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THE 3D PRINTING IMPLEMENTATION IN MANUFACTURING OF AUTOMOBILE COMPONENTS

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Abstract: The paper is focused on the issue of 3D printing and its possible use in automotive production. It introduces the principle of 3D printing and its main advantages. An automobile disk production is demonstrated using 3D printing. The process of the disc production is realized in steps disc design, CAD model creation, wall thickness analysis, STL format creation and loading, 3D print parameters definition, printing process visualization in software environment, and 3D printing process itself.

1 Introduction

3D printing has already existed for several decades, but since 2009 there has been a massive expansion among end users. It was the year when the patent protection of FDM (FFF) technology expired. Recently, there are up to eleven technologies for 3D printing, seven of which are standardized in accordance with ISO/ASTM 52900. Individual technologies use specific materials. The most widespread are plastic string melting, stereolithography and, polymer and metal powder sintering. The 3D printing belongs to additive manufacturing, which creates a physical model of progressively layered material.

2 The 3D printing

3D printing represents a modern concept of creating three-dimensional objects from digital data. The 3D printing initialization starts with the 3D input model from CAD systems. Another way to obtain input data for 3D printing is by means of 3D scanners. The following step is a division of the 3D model into thin horizontal layers, which the printer gradually applies the melted material layer over layer. After hardening and amalgamation of the spread layers, the product gets the final form. The 3D printing process takes several hours. It is true that the print time increases directly proportional to the size of the product [1-4].

At present, the 3D printing is mainly used in the production of plastic products up to 200x200x200mm dimensions. It is a single piece production, in some cases a small batch production. The 3D printing has been used in the manufacture of tools to schools, functional devices, functional metal parts, medicine, art, fashion, etc.

The main benefits of the 3D printing include [5-7]:

- minimal technological and shape constraints over other technologies,
- production efficiency (reduction of cost of tools and devices that are replaced by the 3D printing, up to 98% utilization of material to produce the product, ...),
- production flexibility, that means, it can be manufactured quickly, in required quality and custom made.

3 The 3D printing in manufacturing of an automobile disc

In this part of the paper, an automobile disk production utilizing the 3D printing is demonstrated. The production process of a disc is performed in the following steps [2,5]:

- disk design,
- CAD model creation,
- wall thickness analysis,
- STL format creation and loading,
- 3D printing parameters definition,
- printing process visualiz*ation* in software environment,
- 3D printing process itself.

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The first step is to design a disk shape using a pencil and paper. The proposal is processed in several variants. For the selected disk variant, a 3D model is created in the CAD software. In this case, input for the 3D printing is a three-dimensional CAD model created in SolidWorks 2014 software. Since the designed disk is only used to demonstrate the 3D printing, the relevant STN standards are not considered in parameters and properties of the disc.

The CAD model creation procedure is shown in Figures 1 through 6. First, a disk profile is projected. The Revolved Boss/Base command is used to create a three-dimensional object. The input for the command is a closed disk profile and rotation axis (Centreline) (Figure 1). Following is creation of the internal shape of the disk - using a circle with a selected radius and an Extruded Boss/Base command. Subsequently, the profile from which the material must be removed is drawn and quoted. To remove material, the Extruded Cut command is used (Figure 2). To use the Circular Pattern command, parameters such as the cut-out part profile, the front of the object (blue circle - Figure 2) are required, span extent, number of needed shapes, etc. In this case, it is a flat span of 360 degrees and five beams.

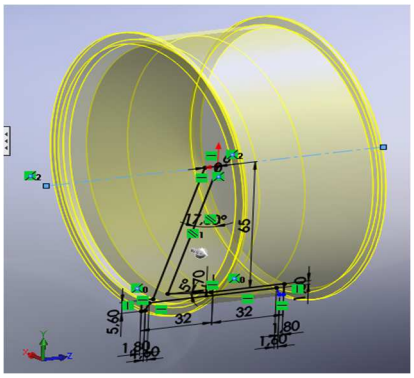

Figure 1 Quoted disk profile

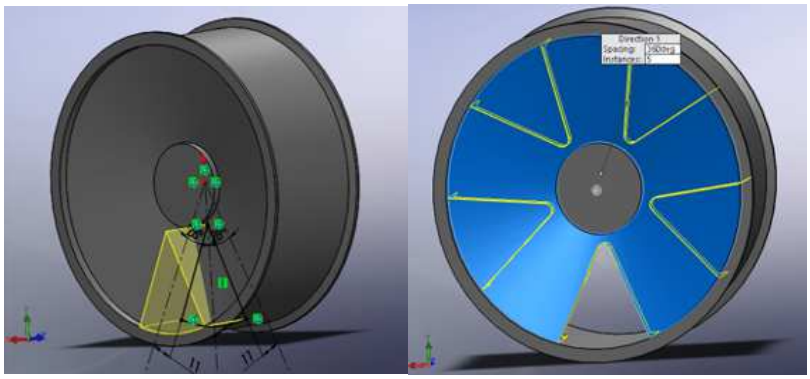

Figure 2 Creation of internal disc shape

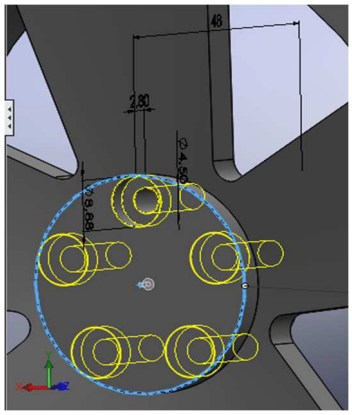

Figure 3 Holes positioning

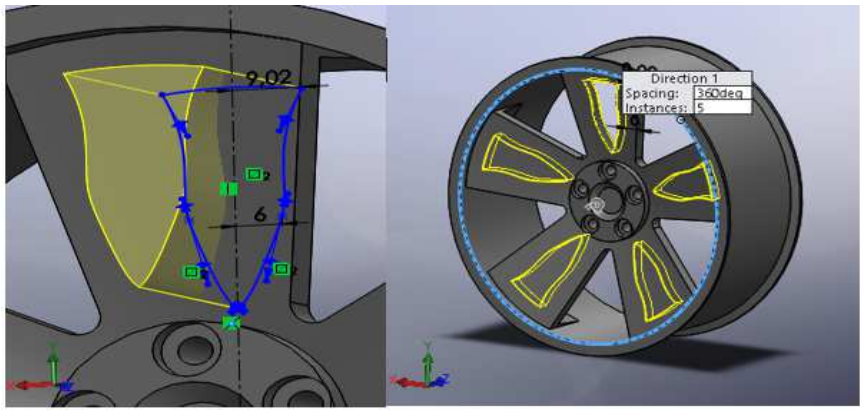

Figure 4 Creating a design using the Extruded Cut and Circular Pattern commands

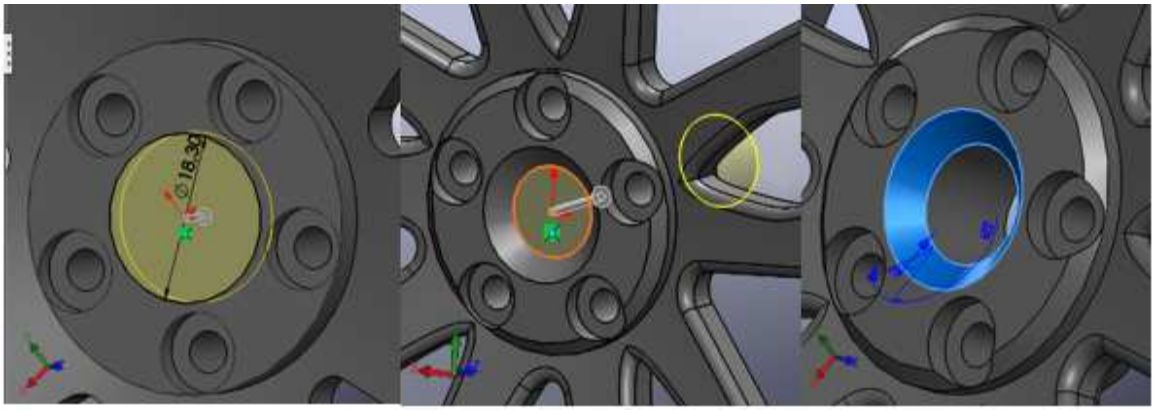

Figure 5 Creation of a driven shaft hole

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Once the wheel beams have been created, it is necessary to draw another circle to the centre of the wheel, in which, after selecting the size and type of the hole, the position of the first hole is applied by means of the Hole Wizard command. The required number of holes is created using the Circular Pattern command, with the procedure used to create disk beams (Figure 3) [6-8].

The next step is to create a new sketch at the centre of the selected beam (Figure 4). The Spline command is used to draw a profile and uses the curve shaping option. After the position is quoted and the curve shape is completed, the Mirror Entities command is used (mirroring). When the profile is finished, the Extruded Cut option is used, after removing the material of the selected shape, the Circular Pattern command is again used, the spacing and number of shapes are set, etc. [6-8].

Figure 5 shows the procedure to create a hole for a driven shaft. The hole is created in the middle of the disc and counter-sinked by the Chamfer command.

The next steps are focused to remove the sharp edges of the disc. To do so, the Fillet and Chamfer commands are used. Removing of sharp edges on the disc increases its aesthetic appearance and security. The final shape and colour of the disc are shown in Figure 6.

The correct wall thickness of the disk is verified by analysis. The results of the analysis provide information on parts of the model in which there is a risk of cracking, spreading flaws, etc. The analysis can be used for the whole model, or only to the selected part of the model. The analysis results are evaluated using the Thickness scale (Figure 7).

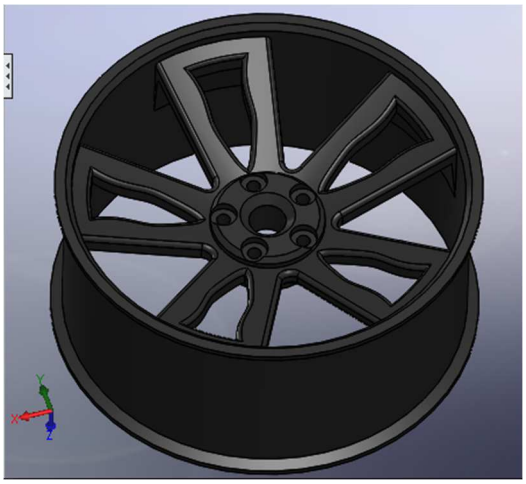

Figure 6 Final shape and colour of the disc

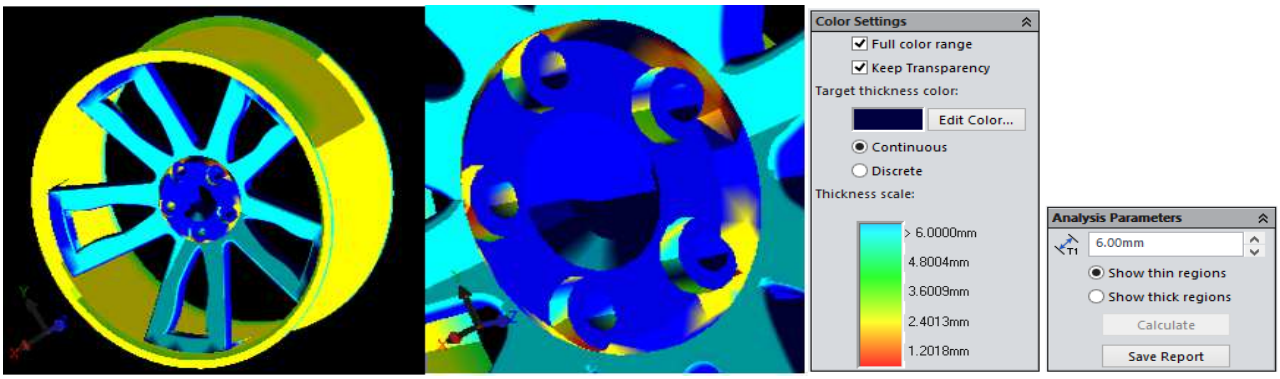

Figure 7 Analysis of wall thickness and analysis parameters

When the shape of the disk is modelled, the STL file is generated, which is the input file for the 3D printer. The STL format retains the shape and dimensions of the disc in the form of small angular pieces (Figure 8).

Subsequently, it is necessary to define the 3D printing parameters such as layer thickness, print quality, fill, fan speed, application layer axis, etc. For the 3D printing of objects such as car disks, it is necessary to use a supporting structure, as without it, focus and beams of the disc would not remain in the desired position. This fact does not need to be considered in the CAD modelling itself, because this problem can be solved by the 3D printer. Before starting the 3D printing, it is necessary to check the input material (quality and quantity). The procedure of printing the disc is demonstrated in Figure 9, [9,10].

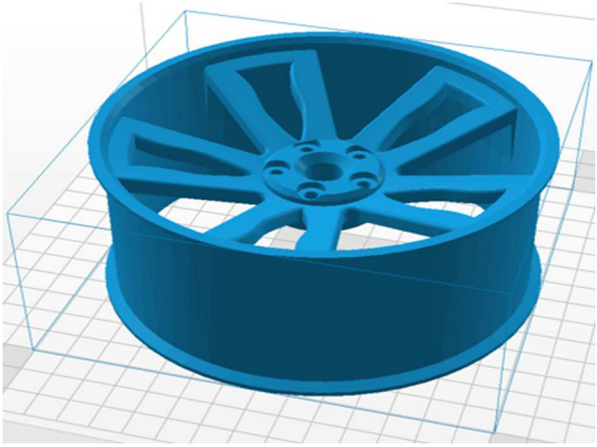

Figure 8 The STL format in the Z-Suite environment

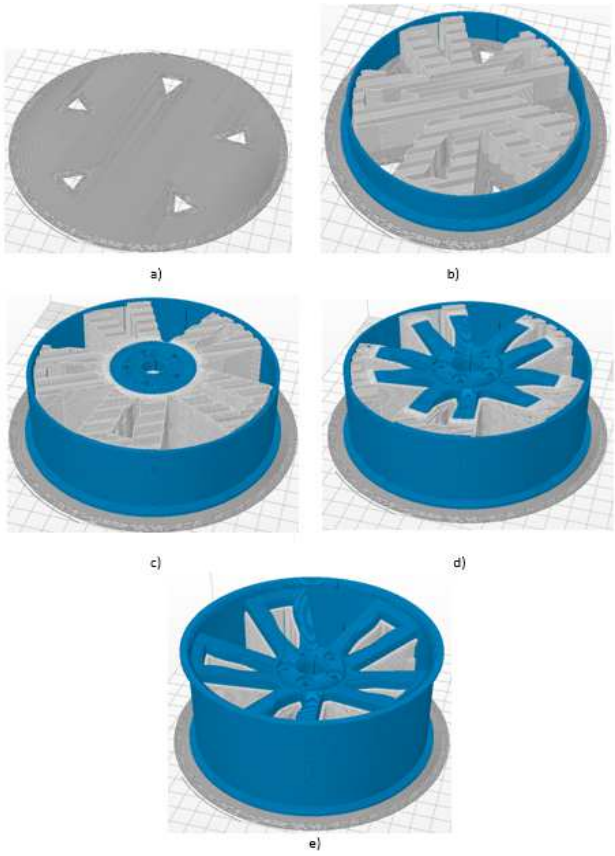

Figure 9 The 3D printing phases of a disc
a) The printing phase of the pad, b) The printing phase of the support structure and hoop,
c) The printing phase of the wheel centre, d) The printing phase of the wheel centre and beams,
e) Visualization of 3D printing with a supporting structure

Figure 10 Physical model made by 3D printing

The finished physical model of a disc produced by the 3D printing is shown in Figure 10. On the surface of the disk are visible layers of gradually laid material. The shape of the disc is not a perfect circle, but a polygon. The surface of the disc can be machined (grind, polish, etc.) as required.

4 Conclusion

Besides to the 3D printing, nowadays also the 4D printing is known. The four-dimensional printing uses a similar technology to the 3D printing - the computer programmes to lay out the material into individual layers that eventually create the entire object. The fourth dimension means that the object changes over time under the influence of heat, humidity or other factors. This is a very difficult and lengthy process, also because of the additional necessity to mechanically programming each printed material so that it changes under the influence of external circumstances. In addition, many of the commercially available printers are able to create an object from just one material. The utilization of the four-dimensional printing can be, for example, in aerocosmonautics or medicine.

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