Vacuum Assisted Resin Transfer Molding Technology

Authors

Azam Ali	14001134046
Mirza Sadullah Baig	14001134041
Danish Riaz	14001134043

Supervisor

Dr. Tipu Sultan
Assistant Professor

DEPARTMENT OF MECHANICAL ENGINEERING
UNIVERSITY OF MANAGEMENT AND TECHNOLOGY
LAHORE

2018

Vacuum Assisted Resin Transfer Molding Technology

Author

Azam Ali	14001134046
Mirza Sadullah Baig	14001134041
Danish Riaz	14001134043

A Project submitted in partial fulfillment of the requirements for the degree of

B.Sc. Mechanical Engineering

Project Supervisor:
Dr. Tipu Sultan
Assistant professor

External Examiner Signature:_____
Project Supervisor Signature: _____

DEPARTMENT OF MECHANICAL ENGINEERING
UNIVERSITY OF MANAGEMENT AND TECHNOLOGY
LAHORE

June 2018

Abstract
Vacuum Assisted Resin Transfer Molding Technology

Azam Ali	14001134046
Mirza Sadullah Baig	14001134041
Danish Riaz	14001134043

Project Supervisor: Dr Tipu Sultan

Assistant professor

The composite materials are widely using in place of conventional materials due to its particular properties. There are a number of methods to manufacture composite material products but Vacuum Assisted Resin Transfer Molding (VARTM) technology has many advantages over RTM. It is a cost effective molding method especially using for long sheets.

Our aim is to make an understanding and feasibility of this technology. Our aim is to manufacture a composite material sheet by using VARTM technology. And after that to make an understanding of VARTM for complex geometry. This is not an easy task because finishing of sheet is not easy to achieve without upper part of mold. Flow of resin effects the finishing of the part. If flow is inappropriate then voids can be produce. Flow timing is an important factor when it will slow or fast it results a defective part. Incomplete impregnation of resin will cause dry spots in the manufactured part. Distribution media places on the top of the fiber to accelerate the resin flow. So, porosity, permeability and thickness of distribution media and fiber or reinforcement are also important factors. Another challenge is to design VARTM process. Inlets for resin impregnation is an important factor that how many inlets

should be for proper impregnation and where these inlets should be introduced to the mold. Leakage of vacuum bag is another challenge so proper sealing of system is required. Vacuum timing is also notable factor. Pressure and temperature of resin to introduce into the mold is also part of design challenges which we will achieve. Finishing of the final part including less voids, better surface finishing, precise and dimensions is the main aim of our project which we will achieve.

Keywords: VARTM Technology, composite material, Resin flow

UNDERTAKING

I certify that research work titled "*Vacuum Assisted Resin Transfer Molding Technology*" is my own work. The work has not been presented elsewhere for assessment. Where material has been used from other sources it has been properly acknowledged / referred.

Azam Ali

14001134046

Mirza Sadullah Baig

14001134041

Danish Riaz

14001134043

ACKNOWLEDGEMENTS

It is our privilege to express our sincerest regards to our project coordinator, Dr. Tipu Sultan and Professor Khazar Hayat, for their valuable inputs, able guidance, inspiration, whole-hearted cooperation and constructive criticism throughout the duration of our project. We deeply express our sincere thanks to our Head of Department Dr. Tariq Mehmood for encouraging and allowing us to present the project on the topic "Vacuum Assisted Resin Transfer Molding Technology" at our department premises for the partial fulfillment of the requirements leading to the award of Bachelor's degree. We take this opportunity to thank all our lecturers who have directly or indirectly helped our project. We pay our respects and love to our parents and all other family members and friends for their love and encouragement throughout our career. Last but not the least we express our thanks to our friends for their cooperation and support.

TABLE OF CONTENT

Undertaking iv

Acknowledgements v

Table of Content vi

List of figures ix

Abbreviations xi

Chapter 1 1

1. Introduction 1

1.1 Composite materials ..... **Error! Bookmark not defined.**

1.2 Vacuum Assisted Resin Transfer Molding (VARTM) Technology ... **Error! Bookmark not defined.**

Chapter 2 ..... **Error! Bookmark not defined.**

2. Literature Review ..... **Error! Bookmark not defined.**

2.1 Permeability and Resin Flow ..... **Error! Bookmark not defined.**

2.2 Resin flow Transfer molding ..... **Error! Bookmark not defined.**

2.3 Vacuum Assisted Resin Transfer Molding (VARTM) ... **Error! Bookmark not defined.**

2.4 RTM Vs. VARTM ..... **Error! Bookmark not defined.**

2.5 Compaction of the Preform ..... **Error! Bookmark not defined.**

Chapter 3 ..... **Error! Bookmark not defined.**

3. Thickness variations ..... **Error! Bookmark not defined.**

3.1 Thickness variations in infusion process ..... **Error! Bookmark not defined.**

3.2 Thickness variations in curing process ..... **Error! Bookmark not defined.**

Chapter 4 ..... **Error! Bookmark not defined.**

4. Vacuum and its effects ..... **Error! Bookmark not defined.**

4.1 Creation of Vacuum ..... **Error! Bookmark not defined.**
4.2 Identification of leakages ..... **Error! Bookmark not defined.**
Chapter 5 ..... **Error! Bookmark not defined.**

5.1 Material ..... **Error! Bookmark not defined.**
5.2 Equipment and their description ..... **Error! Bookmark not defined.**
5.2.1 Vacuum pump ..... **Error! Bookmark not defined.**
5.2.2 Resin (epoxy-hardener) ..... **Error! Bookmark not defined.**
5.2.3 Fiber (carbon fiber/ glass fiber) ..... **Error! Bookmark not defined.**
5.2.4 Vacuum bag ..... **Error! Bookmark not defined.**
5.2.5 Vacuum sealant tape ..... **Error! Bookmark not defined.**
5.2.6 Vacuum catch-pot ..... **Error! Bookmark not defined.**
5.2.7 Vacuum pipes and connectors ..... **Error! Bookmark not defined.**
5.2.8 Release agent ..... **Error! Bookmark not defined.**
5.2.9 Vacuum gauge ..... **Error! Bookmark not defined.**
5.2.10 Peel-ply: ..... **Error! Bookmark not defined.**
Chapter 6 ..... **Error! Bookmark not defined.**

6. Manufacturing of fiber sheet ..... **Error! Bookmark not defined.**
6.1 Overview ..... **Error! Bookmark not defined.**
6.2 Manufacturing process ..... **Error! Bookmark not defined.**
6.2.1 Pre-infusion preparations ..... **Error! Bookmark not defined.**
6.2.2 Infusion process ..... **Error! Bookmark not defined.**
6.2.3 Curing ..... **Error! Bookmark not defined.**
Pictures of project ..... **Error! Bookmark not defined.**
Chapter 7 ..... **Error! Bookmark not defined.**

7. Problems and their solutions ..... **Error! Bookmark not defined.**
7.1 Voids formation ..... **Error! Bookmark not defined.**
7.2 Solutions ..... **Error! Bookmark not defined.**
7.3 Vacuum control ..... **Error! Bookmark not defined.**
7.4 Flow rate ..... **Error! Bookmark not defined.**
7.5 Epoxy hardener ratio ..... **Error! Bookmark not defined.**
7.6 Releasing Agent ..... **Error! Bookmark not defined.**

7.7 Leakages ..... **Error! Bookmark not defined.**
7.8 Non-uniform Thickness ..... **Error! Bookmark not defined.**
Chapter 8 ..... **Error! Bookmark not defined.**

8. Project Management ..... **Error! Bookmark not defined.**
8.1 Overview ..... **Error! Bookmark not defined.**
8.2 Project Management includes ..... **Error! Bookmark not defined.**
8.3 Gantt Chart (Organization's work schedule) ..... **Error! Bookmark not defined.**
8.4 Phases of project ..... **Error! Bookmark not defined.**
8.5 Project Monitoring and Control ..... **Error! Bookmark not defined.**
8.6 Project Closure ..... **Error! Bookmark not defined.**
Chapter 9 ..... **Error! Bookmark not defined.**

9. Design Considerations ..... **Error! Bookmark not defined.**
9.1 Health and Safety ..... **Error! Bookmark not defined.**
9.2 Assembly ..... **Error! Bookmark not defined.**
9.3 Maintenance of the System ..... **Error! Bookmark not defined.**
9.4 Environmental Impact ..... **Error! Bookmark not defined.**
9.5 Economic Impact ..... **Error! Bookmark not defined.**
Chapter 10 ..... **Error! Bookmark not defined.**

10.1 Results: ..... **Error! Bookmark not defined.**
10.2 Limitations ..... **Error! Bookmark not defined.**
Chapter 11 ..... **Error! Bookmark not defined.**

Conclusion ..... **Error! Bookmark not defined.**
Refrences ..... **Error! Bookmark not defined.**

LIST OF FIGURES

Figure 1.1 Continuous and discontinuous fiber composites ..... **Error! Bookmark not defined.**

Figure 1.2 Resin Transfer Molding (RTM) process ..... **Error! Bookmark not defined.**

Figure 1.3 Vacuum Assisted Resin Transfer Technology (VARTM) PROCESS **Error! Bookmark not defined.**

Figure 2.1 Schematic of Resin Transfer Molding ..... **Error! Bookmark not defined.**

Figure 2.2 showing a schematic diagram of the flow front with using HPL ..**Error! Bookmark not defined.**

Figure 2.3 showing difference between RTM and VARTM ..... **Error! Bookmark not defined.**

Figure 3.1 thickness variations during Curing ..... **Error! Bookmark not defined.**

Figure 5.1 Vacuum Pump ..... **Error! Bookmark not defined.**

Figure 5.2 Epoxy-Hardener ..... **Error! Bookmark not defined.**

Figure 5.3 (a) Carbon fiber ..... **Error! Bookmark not defined.**

Figure 5.3 (b) Glass fiber ..... **Error! Bookmark not defined.**

Figure 5.4 Vacuum bag ..... **Error! Bookmark not defined.**

Figure 5.5 Vacuum sealant tape ..... **Error! Bookmark not defined.**

Figure 5.6 Catch-pot ..... **Error! Bookmark not defined.**

Figure 5.7 Vacuum pipe and connectors ..... **Error! Bookmark not defined.**

Figure 5.8 Mold Releasing agent ..... **Error! Bookmark not defined.**

Figure 5.9 Vacuum gauge ..... **Error! Bookmark not defined.**

Figure 6.1 pre-Infusion preparations ..... **Error! Bookmark not defined.**

Figure 6.2 infusion process ..... **Error! Bookmark not defined.**

Figure 6.3 Project setup standard view ..... **Error! Bookmark not defined.**

Figure 6.4 projects setup front view ..... **Error! Bookmark not defined.**

Figure 6.5 project setup top view ..... **Error! Bookmark not defined.**

Figure 8.1 Gantt Chart ..... **Error! Bookmark not defined.**

Figure 10.1 Ansys velocity in xyz direction ..... **Error! Bookmark not defined.**

Figure 10.2 Ansys velocity analysis ..... **Error! Bookmark not defined.**

Figure 10.3 Ansys velocity analysis ..... **Error! Bookmark not defined.**

Figure 10.4 Pressure difference Vs Flow rate ..... **Error! Bookmark not defined.**

Figure 10.5 Temperature Vs Curing time ..... **Error! Bookmark not defined.**

ABBREVIATIONS

DM: Distribution Media

RFI: Resin Film Infusion

RIM: Reaction Injection Molding

RTM: Resin Transfer Molding

VARTM: Vacuum Assisted Resin Transfer Molding

FE: Finite Element

CV: Control Volume

VBRTM: Vacuum Bag Resin Transfer Molding

VBM: Vacuum Bag Molding

RIFT: Resin Infusion under Flexible Tooling

SCRIMP: Seemann Composites Resin Infusion Manufacture Process

HPL: High permeability layer.

CHAPTER 1

1. Introduction

Composite materials have become an alternative to conservative material like metals due to its enhanced properties. It is dominant to other materials due to its remarkable properties like high strength, high stiffness, and light weight. Composite materials are widely used in aircrafts, transportation, sports goods, marines, construction and different structures. There are various technologies to fabricate composite material products like injection molding, hand layup, resin transfer molding (RTM), vacuum assisted resin transfer molding (VARTM), reaction injection molding (RIM), resin film infusion (RFI) and few more. Among these technologies, Vacuum Assisted Resin Transfer Molding Technology (VARTM) is well established method in fabrication of composites. [1]