

CONSTRUCTIVE AND TECHNOLOGICAL CONSIDERATION FOR MAKING THE BODYWORK FOR A FORMULA STUDENT CAR

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ABSTRACT: In the paper are analysed and determinate the optimum solution for making a bodywork for car used in formula student competition. In the first part of the paper the frontal element of a bodywork structure are presented. After the consideration of the generation of this element and positioned of this in rapport with the metallic structure of the car, it is determinate the solution with which can be made the support for generation of the bodywork. The milling machine is a component, which are used in laboratory for make different solution, and component of the car for formula student. An important aspect study in the paper are the deformation of the structure generated at different load forces using an FEA solution from INVENTOR software. Same of this element of the milling machine are generated by 3D printing and are analyse at the last part of the paper.
KEYWORDS: bodywork, CAD, CAM, CAE, 3D printing, PLA

1. INTRODUCTION

There are many ways to make a bodywork, from making it entirely dependent on the human factor to making it almost completely with the help of automatic devices. The creation of a bodywork does not only consider the manufacturing process itself, it also considers the type, the necessary materials used to create a durable, light and visually pleasing bodywork. At the same time, the related costs will be taken into account, because they have a very important factor in its realization. The selection of an appropriate method of manufacturing composite elements for the Formula Student project, which belongs to the UPT Racing Team, was strictly dependent on the cost of the entire manufacturing process and the desired quality of the final product.

The main idea for making the body was to use the method of using a composite material. The main components of the composite material are: mould and reinforcement. The mould is a material that fills the space between the reinforcing elements. Its share in the composite varies from 20 to 80% by volume.

The mould can be of metal or non-metal type (group of polymeric and ceramic composites). Inside the mould is a second component placed, which fulfils the function of transport and due to better strength properties called reinforcement. To ensure the correct manufacture of the composite material it is necessary to combine correctly these two components. In many cases, it requires special preparation of the reinforcement surface (e.g. specific coatings, etching) and appropriate conditions for the fusion process. The selection of the appropriate components is made taking into account the intended purpose of the composite, the conditions of use and, to some extent, the manufacturing technology of the composite.

In order to achieve this body, the official regulations imposed by the FSAE must first be observed. This regulation helps us to see the limit that we can reach in terms of technical characteristics and more. A restriction imposed on the construction of the body is the approach of 75 mm, which means that we can not add any aerodynamic element, or body, which is at a distance of less than 75 mm from the wheel. Having all the rules that we should strictly follow and the limits that we can reach, we can start our activity of designing the bodywork component. This can be done with the help of a CAD or assisted mechanical design program, a program that runs exclusively on the computer being chosen for the design of the bodywork is Autodesk Inventor as a market leader both in terms of access to academic software, but the for ease of design of aerodynamic elements by finite element modelling.

As a method of designing the bodywork, as a component of a car, we need in the first phase to make a mould on which the successive layers of fiberglass and resin can be arranged. This method involves the use of a computer numerical control machine (CNC) that will help us mill the composite materials depending on the shape of the body on which the fiberglass will then be placed with resin.

The machine in question will be made through the operations of creating by 3D printing some necessary parts that must also be designed and tested to see the quality in terms of fatigue resistance and analyse the deformations that can occur.

2. CONSIDERATIONS ON BODY DESIGN

The design program chosen for the realization of the bodywork of the Formula Student vehicle is Autodesk Inventor [1]. This program was chosen because it allows us for the realization of elements with reduced steps compared to other programs of this type. In the first phase, we need the metal structure of the car body and its dimensions. We load and convert the chassis in the program that was made in "step" format, a process that is easily done with this program, because Inventor can convert many types of files with specific format to the format used by it. Later, to facilitate the design activity, we will introduce a vertical auxiliary plan that can be seen in figure 1.

The design process comprises several stages that allow us to generate flat or spatial curvilinear surfaces with which we can give the shape of the body that has an almost final shape shown in figure 2.

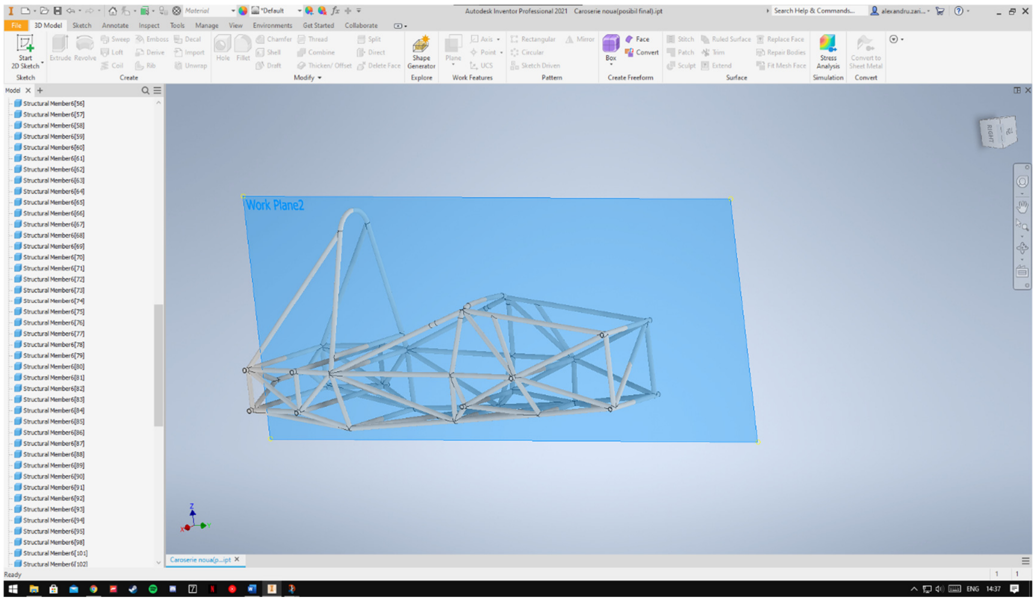

Figure 1. The chassis with the generated plane

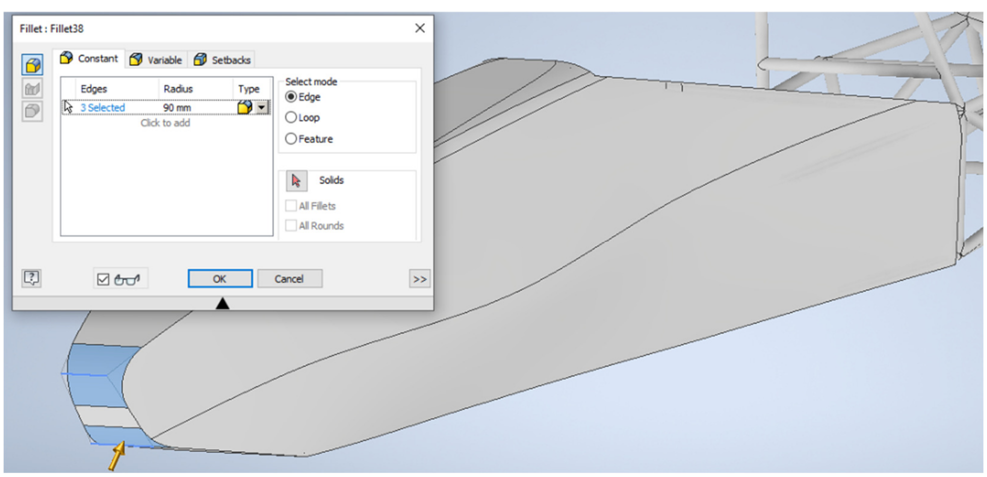

Figure 2. Chassis with one-piece front body

Subsequently, the front part of the body will be divided into two distinct components that will be made separately and mounted on the chassis with 3D-printed fastening systems, an assembly that can be seen in figure 3.

The principle of making the back is similar to that of the front, which is why we will not detail it.

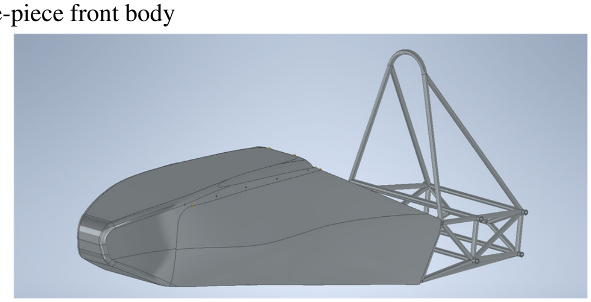

Figure 3. Front body chassis with the two components mounted

3. CONSIDERATIONS ON THE DESIGN OF THE CNC MILLING MACHINE WITH 3D PRINTED COMPONENTS

As in the case of car body design, the same 3D modelling program will be used, namely Autodesk Inventor. This program has once again proved to be extremely efficient in terms of generating parts and combining them in the form of an assembly with constraints that can also be easily found and used with this program.

The components of the machine were made as a spatial body type structure. After that this elements are positioned with orientation and positioning constraints, or centring some in relation to each other, seen in figure 4.

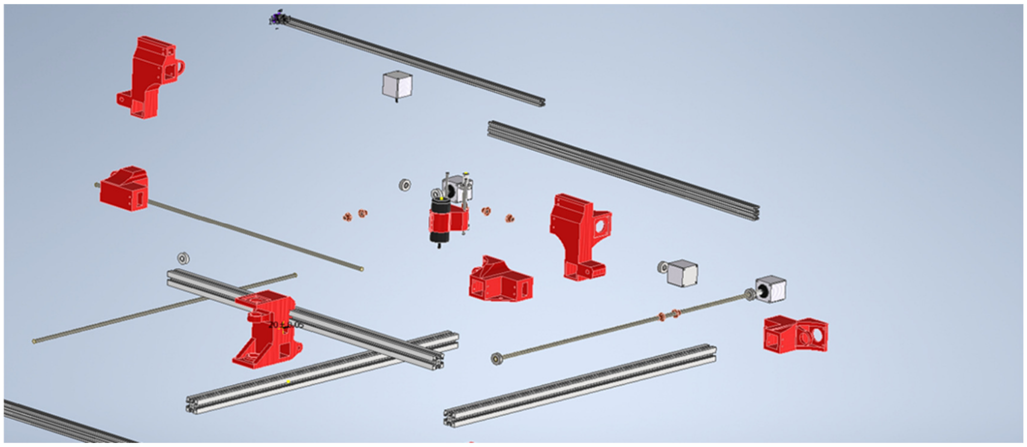

Figure 4. All expanded assemble parts

The completed upper assembly will be positioned on a table with a functional role of supporting the upper part, but also of orientation in order to realize the parts that are subjected to the milling process, seen in figure 5.

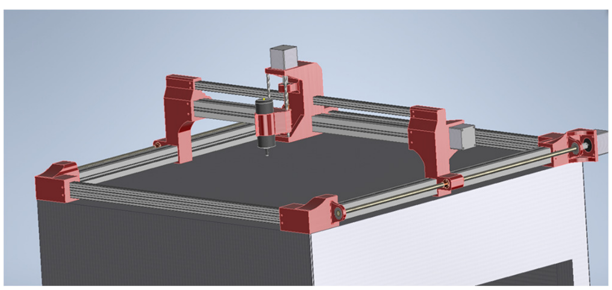

Figure 5. Completed assembly

For the most important component, namely the orientation and positioning of the milling motor, but also its movement along the X axis, the deformations were determined using the finite element analysis module of the Autodesk Inventor 2021 program.

The first important step is the definition of the materials of the components and respectively the definition of the fixed areas and the way in which the loading is performed with specific demands resulting from the calculation program of the processing regime, seen in figure 6. The vertical force at the top is a gravitational type, and the one at the lower central part has the tool axis with which the milling is performed and is the one that can be modified as the load value.

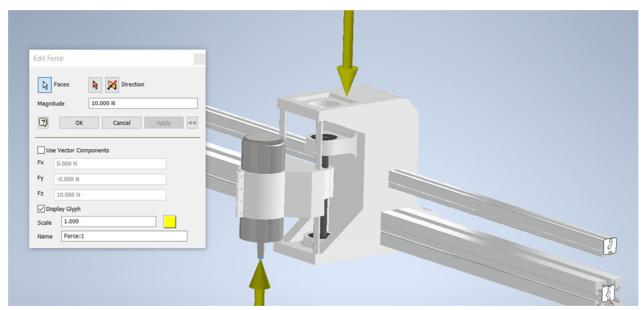

Figure 6. Load force change window

From the simulation program, it is possible to observe that for load forces with a low value of 20 N, the deformation is in the front, seen in figure 7. The deformation values are about 19 microns, while for the higher forces, for example 30 N seen in figure 8, it changes the direction of movement in the vertical direction and the values are about 36 microns.

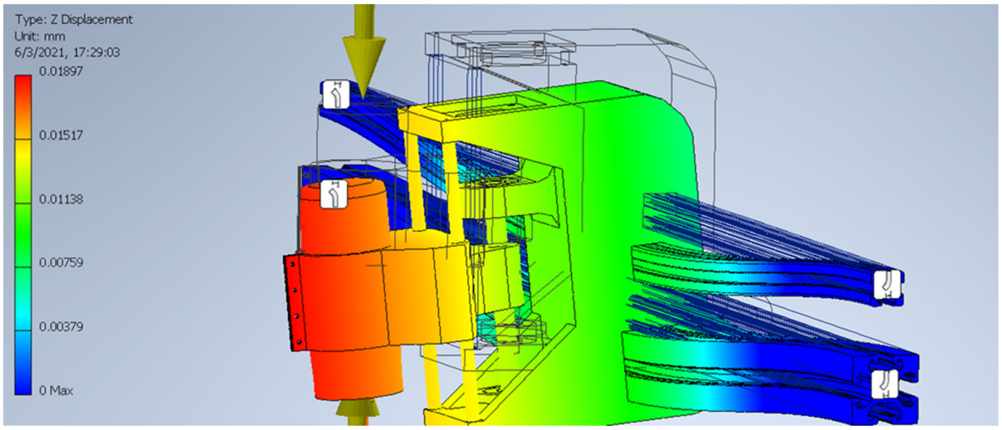

Figure 7. Load force of 20 N

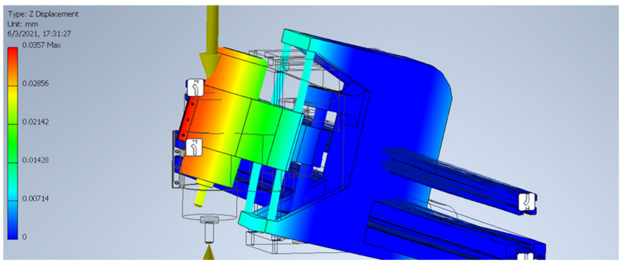

Figure 8. Load force of 30 N

This step is important to study and also to validate the constructive solution. It is possible to observe that if the structure generated for the vertical movement for milling is made by aluminium the value of the gravitational force are approximately 2 units greater than the value of an 3D printed part with PLA or PETG material [2]. For this reason, this element are 3D printed with PLA, and in parallel are take into consideration a study from which we can determinate which material are better for this parts.

4. CONSIDERATIONS ON THE IMPORTANT COMPONENTS REALIZED USING 3D PRINTING

From our point of view, there are some important elements, which can be take into consideration for this part of the study. Two of them are used for movement of milling motor.

First are the vertical part, which made the vertical movement in Z direction in milling process, seen in figure 9.

In the 3D printing solution a Repetier Host [3] with Cura slicer, it is take into consideration. The orientation of this element is important both from the printing time, but also for quality of the part generated, seen in figure 10. The time for printing the part, are 14 hours and 8 minutes with 55,832 meters of filament needed for making it, seen in figure 11.

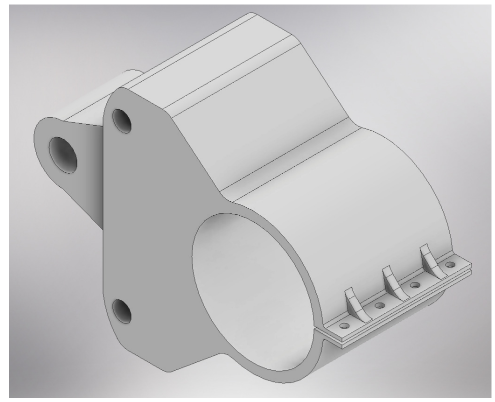

Figure 9. Z movement structure

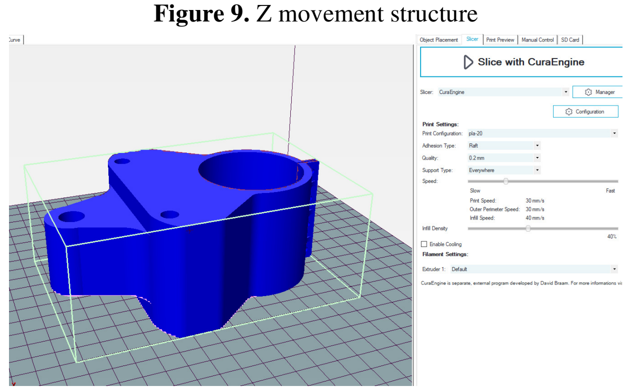

Figure 10. Z structure orientated for 3D printing

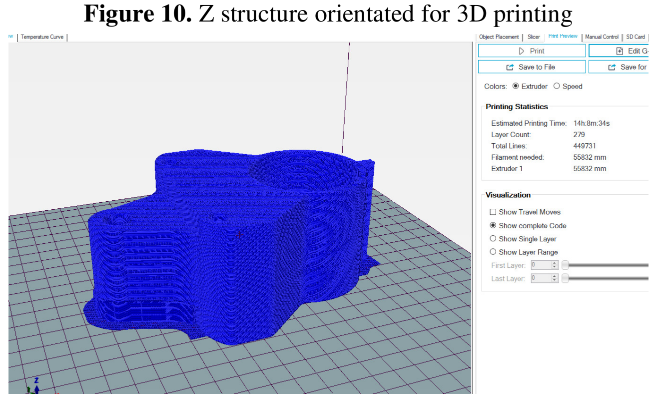

Figure 11. Z structure with supports for 3D printing

To reduce the printing time and material used for making the part, it was generated an internal structure with a lower infill. This solution permit to obtain a similar component with no great difference in term of mechanical proprieties with less material used [4-7].

The second element is the component, which made the movement in X direction figure 12.

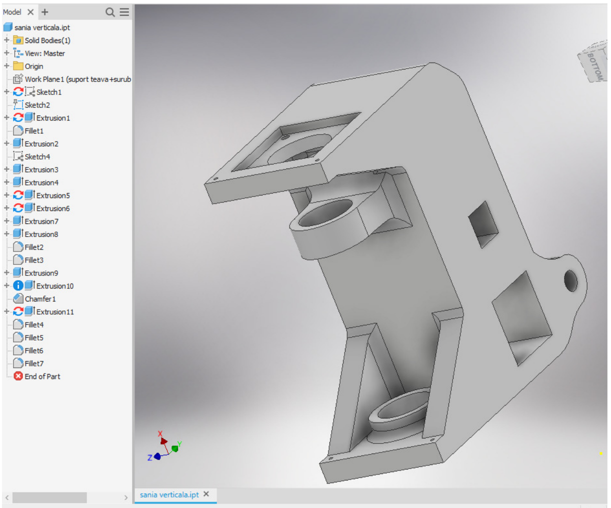

Figure 12. Movement in X direction CAD solution

As a 3D printing solution, a Repetier Host with Cura slicer was take into consideration. The orientation of this element is important both from the printing time, but also for the quality of the part generated, seen in figure 13. The time for printing the part is 61 hours and 48 minutes with 253,997 meter of filament needed for making it, seen in figure 14.

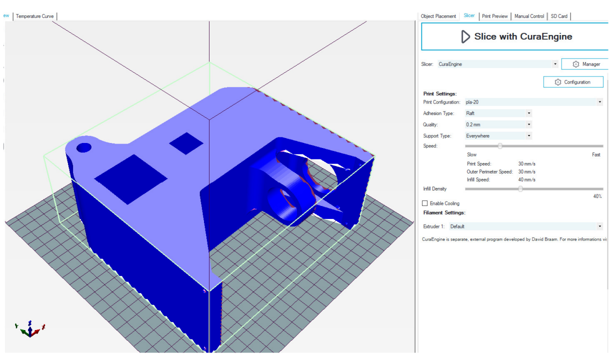

Figure 13. Movement in X direction orientated for 3D printing

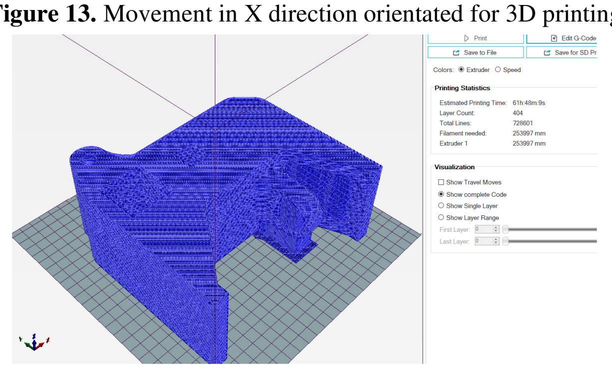

Figure 14. Movement in X direction with supports for 3D printing

5. CONCLUSION

It is possible to observe that the 3D printing solution is one, which reduce the mass of elements but also the deformation of a metallic and non-metallic structure. From our point of view is important to extend this solution both in the CAD-CAM-CAE direction but also in the 3D printing direction.

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