Design and Manufacturing of Composites Chair

Université Concordia University

A. Mostafa, H. Alshahrani, K. Younes, S. Abdelkhalek, D. Ma, J. Ajaja, A. Karimi and Y. Elshami

ABSTRACT

A complete lightweight chair made of glass fiber reinforced plastic (GFRP) was produced using hand-lay-up technique. No metallic joints, supporters, or bolts were used. The chair production was proposed as a competitive project in one of the graduate courses (MECH6521) at Concordia University. Four groups were involved in this competition. Among these four groups, this work has won the best composites chair design and got the full mark grade. AutoCAD 3D design coupled with mechanical stress analysis were employed to produce GFRP chair able to carry a person with maximum weight of 120 Kg. Five layers of continuous epoxy resin and fiber glass laminates were stacked together in different orientations (0°/45°/90°) to enhance the shear-stress resistance. No Autoclave or post curing furnaces were used during the production process. Honeycomb structure was used between the composite laminates in the back and the seat of the chair to provide comfortable sitting position. In order to strengthen the chair legs, L-shape strips were extrapolated from the same fiber cloth used in making the chair body. Moreover, a new internal-bridging methodology was invented in this design to avoid legs distortion or deflection upon loading. The total cost was relatively acceptable comparing to the available resources, since we used a temporary mold to produce only one single product. Thus, the product could be feasible for mass production if the manufacturing process being automated. Safety and quality insurance procedures were applied, and the produced chair passed the loading tests successfully. The professor, the project instructor, was so impressed of the final product and he proposed our design to the industry.

INTRODUCTION

Modern composite materials were developed in the mid-1940s to meet the requirements of the industry in terms of weight, stiffness and strength [1-3]. Aerospace and space industries are certainly ones that have contributed the most to the development of these materials. Different processes are used to manufacture composite materials. Techniques such as automated filament placement (AFP) are used to produce critical components whereas processes such as hand lay-up are used for low stress applications where dimensional accuracy is not required [6-7]. For the scope of this study, hand lay-up processing was used to manufacture a composite seat designed with the requirement of withstanding a load of 80 kg. This poster demonstrates the hand lay-up manufacturing process of composite seat including the design concepts and materials used, details of the mechanical stress analysis, assessment of the quality of the product and remarks on the final product

MOTIVATION

The seat production was proposed as a competitive project in one of the graduate courses (MECH6521) at Concordia University. Two designs were suggested by the course instructor. After agreement with the instructor, we introduced our own design for a complete seat made of composites, facing all the challenges of having a successful product as well as to have the advantage over the competitive groups.

OBJECTIVE

The main objective of this work is to manufacture a seat made of polyester/fiber glass composite materials using hand-lay-up method and cured in the normal conditions. No autoclave and/or post curing furnaces are recommended. Moreover, the product should be able to withstand an 80kg of load.

METHODOLOGY

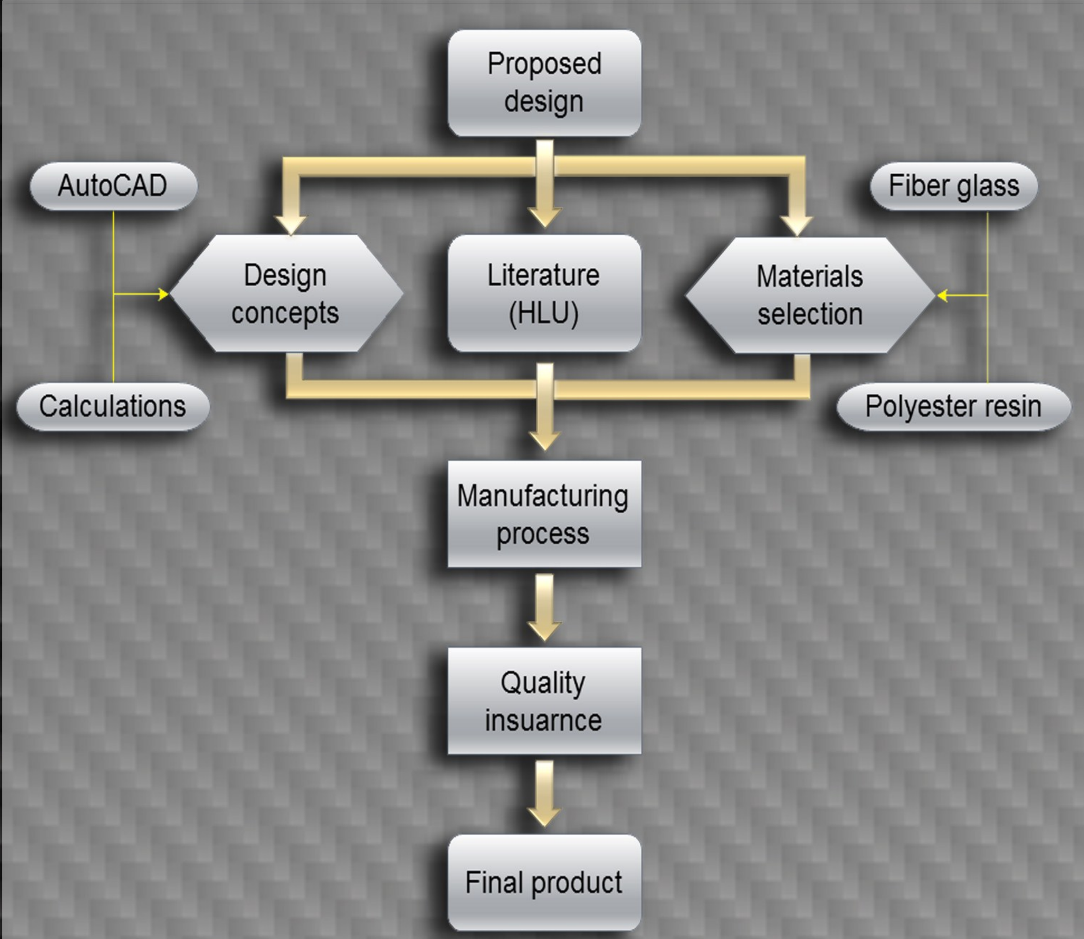


Figure 1: Project methodology flow chart

AutoCAD 3D Design

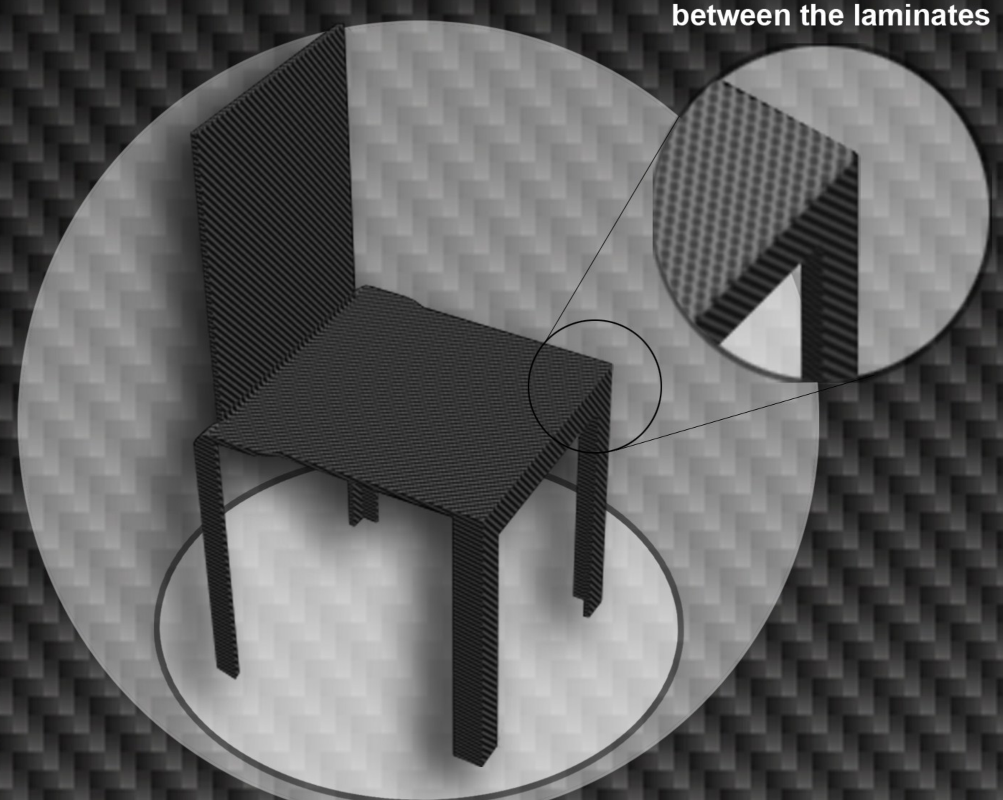


Figure 2: Realistic 3D design for the seat

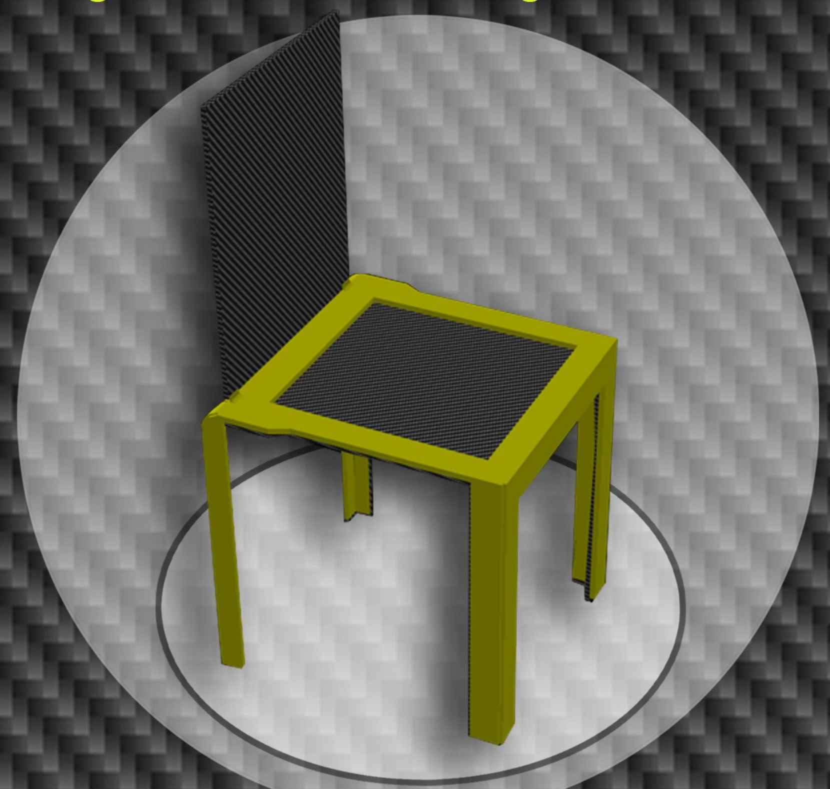


Figure 3: Invented internal-bridging methodology

MATERIALS

Figure 4: Polyester resin and hardener

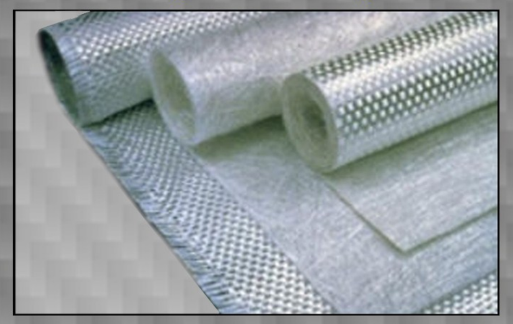


Figure 5: Fiberglass cloth

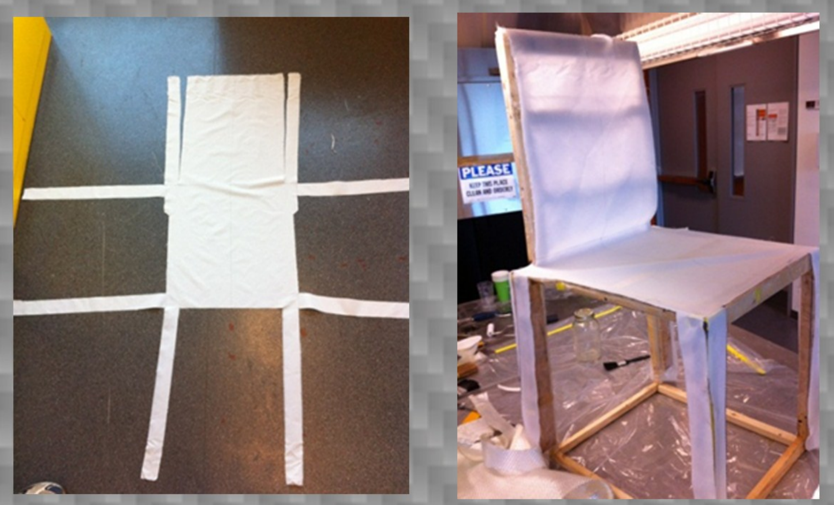
Figure 6: Release agent

PROCEDURE

STEP I: Mold preparation

Figures 7, 8: Wooden mold preparation and plastic sheet covering

STEP II: Fibers preperation

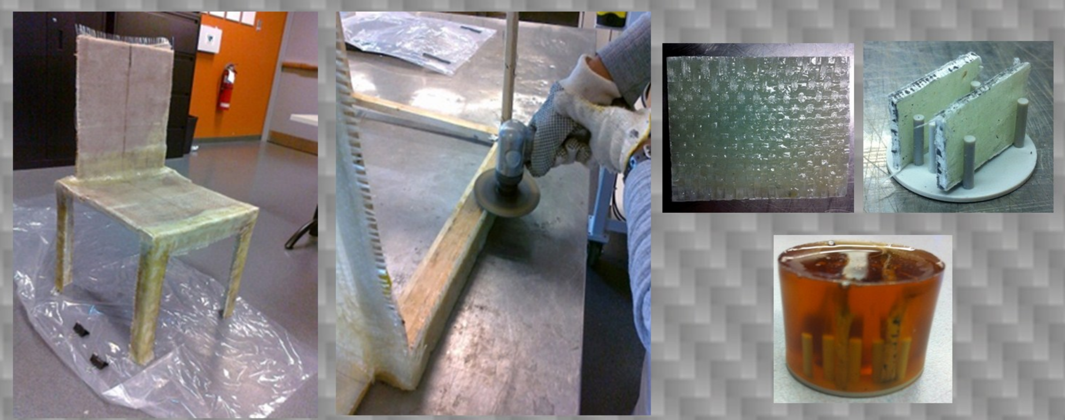


Figures 9, 10: Cutting fiber cloth in a shape similar to the developed seat design

STEP III: Application of epoxy resin/fiberglass composites

Figures 11, 12, 13: Application of the compposites laminates

STEP IV: Finishing and inspection



Figures 14-18: Applying all the composites laminates, trimming the excess edges and microscopic inspection

RESULTS & DISCUSSION

A complete seat made of polyster resin/fiberglass composites has been designed and manufactured. The produced seat prooved that it could withstand 120kg instead of 80kg, since we used safety factor of 1.5 during the design step. Moreover, no metallic joints and autoclave were used in producing the seat. All the resin curing conditions were under normal pressure and room temperature.

Figure 19: The final seat made of polyster resin/fiberglass composites

It was noticeable that the polymeric resins show a degree of shrinkage after curing process. Therefore, it was difficult to take out the composite structure away of the mold. To overcome this difficulty, the mold was easy to be disassembled and the composite seat was taken easily after.

The legs geometry was calculated during the design stage. The thickness of each leg should be 2mm. However, the actual thickness is about 10mm. The reason is that the composite laminates were diverging towards the L-shape edges. Hence, no pressure was applied to keep them stick along the assigned geometry.

The cost of producing such design was estimated to be $200. This value was obtained for producing single piece; however, the cost can be reduced if large quantities of this product are made. Table 1 summarizes the details of the production costs.

Table 1: The expected cost for producing a polyster resin/fiberglass composite seat

Item	Description	Cost
1	Fiber glass	$ 36.48
2	Honeycomb core	$ 44.35
3	Polyester Resin	$ 18.55
4	Epoxy Resin	$ 62.7
5	Black Spray	$ 8
6	Lining Tape	$ 1
7	Wooden parts for Mold	$ 5
8	Plastic sheets for Mold	$ 4
9	Gloves and tools	$ 20
	Total Cost	$ 200

CONCLUSIONS

1- The Hand-Lay-Up process is efficient process to make complex shaped and unrepeatable parts. Besides these advantages, many disadvantages can be concluded after applying the HLU procedure:

- The HLU structures contain many voids, especially if the autoclave equipment is not in use.
- In HLU, the surface quality of the product is very poor. The layer thickness is not homogenous and it depends on the individual labor skills.

2- The cost can be reduced for mass production, especially when the process is automated.

ACKNOWLEDGEMENT

We would like to acknowledge Prof. S.V. Hoa for giving the opportunity to present our capabilities. Dr. M. Xie and Asgar-Khan are also acknowledged for their technical support during the production process and microscopic inspection.

REFERENCES

[1] http://www.dsm.com/en_US/images/drs/history_DSM_Composite_Resins.pdf (Accessed November 2011)
[2] http://strong.groups.et.byu.net/pages/articles/articles/history.pdf (Accessed November 2011)
[3] E. P. Scala, "A Brief History of Composites in the U.S. – The Dream and the Success", JOM, 48 (2), pp. 45-48 (1996)
[4] P. Hubert, "Polymer Composites for Aerospace Applications", MIME 565, , McGill University, winter 2009
[5] http://speautomotive.com/pdfs/11%20Files/ACCE/K4-Corrected.pdf (Accessed November 2011)
[6] S. V. Hoa, "Principles of the manufacturing of composite materials", Destech Publications (2009), Chapters 2-4
[7] S. C. George, S. Thomas, "Manufacturing of Multiphase Polymeric Systems" in "Handbook of Multiphase Polymer Systems", 1st Edition, Boudenne, A. B., Wiley (2011), Chapter 5