

A REVERSE ENGINEERING APPROACH FOR QUALITY CONTROL OF A PLANAR CAM

Iulian Stănăşel¹ Dan Craciun² and Traian Buidos³

¹ University of Oradea, stanasel@uoradea.ro

² University of Oradea, danraciun28@yahoo.com

³ University of Oradea, tbuidos@uoradea.ro

ABSTRACT: In general terms, Reverse Engineering refers to the process of obtaining the virtual 3D model from an existing product. The existence of the CAD model opens new opportunities for the development and manufacture of a new product, the virtual model being remodeled in order to obtain a new product with improved features. Manufacturing of the new product can be achieved either by computer numerically controlled machine tools or through rapid prototyping. In the current period, the reverse engineering technology has been adapted in order to allow dimensional control of parts using 3D scanners, which are efficient especially for complex parts, difficulty in verifying with traditional methods. The paper presents modeling, digital manufacturing and contactless by 3D scanning of a plane cam with complex contour, used in the conveyor control system..

KEYWORDS: reverse engineering, complex surfaces 3d scan

1. INTRODUCTION

The current technological progress is mainly due to increasing the market competition, which causes companies to find out new design and technology solutions in order to deliver new products with superior features as well as attractive ways to improve the quality for products when being launched on the market.

In close connection with the customer's needs, the companies trends to improve their products continuously, in order to get optimal results. For this purpose, companies use and take advantage of the benefits of market analysis techniques to help predict market trends.

In the classic version, the processes of design and manufacturing aim to transform the engineering concepts into real products, activities which take place over a long period [4]. For this reason, according to [3] many new products, are, in most cases, redesigned, based on existing products.

The frequency of product upgrades or renewals is due to high competition between firms, each of them using state-of-the-art technologies to ensure the penetration in the shortest time into the marketplace.

The redesign should be carried out through a well structured systematic process, which is helpful in guiding the work of the department of design and product development team, starting by problem identification to final design and obtaining the real product, thus providing a greater chance of success.

In the past few years, reverse engineering has recorded significant progress [2], mainly due to the development of 3D contactless scanning technology.

Reverse engineering enables innovative procedures which have the advantage of being able to get quickly and precisely acquire of a large number of points on complex surfaces. It became accessible, and it has been much more used in industry and universities.

In the field of mechanical engineering and industrial production, the term Reverse Engineering refers to the process of obtaining a 3D virtual model starting from an existing product [1].

The existence of a virtual 3D model opens up new opportunities for the development and manufacturer of a new product. So, the physical replica can be reshaped in order to obtain a new product with improved features. Manufacturing is carried out either using Computer Aided Manufacturing applications for numerically controlled machine tools or rapid prototyping..

In the beginning, reverse engineering techniques were used to achieve the virtual 3D model of an existing product, but in the last period, the technology was adapted to allow also the dimensional control of the parts.

The dimensional control can be achieved either by contact methods using coordinate measuring machines or by 3D scanning. The pieces are digitized, and the obtained data are used in a measuring software application, where they are compared to the original CAD model to determine the errors in different points.

The ability to manipulate easily a large amount of data acquired by scanning makes this verification technology a very advantageous one, especially for products with complex surfaces which are difficult to be checked with traditional methods or even with coordinate measuring machines.

The paper presents a method for checking the complex geometry parts using contactless 3D scanning. The part to be checked is a planar cam used in a conveyor control system.

2. 3D MODEL AND MANUFACTURING OF THE CAM

The planar cam (1) is intended to operate the lever of the tractor hook (2) on the tractor trolley in order to allow or to avoid coupling with the fork (3) of the transport trolley located in the charging station (Figure. 1).

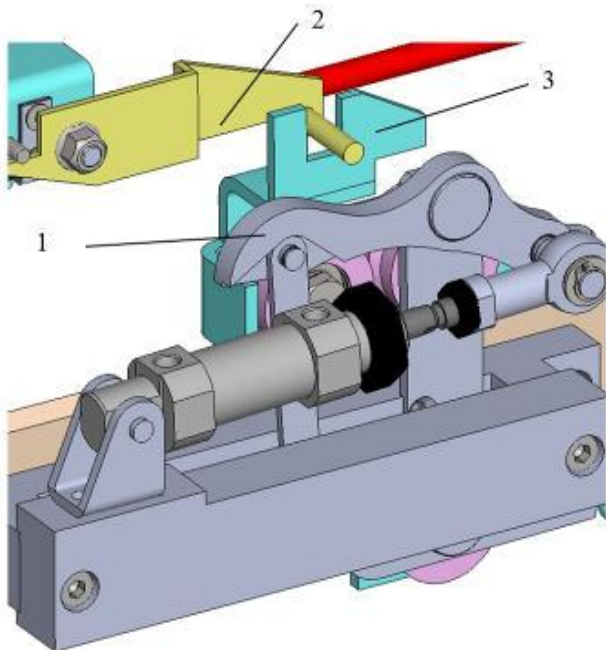


Figure.1. The 3D model of the cam assembly.

In Figure 2 is shown the 3D model of the cam.



Figure 2. The 3D model of the cam.

The contour of the cam is defined by several complex curves whose points have been determined with a computing program and used in a 3D modeling application.

The complexity of the cam contour made necessary to manufacture on a numerically controlled machine.

In order to obtain the CNC program, a Computer Aided Manufacturing (CAM) application has been used to generate the tool paths used for processing.

The use of the manufacturing module of Siemens NX for milling involves completing specific steps in which the geometric and technological parameters for the cam processing are configured.

The first step consists in the import of the 3D model of the piece in the CAM application, followed by the modeling of the block of material that will form the blank from which the cam has to be made.

The blank will include the addition of material for the clamping in the device where it will be fixed during processing.

Then are defined the cutting tools, and their geometric parameters, the number of teeth, the tool position in the tools magazine of the machine tool, the tool length and there are indicated registers for tool correction of the length and radius.

The CAM application allows the use of several processing strategies, optimizing the route by following the choice of strategy for which the processing time is the lowest.

It is possible for the finishing operation to indicate the roughness that must be obtained, and the application optimizes the cutting parameters to ensure the specified roughness.

The tools paths used for the machining of the cam are shown in Figure 3.

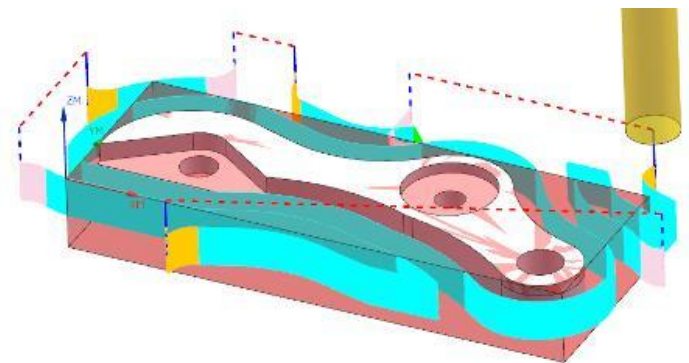


Figure 3. The tools paths

After virtual processing, you can make the first check to compare the dimensions of the obtained workpiece with the 3D model Figure 4.

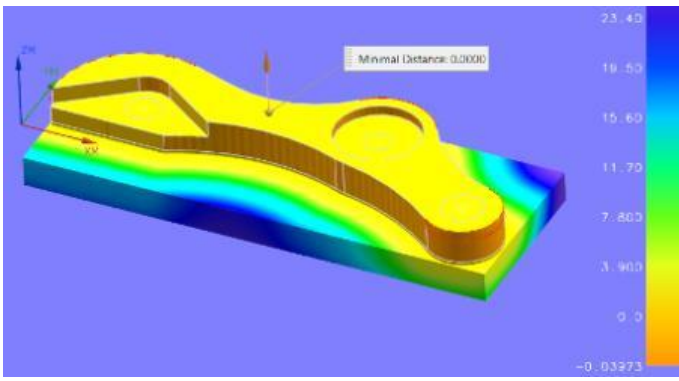


Figure 4. Comparison of the dimensions of the machined workpiece with the 3D model

In order to obtain the CNC code for the equipment on which the processing will be carried out, the data resulting from the simulation is processed. From the library of the CAM application, it was chosen a postprocessor for a CNC machining center with a vertical axis.

Before being used for machining, it was checked the tool path resulted by running the CNC program on the numerically controlled machine simulator. Figure 5 shows the actual processing of the cam.



Figure 5. The cam manufacturing.

3. 3D SCANNING

Due to the complexity of the piece and the difficulty of checking the dimensions of the outer contour of the cam with traditional instruments, the 3D scan verification method was used.

This method allows you to retrieve a large amount of information from the surface of the scanned object and they are converted into digital data represented by a very dense network of points (cloud of points) that replicates the shape of the scanned object.

For the processing of scanned data, the commercial software Shiningform XOR was used. The cloud of points is transformed into a triangular network of surfaces that approximates the surface of the scanned physical object (STL format).

The obtained data can be saved and can be used for different applications (to make a copy of the scanned object, to use certain information in order to redesign the scanned object, to perform measurements and quality inspections etc.).

For this case study, an optical scanner Optim II provided with blue light and with two optical cameras was used [5]. This allows acquiring only those points which are located in the field of vision of the two optical cameras that equip the scanner. For this reason, for complete scanning of an object, there are necessary to perform multiple scans from different angles. This is simplified by using a numerically controlled rotating table integrated with the scanning application. The equipment used is shown in Figure 6. For the case study, ten scans were carried out, the resulting data being shown in Figure 7.



Figure 6. The equipment used to scan the cam.

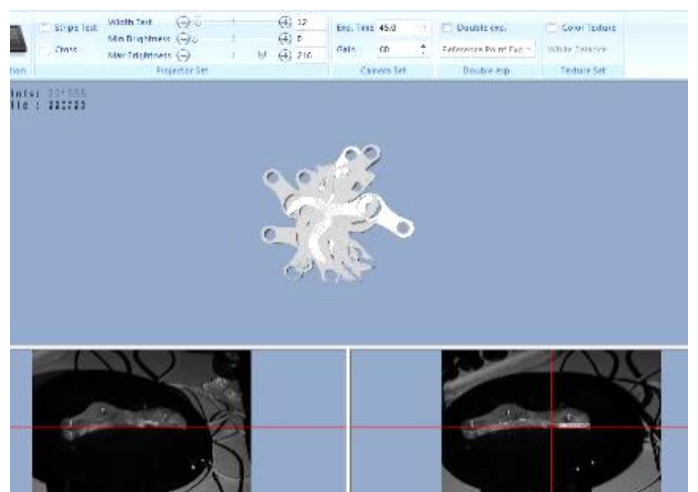


Figure 7. The data obtained by scanning of the cam.

The scanned data are imported into the reverse engineering Shiningform XOR application in which they are processed in order to obtain a cloud of points belonging to the surfaces of the cam (Figure 8).



Figure 8. Scanned data imported into the reverse engineering application

In the reverse engineering software, several steps are taken into account when is proposed to align the scanned data, so that it results in an accurate reproduction of the scanned physical object (Figure 9).



Figure 9. The alignment of scanned data.

After completing the alignment operations, is obtained the clouds of points of the cam (Figure 10).

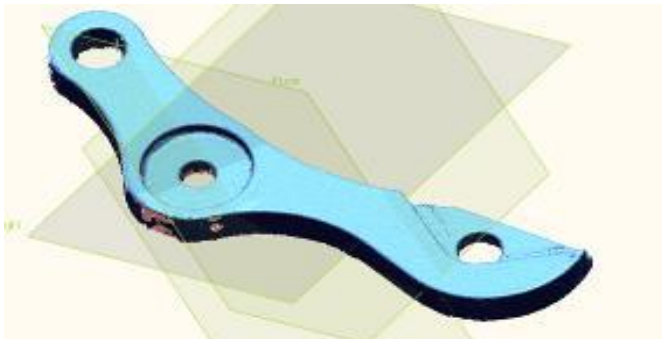


Figure 10. The cloud points of the cam.

4. VERIFICATION BY 3D SCANNING

In order to check the cam, a commercial application Shningform XOV was used. It allowed the comparison of the 3D model of the cam with the cloud of points obtained after the scan of the cam after manufacturing. In terms of working mode, the main steps involve loading the 3D model data (etalon), uploading the scanned data of the physical model to be checked, then follow the alignment of the cloud of points with the 3D model and set the allowed tolerance field (Figure 11).

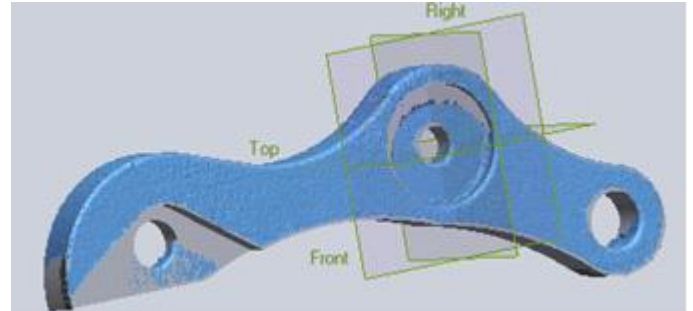


Figure 11. The alignment of the cloud of points with 3D model.

After aligning the data, you can make a comparison between the 3D model and the scanned data.

In Figure 12 is presented the total deviation as a colored map. The green color signifies that the scanned points are in the accepted tolerance field. It is also possible to obtain information on the deviations of points located on the contour of the cam (Figure 13), and finally, a detailed report can be generated (Figure 14). From the analysis of the data obtained after verification, it was found that the dimensions of the cam are in the tolerance field ± 0.03 mm, being respected the conditions imposed in the execution drawing of the cam. After the cam and other components were machined, the actuator assembly has been carried out (Figure 15).

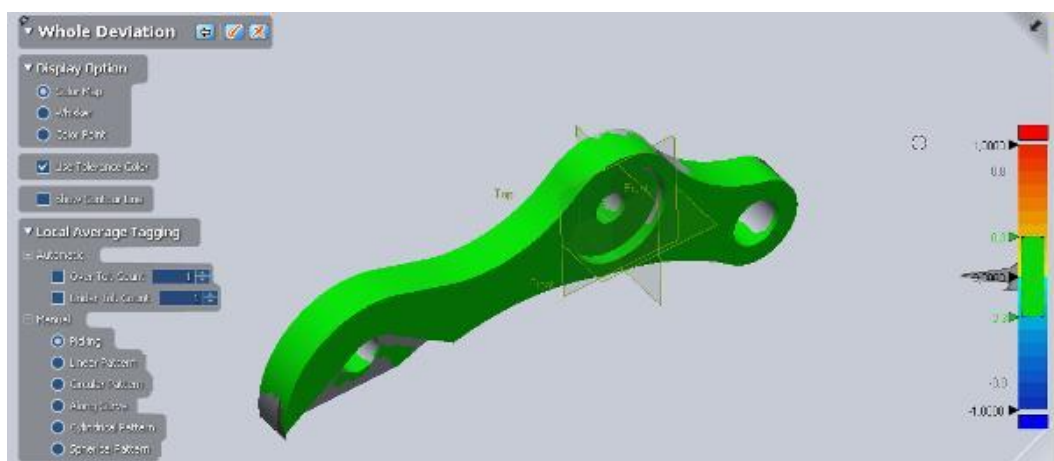


Figure 12. Total deviation.

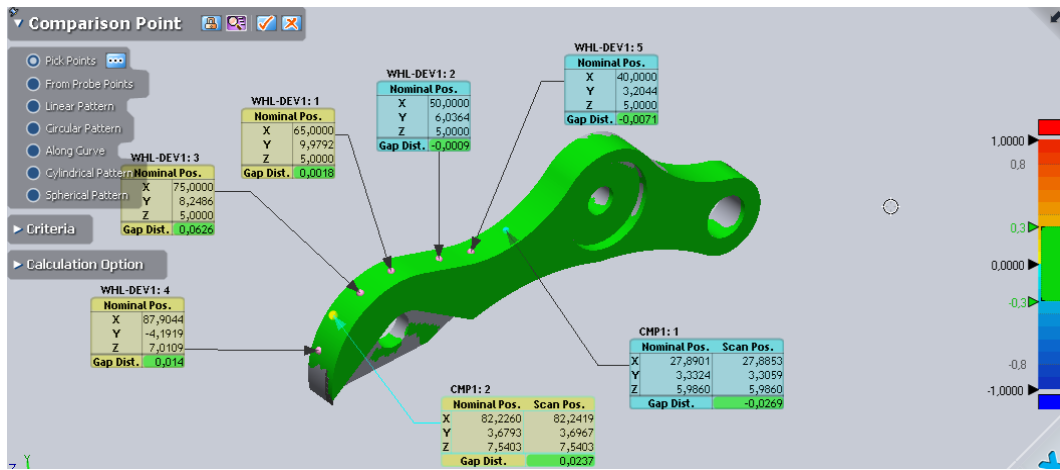


Figure 13. The deviation of points located on the contour of the cam

Name	Visibility	Nominal Pos.			Scan Pos.			Gap Dist.	Value	X
		X	Y	Z	X	Y	Z			
Feature: WHL-DEV1										
WHL-DEV1: 1	<input checked="" type="checkbox"/>	65	9,9792	5	64,9996	9,981	5	0,0018	-0,0004	
WHL-DEV1: 2	<input checked="" type="checkbox"/>	50	6,0364	5	50,0003	6,0355	5	-0,0009	0,0003	
WHL-DEV1: 3	<input checked="" type="checkbox"/>	75	8,2486	5	75,0231	8,3068	5	0,0626	0,0231	
WHL-DEV1: 4	<input checked="" type="checkbox"/>	87,9044	-4,1919	7,0109	87,917	-4,1857	7,0109	0,014	0,0126	
WHL-DEV1: 5	<input checked="" type="checkbox"/>	40	3,2044	5	40,0011	3,1974	5	-0,0071	0,0011	
Count		5	5	5	5	5	5	5(100.0/0.0/0.0)		5
Sum.		317,9044	23,2766	27,0109	317,9412	23,3349	27,0109	0,0705	0,0368	
Min.		40	-4,1919	5	40,0011	-4,1857	5	-0,0071	-0,0004	
Max.		87,9044	9,9792	7,0109	87,917	9,981	7,0109	0,0626	0,0231	
Avg.		63,5809	4,6553	5,4022	63,5882	4,667	5,4022	0,0141	0,0074	
Std. Dev.		17,1146	4,9707	0,8044	17,1209	4,9777	0,8044	0,0252	0,0092	
RMS		65,844	6,8103	5,4617	65,8528	6,8234	5,4617	0,0289	0,0118	
Var.		292,9083	24,7083	0,647	293,1238	24,7779	0,647	0,0006	0,0001	

Figure 14. The measurement report.

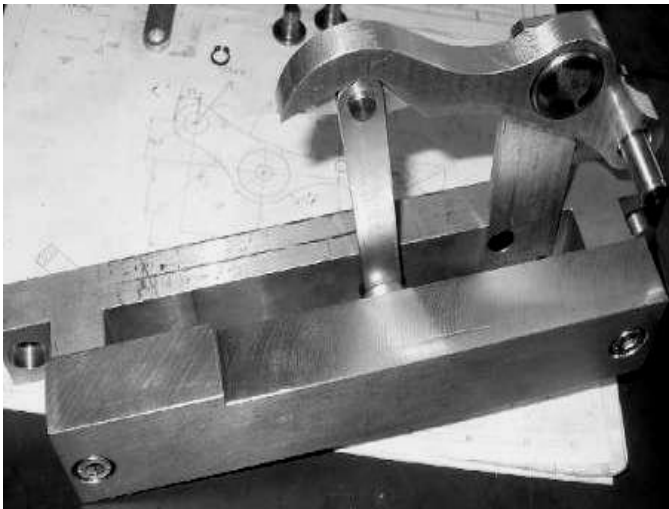


Figure 15. Cam assembly.

5. CONCLUSIONS

The 3D model of the cam was created using a Computer Aided Design application.

The complexity of the 3D model has made it necessary to use a Computer Aided Manufacturing (CAM) application to obtain the tool paths used in CNC machining.

Checking the manufactured cam was done through 3D scanning using an optical scanner.

Digital data has been processed using specialized software to compare it to the 3D cam model.

The results of the analysis indicate that the actual model is within the limits of the tolerance field imposed in the execution documentation.

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