# THE FUTURE OF MAKING THINGS BEGINS NOW

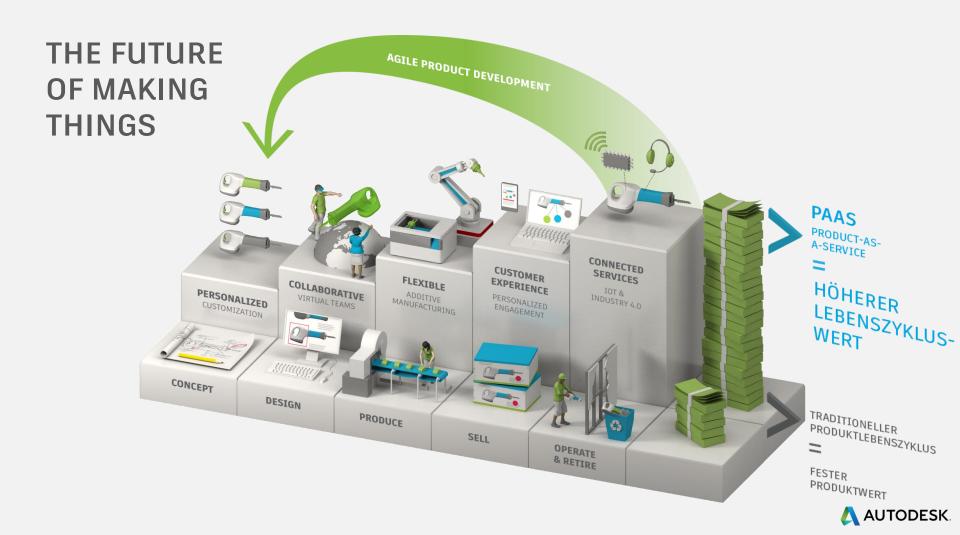
# **Moldflow in Leichtbauanwendungen**

Matthias Fink Simulation Solutions Engineer



## Agenda

- The Future of making Things
- Advances in Manufacturing for Continuous Fiber
- Resin Transfer Molding in Moldflow
- BMC in Moldflow



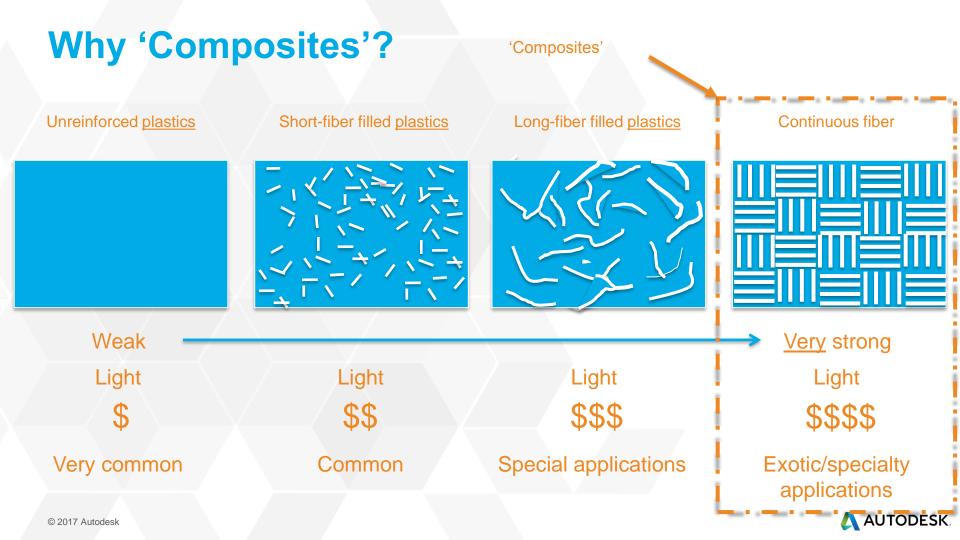
#### PRODUKTINNOVATIONSPLATTFORM



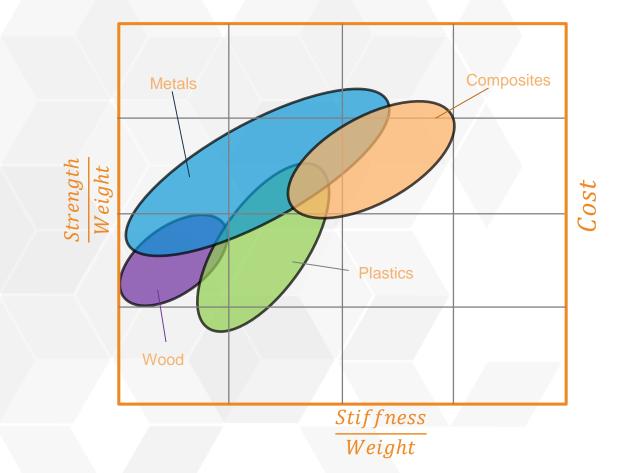


#### **'Composites' for Strength** Lightweighting Initiatives

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# Why 'Composites'?





#### **Market & Material Challenge**







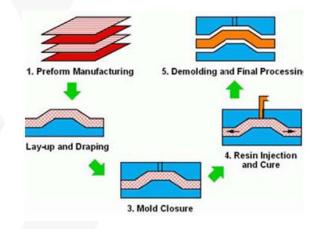
# **Resin Transfer Molding (RTM)**

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#### **Resin Transfer Molding (RTM) Flow Analysis**

- Analyze the flow through porous media (preform)
- Preforms (reinforcements) are present in the mold as dry form





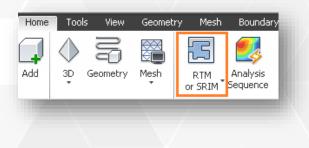


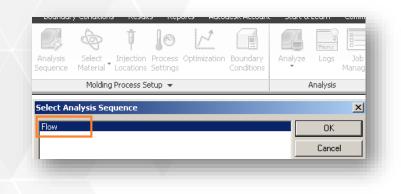
#### **Resin Transfer Molding Analysis**

- RTM 3D flow analysis:
  - Regular RTM Flow analysis (only macroscopic flow)
  - Simulate anisotropic permeability in the thickness direction
  - Better handling of parts with complicated geometry than mid-plane RTM simulation
  - Handle vacuum pressure using venting analysis
  - Handle gravity effect



#### **Work Flow**





- Molding process: RTM or SRIM
- Only "Flow" analysis sequence
- Assign "Preform element (3D)" for the elements in the area for RTM analysis



#### **Preform Properties for Preform Element (3D)**

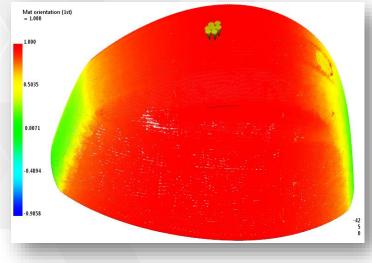
eform element (3D)
Part Surface Properties Preform Properties Mold Properties
Preform (3D)
Density: 1150 Edit Select
Preform orientation (1st principal direction)
dx 1
dy 0
dz 0
Preform orientation (2nd principal direction)
dx 0
dy  1
dz 0
Adjust preform orientation to follow along the local surface
Adjust porosity and permeability with local thickness
lame Preform element (3D) #1
1
Apply to all entities that share this property

- Preform orientation: 1<sup>st</sup> and 2<sup>nd</sup> principal directions
- Adjust preform orientation to follow along the local surface (default: On)
- Adjust porosity & permeability with local thickness (default: Off)



#### Input Data Option: Preform Element (3D)

- Adjust preform orientation to follow along the local surface
  - Adjust preform orientation automatically to follow along the surface
- Adjust porosity & permeability with local thickness
  - Use the difference in local thickness and the reference thickness to adjust porosity and the permeability from the input values
  - Use the thickness information from "dual-domain" to improve local thickness accuracy



Mat Orientation (1<sup>st</sup>)



#### **Preform / Filler Properties for Preform (3D)**

escription Preform Pr	operties	Filler Properties
Preform porosity and p	ermeability	(3D)
phi	0.5	[1e-005:1]
К11	1e-00\$	m^2[1e-017:0.001]
K22	1e-00\$	m^2 [1e-017:0.001]
К33	1e-00\$	m^2 [1e-017:0.001]
Reference thickness	2	mm (0:100)

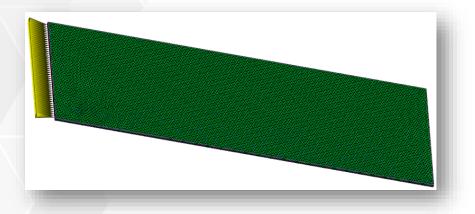
1 mor	data –				
	Description		Weight % [0:100]		
1	Glass	Mat	50		

- Porosity: The ratio of the void volume to the cavity volume
- Permeability in 3 principal directions: K11, K22, K33
- Reference thickness: The part thickness at which the porosity/permeability are measured
- Select the fiber mat materials



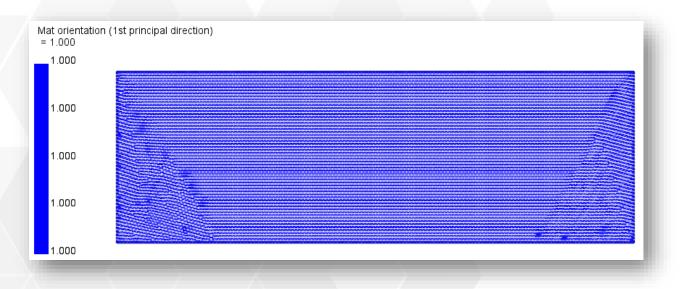
#### **Test Case: A Rectangular Plate**

- Dimension: 300 x 100 x 2 mm
- Injected from one side
- 1<sup>st</sup> Principal direction: Length direction
- Flow rate: 0.5 cm<sup>3</sup>/sec
- Viscosity: 0.4 Pa-sec
- Permeability (isotropic): 1.0x10<sup>-9</sup> [m<sup>2</sup>/sec]
- Porosity: 0.5





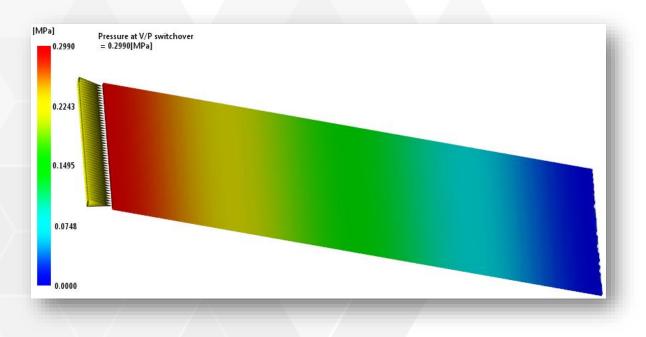
#### **Results**



- All the results available for Reactive Molding
- Additional results for RTM
  - Mat orientation (1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> principal direction)



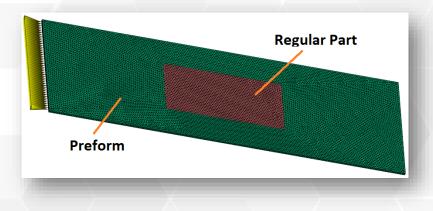
#### **Injection Pressure**



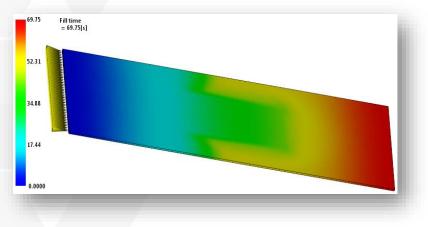
- Injection pressure from simulation: 0.299 MPa
- Analytical solution: 0.3 MPa



#### **Mixture of Preform and Regular Part**



Flow in the regular part region (no fiber mat) is faster





# **BMC Validation TUM**

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### **BMC Validierung**

Screening of methods for process modeling and simulation of Bulk Molding Compounds (BMC)

Semesterarbeit von Thomas Roth

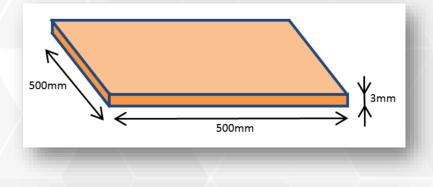
an der Fakultät für Maschinenwesen der Technischen Universität München

Betreut von:

Univ.-Prof. Dr.-Ing. Klaus Drechsler Lehrstuhl für Carbon Composites Wiss. Mitarbeiter Dipl.-Ing. Mathias Hartmann Lehrstuhl für Carbon Composites



## **BMC Validation Setup**



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	500mm	$\rightarrow$

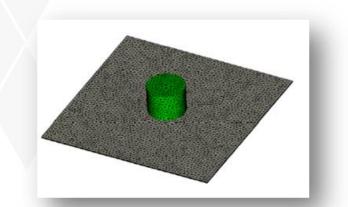
target thickness	3	mm
compression speed	0.73	mm/s
maximum compression force	30	kN
compression temperature	80	°C
compression time	apprx. 125	s
curing temperature	180	°C





## **BMC Validation Setup**

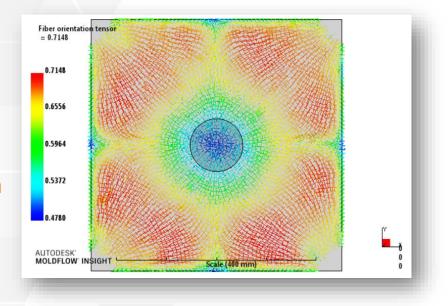
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#### **BMC Validation Results**

"Moldflow simulation results are by a small margin the most accurate to the experimental fiber orientation. Furthermore there is no non-smooth behavior and the parallel fiber alignment near wall areas are in consent to literature observation."





#### Kernaussagen

- Autodesk stellt sich den Herausforderungen einer sich ändernden Industrie und entwickelt Werkzeuge, welche die sich verändernden und auch neu hinzukommenden Prozesse unterstützt
- Hierbei liegt ein Schwerpunkt auf Leichtbau und additiven Verfahren
- Systeme wie Moldflow sind heute in der Lage die Herstellbarkeit vieler Leichtbauanwendungen zu überprüfen und zu optimieren

# Thank you!

# **Questions?**

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