

RAPID PROTOTYPING TECHNOLOGY AND 3D SCANNING VERIFICATION. CASE STUDY

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ABSTRACT: The rapid prototyping technology allows to obtain the physical models of the products in a short time and with minimum costs, which allows the study of the designed product characteristics, before the product to be launched in the execution. Checking the products with complex shape is difficult or even impossible to achieve them with conventional methods. By development of the digital technologies, the 3D scanning becomes more and more performant and more accessible to companies. By the 3D scan may be carrying out checks for complex surfaces with appropriate accuracy in a short time. In this paper the authors present how to obtain a complex part through rapid prototyping using Fused Deposition Modelling technology and verification by 3D scanning technique. It presents a case study for a pump impeller.

KEYWORDS: impeller, rapid prototyping, 3d scanner

1. INTRODUCTION

Increasing competition has determined the companies to find new methods of rapid development of products while reducing costs and increasing quality.

A technology recently appeared and in continuous development is rapid prototyping. This technology allows to obtain the products directly from the CAD model, without being necessary auxiliary devices and tools. The product can be carried out at different scales of constructions according to the needs of the manufacturer.

Although the quality of the products obtained by rapid prototyping is not the ones obtained by other manufacturing processes (injection, machining et.all), this technology offers the advantage that these manufacturing techniques allow to obtain physical models of products in a short time and with minimal costs, and also allows the study of the characteristics of the designed product according to the requirements of the customer and applying any corrections before the product is launched in the execution.

Another recent approach resulted from the necessity of optimization the manufacturing time is the product checking through 3D scanning method. With the progress of technology, 3D scanning becomes more efficient, but also accessible to companies.

3D scanning can perform checks for complex

exterior and interior surfaces with adequate precision in a short time.

The presented paper falls within the research subject of several studies conducted by researchers who perform the manufacturing of various components of the pumps through rapid prototyping.

Thus, in the work [1] are shown the steps needed to obtain the centrifugal turbine housing as well as the steps for checking the dimensions for obtained part.

Another paper [2] presents a comparative study and various methods of obtaining of pump impeller and highlights the advantages of rapid prototyping.

The researchers [3] presents a case study for obtaining of pump Impeller using rapid prototyping by stereolithography method, and highlights some advantages of this method comparing to the traditional methods.

In the same way researchers [4] show the possibility of using the parts obtained by rapid prototyping for casting process of mini turbines runner.

The authors of the [5] present in the article more techniques of rapid prototyping for the achievement of components from various fields of activity, casting, medical models, artwork, and models on engineering analysis et.all.

There are also concerns for checking parts of complex shapes obtained by rapid prototyping using modern techniques and tools of high productivity such as 3D scanners.

So the authors of the [6] show the way to check the deformations of a sailing yacht.

Based on the research [7], in this article the authors present the method of production by rapid prototyping an impeller previously modeled, in order to obtain a spare part for a worn impeller.

The 3D model of the impeller obtained by reverse engineering is presented in [8]. In figure 1 is presented the 3D model of designed impeller.

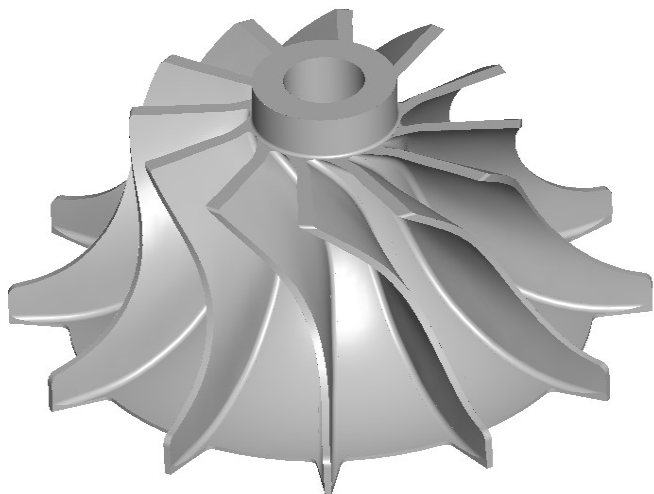


Figure 1. The 3D model of the impeller [8].

2. THE 3D PRINTING OF THE IMPELLER

In order to achieve the physical model of the impeller, was used 3D printer Inspire S200, which uses Fused Deposition Modelling technology.

The material used is ABS as filament form. It passes through an extrusion head, which heats and deposits it in successive layers. Solidification of these layers (cooling) leads to get the physical model (figure 2).

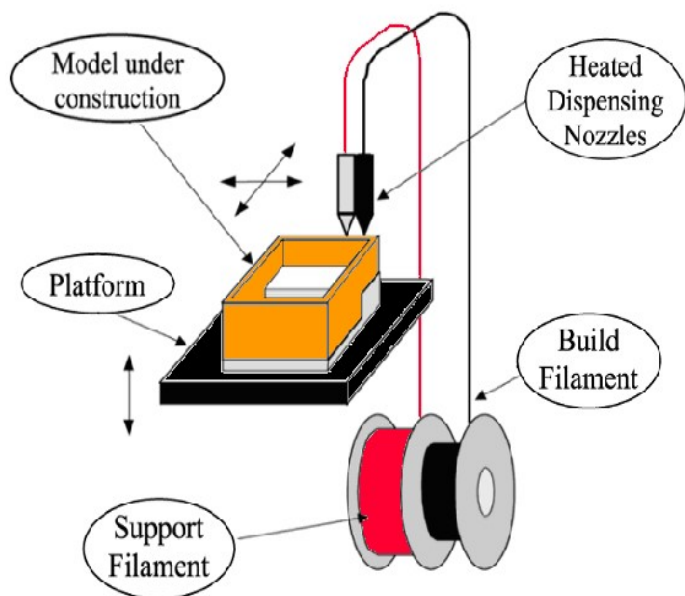


Figure 2. The principle of FDM printing. [9]

Using the printer basically involves bringing the 3D CAD model in a dedicated software application for 3D printing (figure 3) and dividing in layers.

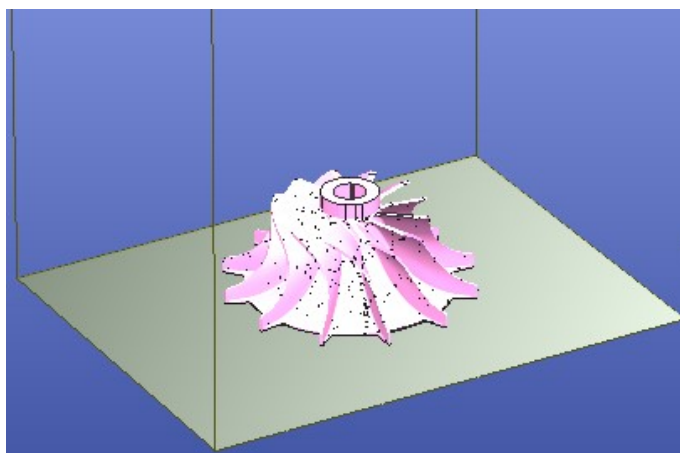


Figure 3. The 3D model of impeller imported in a printing application.

In order to deposit layers of molten material both printer table and the extrusion head run commands coordinated by CAM application of the system correlated with the geometry of the CAD model of the object to be printed.

The reduction or prevention of thermal deformation due to cooling of the deposited material is done by heating the work chamber of the printer. In order to obtain the parts which have areas in the console, interior hollows or complex geometries, as is the case of the impeller, it is necessary to use a support material which has the role to support the material for the construction of the physical model.

Physical part, carried out by 3d printing, before cleaning the support material is shown in figure 4



Figure 4. Physical part before cleaning the material support

After obtaining the physical model by 3D printing, the support material must be removed by mechanical or chemical methods, in which case it shall be used water baths with dissolving solutions.

In figure 5 is presented the 3D model achieved by rapid prototyping alongside with the worn model of the impeller.

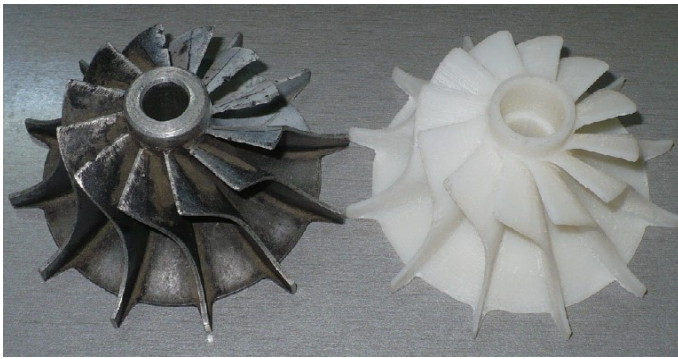


Figure 5. The physical models of worn and printed impeller.

3. THE 3D SCANNING OF THE MODEL

Considering the complexity of the printed part and the difficulty of checking with traditional tools, verification of the obtained physical model was achieved through 3D scanning. By 3D scanning method is taken up a large amount of information from the surface of the scanned physical object, which are later transformed into a virtual digital data represented by a very dense network points (a cloud of points), which reproduce the physical shape of the scanned object. By using a specialized software application this cloud of points is converted into a triangular mesh that approximates the surface of the scanned physical object (STL format). This digital data can be saved and can be used in various applications (to make a copy of the scanned part or to use some information in order to redesign the object, to check the dimensions and quality inspections et.all).

For the presented case study it has been used the optical scanner OPTIM II.

In case of using the optical scanners can be acquired only those points which are visible to the two cameras of the scanner. For a complete scan of an object, it is necessary to perform several scans from different angles. This is easier if it is used a rotary table numerically controlled and integrated with scanning application (figure 6)

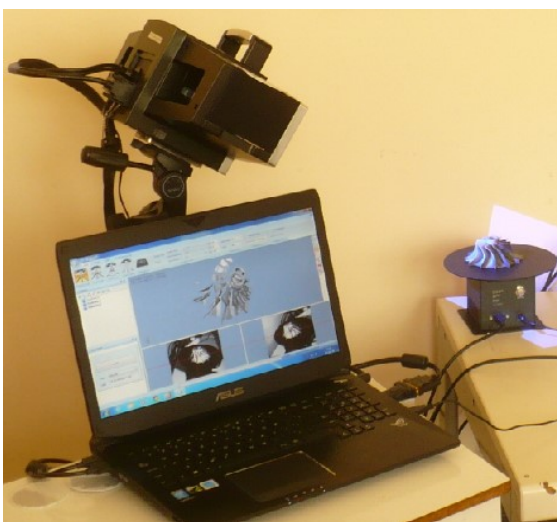


Figure 6. The use of rotary table to scan the impeller

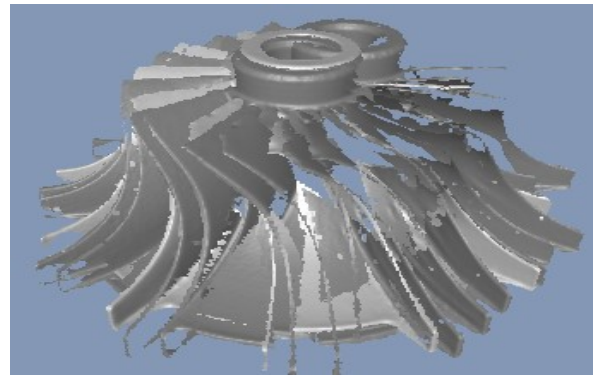


Figure 7. The digital data obtained by successive scans.

The data resulted by successive scans of the impeller realized by rapid prototyping are presented in figure 7. The processing of scanned data was achieved by using the reverse engineering application Shiningform XOR

4. THE VERIFICATION BY 3D SCANNING

For dimensional checking of the impeller obtained by rapid prototyping it was used the software application SHININGFORM XOV. The application has a very simple and intuitive interface, and it is destined to carry out the dimensional measurements based on scanned data. It allows the determination of the whole deviation sectional deviation, verification reports et.all. The first step assumes the import of CAD model, and then the load of the scan data of the physical model that must be checked (figure 8).

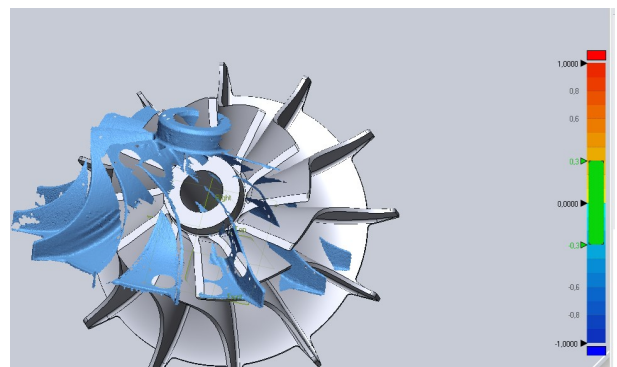


Figure 8. Import of CAD model and the scanned data.

Checking means the alignment of the scan data with the CAD model considered standard (figure 9) and then establishment the tolerance range.

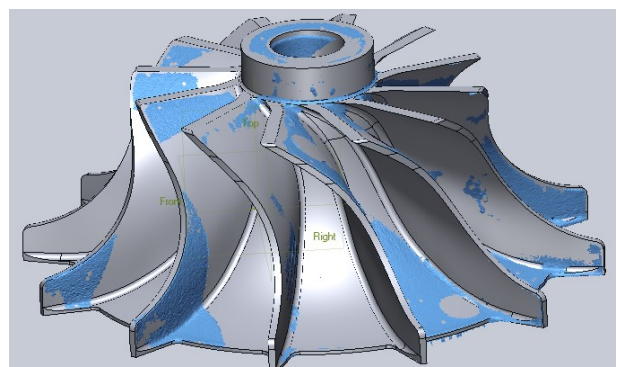


Figure 9. The alignment of the scan data with CAD model.

In this case, taking into account of the accuracy possible to be achieved by 3D printer, the range of tolerance is ± 0.2 mm. The report regarding whole deviation is presented in figure 10.

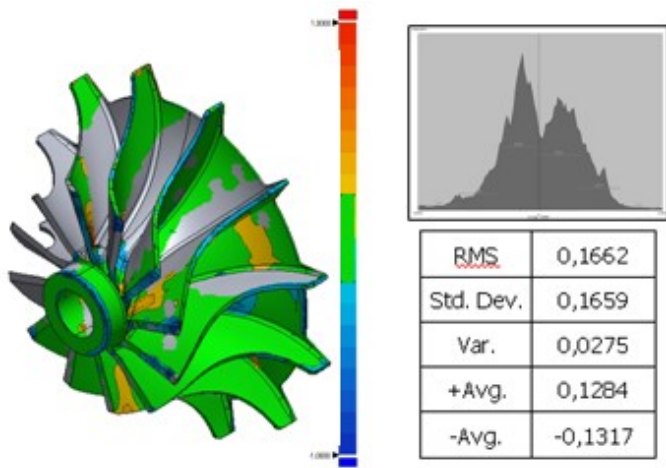


Figure 10. Whole deviation

The Shiningform XOV application allows you to perform measurements in different planes. It was studied the deviation of the profile in different sections located in parallel planes to the top plane and spaced at 8 mm toward one another (figure 11)

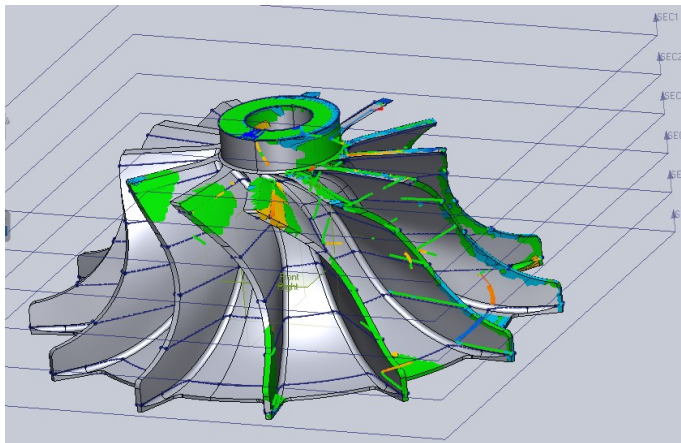


Figure 11. Parallel planes for profile study

In figures 12-16 are presented the results of the measurements in different planes parallel to the top plane.

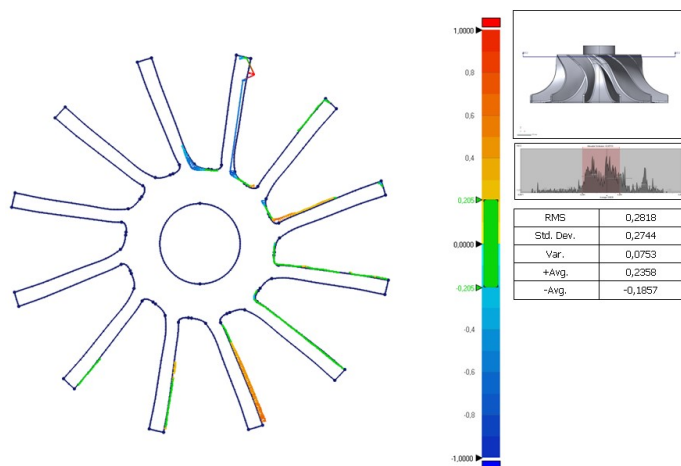


Figure. 12. The profile deviation at 16 mm to the top plane.

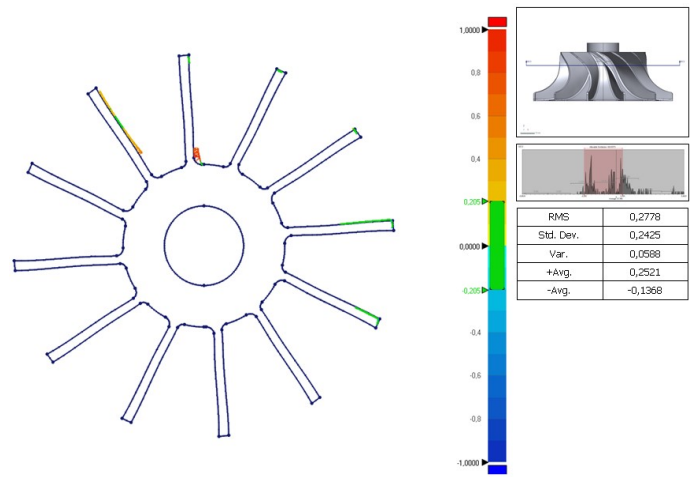


Figure 13. The profile deviation at 24 mm to the top plane.

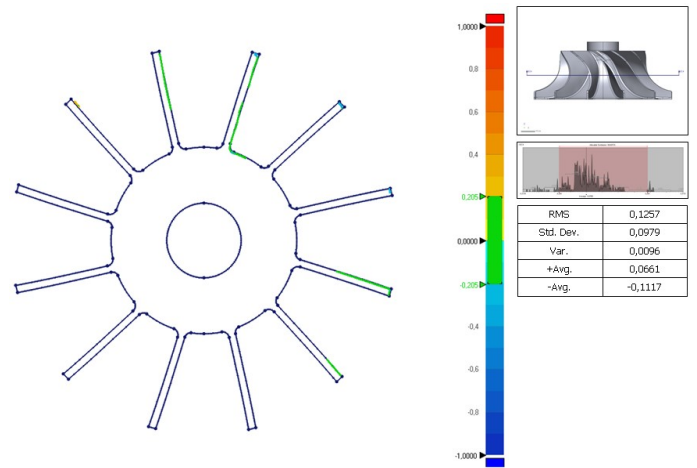


Figure 14. The profile deviation at 32 mm to the top plane.

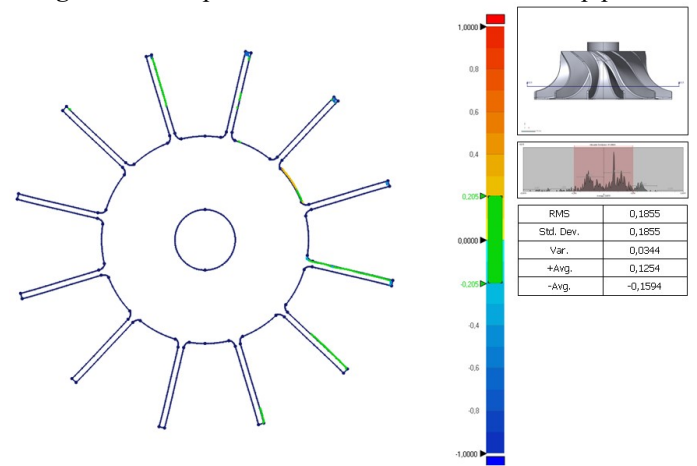


Figure 15. The profile deviation at 40 mm to the top plane

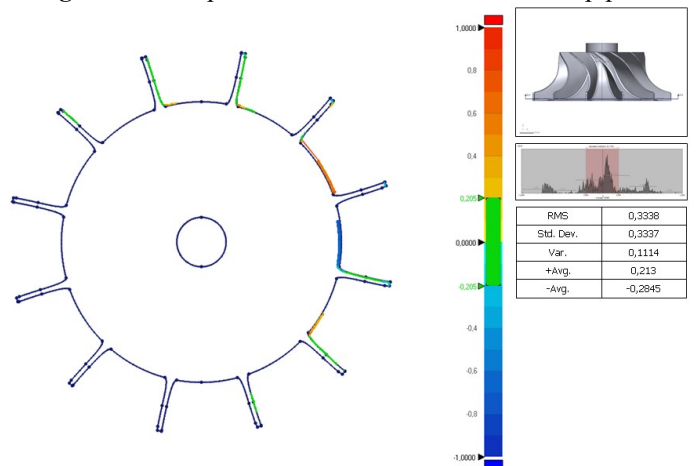


Figure 16. The profile deviation at 48 mm to the top plane

Analysis of the results shows that the accuracy of the workpiece obtained by rapid prototyping is in the range of ± 0.2 mm, which corresponds to the possibilities offered by FDM technology.

The majority of the errors which are outside of this range are due to improper removal of the support material, used in the construction of the impeller.

This was mechanically removed and either due to the adhesion to the construction material or because it was not possible to be correctly removed, or was also removed construction material from different areas of the impeller.

5. CONCLUSIONS

The rapid prototyping technology by FDM method is simple, quiet and allows 3D printing of high complexity components .

As a disadvantage can be mentioned low speed of construction.

The accuracy of the part presented in this case study is in the field of ± 0.2 mm, which corresponds with the overall accuracy offered by this technique.

For high complexity parts is recommended to use the ABS Breakaway as support material.

The accuracy can be improved by changing the thickness of the deposited layer and also the speed of movement of extruder head.

In case of deposit in thinner layers, is increasing the number of layers and also the printing time, but is obtained a greater density and accuracy of the part.

The dimensional checking using the 3D scanners offer several advantages:

- great productivity;
- easy to use the software for measurement;
- the possibility to acquire the digital data of high complexity surfaces, which cannot be measured using traditional methods.
- they can compare very easily and accurately digital data of the scanned product with the CAD model, and can be obtained the deviations in any point of the studied surface, in a very short time.
- scanned data can be processed and can be used in different CAD systems.

6. ACKNOWLEDGEMENTS

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