Faserinstitut Bremen e.V. on behalf of CTC

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COMPOSITE TECHNOLOGY CENTER STADE

AN AIRBUS COMPANY

Theoretical and experimental validation of composite processes

COMSOL Conference Rotterdam 2017

COMSOL CONFERENCE 2017 ROTTERDAM

Content

- Context and Objective
- COMSOL Model Set Up
- Results
- Comparison with and without bagging material
- Next steps

Context and Objective

Context:

Vacuum bagging of CFRP components

Aim:

Analyse the thermal behaviour of a given vacuum bagging with respect to heat transfer through conduction and radiation

Approach:

Set up a model with the help of COMSOL in order to predict temperature distribution for various process condition (→ Fast and cost efficient technology development)

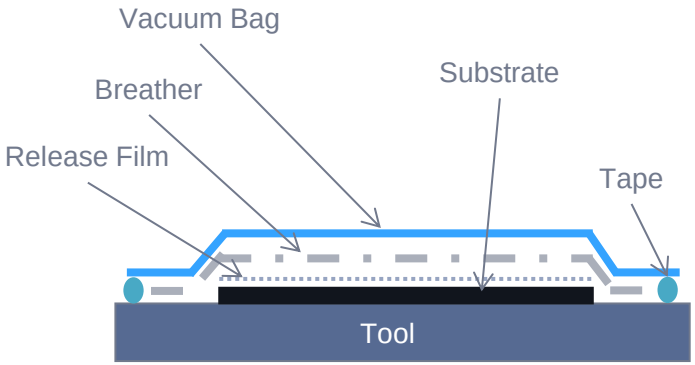
Objective

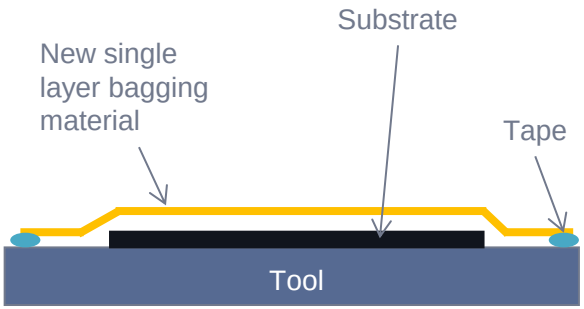
Classical Vacuum bagging:

- Three different layers
- Each layer has own property

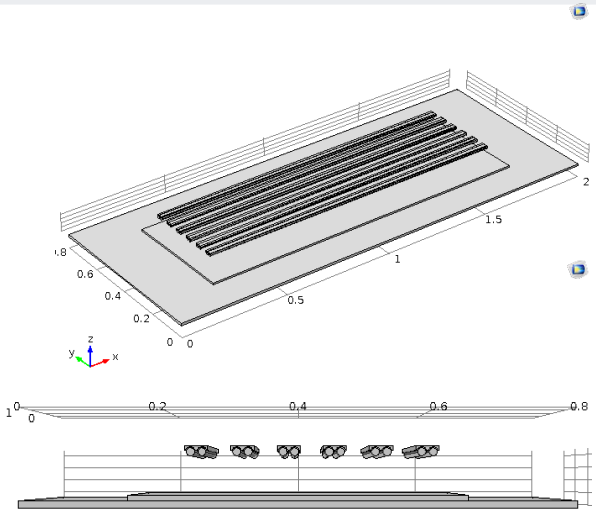
New bagging material:

- One layer
- All properties are included



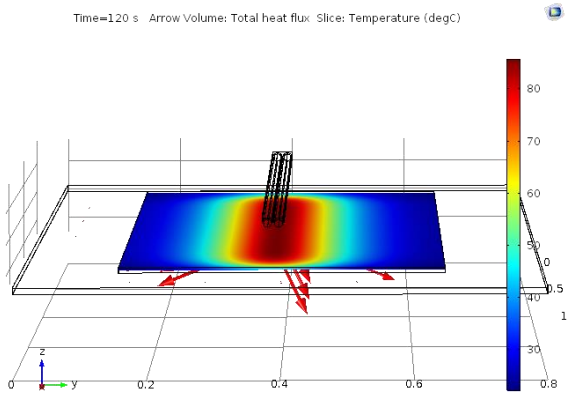


Objective



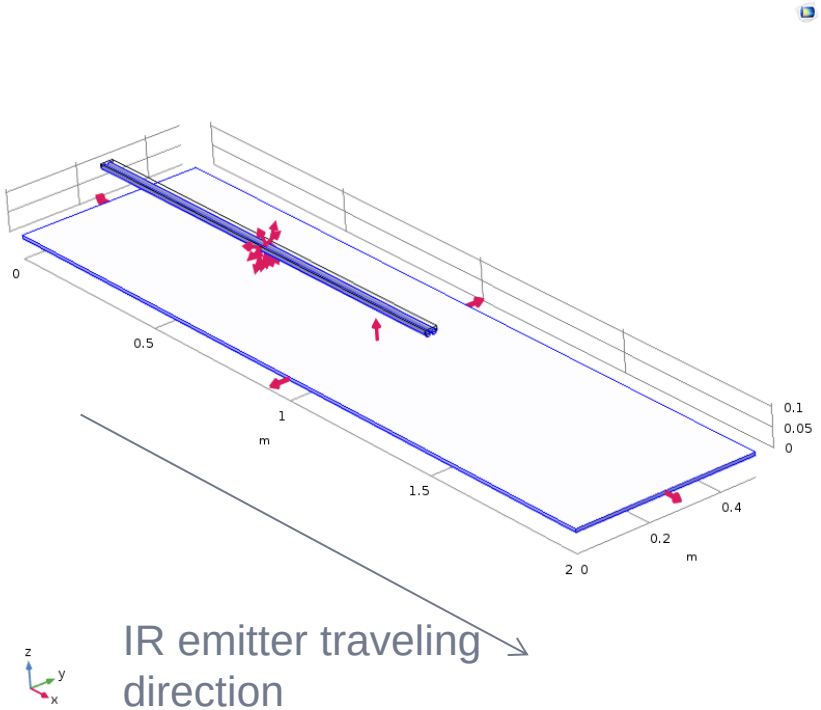
Parametric Model

Real Set Up



Detailed selected analysis

COMSOL Model Set Up



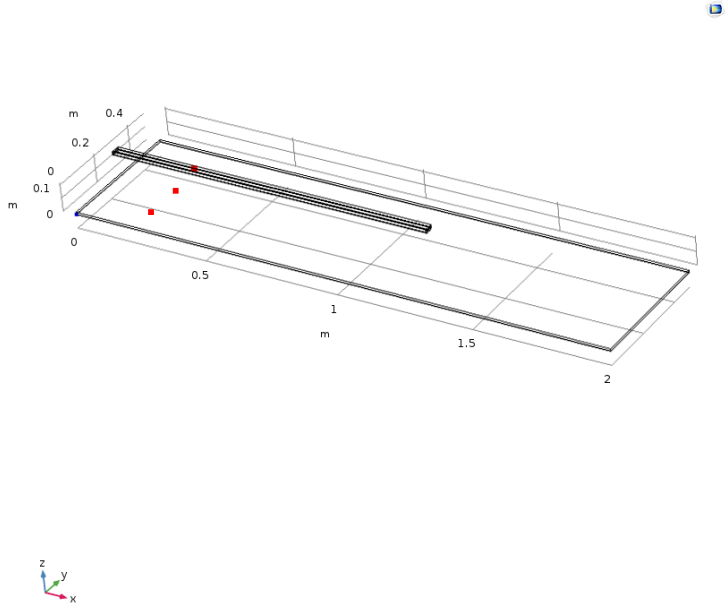
IR emitter traveling direction

- Component 1 *(comp1)*
  - Definitions
  - Geometry 1
  - Materials
  - Heat Transfer with Surface-to-Surface Radiation *(ht)*
    - Heat Transfer in Solids 1
    - Initial Values 1
    - Thermal Insulation 1
    - Diffuse Surface 1
    - Heat Flux 1
    - Heizleistung
    - Temperature 1
    - Bagging material
  - Solid Mechanics *(solid)*
    - Linear Elastic Material 1
    - Free 1
    - Initial Values 1
    - Fixed Constraint 1
    - Prescribed Velocity 1
    - Prescribed Displacement 1
  - Multiphysics
  - Mesh 1

Results

Quasi static approach

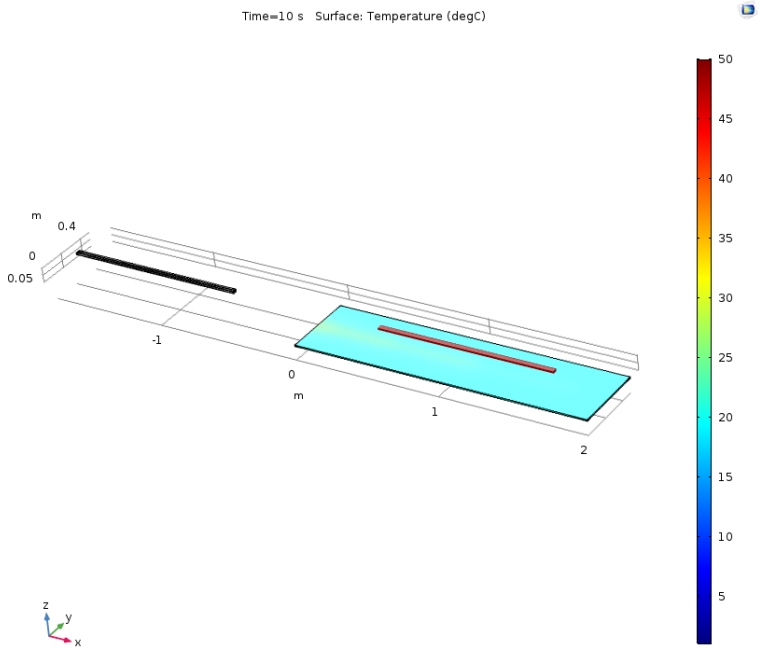
Solid mechanics module: off



Position Thermocouples

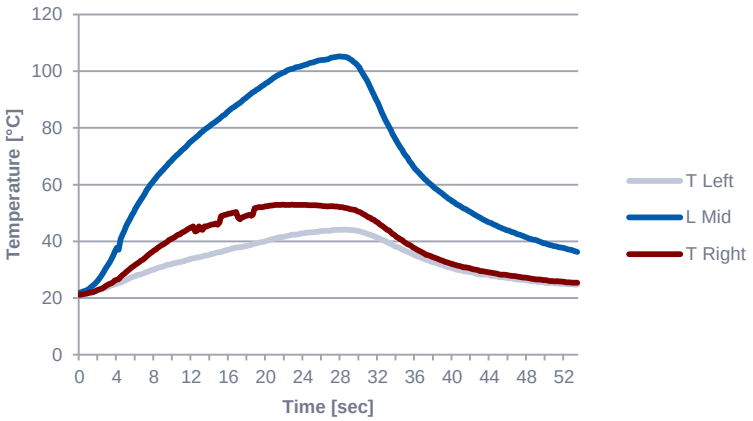
Dynamic approach

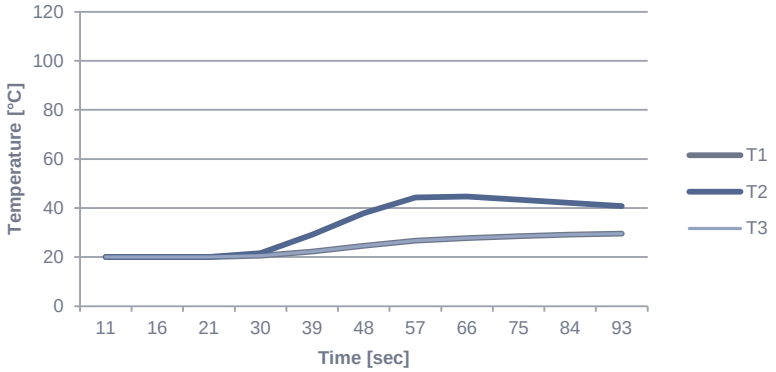
Solid mechanics module: on



Moving of IR emitter

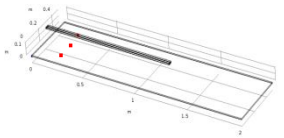
Results without bagging material



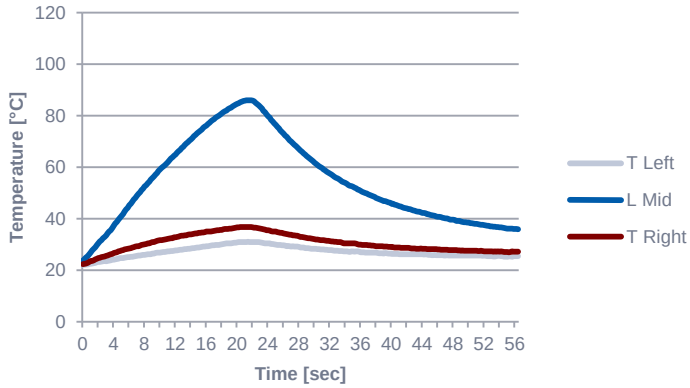


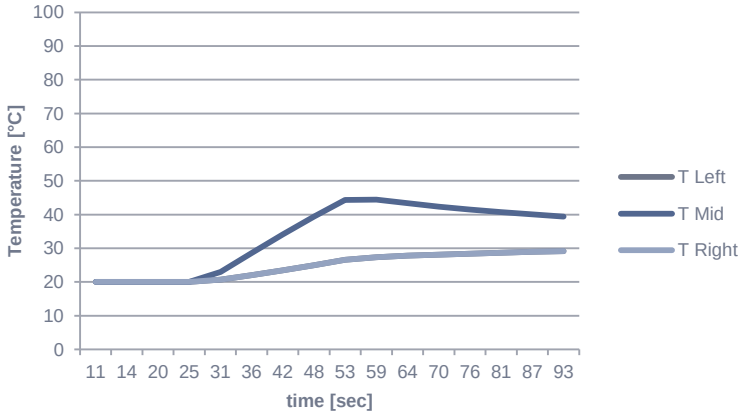
Comparison of moving IR emitter without bagging material
Left: Measured results
Right: Results from COMSOL

→ Reached temperature and cooling rate not comparable



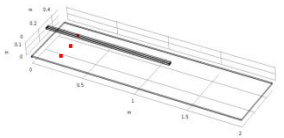
Results including bagging material



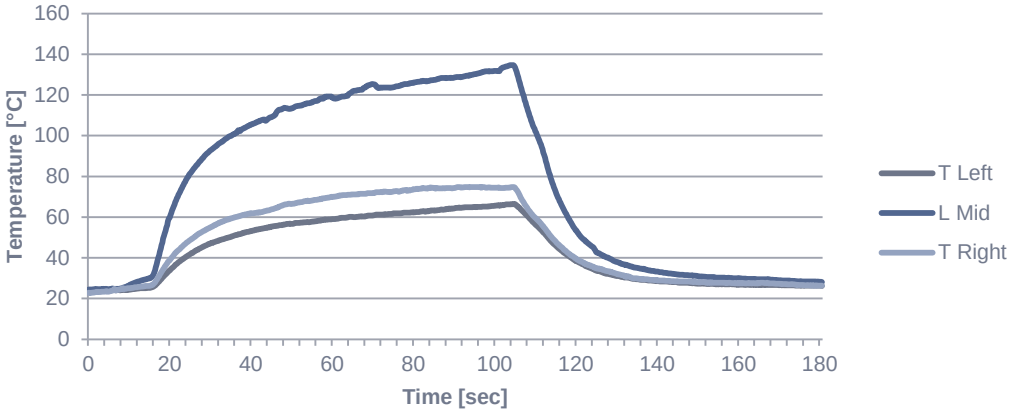


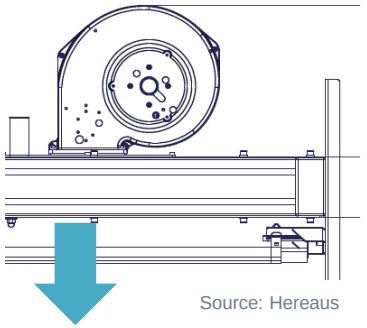
Comparison of moving IR emitter with bagging material
Left: Measured results
Right: Results from COMSOL

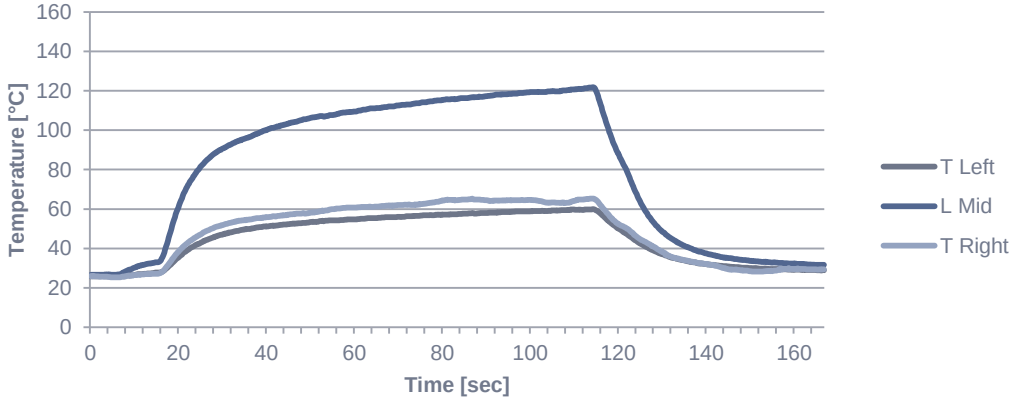
→ Reached temperature and cooling rate not comparable
→ Second result from Simulation shows higher value compared to simulation without bagging material



Root Cause Analysis







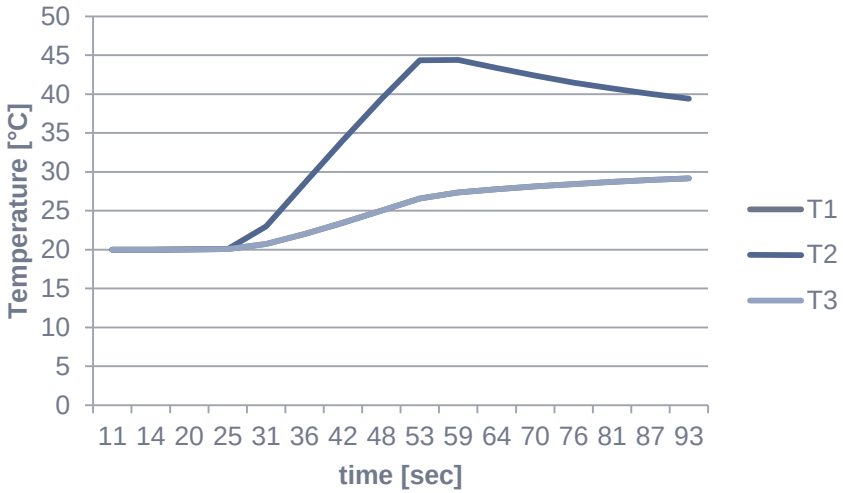
Upper diagram without cooling fan

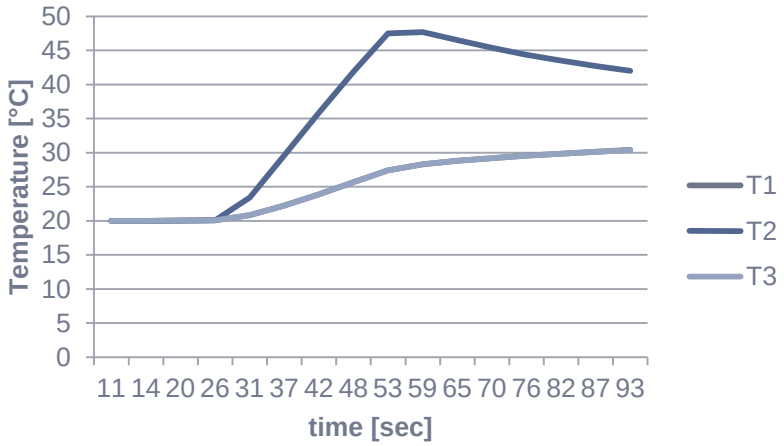
Lower diagram including cooling fan

→ Comparable curve characteristics

→ Ca. 15°C temperature difference

Root Cause Analysis





Upper diagram with emission coefficient of 0,75

Lower diagram with emission coefficient of 0,85

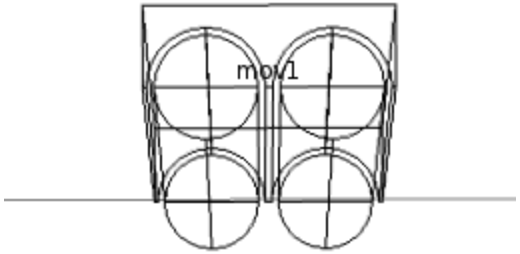
→ Comparable curve characteristics

→ Temperature delta ~2,5°C

Next Steps

Further points of analysis:

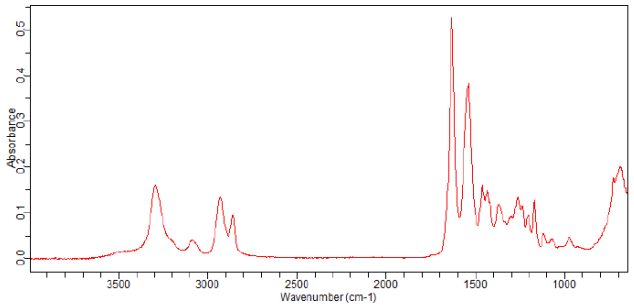
- Values for bagging material to be measured and not taken from literature
- Implementation of reflection through more accurate emitter modelling



- Calculation of wavelength dependent absorbance of radiation

→Therefore extensive analysis of emitter and materials necessary

- Wavelength dependency of emitter (Spectral emission) to be considered



- Moisture of substrate

→ Not modeled yet

EITeC e.V.

COMPOSITE TECHNOLOGY CENTER STADE
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aufgrund eines Beschlusses des Deutschen Bundestages

Backup

Material Data:

Name	Value	Unit
Heat capacity at constant pressure	900	J/(kg·K)
Density	2700	kg/m³
Thermal conductivity	201	W/(m·K)
Surface emissivity	0.8	1

Name	Value	Unit
Heat capacity at constant pressure	CPWerte(T)	J/(kg·K)
Density	1.258	g/cm³
Thermal conductivity	0.35	W/(m·K)
Surface emissivity	0.75/0.85	1