Universität Bremen

FASERINSTITUT BREMEN FIBRE

Water Vapor Transmission Through Bagging Materials for Composite Processes

COMSOL CONFERENCE 2018 LAUSANNE

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Context

Context:

Vacuum bagging of CFRP components within the thermal treatment

Aim:

Analyse the water vapor transmission through a bagging material depended on the material composition and concentration gradient

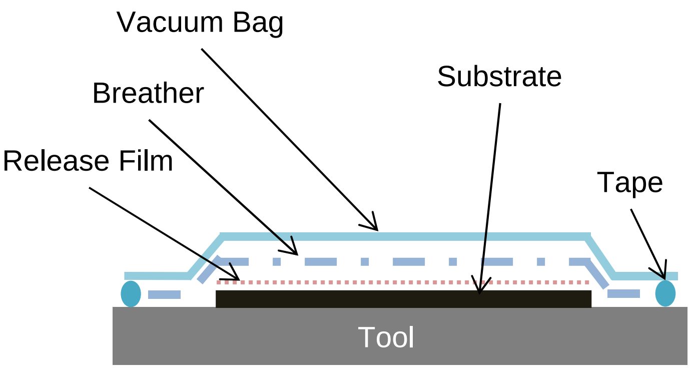
Approach:

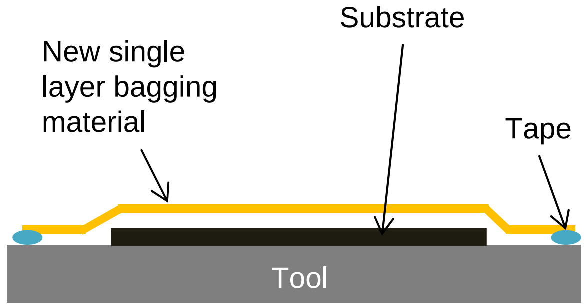
Set up a model with the help of COMSOL in order to predict moisture distribution during thermal treatment (→ Fast and cost efficient technology development)

Objective

Classical vacuum bagging:
- Three different layers
- Each layer has own property

New bagging material:
- One layer
- All properties are included





Material Description

New bagging material:

- Release property is already included in material

- Release properties of material can be out of different materials.

- Option1: Surface with ethylene tetrafluoroethylene (ETFE)

→ Moisture barrier comparable to todays vacuum set up

- Option 2: Thin surface treatment

→ Barrier properties lower than in todays vacuum set up

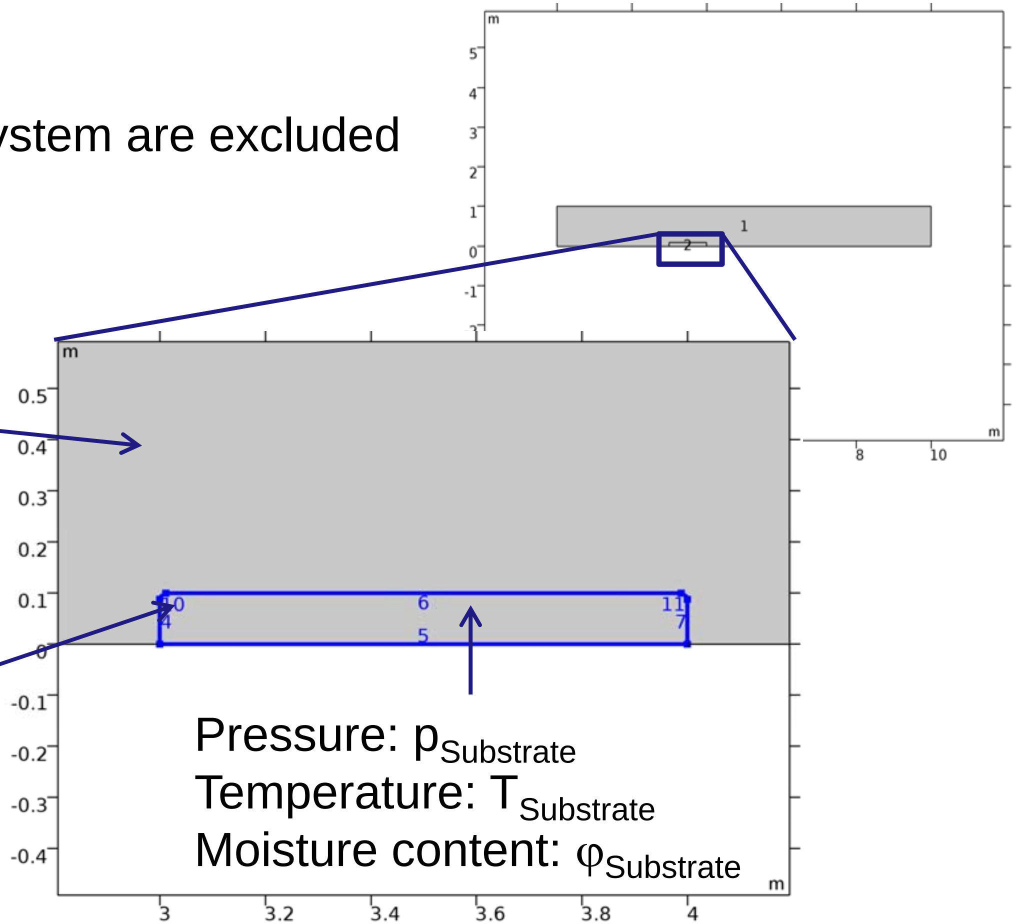
→ ~ Factor 4 more moisture transport than current material set up

Moisture distribution

- Only water vapor is analysed
- Volatile components of the resin system are excluded

Pressure: $p_{Oven/ACL}$
Temperature: $T_{oven/ACL}$
Moisture content: $\varphi_{Oven/ACL}$

Pressure: $p_{Barrier}$
Temperature: $T_{Barrier}$
Moisture content: $\varphi_{Barrier}$



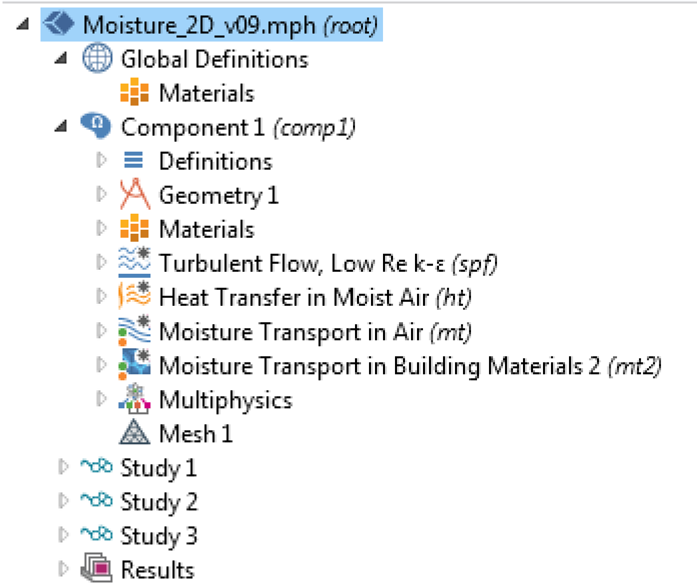
Model Set-up

Model Set-up:

- Air Flow
- Heat Transfer
- Moisture Transport

Solver

- Solution time for air flow: 3min, 10 seconds
- Time dependent solver regarding heat and air flow: 1h for 30 min timeframe

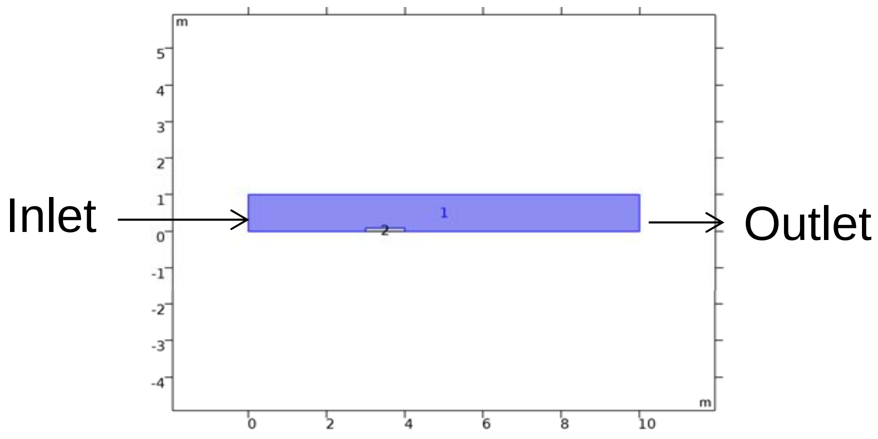


COMSOL Model Set-Up

Air Flow (Stationary):

- Modelled with 'Turbulent Flow (k-ε-Model)'
- Assumption: Velocity and pressure are independent of the air temperature and moisture content
- Calculate the flow in advance and use it as input
- Input:

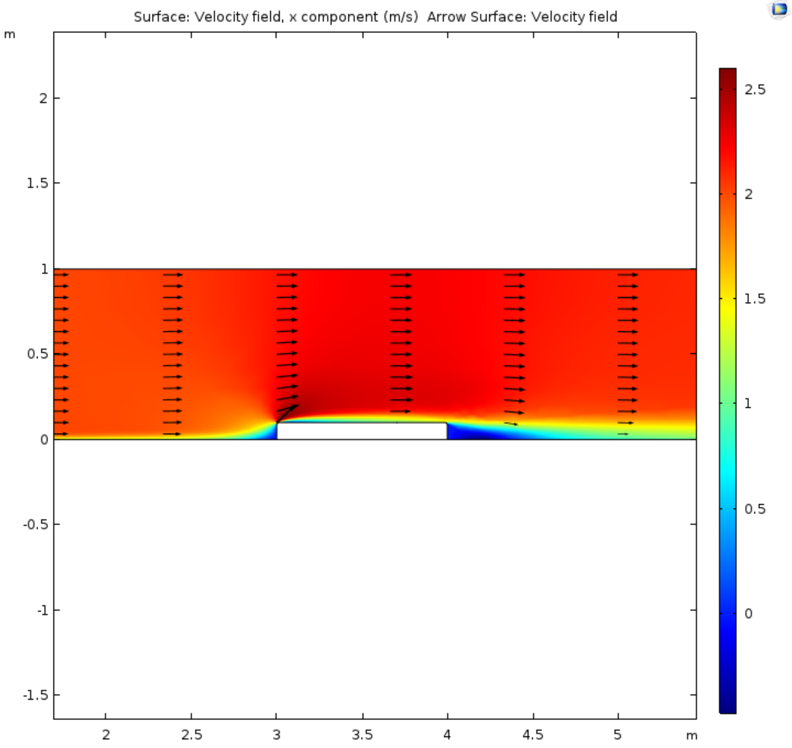
Velocity: 2m/s

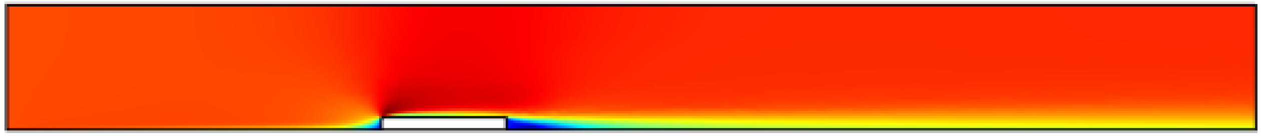


Simulation of turbulent flow

Turbulent Flow:

- Oven with Inlet and Outlet
- Velocity dependent on part geometry





COMSOL Model Set Up

Heat transfer:

- Modelled with 'Heat transfer in moist air'

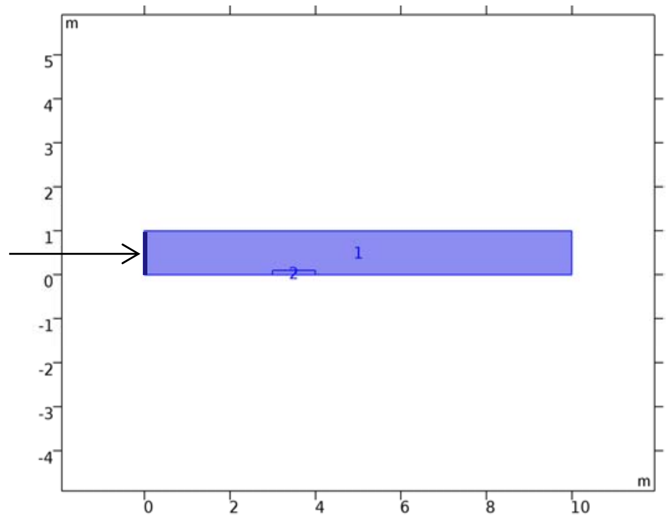
- Heat transfer through conduction within the material and through convection and radiation in the moist air.

- Input:

Initial value: 20 deg C

ACL temperature: 180 deg C

Inlet

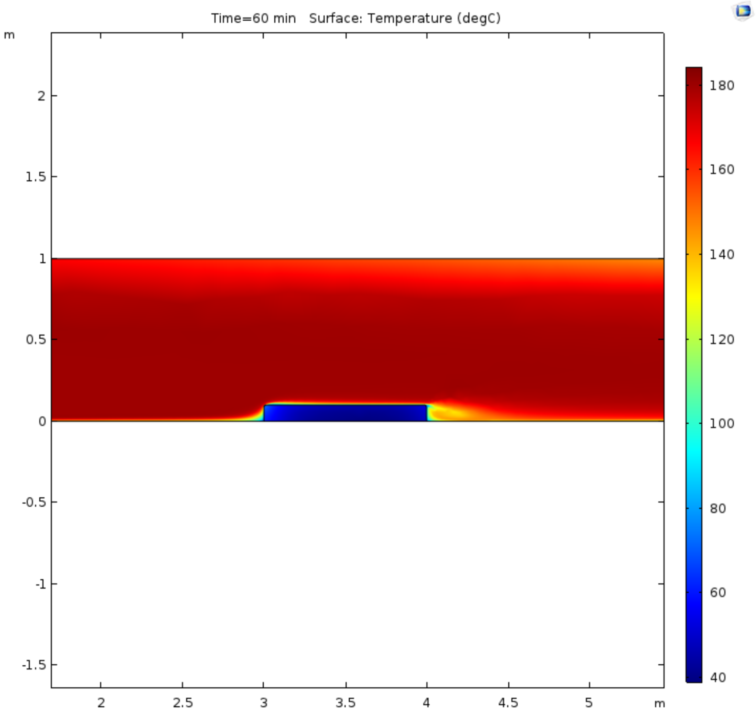


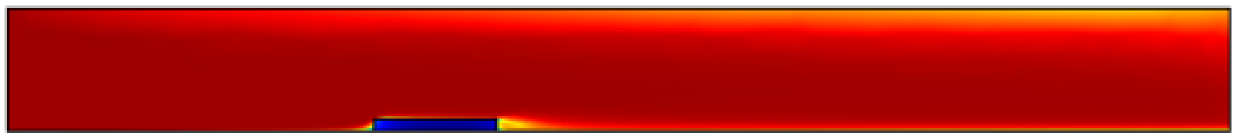
Simulation of Heat Transfer

Temperature distribution:

- Temperature distribution from inlet towards outlet
- Low distribution within material
- Low measured thermal conductivity of material

→ Insulation layer





COMSOL Model Set Up

Moisture transport:

- Modelled with ‘Moisture transport in air’

- Diffusion is calculated by Fick‘s law in the direction of concentration difference
- Molar flux due to diffusion is proportional to the concentration gradient

- Input:

Initial value air: 20% Moisture

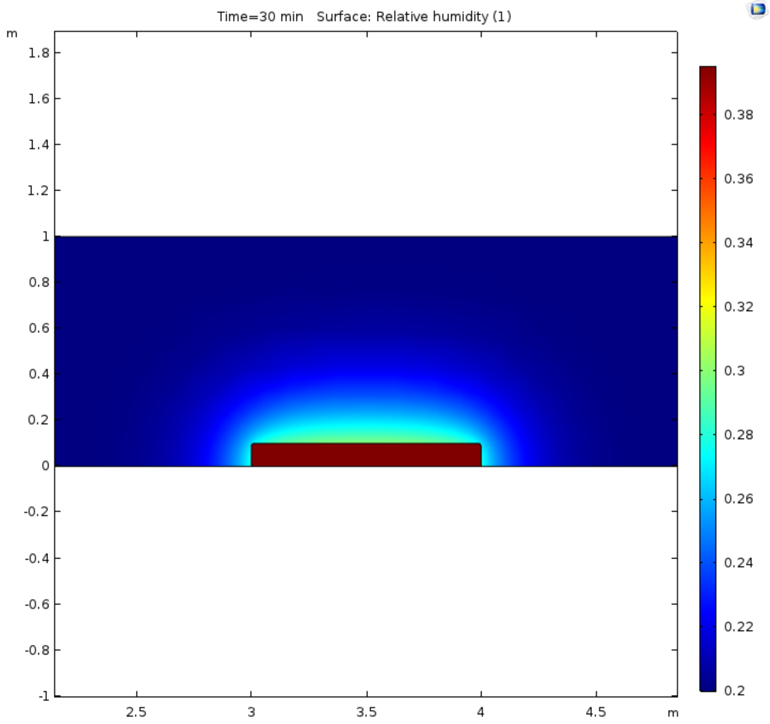
Initial value material: 40% Moisture

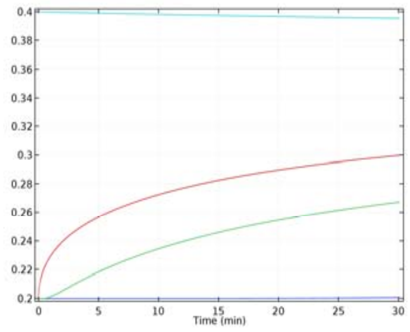
Results on moisture transport

Moisture distribution:

- Moisture flux from part to air

→Difference due to different vapor permeabilities and heat interface can be seen





Next Steps

- Implement moisture flow multiphysics interface
- Simulate full curing cycle within COMSOL
- Validate model with meassurements

Acknowledgement

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Thank you for your attention!