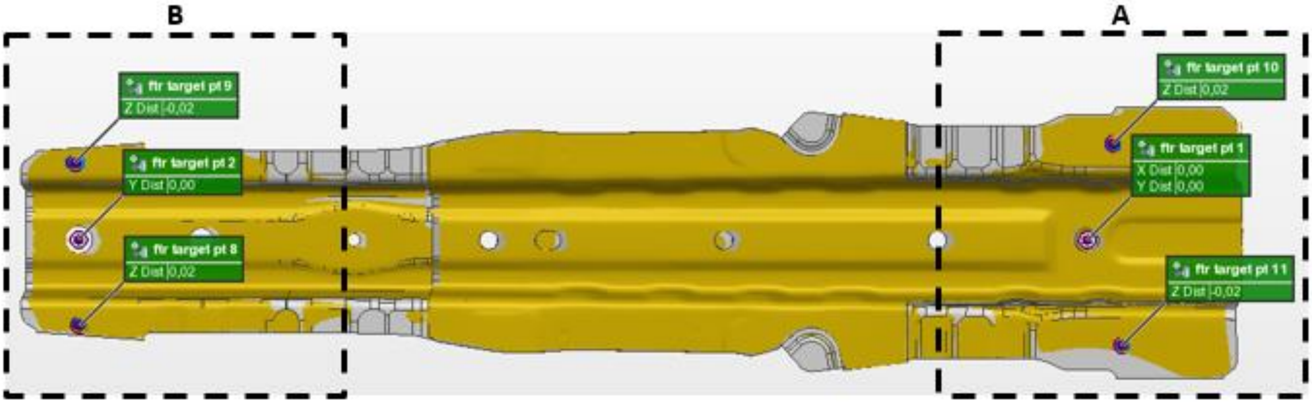
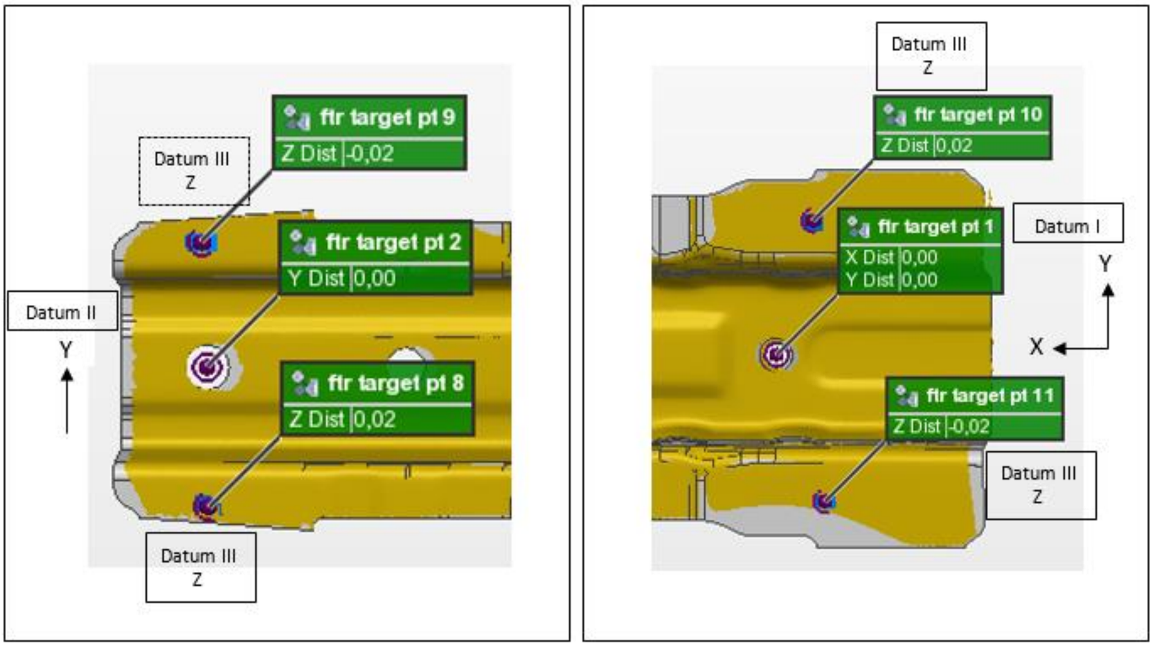


Figure 8: Measured Datum Positions After Alignment



B Area *A Area*

Figure 9: A & B Details

Since there is a dimensional difference on datum surfaces of the part, two different methods were used to define Datum III areas. In the first method, planes were defined as locators and average surface value has taken into account to lock the part on Z direction (Fig. 10).

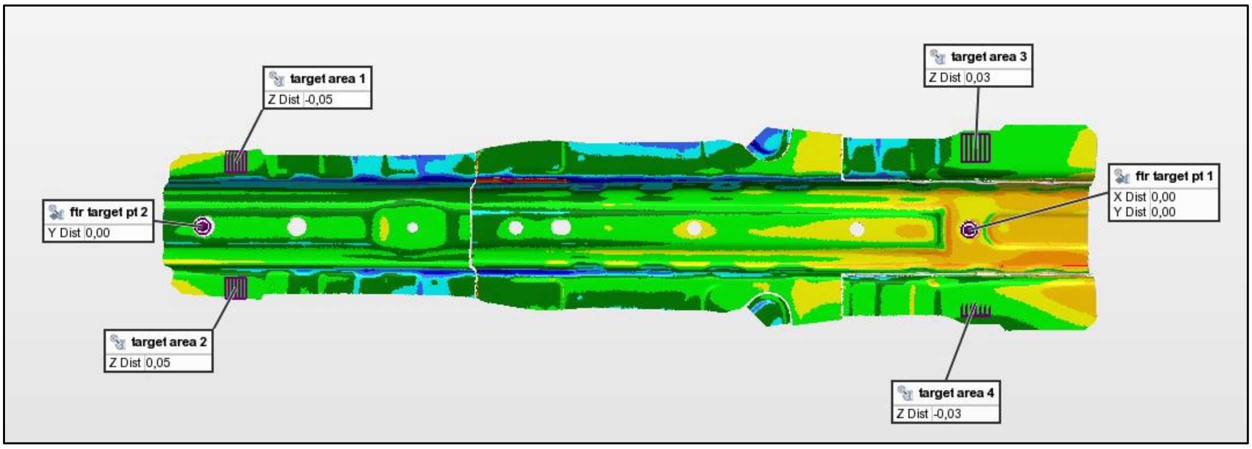


Figure 10: Colormap Result Generated by Plane Fixation Method

On the other method, the lowest surfaces values in Z direction were taken into the account in order to lock and evaluate the part (Fig. 11). In the first method, the error of surface has been distributed to rest of part equally therefore general quality of surface has changed gradually. However, in the real time, checking fixtures contact the part on the lowest surface point via locator therefore its considered that second method simulates the real condition fairly. In order to confirm the dimensional accuracy and compare the values, measurements were conducted from fixture nor fixtureless methods both. Evaluation is figured out by color-maps. Color-maps express how far the component's measured dimension from its actual CAD data.

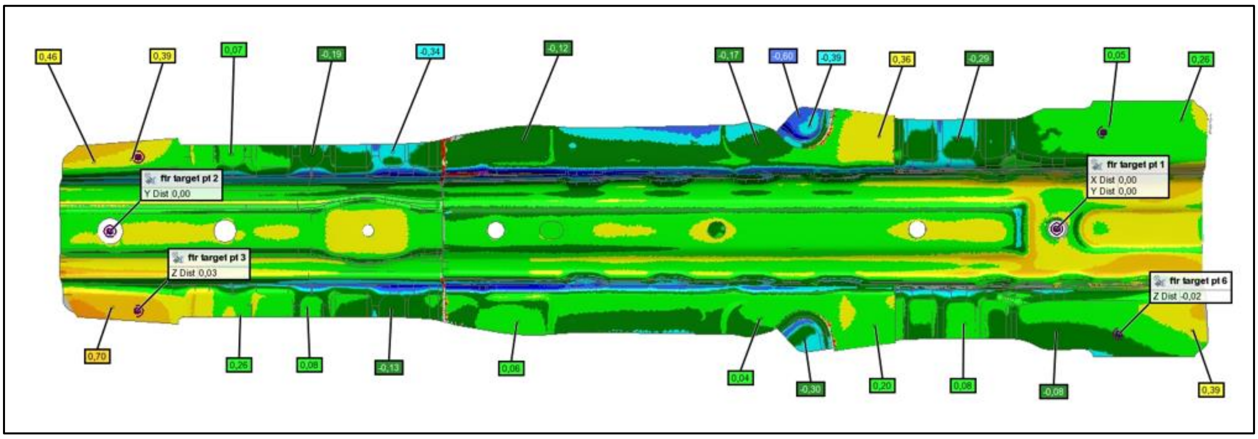


Figure 11: Colormap Result Generated by Point Fixation Method

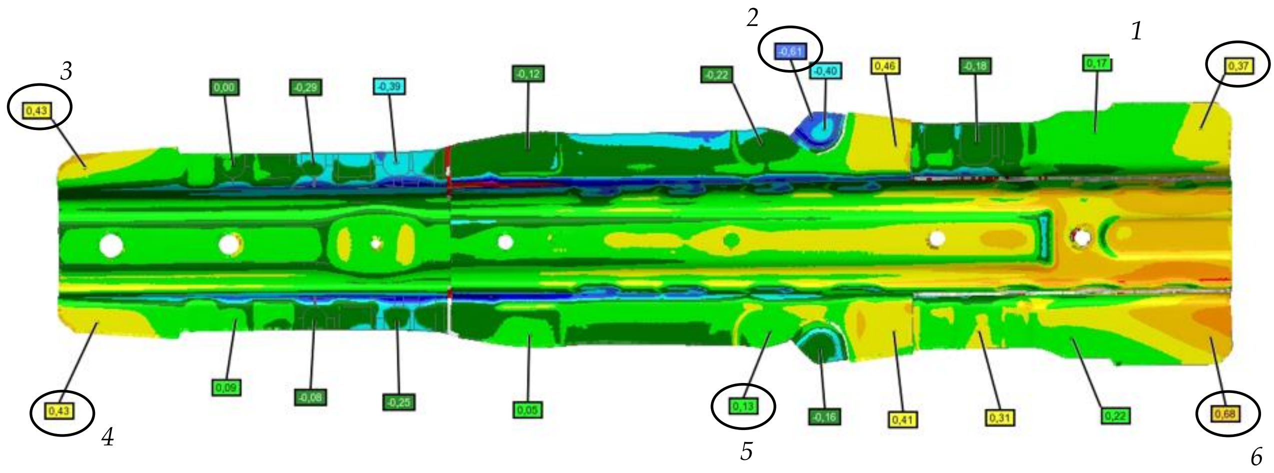


Figure 12: Comparison Points and Quality Color-Map via Fixture Measurement

3. Results

Measurements of fixture nor fixtureless are compared in table 1. When the results are reviewed, the surface values are close to each other in fixture and fixtureless evaluation. Margin of error of fixation has increased because of the surface deviation on the datum III locations. Therefore, surface differences were observed in locations where datum IIIs exist. Its seen that deviation between datum surfaces were reflected on the part as unbalancing. Its concluded that this method may give the quality idea of components in case of fixture does not exist.

Table 1: Comparison of Results (mm)

Comparison Points	Measurement with Fixture	Method I Plane Datum	Method II Point Datum
1	+0,37	+0,40	+0,26
2	-0,61	-0,48	-0,60
3	+0,43	+0,30	+0,46
4	+0,43	+0,30	+0,70
5	-0,16	-0,20	-0,30
6	+0,68	+0,50	+0,39

4. Discussion and Conclusion

Automobile manufacturers are in effort to decrease equipment expenses in order to increase their profit. The checking fixtures are expensive and fragile equipment which are essential to detect quality of sheet metal parts. Obtaining the quality status of components and making sure the they meet the customer needs without using a checking fixture will provide an innovative outlook for budget and technical areas. On this purpose feasibility of this technique has been tested.

Results are close each other according to the test results of measurements from fixture nor fixtureless which may give an idea for quality status of components. However, deflection of components is heavily dependent on their size and geometrical shape. Deflected parts must be conditioned and measured under clamp force (Camelio, et al.,2004). In order to get better results in virtual fixation more data such as Young's modulus, Poisson ratio and material density have to be included and studied with finite elements analysis (Weckenmann & Weickmann, 2006). This study will help to future researches to achieve more advance knowledge and contribute to the development of metrology competencies, improvement of part analysis, reporting, feedback processes and enrichment of literature.

References

[1] Weckenmann, A., Akkasoglu, G., & Werner, T. (2015). Quality management – history and trends. The TQM Journal, 27(3), 281–293.

[2] Weckenmann, A., & Weickmann, J. (2006). Optical inspection of formed sheet metal parts applying fringe projection systems and virtual fixation. *Metrology and Measurement Systems, 13*, 321-334.

[3] Camelio, J.A., Hu, S.J., & Ceglarek, D. (2004). Impact of fixture design on sheet metal assembly variation. *Journal of Manufacturing Systems, 23*, 182-193.

[4] Weckenmann, A., Gall, P., Gabbia, A. (2005). 3D surface coordinate inspection of formed sheet material parts using optical measurement systems and virtual distortion compensation. Proceedings of SPIE - The International Society for Optical Engineering. 5776.

[5] Jaramillo, A.E., Boulanger, P. & Prieto, F. (2011). On-line 3-D system for the inspection of deformable parts. Int J Adv Manuf Technol 57, 1053–1063.