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REVERSE ENGINEERING USED IN THE DESIGN OF ADJUSTABLE TAPER PIPE THREAD TAP

BY

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Abstract. The main purpose of this paper was to track the main components and problems of the design mode using reverse engineering, namely scanning and transforming the information into the CAD product and to see the economic benefits that this method can bring within a company with mechanical profile.

Keywords: 3d scan; thread tap; reverse engineering.

1. Introduction

Reverse engineering, also named back engineering, is an concept that consist in extracting information about the design and how works structures, assembly that are included in machine tools, aircraft, mechanical structures and other product. This process implies deconstructing components from mechanical products and reconstruct them in order to improve the function. Thus the process enables to determine the way a product was designed and to give the possibility to recreate it. The name reverse engineering process is given because it is a process in which it start from the product and it is working backward in

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order to determine the design. This appear of this concept is due to a shortage of knowledge regarding the engineering methods that went into creating the specific product. The challenge is to obtain knowledge of the original design by disassembling the product piece-by-piece. Companies often use reverse engineering on old mechanical component, such as gearbox. Frequently, the products in question is no longer on the market and the manufacturers are gone out of business. Reverse engineering allow to rediscover these initial design and then to bring up to date the product. Reverse engineering allow to develop components that bring together new and old concept, thus assuring that older equipment connect their devices to modern computing equipment (Roșca, 2010). The advantage of reverse engineering is that it is a way to obtain the design of the original product. Companies use reverse engineering to regain design data on their own products that are no longer manufactured (Ureche, 2015). For example, a small company that has more than 40 years may have manufactured numerous products before the days of computer-aided design and digital file storage (Paizi and Stere, 1980). Consequently, these older products are based on paper blueprints. Using reverse engineering, companies can achieve their lost designs and create archives. Even if the company has their paper blueprints, they want to create a digital version of them to make the plans. The companies use the reverse engineering techniques to create the digital design file. One example is from automotive industry where thanks to reverse engineering, it can be bring a classic vehicle design back to life and make it fully functional without changing the design of the car's systems. Reverse engineering requires a series of steps to gather precise information on a product's dimensions. These steps will be explained in the following. Often, engineers will enhance the design with new developments and innovations (Dibya, 2017).

2. Method and Apparatus

We use two types of apparatus/scanner: David SLS2 which use white light in scanning and HandyScan 3D 300 in order to scan adjustable taper pipe thread tap. There will be problems in the threading part (Pruteanu, 2010).

Fig. 1 – The scanner presentation.

David SLS-2, Fig. 1, is a scanner that captures three-dimensional surfaces and creates 3D models using mobile hardware with structured light scanning technology using a projector instead of a laser. DAVID will use the video projector to design a number of tape models per object. The camera will follow this from another point of view (left or right of the projector) and will take (at least) an image of each model. Based on the deformations of the tape patterns in these images, DAVID will calculate a precise 3D point cloud of the object's surface.

Fig. 2 – HandyScan 3D 300 Scanner.

Another scanner was used to scan the tarot components - HandyScan 3D 300 developed by AMETEK Creaform Inc, Fig. 2. This fact was justified by the complexity of the tool, which did not allow capturing certain hidden areas of the piece with the David SLS-2 scanner.

The scanning process with this device is a simple one. In the first phase, a calibration is performed which involves positioning the scanner on top of a panel and focusing the laser beam in the indicated area Fig. 3. This area is changed several times during calibration until the laser beams determine their optimal position in space. This process should only be repeated if the scanner is moved to another working environment or the atmospheric conditions in the space where the scan was performed are significantly altered.

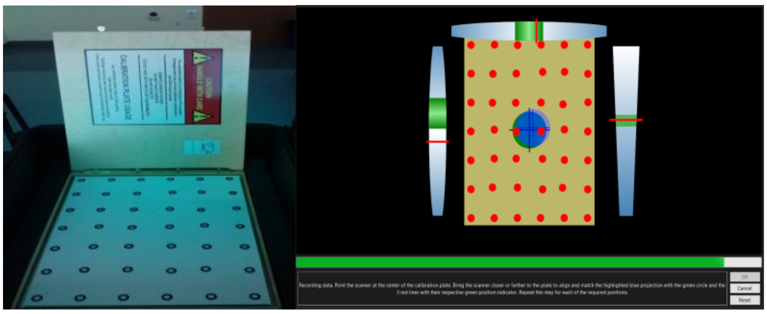

Fig. 3 – Scanner Calibration.

In Table 1 we present the parameters of the scanner (www.cati.com).

Table 1
Scanner Parameters

Parameters	Values
Precision	Up to 0.04 mm (0.0016 in.)
Volumetric Precision	0.020 mm + 0.100 mm/m (0.0008 in. + 0.0012 in./ft)
Resolution	0.100 mm (0.0039 in.)
Measuring Rate	205 000 measurements
Light source	3 laser beams intersected
Class	2M (eye safety)
Scanning Area	225 x 250 mm (8.8 x 9.8 in.)
Minimum Distance	300 mm (11.8 in.)
Depth	250 mm (9.8 in.)
Part Dimension	0.1 – 4 m (0.3 – 13 ft)
Software	VXelements
Weight	0.85 kg (1.9 lbs.)
Dimensions	77 x 122 x 294 mm (3.0 x 4.8 x 11.6 in.)
Connectivity	1 X USB 3.0
Working temperature	5-40°C

A configuration of the scanner to determine the optimum scanning speed according to the piece to be scanned will be carried out, but this speed can be changed later during the scanning, depending on the complexity of the area. This process must be repeated for each part (Fig. 4). One last thing before effective scanning is to place the so-called "targets" on the piece. They must be positioned so that, when the laser beams are focused on the piece, they will recognize at least 4 "targets" so that they can be taken into account. Accuracy is higher when using these targets.

The same operation is made for the DAVID scanner (Fig. 5, Fig. 6).

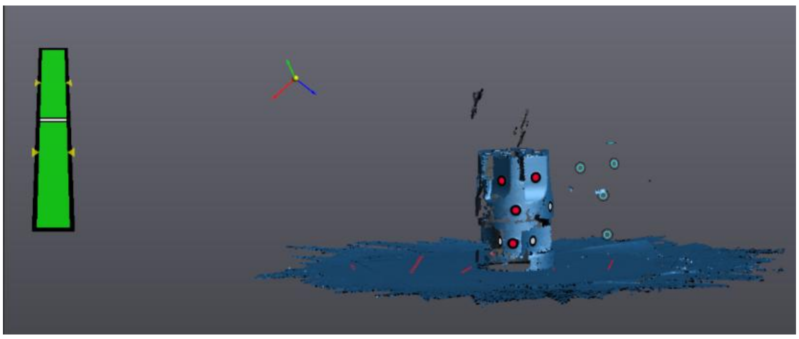

Fig. 4 – The target point application and the optimum distance confirmation.

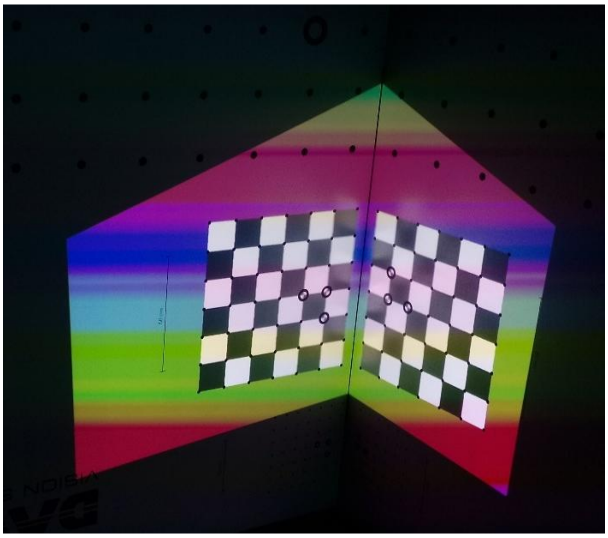

Fig. 5 – Pre-calibration image.

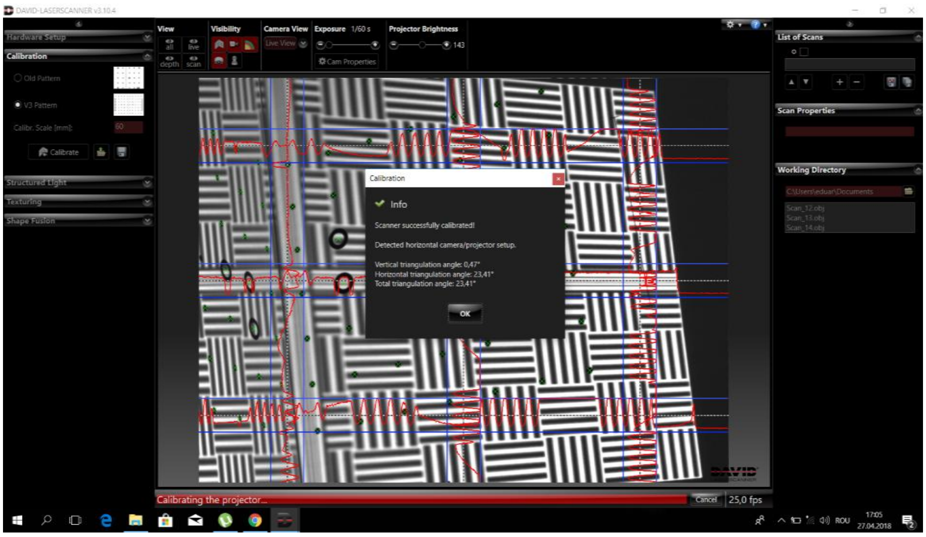

Fig. 6 – Calibration process finished.

3. Results

After the calibration process we start to scan the components of the taper pipe thread tap. In Fig. 7, Fig. 8, Fig. 9 we present the components of the cutting tool during the process of scanning.

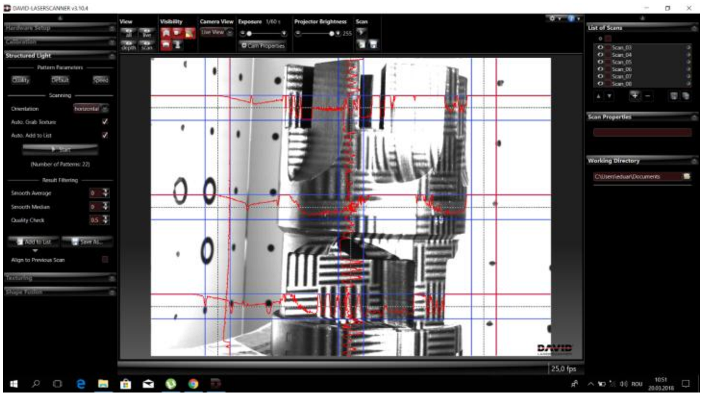

Fig. 7 – The taper tap body during the process of scanning.

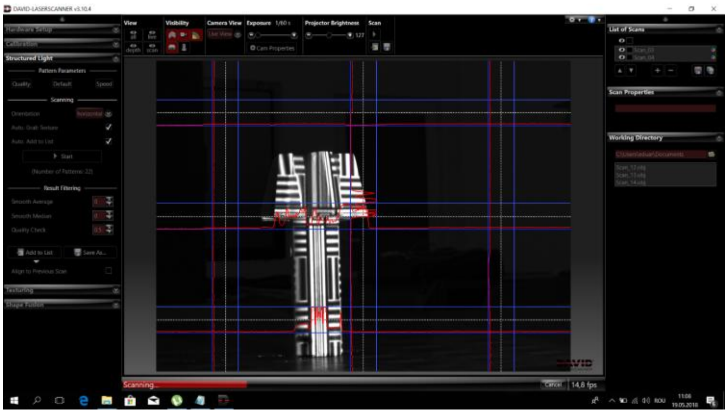

Fig. 8 – The adjustable component during the process of scanning.

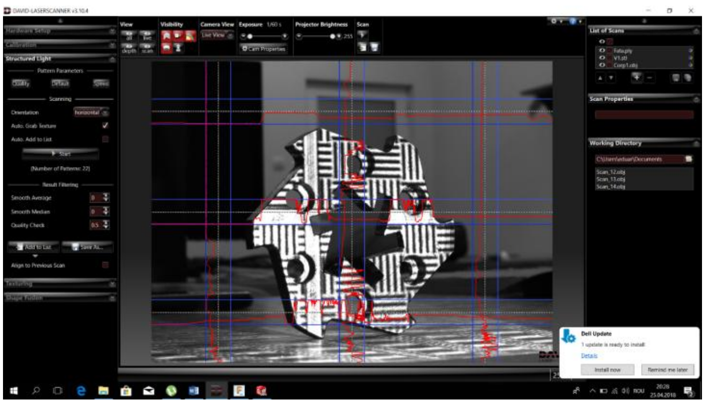

Fig. 9 – The clamping element during the process of scanning.

The scanned image is then processed and in Fig. 10 we present the stages that were carried out in order to obtain the model after 3d scanning.

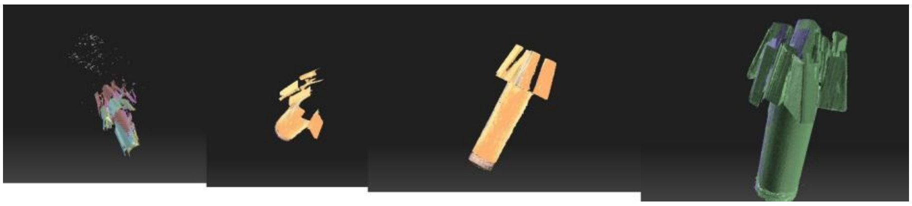

Fig. 10 – The stages of obtaining the model by 3D scanning.

In Fig. 11 and Fig. 12 we present the initial and final model obtained through scanned process.

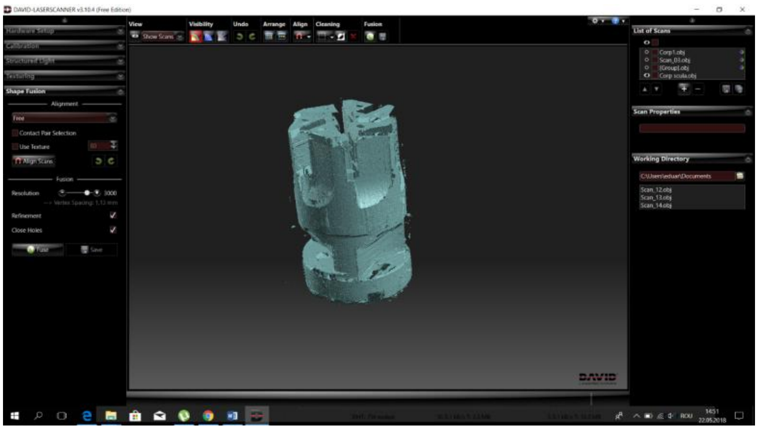

Fig. 11 – Initial model.

Fig. 12 – The final model.

After the final render of the model parts these are imported in a CAD software. The final results are presented in the Fig. 13.

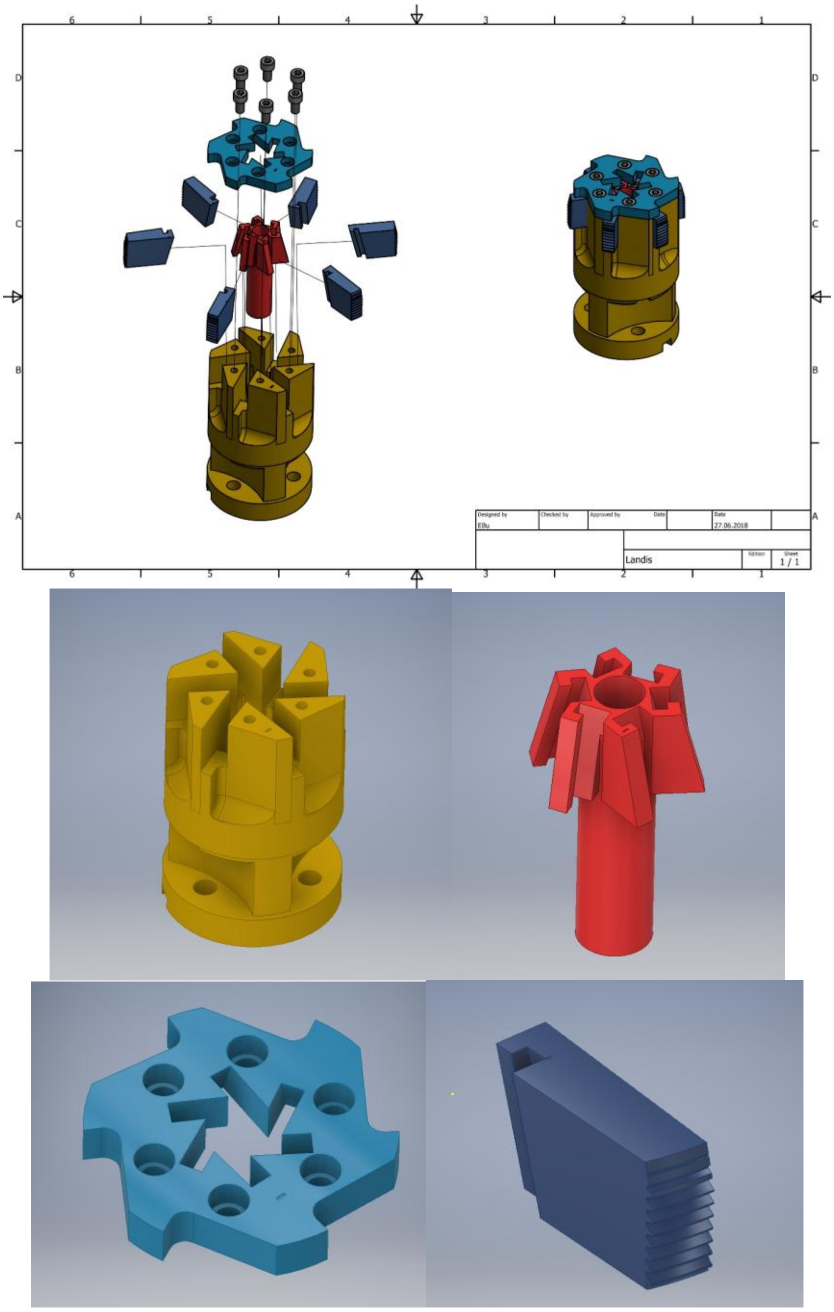

Fig. 13 – The final CAD model obtained based on 3D scanning process.

4. Conclusions

The main purpose of this paper was to track the main components and problems of the design mode using reverse engineering, namely scanning and transforming the information into the CAD product and to see the economic benefits that this method can bring within a company with mechanical profile.

There were encountered many problems in obtaining the CAD model based on 3D scanning. In the following we present some problems:

• *shiny material of the piece* - David SLS-2 scanner is based on the projection of the structured light onto the scanner body, and depending on the deformation mode of the projected strips, the attached camera with a very high resolution can read the shapes of the piece and then create a point cloud that follows that form. If the material is shiny, the projected light is strongly reflected, and the camera can no longer follow the real shapes of the model. This shortcoming was eliminated by using a special scanning spray that covers the piece with a white powder coating and gives them the property of no longer reflecting light, respectively white being dull. This film can be removed very easily after scanning by washing. For the piece not covered in the figure above, after the scan it was possible to observe - besides this - also foreign elements behind it, as can be seen in the image above.

• *environment* - the light from the outside can influence the process. It was noted that some areas of the part were not recognized after the scan although at the time of the calibration it was intended that the part was sufficiently illuminated. However, when the intensity of light entering the room changed from the time of calibration, changes could be recognized on the surface to be scanned.

• *vibrations during the process* - many times during the scan, the mass on which the piece was positioned is touched, the piece starting to vibrate. In this case, the scan had to be repeated because the obtained image did not resemble the real shape at all - if the vibration was high in amplitude; and if the amplitude was small, the obtained form introduced errors. If a new scan was done in with the track positioned in the same way it could be seen that the two scans did not match.

• *the focusing power of the projector* -a prerequisite for a proper scan is that the light is projected very well on the model. The projector we had available could not focus very well the small pieces, in our case the tool teeth. The correction of this problem was done by focusing the projector on a large piece (the body of the tool) that was subsequently placed in the teeth, thus being part of the complete image created by the body of the tool and teeth.

• *Scanning shaded and deep areas* - an obstacle that I did not overcome was the realization of the interior, shaded and deep areas. The geometries of the other components of the assembly were used to determine their geometry, modeling them so as not to hamper the joint, but also to ensure the maximum travel of the central cone vertically.

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INGINERIE INVERSĂ UTILIZATĂ
ÎN PROIECTAREA TARODULUI AUTOREGLABIL DESTINAT
FILETĂRII CONICE

(Rezumat)

Scopul principal al acestei lucrări a fost de a urmări principalele componente și probleme ale modul de proiectare utilizând reverse engineering-ul și anume scanarea și transformarea informației în produsul CAD și de a vedea beneficiile economice pe care le poate aduce această metodă în cadrul unei firme cu profil mecanic.