Liquid Compression Molding (LCM) Technology for Mass Production of Continuous Fiber Composite Epoxy Matrix Components

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The car industry implements light weight solutions to comply with CO_2 emission and fuel consumption reduction legislation

How can we achieve a potential weight reduction of 70% at competitive part cost

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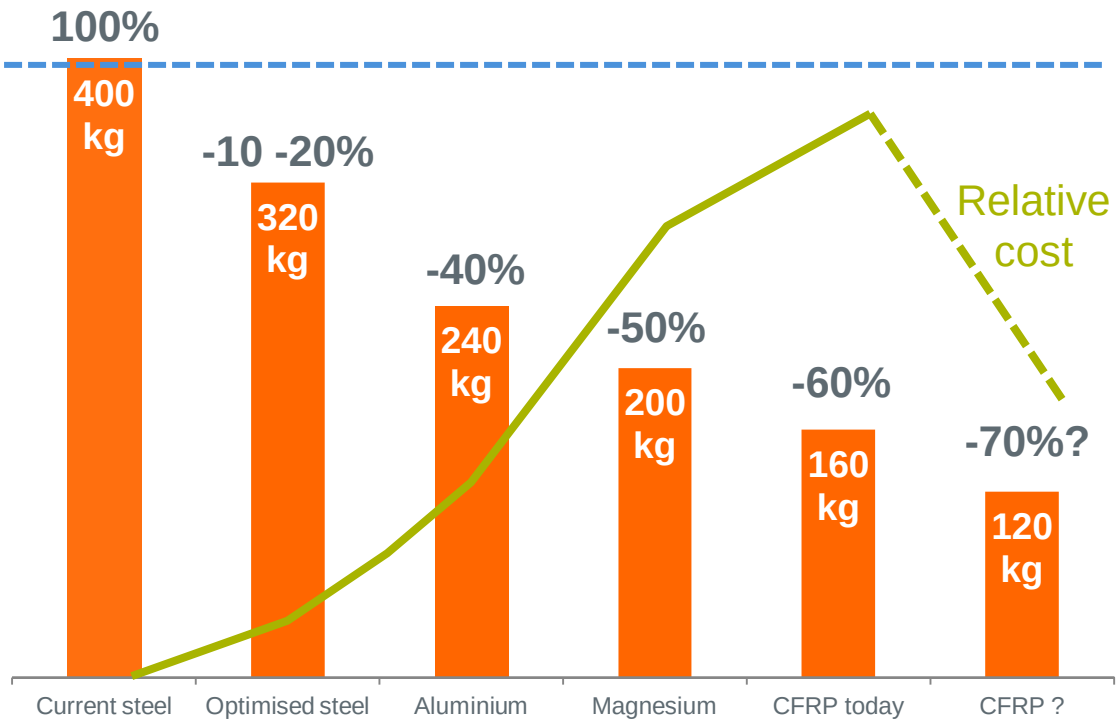
CFRP Epoxy Composites



50% material

- 40 - 45% carbon fiber
- 5 - 10% resin

50% processing

- Quicker curing matrix
- Process optimization
- Near-end-contoured preforms
- Automation

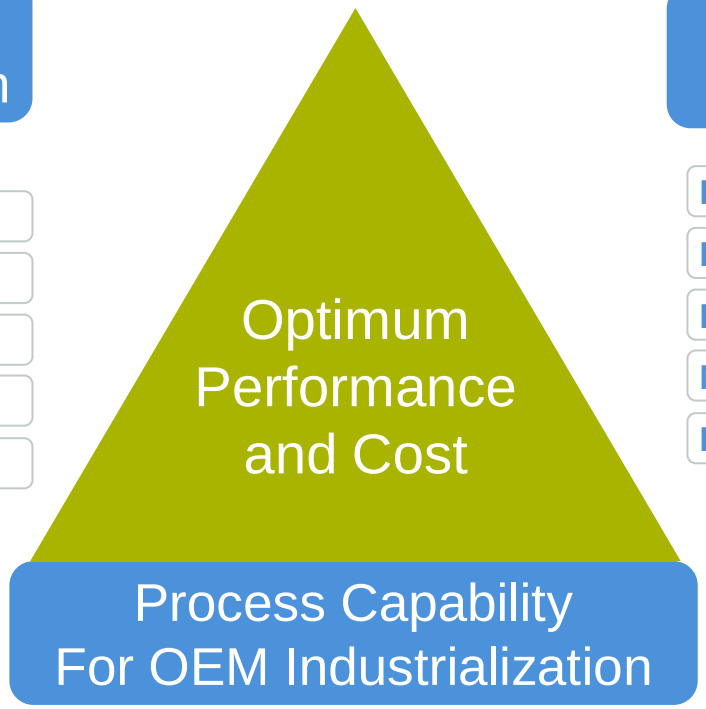
Source: Roland Berger

Optimum CFRP performance and cost is complemented with good design

HP-RTM	**LCM**	**Injection Moulding**	**Prepreg**
Towpreg	**Preforming**	**SMC**	**FiWi**

Partnerships Through Value Chain

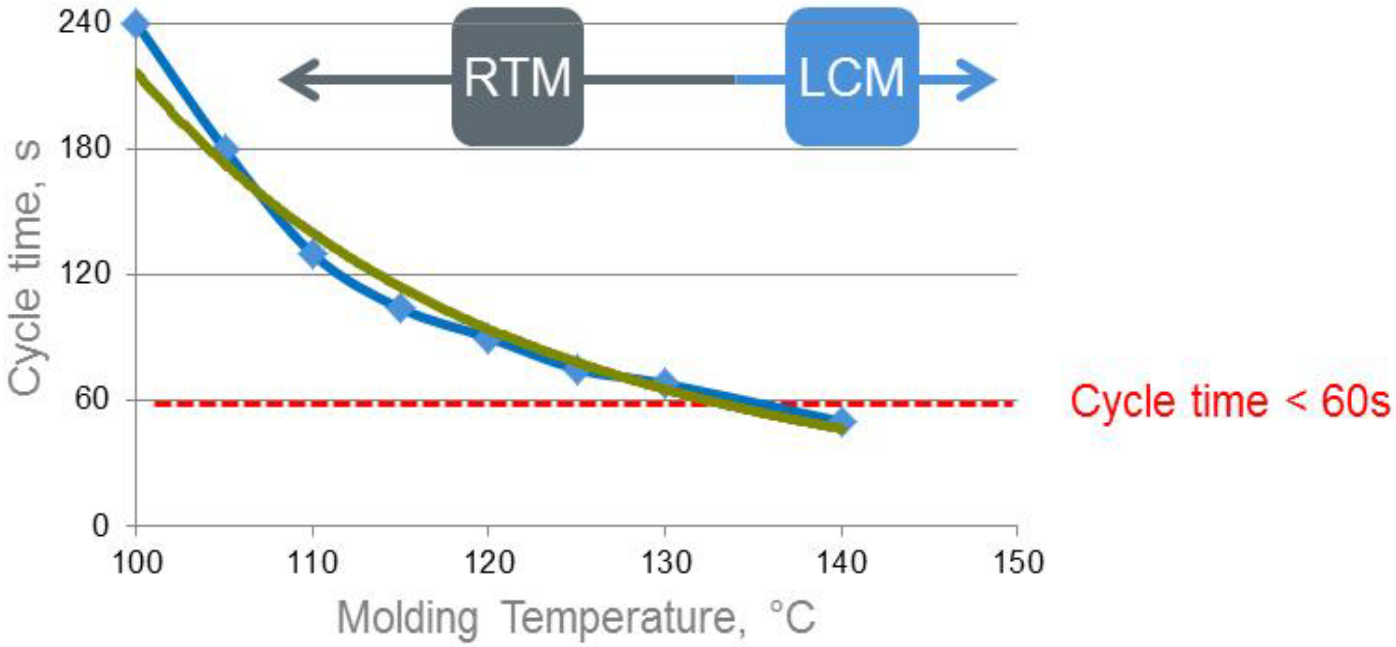
- Equipment Suppliers
- Part Design and Modeling
- Process Design and Modeling
- Tool Fabrication
- Reinforcements



Materials

- Liquid Resins
- Hot Melts
- Perform Binders
- Mould Release Agents
- Prototyping Systems

Complimentary Manufacturing Processes: Resin Transfer Moulding (RTM) and Liquid Compression Moulding (LCM)



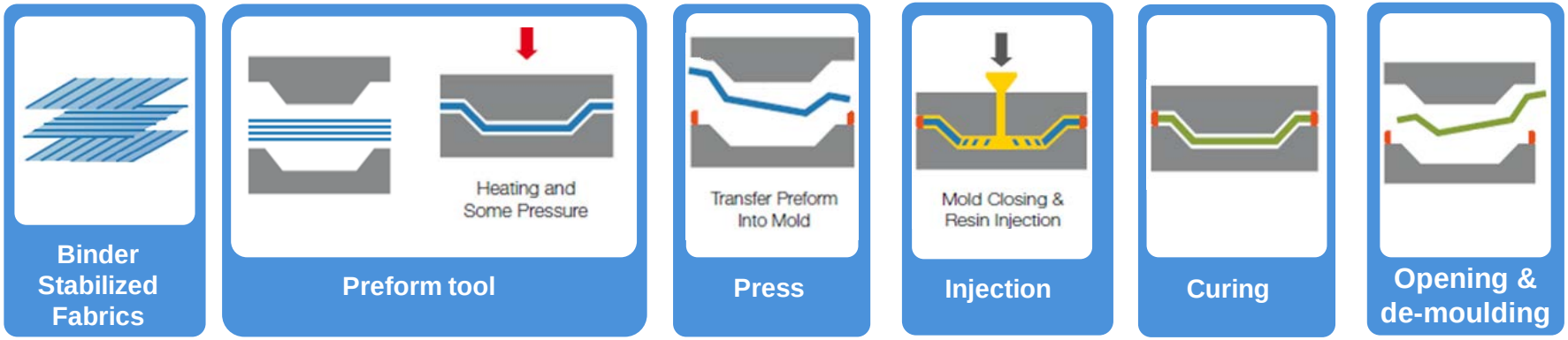
- Robust process technologies for rapid manufacturing of continuous fiber composites
- Compatible for range of simple to complex part geometries

HP-RTM Process Overview

In the HP-RTM process, resin is injected into the fabric preform in closed matched metal tooling in a compression press

Cycle time is driven by number of factors:

- Press and injection equipment
- Part size and complexity
- Resin type and quantity
- Injection flow rate (driven by geometry and preform permeability)

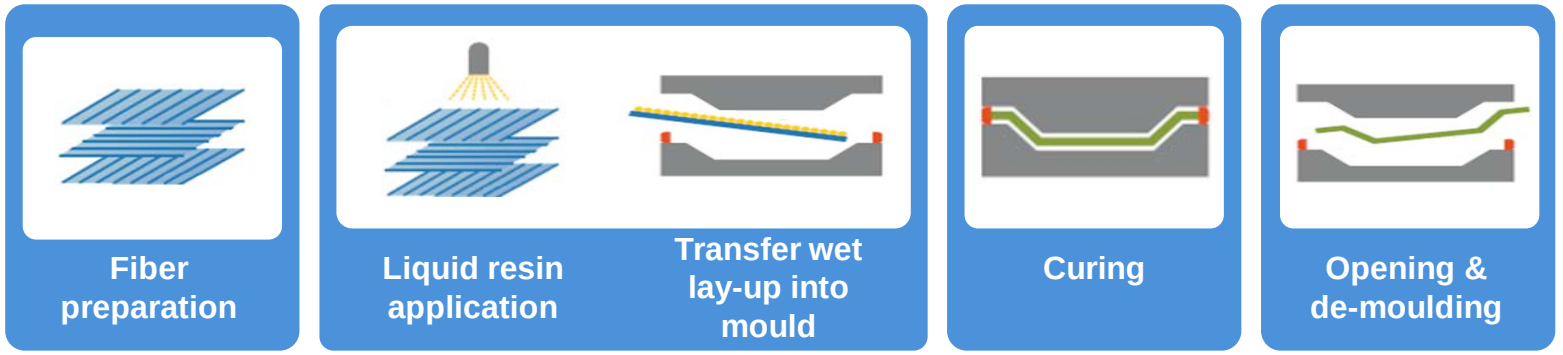


LCM Process Overview

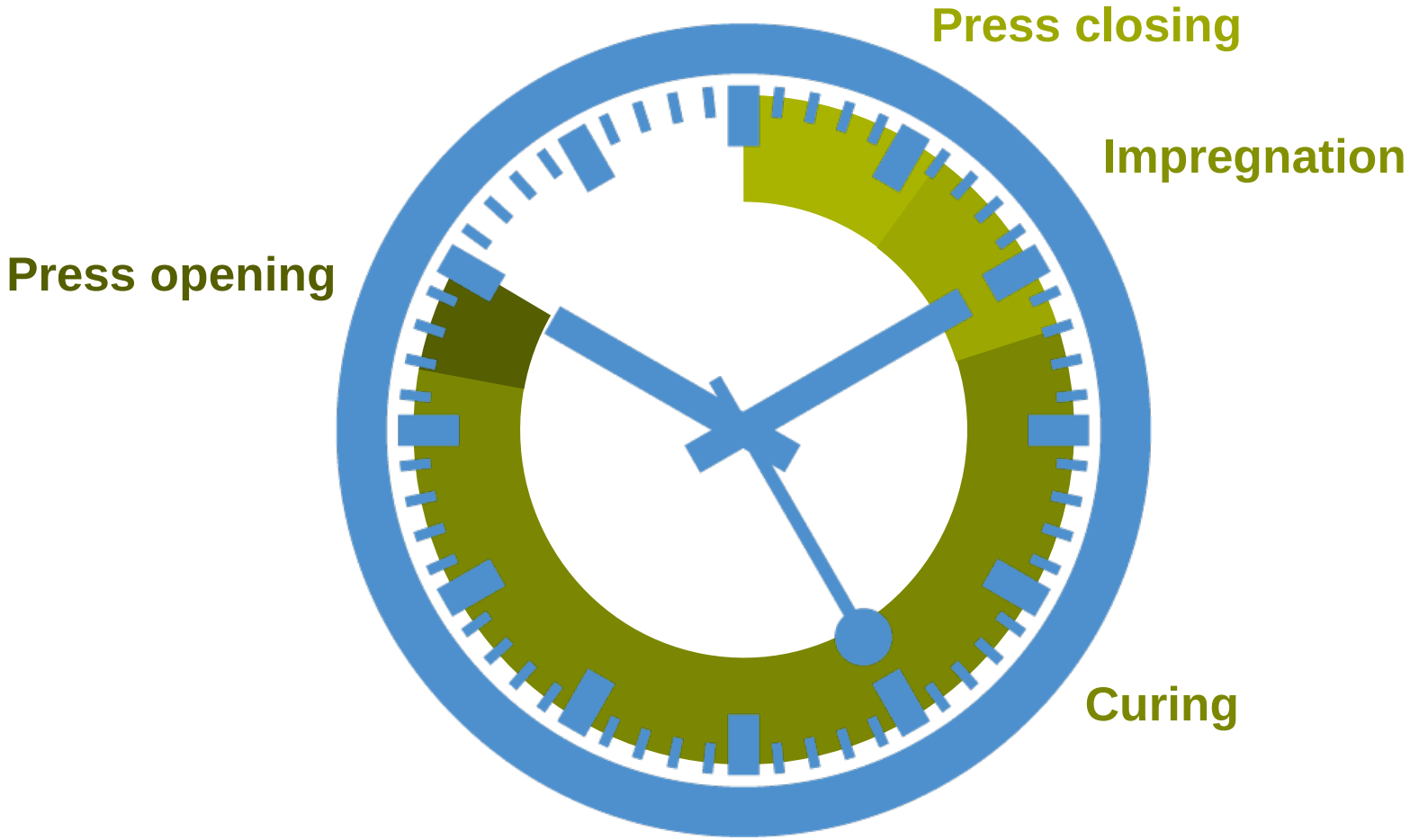
In the LCM process, the resin is applied to the top of the fabric, either outside or inside the open tool cavity. The press then closes and resin is pressed into the laminate, primarily in ‘z’ direction

Process and Cycle Time Advantages:

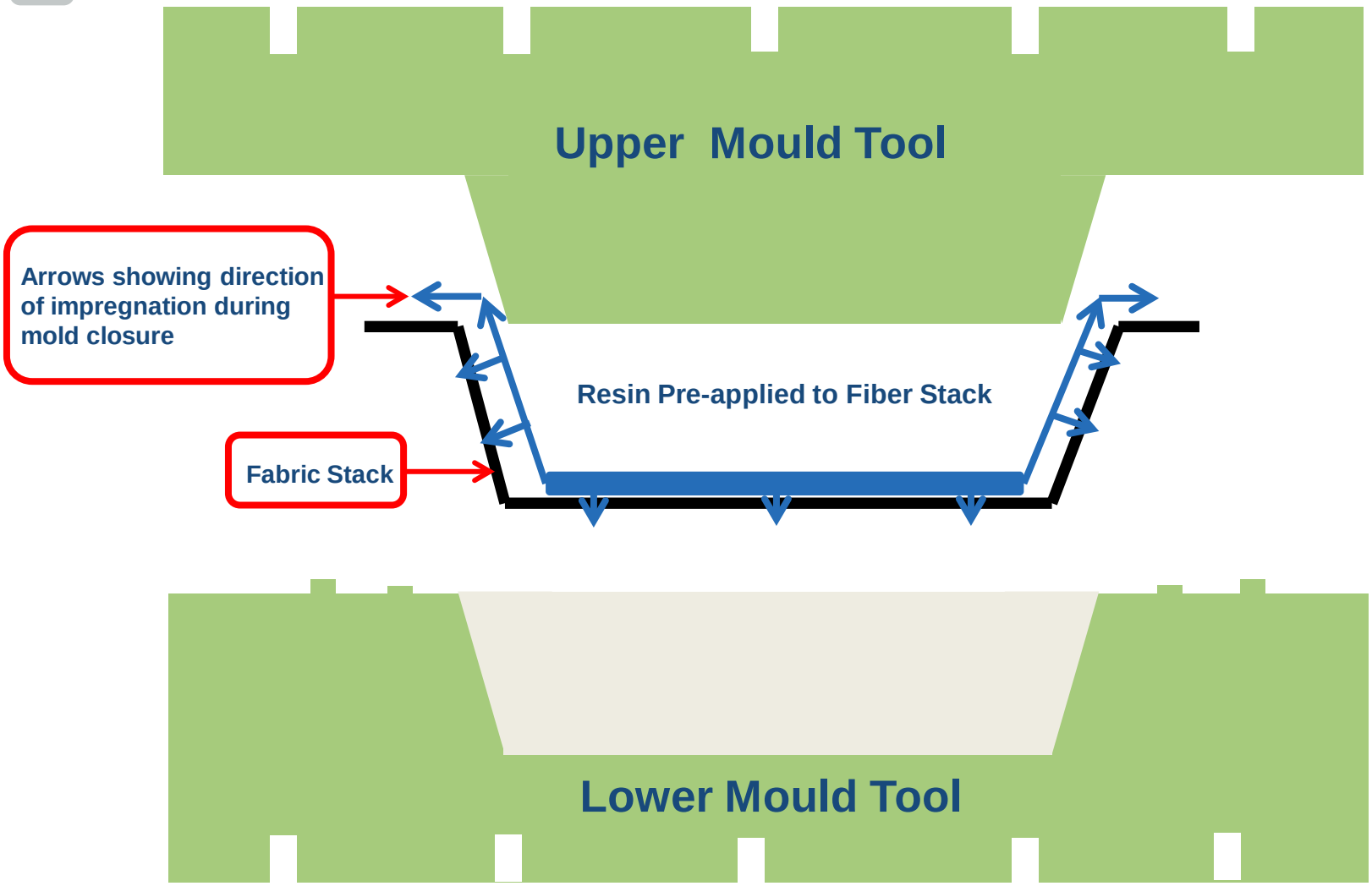
- Preforming not required for majority of compatible parts – removing process step
- Faster impregnation of fiber than with RTM injection



LCM cycle times of 50 seconds have been demonstrated



LCM Moulding Tool - Cross Section



Both RTM and LCM require technical expertise and process development

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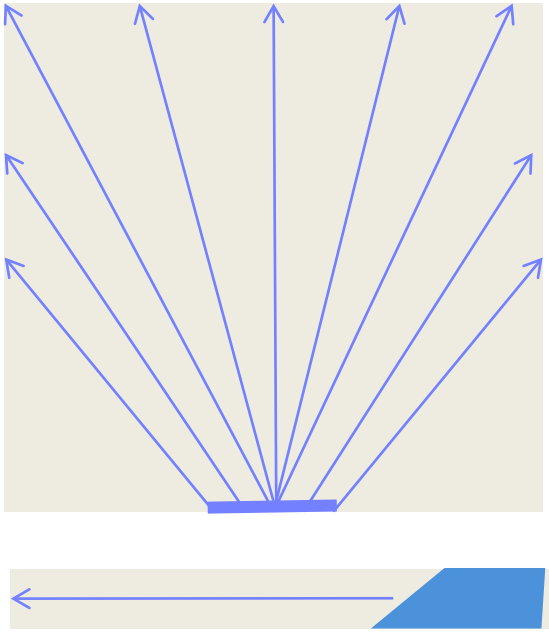
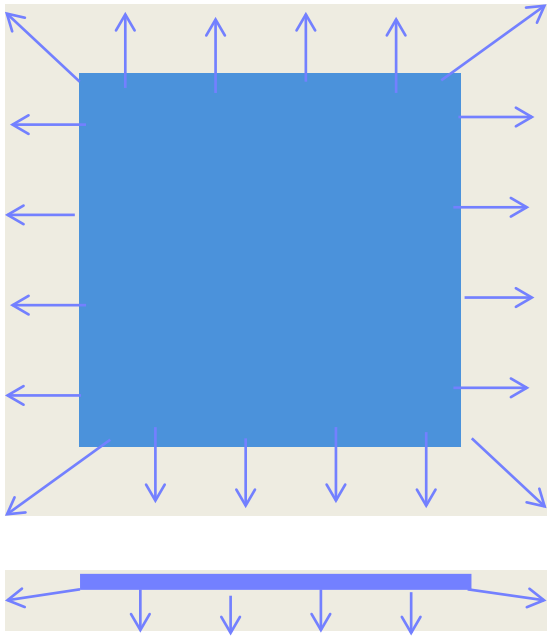
RTM



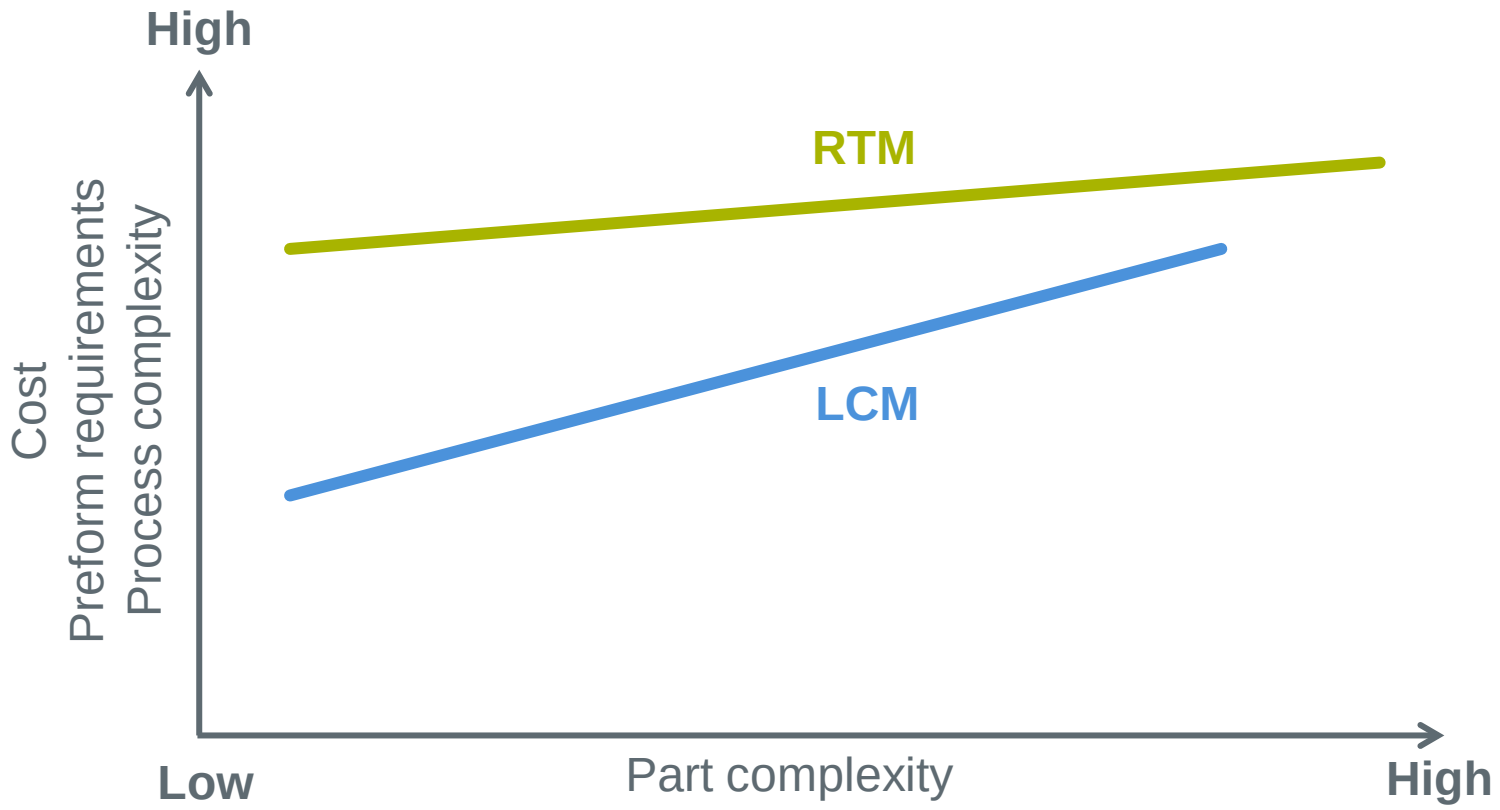
Resin Flow/Fiber Impregnation (during Injection)

LCM



Resin Flow/Fiber Impregnation (during Mold Closure)

Liquid Compression Molding (LCM) is cost attractive with increasing complexity of parts



Considerations to compare for CFRP part cost

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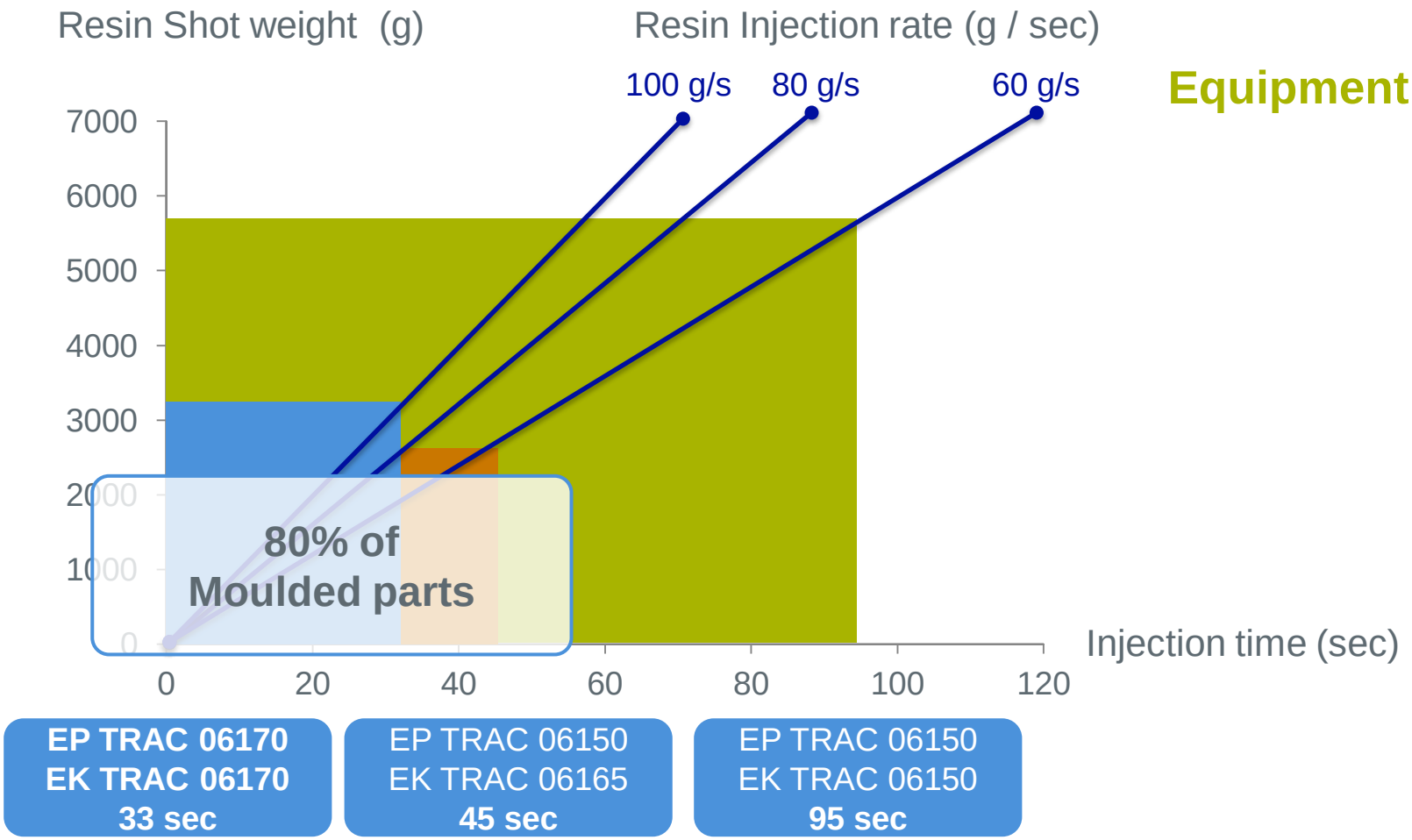
Example Part -

Dimensions : 1500 mm x 1200 mm x 3mm
Volume (cm3) : 5.400
Resin amount (g) : 2.400

Process		RTM	High Pressure - RTM	LCM
Injection rate	(g/s)	40	100	100
Process temperature	(°C)	120	120	140
Cavity pressure	(bar)	15	80	30
Required injection time	(s)	60	24	N.A.
Tool cycle time	(s)	**360**	**93**	**50**
Injection equipment		3K RTM	3K HP-RTM	3K RTM
Press	(ton)	500	2.500	1.000
Tooling cost	Relative	x1.5	x2	1
Build rate pc/year		20.000	70.000	120.000
Fixed tooling cost/part	Relative	x11	x4	1

The part size and equipment determine the material processing window



The BMW 7-Series Carbon Core illustrates body-in-white mixed material use

BMW 7-Series
Various CFRP parts e.g. roof arc and tunnel reinforcement
BMW
SOP: 2015





Source: BMW Group

Benefits

- 40 kg weight reduction vs. steel in the Carbon Core body structure
- Fast curing cycle enabled by Hexion latest resin technology
- Multi material mix – engineered to performance

Applications - Epoxy CFRP LCM & RTM technology for structural applications

BMW 7-Series
CFRP roof arc
EP TRAC 06000/
EK TRAC 06130

Complex part geometry requires HP-RTM process

Benefits
- Designed to the shape of the car body
- Fast curing cycle with HP-RTM
- Outstanding weight / performance ratio

BMW 7-Series
CFRP tunnel reinforcement
EP TRAC 06000/
EK TRAC 06130

Simple geometry of part is compatible with LCM process

Benefits
- Local reinforcement enhances torsional stiffness

Key Takeaways

Liquid Compression Molding (LCM):
Complimentary moulding process to HP-RTM for molding simple to complex geometry composite parts

Key LCM process benefits:
Fastest process technology for manufacturing continuous fiber composites today – Cycle times less than 90 seconds

Cost competitive:
Robust processing and rapid cycle time for LCM manufacturing makes Epoxy CFRP increasingly competitive as a lightweighting technology

Thank you!

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