Dynamic
Photo-**M**echanics
Laboratory

THE
UNIVERSITY
OF RHODE ISLAND

Composite fabrication via

VARTM Process

Birendra Chaudhary

Department of Mechanical, Industrial and Systems Engineering

METHODS USED IN MANUFACTURING OF COMPOSITES

- Wet lay-up method

  Wet composite is rolled by hand to evenly distribute the resin and thereby removing the air pockets

- Pultrusion

  Continuous reinforcement fibers are impregnated with resin and passed through a die

- Resin transfer molding (RTM)

  Mold is loaded with the reinforcement material and then closed

  Resin is injected at the center of the top surface of the mold

- Vacuum Assisted Resin Transfer Molding (VARTM)

  Dry preform is placed into the tool and vacuum bagged in conjunction with resin distribution and vacuum distribution lines

VACUUM ASSISTED RESIN TRANSFER MOLDING (VARTM)

- Relatively low cost for high volume production
- Simple low-cost tooling
- Very large and complex parts are practical
- High fiber volume fraction than hand lay-up
- On site manufacturing and repairing is possible
- Reduced environmental concerns than hand lay-up as it is closed system

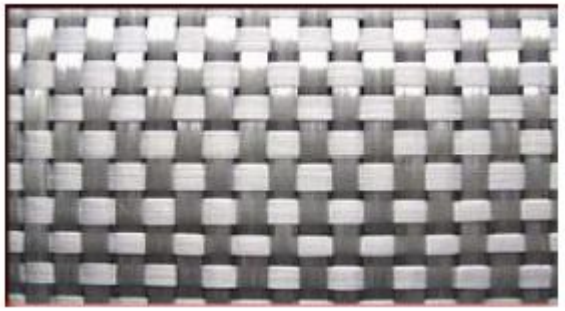


Fig 1. Woven Roving E-Glass

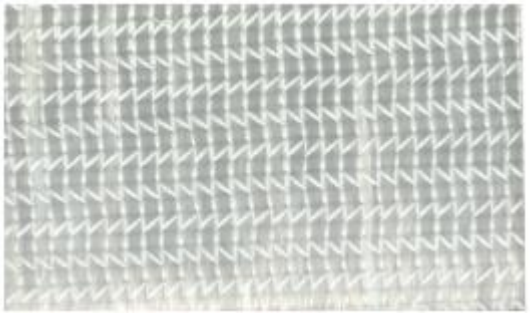


Fig 1. Stitch Bonded E-Glass

Source: Fig. 1, 2 Bolick , Ronnie. Composite Fabrication via the VARTM Process. www.trianglepolymer.com/resources/Intro+to+the+VARTM+process.pdf

STEPS FOR VARTM PROCESS

- Mold preparation and fabric lay up
- Sealing off the mold and running vacuum
- Resin preparation and degassing
- Resin impregnation
- Post cure of fabricated panels

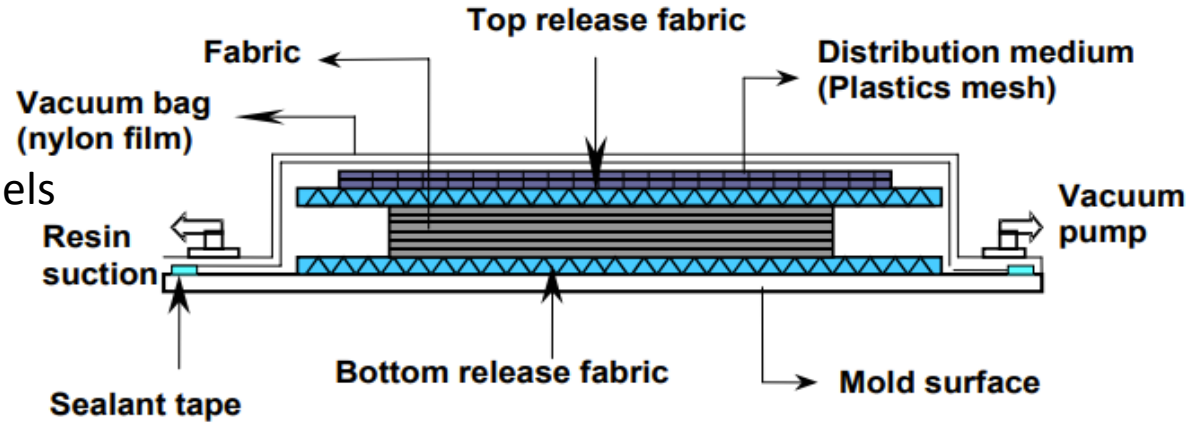


Figure 1. Schematic for the Fabrication of the Composite Panel

Source: *Figure 1. Kelkar, Ajit D., et al. Low Cost Manufacturing of Textile Composites Using Vacuum ... www.researchgate.net/profile/Ajit-Kelkar/publication/228769475_Low_Cost_Manufacturing_of_Textile_Composites_Using_Vacuum_Assisted_Resin_Transfer_Molding/links/0deec535979fcaa2bd000000/Low-Cost-Manufacturing-of-Textile-Composites-Using-Vacuum-Assisted-Resin-Transfer-Molding.pdf.*

Mold Surface

- Fabrication of the composite panel is either a metal plate or a glass plate
- Has a provision of heating while the fabrication is in progress

Mold Surface Protection

- Facilitates the easy removal of the panel from the mold surface after the fabrication process is over

Fabric Lay-up

- Precaution should be taken in stacking
- Edges of the fibers should align to each other

Top Release Fabric

- Peel ply* is placed on the top of the stacked sequence of fabric
- allows for easy removal of the composite panel after fabrication from the vacuum bag

Fig. Experimental VARTM Setup

**porous release material which facilitates the resin flow through*

Distributive Medium

- Mesh (Blue) laid on top of the top release fabric
- Maintains an even distribution of resin on the top of the panel
- Facilitates the flow of resin through the thickness of the panel

Resin and Vacuum Distribution Line

- Spirally cut tubes are used
- Used for uniform resin distribution and vacuum line

Sealing the mold

- Sealant tape is used

Vacuum Bag

- Film is placed all over the mold area and is sealed firmly using special sealant tape
- Helps to maintain a uniform vacuum throughout the molding process

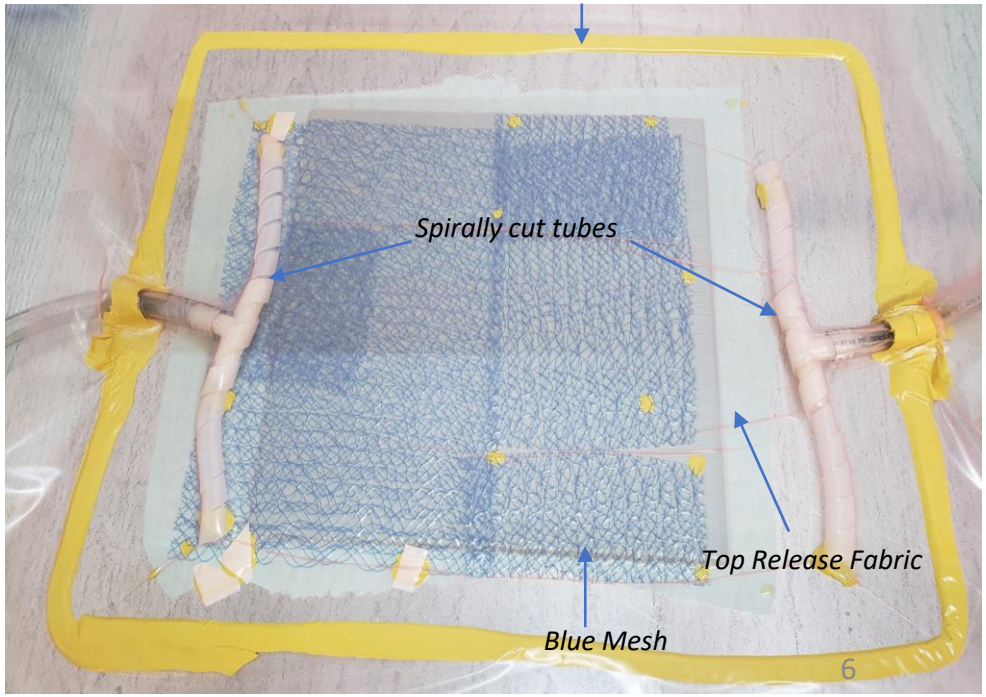


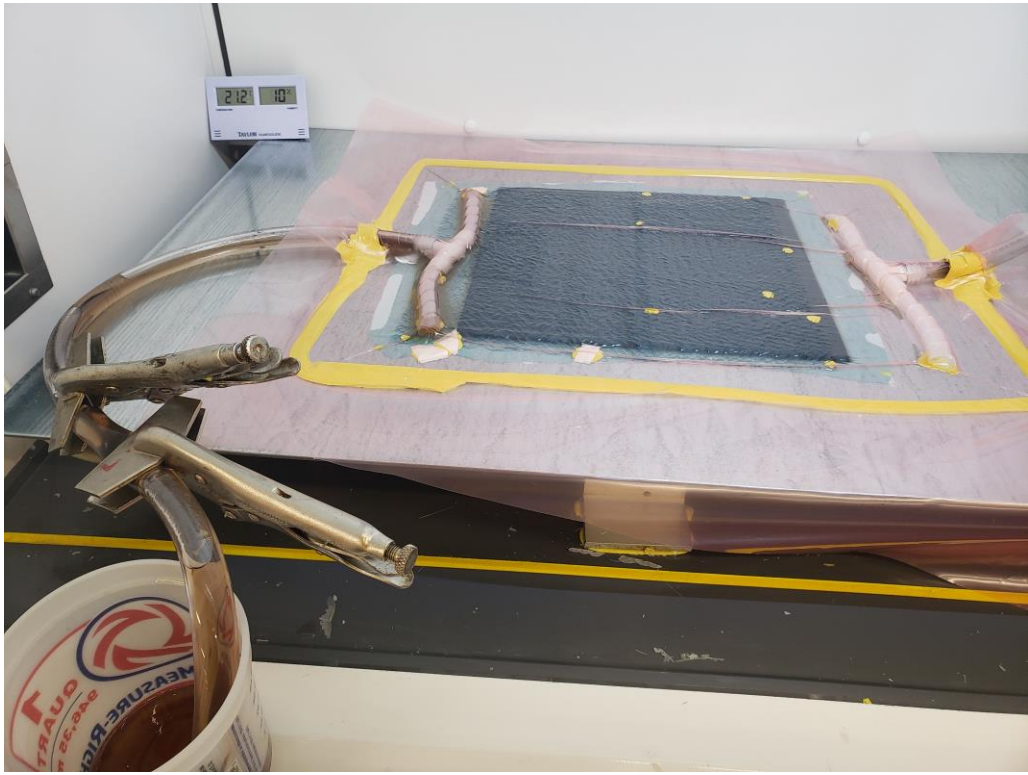
Fig. Experimental VARTM Setup

Resin preparation and degassing

- Resin is mixed with catalyst, promoter and with precalculated gel time
- percentage suggested by the resin manufacturer
- Before adding the resin to the mold, it must be free of all the air pockets that may cause voids if they enter the mold
- Resin is kept in a vacuum chamber that maintains a vacuum
- This enables the suction of all the gases that have been trapped into the resin

Resin impregnation

- Resin is mixed with catalyst, promoter and gel time retarder in the precalculated (Cobalt Nap, DMA and MEKP)
- percentage suggested by the resin manufacturer
- Before adding the resin to the mold, it has to be free of all the air pockets that may cause voids if they enter the mold
- Resin is kept in a vacuum dome that maintains a vacuum
- This enables the suction of all the gases that have been trapped into the resin



Guidelines for using Promotors and Catalyst

TYPICAL NON REINFORCED MECHANICAL PROPERTIES AT 25°C/77°F

Properties	Unit	Value	Test Method
Tensile Strength	psi	10,153	ASTM D 638
Tensile Modulus	Kpsi	450	ASTM D 638
Tensile Elongation	%	9.0	ASTM D 638
Flexural Strength	psi	19,580	ASTM D 790
Flexural Modulus	Kpsi	440	ASTM D 790
Heat Deflection Temperature	°C/°F	87/189	ASTM D 648
Hardness, Barcol Model 934-1	HB	35	ASTM D 2583

GUIDELINES FOR INITIATOR AND PROMOTER ADDITIONS

Gel Time at 18°C/ 65°F	Cobalt Nap 6%	DMA	High-Point 90 MEKP
15 +/- 5 minutes	0.60	0.40	1.50
30 +/- 10 minutes	0.50	0.20	1.50
60 +/- 15 minutes	0.30	0.10	1.50
Gel Time at 25C (77F)			
15 +/- 5 minutes	0.50	0.50	1.50
30 +/- 10 minutes	0.40	0.40	1.25
60 +/- 15 minutes	0.20	0.20	1.50
Gel Time at 0C (86F)			
15 +/- 5 minutes	0.50	0.50	1.50
30 +/- 10 minutes	0.30	0.30	1.50
60 +/- 15 minutes	0.25	0.25	1.25

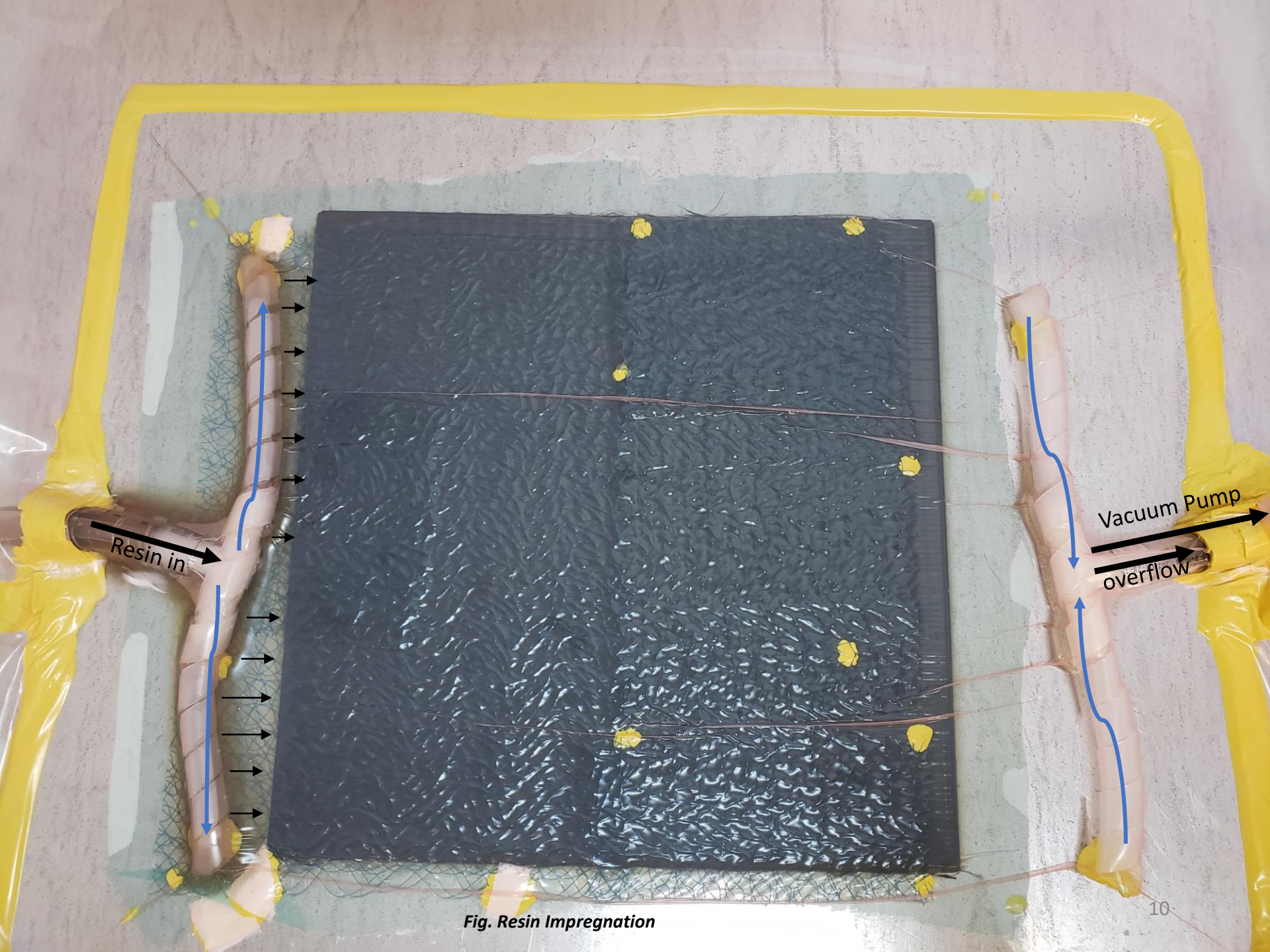


Fig. Resin Impregnation