LIGHT RTM DESIGN AND MANUFACTURING

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YOUR HOSTS

Alastair Komus, M.Sc., P.Eng.
Partner, A&S Composites Engineering

- 20 years of experience in design, analysis, testing, and manufacturing of composite structures
- Industries supported include aerospace, defence, marine, mass transit, agriculture, industrial, energy, sporting goods, and thrill rides
- Registered Professional Engineer from Ontario through BC
- Responsible for ensuring engineering and manufacturing capabilities at A&S Composites Engineering seamlessly integrate through all stages of product development

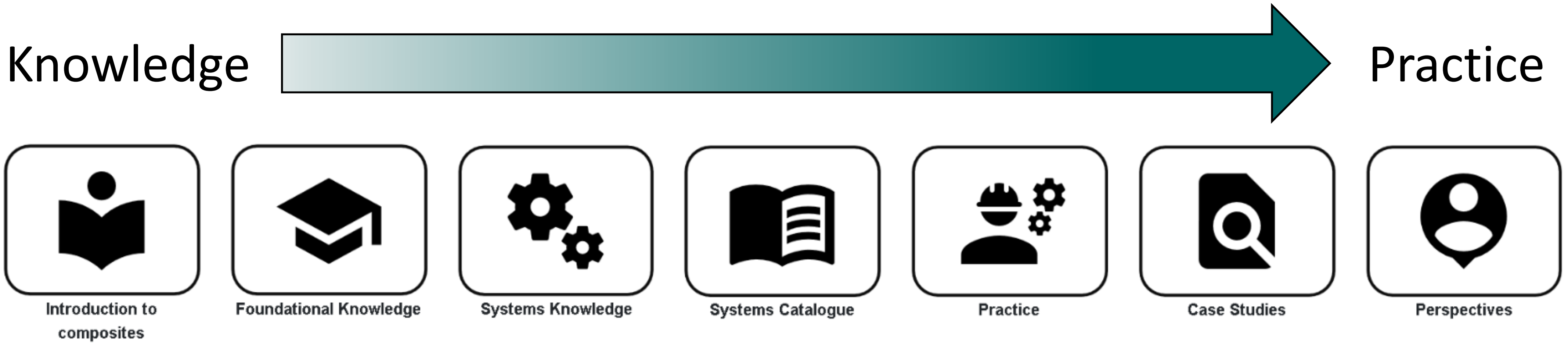
A&S Composites Engineering

KNOWLEDGE IN PRACTICE CENTRE (KPC)

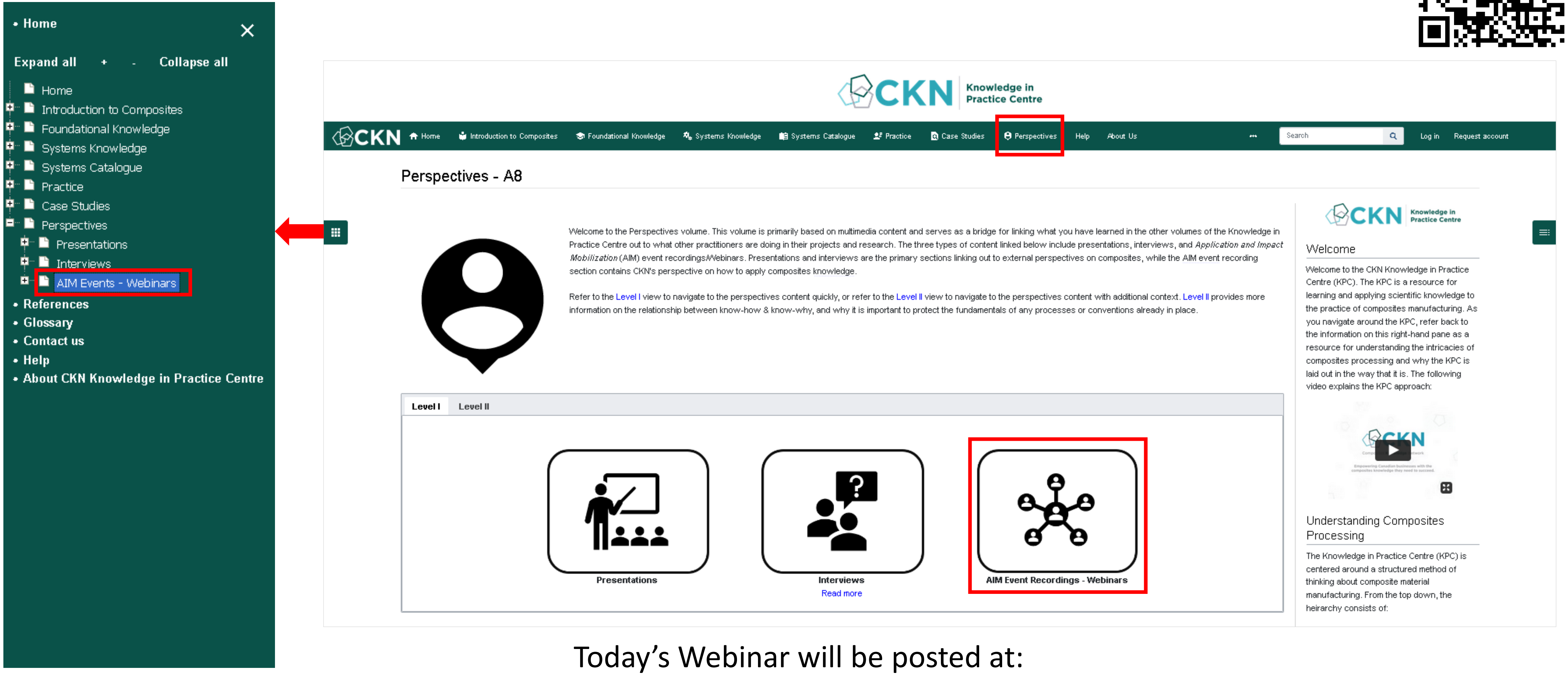
- A freely available online resource for composite materials engineering:

compositeskn.org/KPC

- Focus on practice, guided by foundational knowledge and a systems-based approach to thinking about composites manufacturing



PAST WEBINAR RECORDINGS AVAILABLE



Today's Webinar will be posted at:
https://compositeskn.org/KPC/A416

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TODAY'S TOPIC:

Light RTM Design and Manufacturing

OUTLINE

- Process Overview
- Theory
- Design
- Quality and Troubleshooting

ADVANTAGES

- Can produce near-net shapes (limited trimming)
- Produces consistent parts
- Produces smoother B-side surface than open mould
- Higher production rates than wet layup
- Reduced labour compared to wet layup
- Reduced VOC emissions
- Less expensive capital equipment than RTM
- Lower tooling cost than RTM

DISADVANTAGES

- Lower fibre content than RTM and VARTM
- B-side surface finish not as good as metallic tooling
- More expensive tooling than open mould
- More equipment than wet layup
- Longer cycle times than RTM or compression moulding

INDUSTRY AND APPLICATIONS

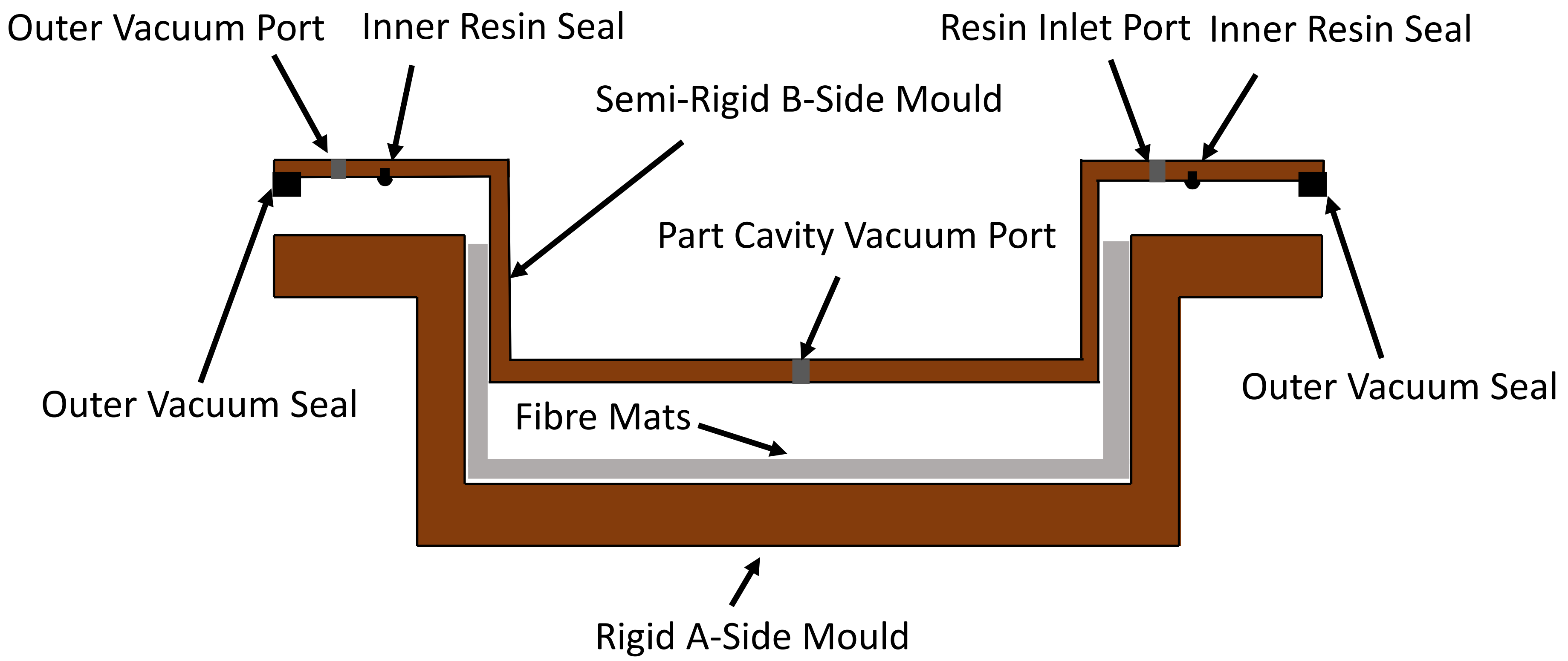
Industries

- Transportation
  - Buses
  - Trucks
  - Rail
- Marine
- Agriculture Equipment
- Recreational Vehicles
- Energy
- Industrial
- Entertainment

Applications

- Exterior and interior panels
- Floors
- Doors
- Hatches
- Decks
- Equipment boxes
- Blades
- Building panels
- Water slides

PROCESS OVERVIEW



PROCESS OVERVIEW

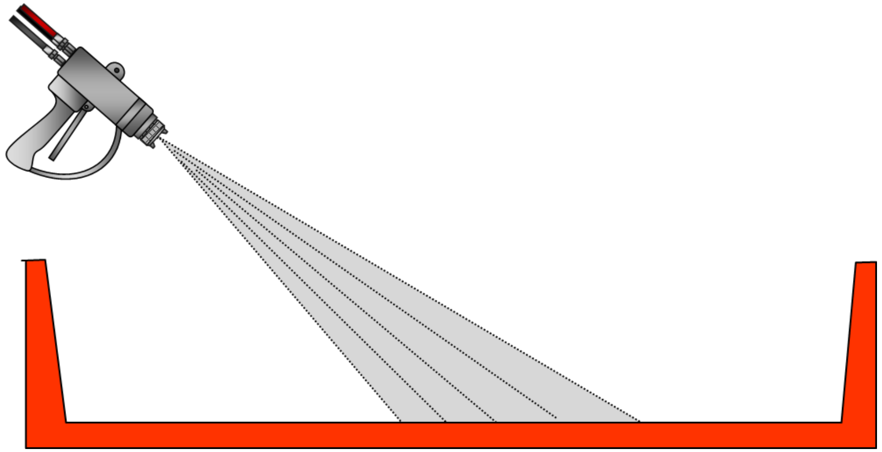
1. Clean and prep tool

- Inspect the tool surface for defects
- Clean the tool with a cloth wetted with isopropyl alcohol or acetone
- Apply release agent to the surface of the tool
- Impossible to get a good quality part if tool isn't clean and released
- Lack of tool preparation can lead to:
  - Surface defects
  - Warping
  - Cracking

PROCESS OVERVIEW

2. Spray gel coat

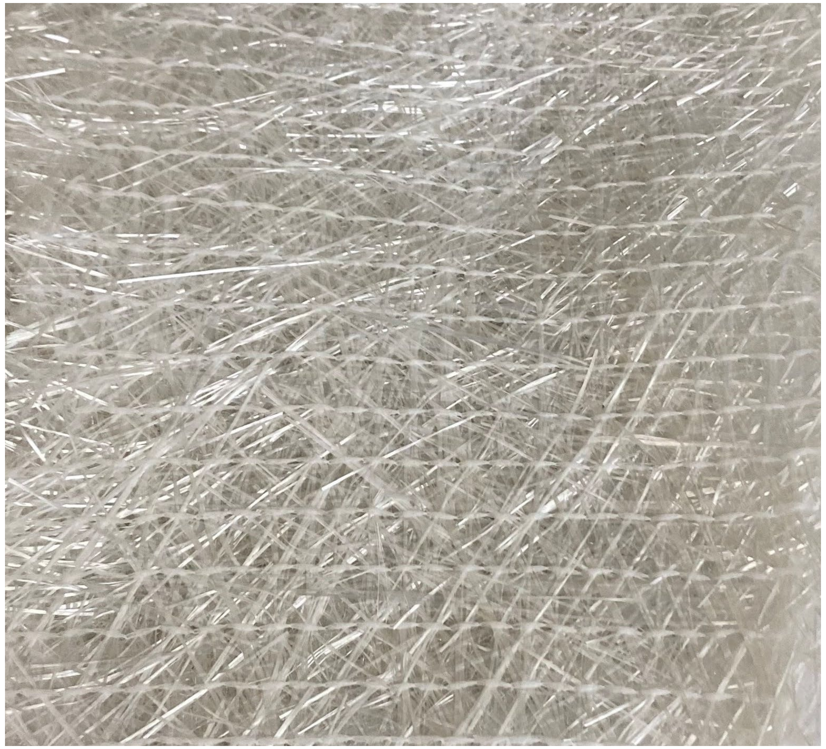
- Apply gel coat evenly across the tool and cover all surfaces
- Check the thickness of the gel coat
- Imperfections in the gel coat will appear as imperfections on the part



PROCESS OVERVIEW

3. Materials trimmed and kitted

- Trim fibreglass plies and cores to the specified sizes
- Properly sized materials help to reduce resin rich areas



PROCESS OVERVIEW

4. Layup fibre or core materials

- Place the mat (or core) on the tool surface or previous ply
- Ensure material is pushed into all corners and radii
- Ensure material orientation is correct
- Do not overlap material
- Tear or shred fibreglass edges to prevent gaps
- Ensure core placement is correct

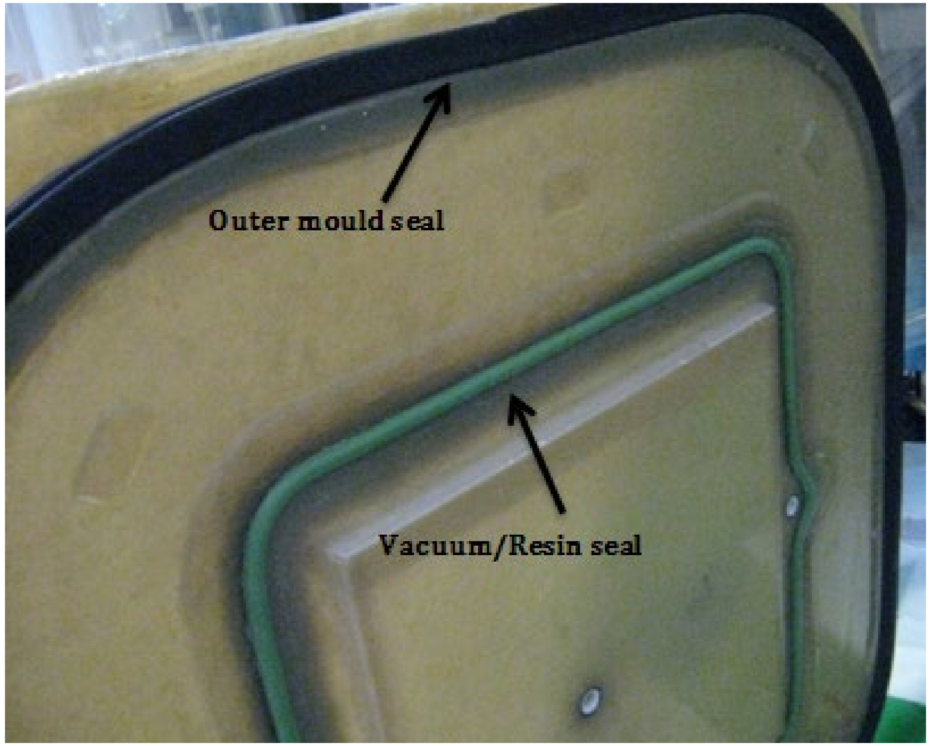
5. Trim excess material

- Trim excess material to ensure it does not travel past where the inner seal sits
- Clean any fibre strands from the seal area

PROCESS OVERVIEW

6. Inspect B-side tool

- Ensure seals are in good condition
- Remove any resin that is built up on the tool surface
- Clean B-side tool
- Apply release agent if required
- Any defects on the B-side tool will show up on the part



PROCESS OVERVIEW

7. Lower B-side tool

- Align B-side tool evenly on all sides
- Ensure material in the A-side is not moved
- Firmly push B-side tool down until outer wing seal makes contact with A-side tool
- Good seal is critical to avoid dry spots and air voids

PROCESS OVERVIEW

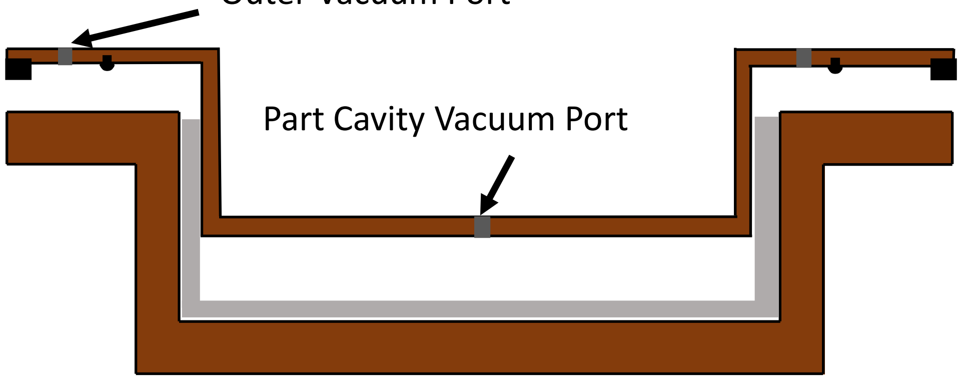
8. Attach resin injection lines

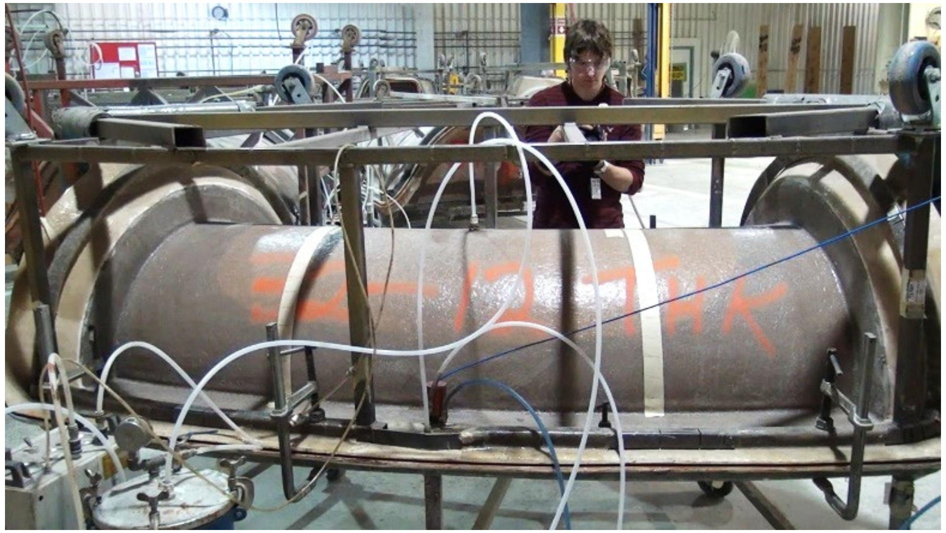
- Inspect the fittings to ensure there is no resin build up
- Insert the fitting into the top cover and attach lines
- Attach lines from part cavity to catch pot
- Seal all connections by using yellow sealing tape
- If connections aren’t sealed it can result in air travelling into the part

PROCESS OVERVIEW

9. Attach vacuum lines

- Inspect the fittings to ensure there is no resin build up
- Attach the vacuum line fittings into the top cover
  - Full vacuum attached to outer vacuum channel
  - Half vacuum attached to catch pot
- Seal all connections by using yellow sealing tape
- If connections aren't sealed it can result in air travelling into the part

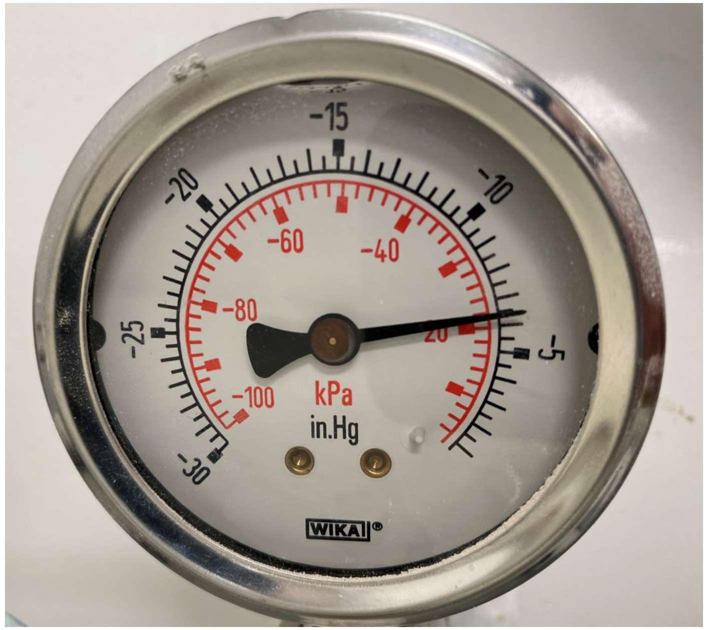




PROCESS OVERVIEW

10. Turn on vacuum and test for leaks

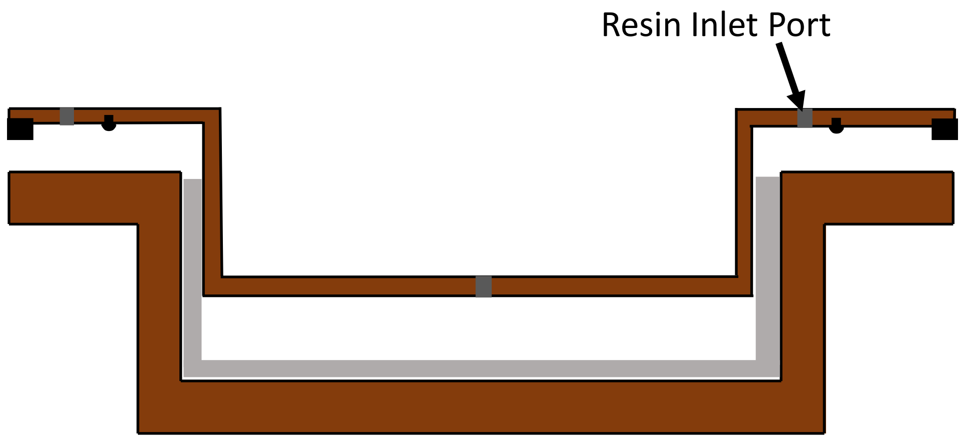
- Turn on vacuum
  - Wing seal should compress against the tool
- Test for leaks
- Critical to make sure there is a tight seal
  - Leaks will result in air voids



PROCESS OVERVIEW

11. Attach injection gun

- After testing the vacuum attach the injection gun
- Inspect the injection gun
  - Ensure there is catalyst
  - Check the catalyst level
  - Verify there are no leaks around the pumps
  - Verify the solvent container is full

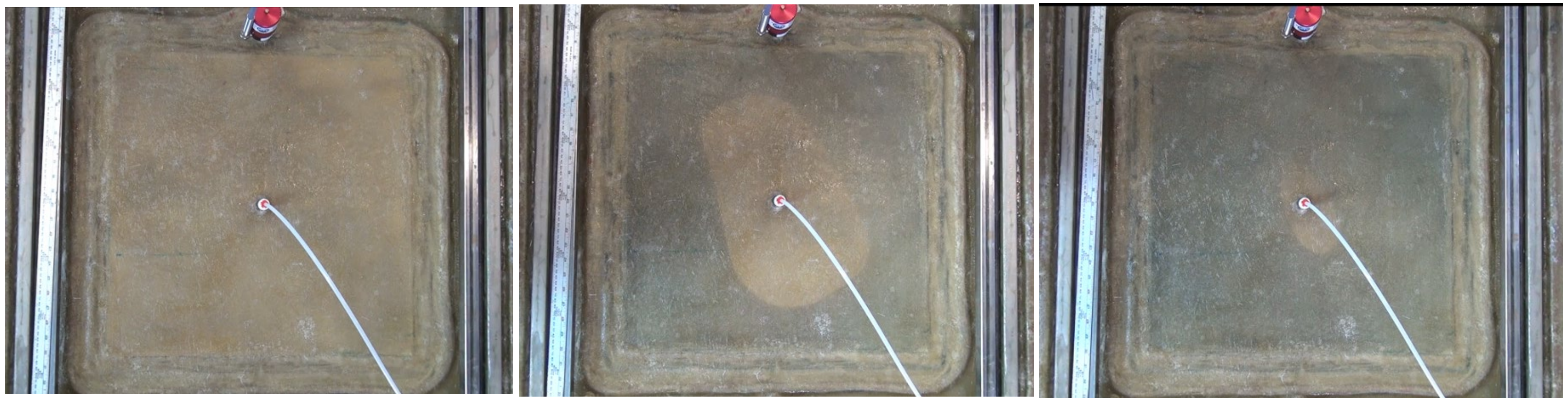


- Incorrect mixture of catalyst and resin will result in under cured parts or parts that cure at too high a temperature

PROCESS OVERVIEW

12. Start injection process

- Set equipment to predetermined number of resin strokes
- Start the injection process
- Important to use the correct number of resin strokes
  - Not enough strokes will result in dry areas
  - Too many strokes will result in resin rich areas



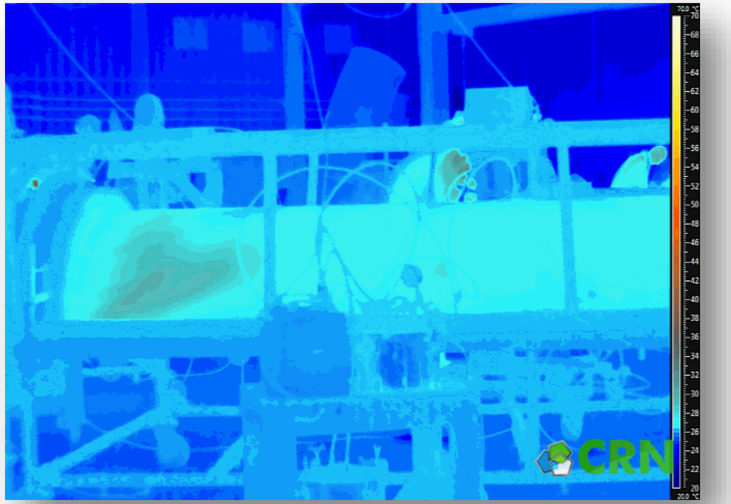
PROCESS OVERVIEW

13. Stop injection process

- After injection completed, pinch off the injection hose and place tape over the end to prevent drips
- Disconnect the injection gun and purge equipment with acetone

14. Cure

- Ensure vacuum lines stay connected during the curing process
- Resin will begin to gel and start to give off heat
- Peak temperature is reached while resin hardens
- Part will cool down while continuing to harden



PROCESS OVERVIEW

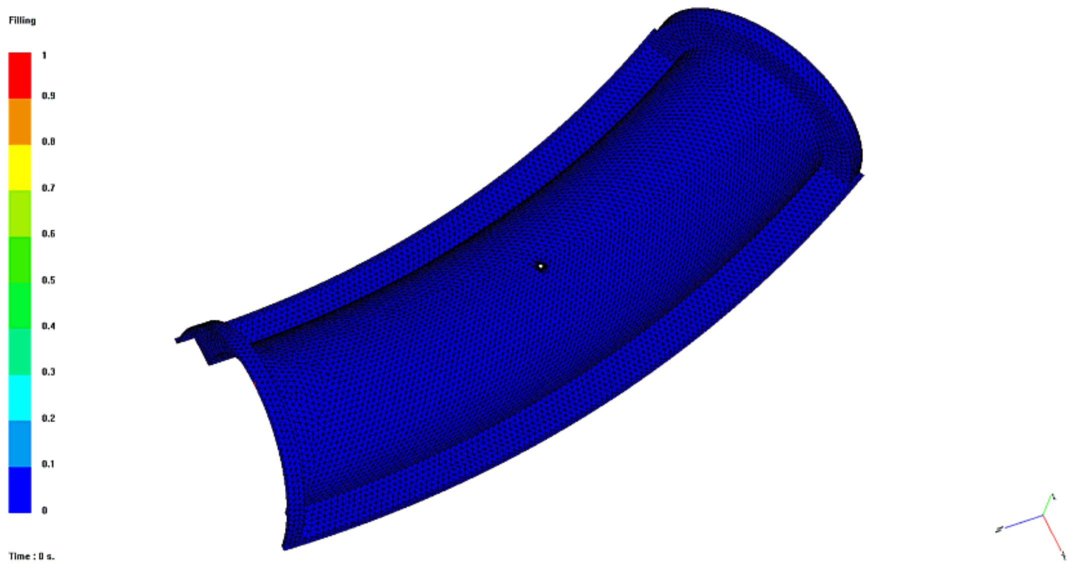
15. Demould

- Wait to demould until:
  - B-side mould has returned to room temperature (75 – 80F) or
  - Barcol hardness number is 30 to 35
- Use rubber mallet and plastic/wood wedges to release part from mould
- Ensure entire perimeter is loosened before removing part

THEORY

- Darcy's law is used to model fluid flow through porous media, and like RTM and VARTM processing, the law can be used to model flow with LRTM processing

$$Q = -\frac{KA}{\mu}\frac{\Delta P}{x}$$



Where:

- Q = Volumetric flow rate
- K = Preform permeability
- A = Preform cross-sectional area
- μ = Resin viscosity
- ΔP = Pressure differential across preform
- x = In-plane flow distance of pressure differential

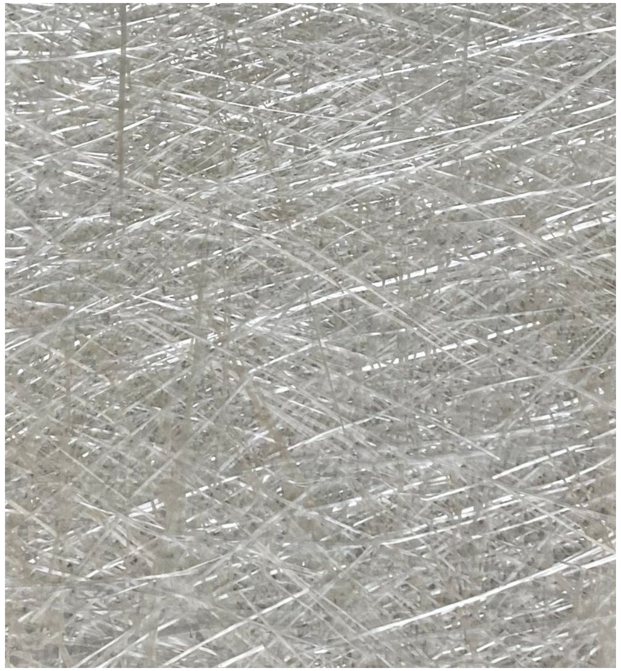
THEORY

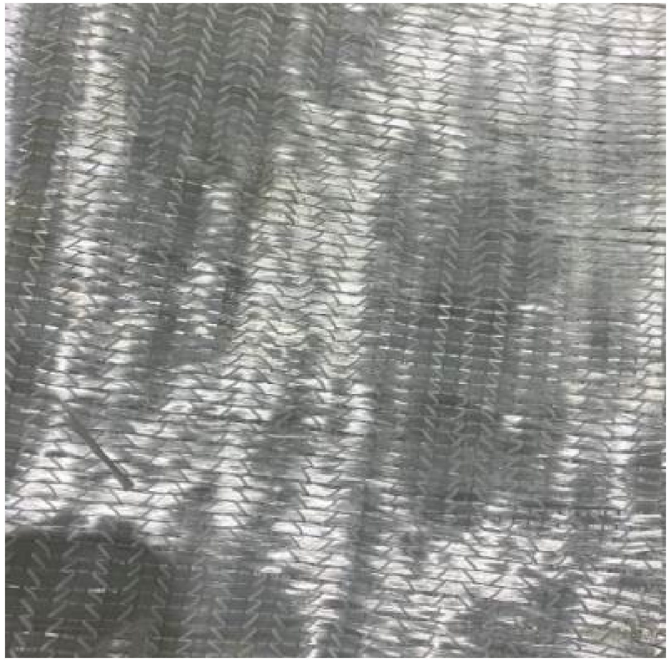
- Increase flow rate by:
  - Lowering viscosity
  - Decreasing in-plane flow distance
  - Increasing preform permeability
  - Increasing pressure differential
- Advantages of increased flow rate:
  - Reduces fill time
  - Decreases probability of dry spots
- Disadvantage of increased flow rate:
  - May not allow for the escape of volatile gases resulting in porosity
- Darcy's Law and numerical methods can be used to model flow during LRTM processing
  - Challenge is flexibility of the counter mould which changes the permeability of the reinforcements and the cross-sectional area

MATERIALS

Reinforcements

- Continuous filament mat and chopped strand mat are most common
- Directional stitched mats used to increase stiffness and strength
- Sandwich mat with synthetic non-woven core between chopped strand mat for resin flow





MATERIALS

Reinforcements

- Polyester non-woven mats with resin channels for improved flow and print blocking
- Non-woven glass or polymer surface veil to block print through

MATERIALS

Resins

- Polyester, vinyl ester, and epoxy
- Low viscosity 50 to 200 mPa-s (centipoise)
- Gel time long enough for degassing
- Low shrink resin reduces likelihood of print through

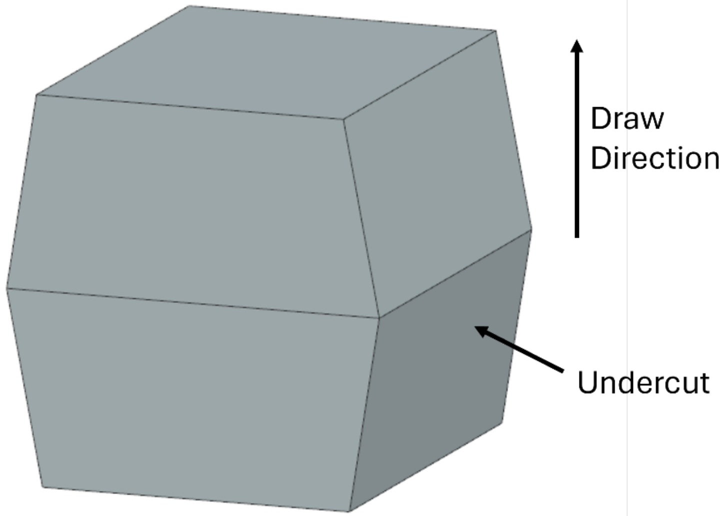
MATERIALS

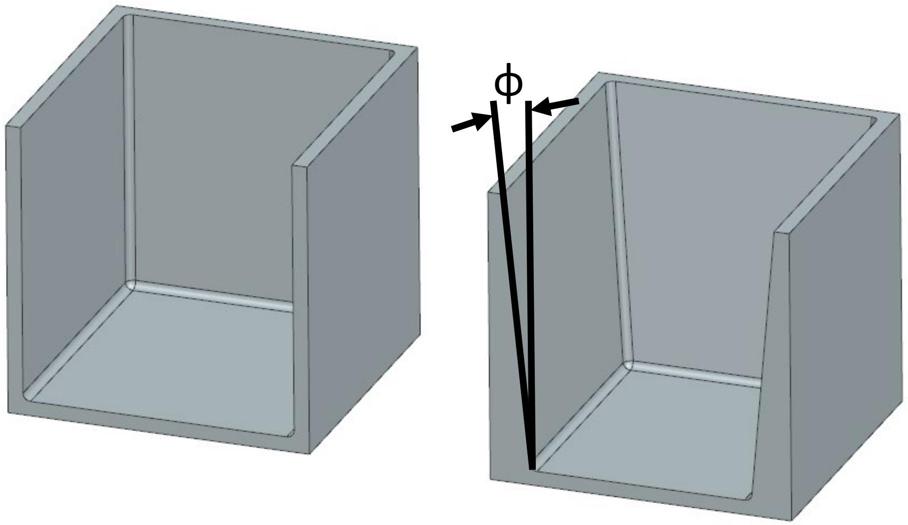
Cores

- Open cell cores are not suitable because they fill with resin
- Almost all closed cell cores can be used
- Grooves or perforations added to improve resin flow

SHAPE

- Avoid undercuts
  - Split tools can lead to vacuum leaks
- Provide generous radii
  - Can lead to fibre bridging
- Draft
  - Include minimum 1 to 2 degrees of draft





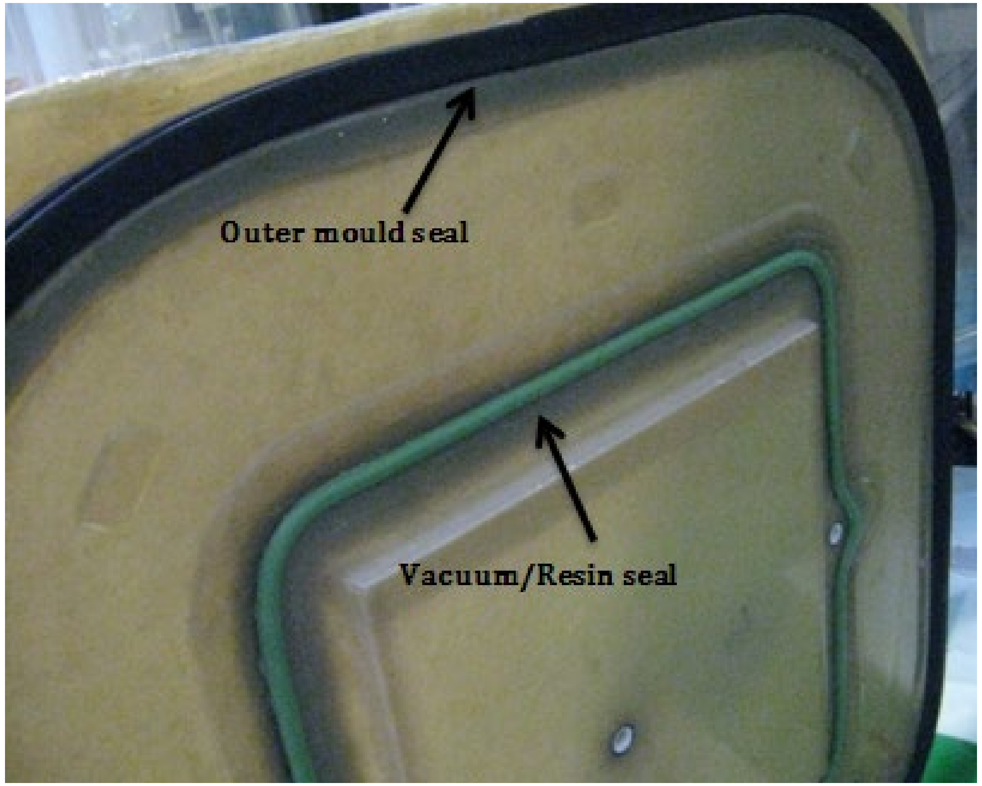
SHAPE

Part thickness

- Avoid overlap splices
- Fray mat edges for butt joints
- B-side cover sets the part thickness
- Adding plies after cover built:
  - Reduces permeability
  - Increases difficulty to close cover
  - Increases probability of print through

TOOLING

- Usually made from fibreglass
- Top cover is required
  - Outer vacuum seal
  - Inner resin seal
- Requires resin and vacuum ports
- Inner resin seal acts as barrier between infused part and vacuum area
- Outer vacuum seal acts as barrier between vacuum area and ambient



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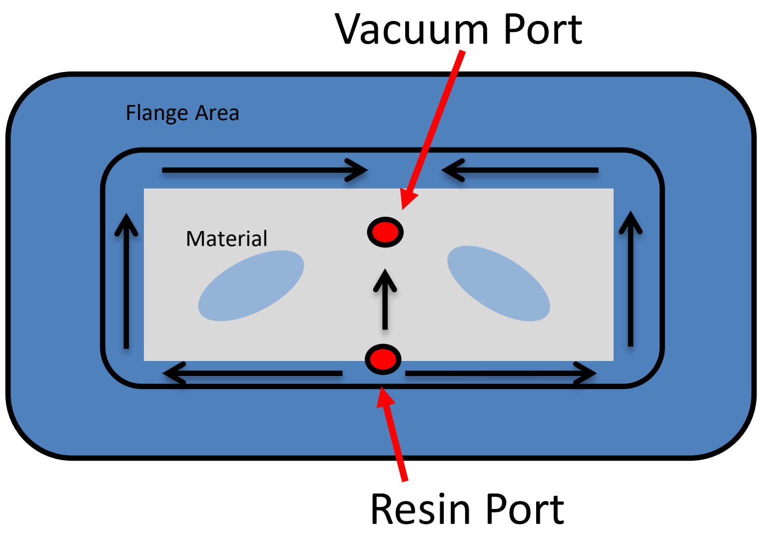
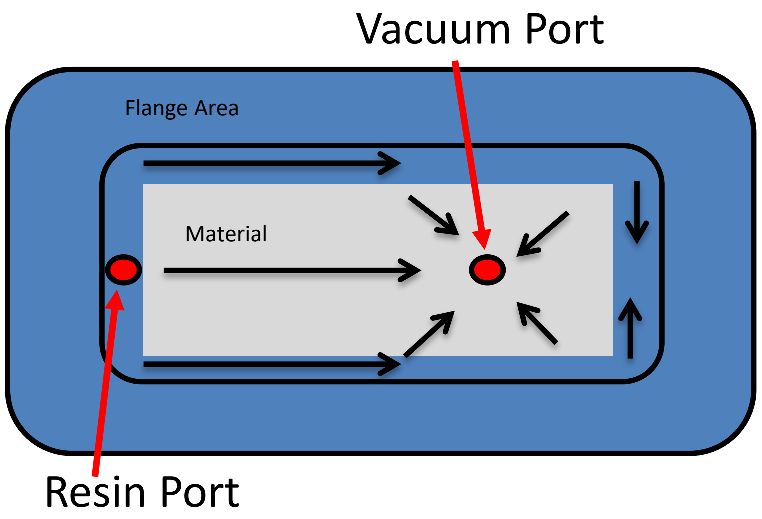
TOOLING

- Injection port and vacuum port location are critical
- Once resin enters the cavity it will flow in the path of least resistance
- Port should be placed so all material will be infused before the resin reaches the exit port
- Left picture will likely result in dry spots
- Right picture more likely to infuse fully





EQUIPMENT

- Vacuum source
  - Venturi
  - Vacuum pump
- Resin injection system
  - Pressure pot
  - Hydraulic resin injection system

QUALITY AND TROUBLESHOOTING

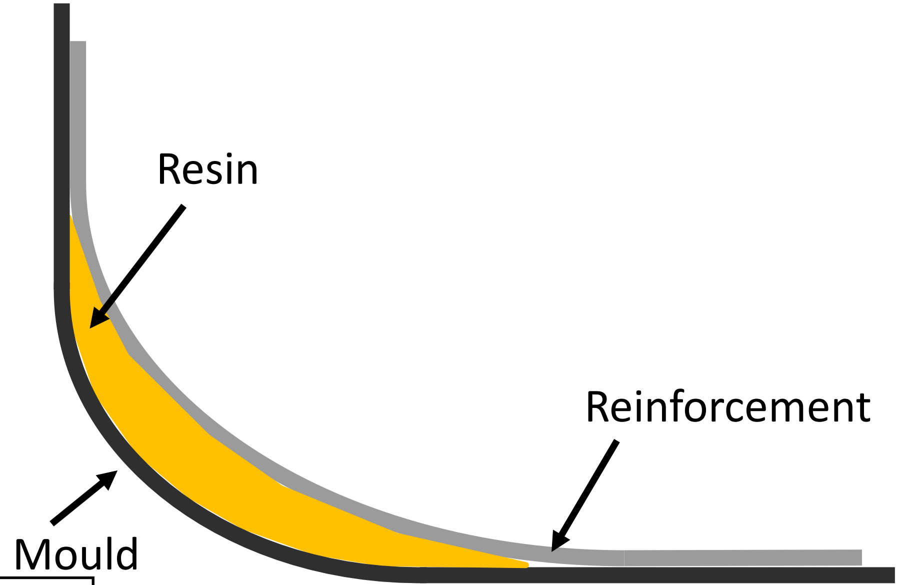
Air Voids

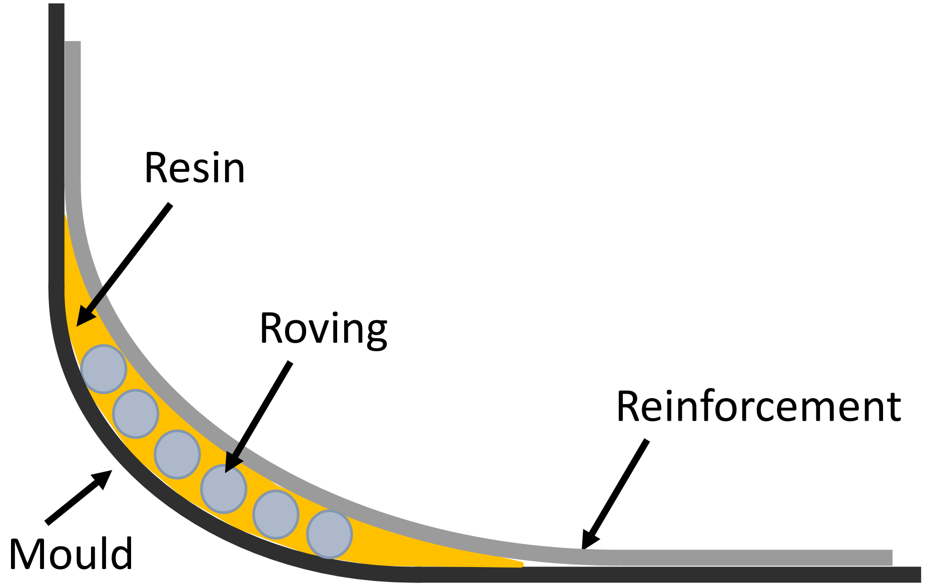
- Usually occur due to leaks
  - Insufficient clamping force on vacuum chamber (part too thick)
  - Poor job of sealing fittings (check tacky tape)
  - Failure to clean loose fibres from sealing flange

QUALITY AND TROUBLESHOOTING

Cracking

- Generous radii should be incorporated into the part design where possible
- Recommended minimum radius of 1/8 inch
- Must ensure fibre follows tool surface especially in corners
- Roving may be pushed into radius to help prevent cracking



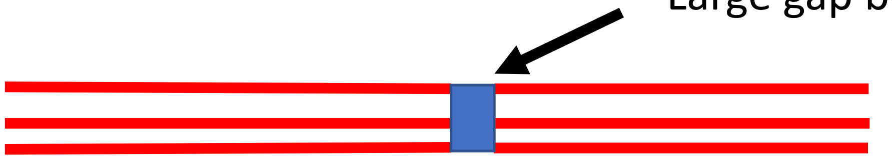


QUALITY AND TROUBLESHOOTING

Cracking

- Gaps can result in resin rich areas that crack and print through

- Fibreglass material edges should be torn/shredded to avoid gaps



QUALITY AND TROUBLSHOOTING

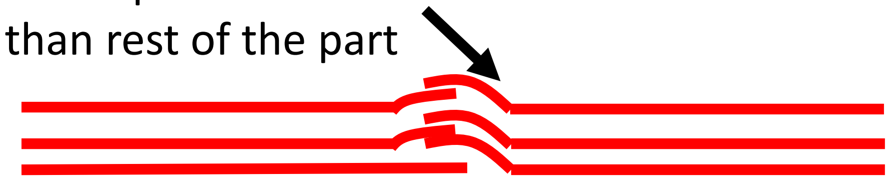
Dry Spots

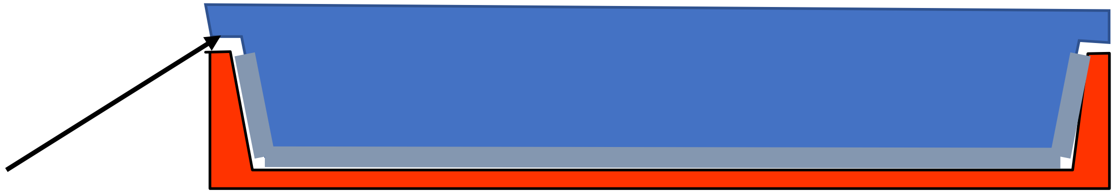
- Occur when fibres are not fully wet out by resin
- LRTM requires the use of resin flow materials
  - Sandwich mat with synthetic core used to promote resin flow
  - May need flow materials on both sides of cores to ensure good wet out on both sides of the part
  - Core may include grooves
  - Core may include perforations to promote resin flow on both sides of the part

QUALITY AND TROUBLESHOOTING

Dry Spots

- LRTM tool cavity is designed for a specific material thickness
  - If too thick resin flow is choked off
- May occur if plies are overlapped
- May occur if wrong thickness of material is used
- May occur if extra plies are included

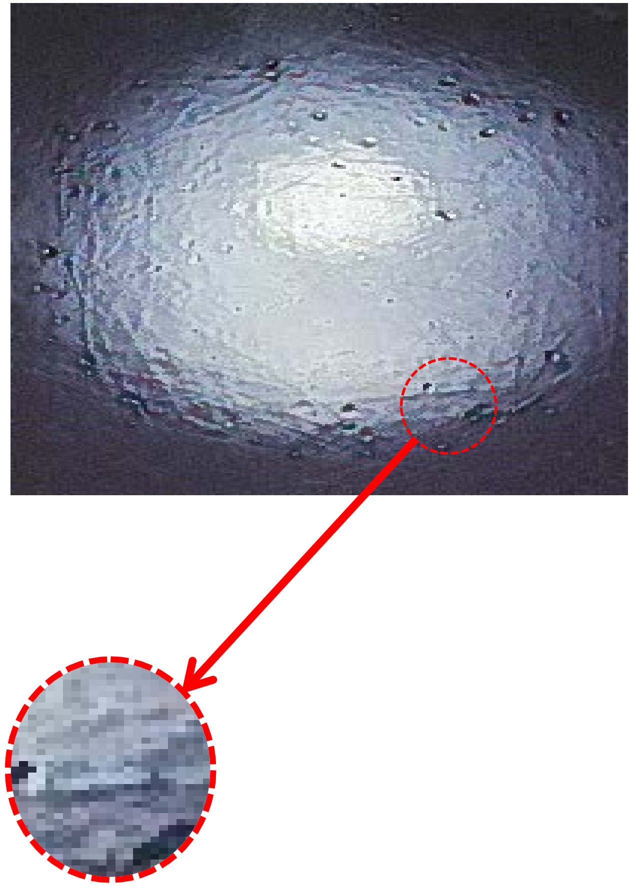


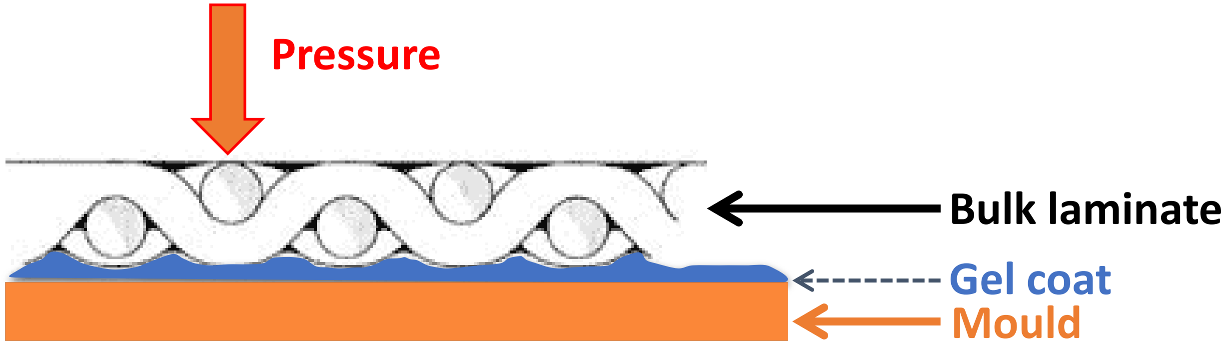


QUALITY AND TROUBLESHOOTING

Surface Quality

- Print through
  - Fibre form can be seen on the part surface
  - Caused by resin shrinkage constrained by fibres or cores





QUALITY AND TROUBLESHOOTING

Surface Quality

- Print through
    - Important to include veil, polyester mat, or other similar materials to act as print blockers
    - For stitched mats that include a layer of chopped strand mat the chopped strand mat should face the exterior surface to help block print through
    - Can occur if part thickness is incorrect or wrong vacuum level is applied
        - Results in resin pooling where the extra resin shrinks

RECAP

- LRTM used a rigid A-side mould and semi-rigid counter mould
- Part is infused using vacuum or low injection pressures
- Well suited for producing consistent parts with good surface finish on two sides
- Higher production rates and lower cost compared to wet layup with less expensive capital investment compared to RTM
- Darcy’s law used to assess flow during LRTM processing and can guide reinforcement, resin, and processing options
- Care must be taken during design of the parts and tooling to reduce quality defects

Thank you for joining us!

Keep an eye out for upcoming AIM events:

Aging Mechanisms in Fibers and Polymer Materials: Implications for Long-Term Performance and Reliability

Hosted by Dr. Pierre Mertiny
June 24, 2026
https://compositeskn.org/KPC/A417

And don't forget to visit the KPC for more information:

https://compositeskn.org/KPC

Today's Webinar will be posted at:
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QUESTIONS

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