

IMPROVEMENT OF SURFACE QUALITY DURING VARTM PROCESSING

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Objectives

- Evaluation of surface roughness of Vacuum Assisted Resin Transfer Molding (VARTM) processed composite parts
 - Create surface roughness measurement capability
 - Evaluation of surface roughness of different preforms
 - Evaluation of different caul plates
- Evaluation of VARTM process variations allowing application of caul plate
- Scale-up to manufacture large-scale hydro-dynamic surfaces, such as 1/4-scale twisted rudder

Large-Scale Composite Structures via VARTM



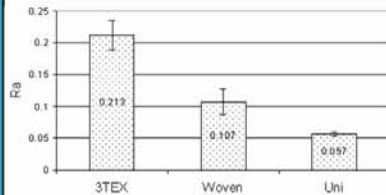
Surface Roughness Evaluation



$$R_a = \frac{\sum_{i=1}^N |t(x_i) - \bar{t}|}{N}$$

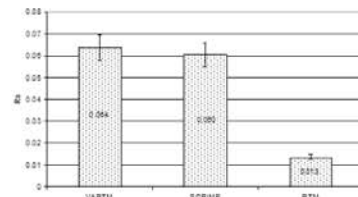
- R_a : Average roughness
- $t(x_i)$: Thickness on the i th point
- \bar{t} : Mean thickness
- N : Number of measurement points

Surface Roughness of the Preforms



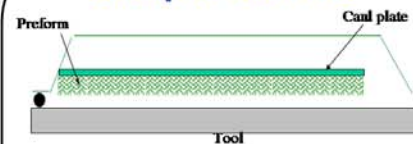
- 3WEAVE™ from 3TEX
- 24oz. woven fabric from Vetrotex
- 9oz. unidirectional E-glass preform (Hot Melt Woven HMW) from Matrix Composites

Comparison of VARTM and RTM Surface Quality



➔ Application of caul plate will improve surface quality

Concept of Caul Plate

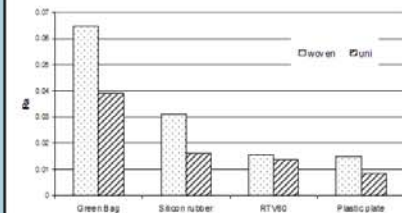


Different caul plates for surface evaluation of the VARTM parts

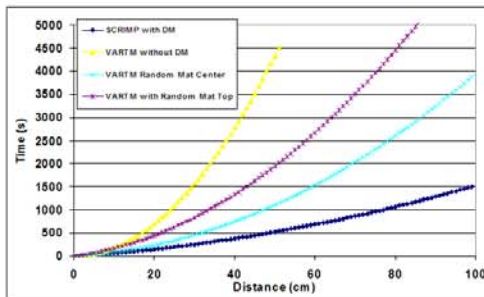
- 1) nylon bagging film from AIRTECH
- 2) silicon rubber and RTV60 from GE
- 3) semi-rigid caul plate (EG-864) from NVF

	Nylon bagging film	Silicon rubber	RTV60	EG-864
Hard modulus [N/mm ²]	14.8	1.3	5.71	22,000
Thickness [mm]	0.38	15	15	2
Modulus stiffness [N/mm]	5.6	19.5	85.6	44,000

Surface Roughness for Composite Parts Made with Different Caul Plates



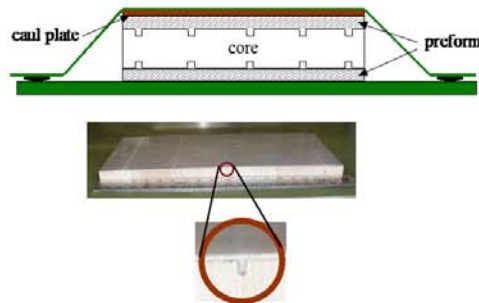
Flow Behavior for VARTM and SCRIMP *



CHALLENGE: APPLICATION OF CAUL PLATE DOES NOT ALLOW USE OF DISTRIBUTION MEDIA

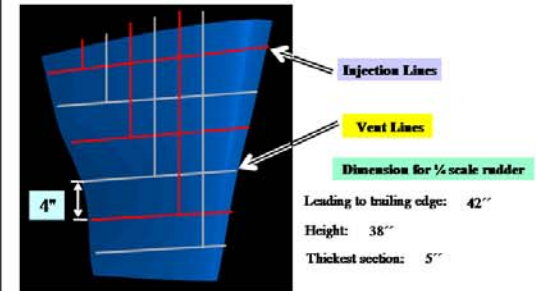
* Seemann Composite Resin Infusion Molding Process

Manufacturing Concept to Avoid Distribution Medium



➤ Grooved channels in core to eliminate the distribution media in the process

Alternating Injection Scheme To Manufacturing 1/4-Scale Twisted Rudder



Alternating Injection Scheme

- ✓ Channels are configured to be alternating vents and gates
- ✓ All injection lines are opened at the same time

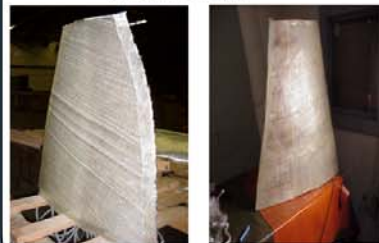
Manufacturing 1/4-Scale Twisted Rudder



Caul plate

Twisted Rudder

1/4 Scale
Twisted Rudder



Fabric lay-up

Infused part

Summary

- ✓ Requirements of different surface roughness can be met with the right choice of stiffness and thickness of caul plate
- ✓ With the proper caul plate, surface quality is comparable to RTM parts
- ✓ Low-cost tooling (core is the tooling) reduces overall cost
- ✓ The right infusion scheme ensures complete wet-out

➔ New low-cost process with high surface quality has been developed with demonstrated potential for scale-up of large hydrodynamic surfaces.



Acknowledgements

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