DESIGN AND MANUFACTURE OF A HIGH EFFICIENCY UNIBODY CAR IN COMPOSITE MATERIALS

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1. Introduction

The demand for a sustainable economy and an increased priority of energy safety is increasing interests and investments at the field of electrical vehicular transports [1]. Following these ideas, the EFICEM team of Federal University of Santa Catarina is a group that has the objective to produce new prototypes that aimed to obtaining a better efficiency. The team competes annually at the Shell Eco Marathon Brazil and at Shell Eco Marathon Americas, the competition that has the most efficiency cars in the world [2]. The production of a new careen for the new prototype entire of composite materials as carbon fiber and epoxy resin aimed to fix the problems of the last prototype. The problems were structural rigidity, small intern surface, aerodynamics performance. Furthermore, the entire part must be in accordance with new rules of the competition. This manuscript reports all the conception and manufacturing steps of the unibody car.

2. Experimental

The manufacturing of the unibody structure started with a project in 3D software CAD/CAM (computer-aided design) Solid Works 2018. After this step, a high-density polyurethane block was machined using a precision CNC vector machining at Protville company to obtain the plug. From this plug, the mold was manufactured in composite via spray-up process. This manufacturing step was carried out at Lan Fibras Company, located in Joinville/SC. The materials used were roving fiberglass and ortho-polyester resin. Afterwards, this mold was used at the final lamination. In order to achieve the final part – unibody car - a vacuum bag process was performed. For structural performance a sandwich panel was used, where the materials were layers of carbon fiber cloth (200g/m²), core material of semi-rigid PVC foam (6mm width) D60 Divinicell and epoxy resin from Barracuda Composites company AR260 with AH260 cure agent. The steps are shown in **Fig. 1**.

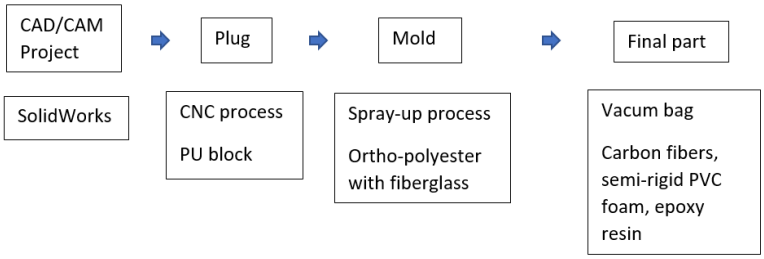

Fig. 1 – *Summary of the manufacturing steps of the unibody.*

3. Results and Discussions

Hereby, the details about the process steps are described. Initially, the main dimensions of the unibody were projected considering the requirements of the Shell Eco Marathon 2018[2]. From the last version, an extra distance between the pilot and the front of the car was included, which also guarantees a wider visibility of the pilot. In addition, a larger internal space and better insulation of the pilot in relation to the steering system and wheels were also some of the requirements of the new project. Even with these modifications, the design needed to maintain the fundamental aspects of aerodynamics and droplet shape of the car. **Fig 2** shows the project with all the requirements. The next step was to obtain the plug, which must replicate in three dimensions the project of the final part. For this, a polyurethane block was machined, see **Fig. 3**.

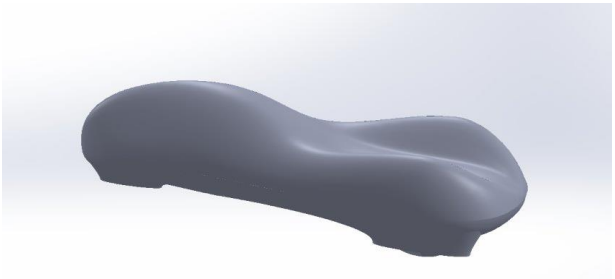

Fig. 2. *3D Solid Works project of the entire project*

Fig. 3. *Plug in polyurethane after machining.*

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Afterwards the plug was prepared to the next step. Since the material of the block adheres with the polyester resin used in the spray-up process, it was necessary to use a water-based acrylic paste together with a water-based paint for the insulation of the plug. After finishing the plug, the mold got laminated using fiberglass and resin via spray up process. The process should provide a rigid and robust component, which will be used as a mold of the final part. **Fig 4** shows the mold after the process. The crucial point of the process was the final part. In order to achieve a high performance part, a vacuum bag process was used. The vacuum removes the excess of resin and removes any voids from the lamination [3-4]. First, resin was spread all over the mold and then positioned the first layer of carbon fiber. Then, the semi-rigid PVC foam, previously cut, were placed onto the entire mold. Sequentially, resin was once again passed through with other layer of carbon fibers, forming the sandwich structure. Finally, bag was used to seal the entire mold. The bag was sealed with sealing tape. The vacuum pump was used at a pressure of 500 mm Hg for approximately four hours. Finally, the unibody was demolded, see **Fig 5**.

Fig. 4. *Mold after spray up process, bottom view*

Fig. 5. *Composite unibody demolded.*

Fig. 6. *EFICEM prototype competing at Shell Eco Marathon Americas 2018*

4. References

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