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COMPOSITE BODYWORK DESIGN AND CREATION PROCESS IN FSAE. CASE STUDY AGH RACING

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ABSTRACT

In this paper there is manufacturing of bodywork of a race car presented with a case study of AGH Racing team. Design and creation process begins form virtual prototyping of a model though mold manufacturing and ends up on infusion process.

In order to achieve intended properties of composite materials a proper bonding of reinforcing layers has to be conducted during manufacturing process. It is one of the fundamental quality evaluation criterion while considering fabrication processes.

KEYWORDS: Composite Parts, Manufacturing, Infusion, Mould, Hot Wire Cutter

INTRODUCTION

There are many methods of creation of composite materials – from entirely dependent from the human factor, to almost fully automate. Selection of a proper manufacturing method of composite elements in case of Formula Student project to which AGH Racing team belongs was strictly dependent from the cost of the whole fabrication process and desired quality of the final product.

The main components of the composite material are: matrix and reinforcement. The matrix is a material filling the space between the reinforcing elements. Its share in the composite ranges from 20 to 80% of volume. The matrix may be metals

(Metallic composites group) or non-metals (group of polymer composites and ceramics). Inside the matrix, there is a second component placed which fulfill carry function and due to better strength properties called reinforcement. In order to ensure proper manufacture of the composite material it is necessary to correctly combine these two components. In many cases, it requires a special preparation of the surface of the reinforcement (eg. Specific layers of coating, etching) and corresponding conditions for merging process. The selection of suitable components is made by taking into account the intended purpose of the composite, conditions of use and to some extent anticipated composite manufacturing technology. There are glass, carbon, poliaramid and ceramic fibers. This article focuses on the presentation of the first three with a use of polymer matrix.

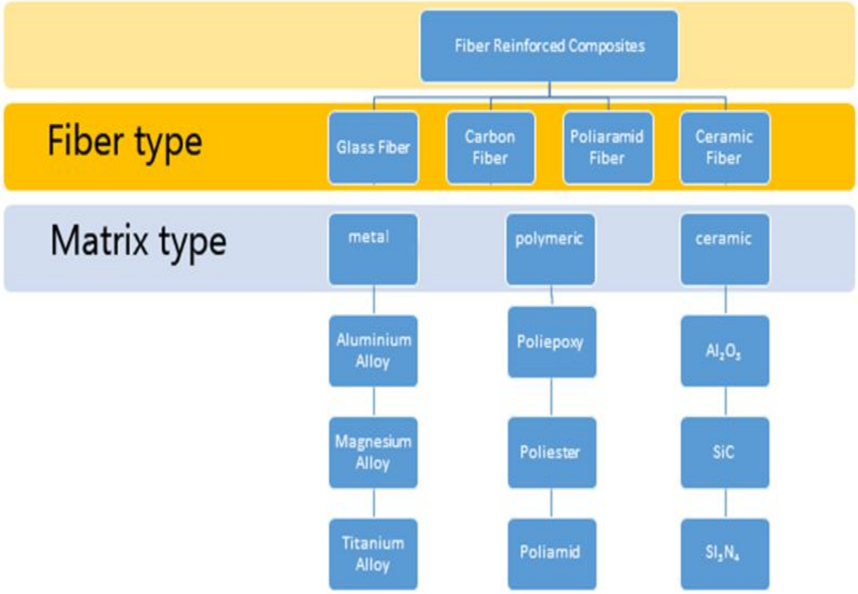

Figure 1

Carbon fibers are primarily used in the composites production, where exist a necessity to combine lightness with a rigidity. Poliaramid fibers also known as Kevlar, have a much better impact strength, and thus are often used in the defense industry. The glass fibers provide the weakest strength and have the worst properties from all above mentioned. However, in many cases this choice is determined by the low offered cost.

Material	Elastic Modulus E [GPa]	Elongation Strength Rm [GPa]
Carbon Fibers	253	4,5
Kevlar	124	3,6
Glass Fibers	86	4,5
Poliepoxy Warp	4	0,1
Carbon Fiber Reinforced Composite	145	2,3
Kevlar Fiber Reinforced Composite	80	2,0
Glass Fiber Reinforced Composite	55	2,0

Figure 2

In order to obtain the intended properties of the composite material there is a necessity to proper combine a reinforcement with a matrix in the production process. Greater volume of the carrier material (fiberglass, carbon or Kevlar) in the composite material means better properties. It is one of the main criteria while evaluating manufacturing technologies, which are very numerous - from the methods which are dependent from the human factor to the one that are almost completely automatic. Selection of method in case of Formula Student project is strictly dependent on the the budget of a particular team.

BODYWORK MANUFACTURING PROCESS IN AGH RACING

Mould

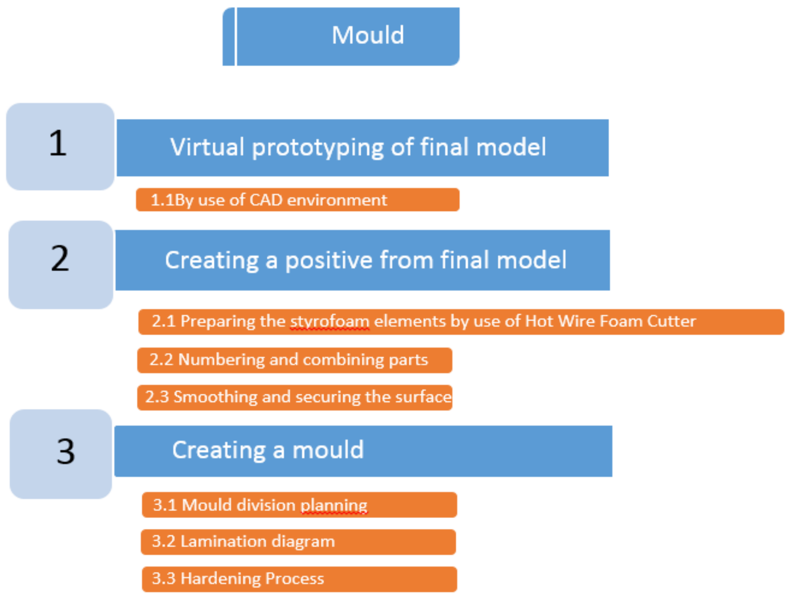

Figure 3

The first step towards creation of mould is virtual prototyping of a final model. Such designed and next manufactured from the given material shape is then subjected to a further process reflection, thereby creating a mould from positive.

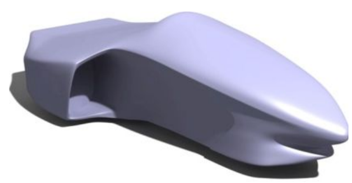

Figure 4

In the case of AGH Racing team, as the material for positive, the styrofoam was chosen. Due to its availability, cost and ease of processing. To its formation, a numerically controlled hot wire cutter was used.

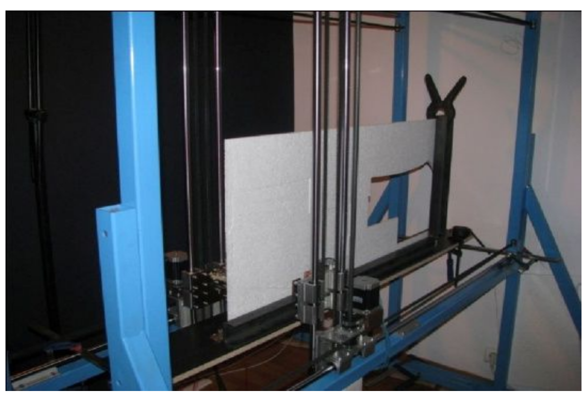

Figure 5

At the stage of virtual prototyping the model is divided into many pieces to fit in the working area of the machine. While differences in the dimensions of styrofoam blocks reached up to 2 millimeters it became necessary to implement compensatory measures and to improve the control code, which further allowed almost complete elimination of dimensional errors. Moreover an important issue was a proper selection of wire temperature to the material thickness because it is too low value posed a threat to tear the wire and too high- melt the styrofoam. During the cutting performed by the machine, each part was given a number to allow further bonding for the purpose of assemble.

Figure 6

Such fabricated positive of a model was then putted by use of universal putty (or acrylic for minor irregularities) to smooth the surface and prevent corrosive effects of resins used in the further stages. The culmination of these treatments was imposing a varnish spray on the entire surface of the model, and then inequality grinding by use of sandpaper of high gradation. This step was very laborious, since the occurrence of defects in form of surface irregularities threatened obtaining a mould of a low accuracy.

Figure 7

Just before proceeding the mould manufacture and in order to obtain a precise shape of the final model, it is necessary to select proper mould layout to allow further, non-invasive stripping of the final model. For this purpose, in a place of the future division lines the thin walls of plexiglass (of 1 mm thickness) were inserted on the surface of the positive of a model.

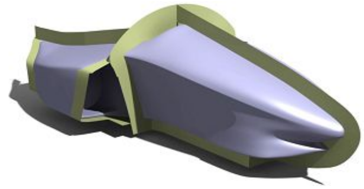

Figure 8

For such designed surface there were gel coat layer, reinforcement and resin applied by use of hand lamination method. The role of the barrier resign was to protect from exothermic reactions that might occur during the curing of epoxy resins. Heat distribution is significant because it negatively affects the final structure of the gel coat surface, and consequently -result in further difficulties in demoulding and poorer quality of the final product. Depending on the size of the mould it

must be reinforced with a suitable number of layers of glass fiber, epoxy resin so as to ensure adequate stiffness and strength to withstand the vacuum pressure. The time of hardening process of such prepared mould varies mainly depending upon the resin / gel coat and hardener. The gel coat loses its plasticity for a period of about 20 to 65 minutes. The epoxy resin needs 35 to 200 minutes. Such prepared mould is suitable for demoulding from positive and ready for infusion process.

Figure 9

Infusion

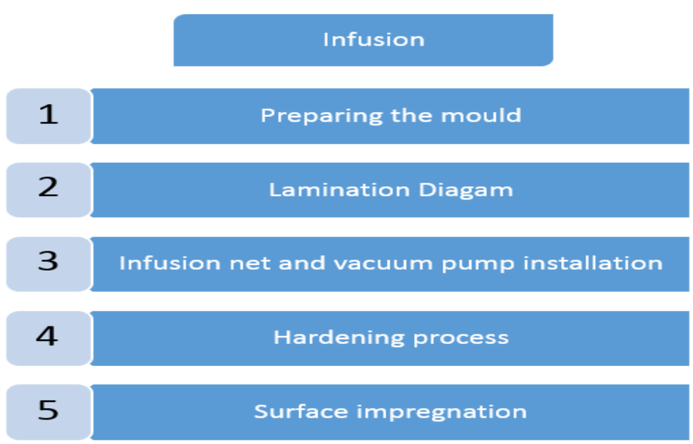

Figure 10

Vacuum Infusion is one of open mould forming method which allows to obtain a composite characterized by a very high performance. Manufacturing begins from overlapping layers of reinforcement (without resin) which are next fixed by use of an adhesive. In the following step, in order to enable resign distribution, the channels are placed for resin injection and suction of air from the vacuum bag. By means of pressure difference between the channel inlet and the outlet the resin is sucked between the vacuum bag and the form and distributed through the whole space. The cost of the process is higher than in the case of hand lamination, however, the quality compensates this inconvenience.

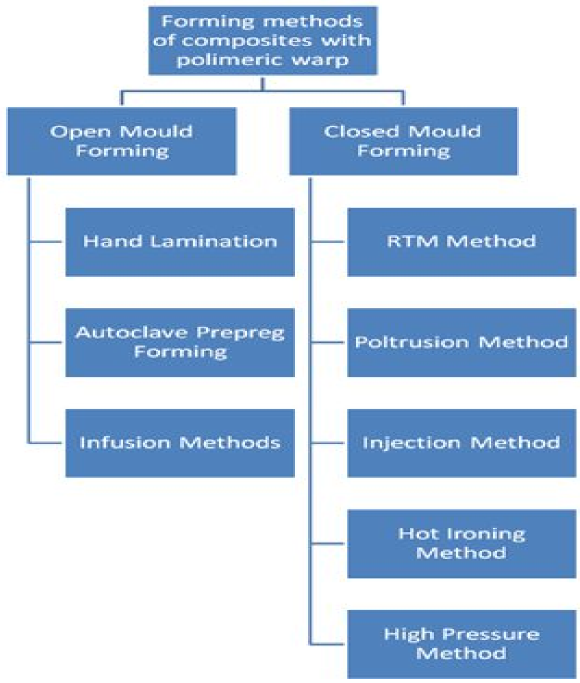

Figure 11

In case of AGH Racing actions designed to begin the process of infusion were associated with the need to ensure that the internal side of the mould is perfectly smooth to avoid problems with the demoulding of the final product. For this purpose, the surface was polished with wax, and then treated with a layer of polyvinyl alcohol. On such prepared surfaces, by use of a special glue,the layers of fibers were overlapped. In the case of AGH Racing two layers of carbon fiber and single layer of Kevlar (both Twill weave) were chosen for that purpose.

Figure 12

After material forming process, on the surface of the mould, there is infusion net and tubing was installed to enables flow of epoxy resin. Tubing was deployed along the edge of the mould in order to provide the best and most efficient flow of matrix. Thus prepared components were then put into the vacuum bag, in which two valves were placed one for vacuum pump and second resin reservoir.

Figure 13

In fact, the process of infusion can be considered from the moment of connection of the vacuum pump.

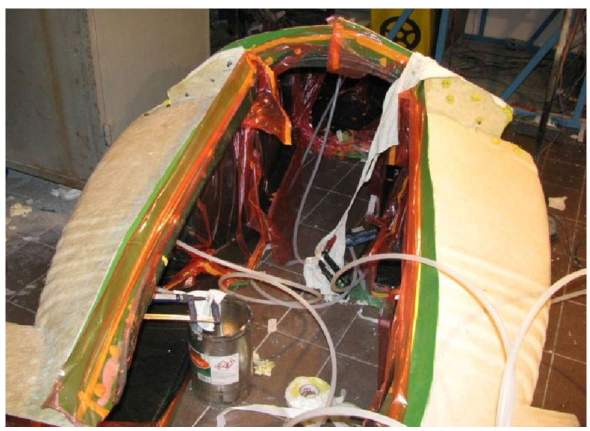

Figure 14

The whole process lasts several hours, until resin was completely hardened. This time varies depending on the type of resin and the amount of hardener used in the blend. The result of all these operations was a finished final product that needed to have vacuum bag, net and tubing removed and then be demoulded.

Figure 15

Obtained final model still required purification from residues, trimming any excess material and impregnation.

Figure 16

CONCLUSIONS

Considering conduction of such processes in academic environment is strongly supported by the fact that a good quality of the final product does not always come with a necessity to incur high cost. Moreover simplicity of the whole processes gives the ability to produce the models of any shapes and sizes, significantly expanding spectrum of future applications.

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