

Faserinstitut Bremen e.V. on behalf of CTC
A. Häberle, P. Fideu, A. Herrmann



COMPOSITE TECHNOLOGY CENTER STADE

AN AIRBUS COMPANY

Theoretical and experimental validation of composite processes

COMSOL Conference Rotterdam 2017

COMSOL CONFERENCE 2017 ROTTERDAM

© AIRBUS Operations GmbH. All rights reserved. Confidential and proprietary document.



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

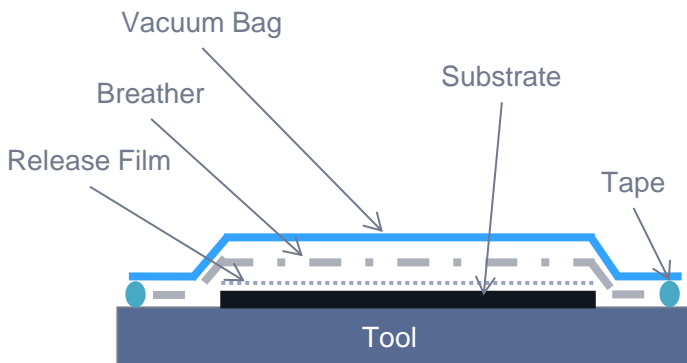
Approach:

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

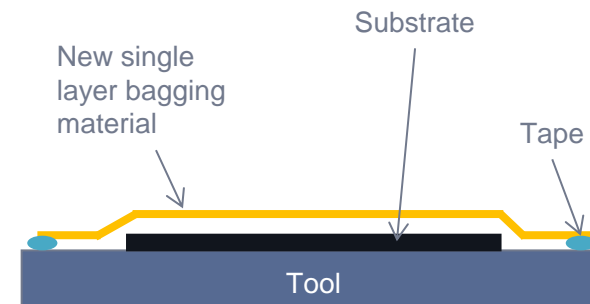
Classical Vacuum bagging:

- Three different layers
- Each layer has own property

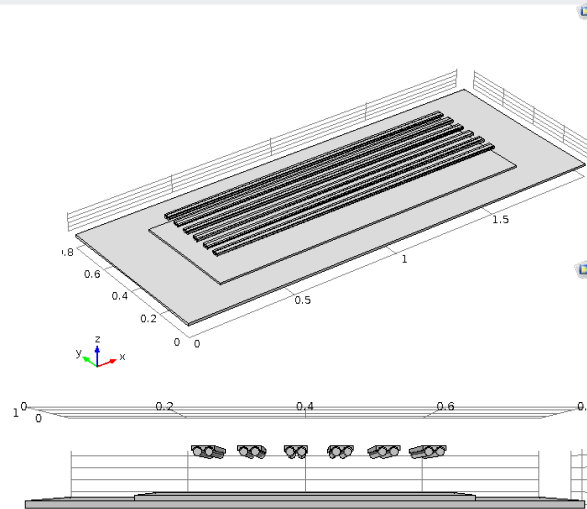


New bagging material:

- One layer
- All properties are included



Objective

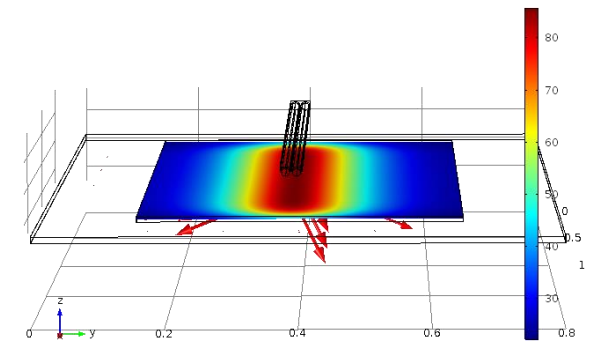


Parametric Model



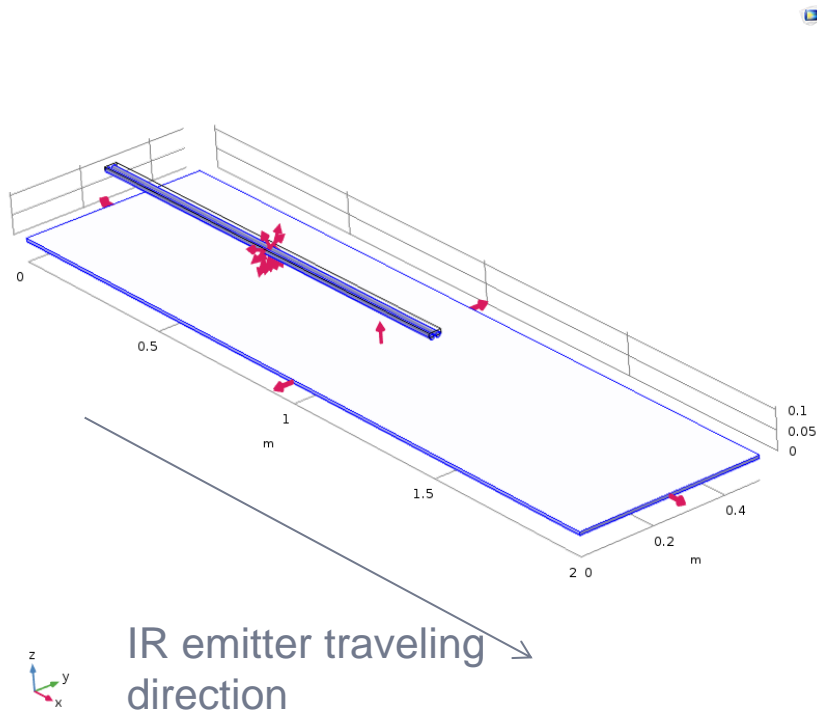
Real Set Up

Time=120 s Arrow Volume: Total heat flux Slice: Temperature (degC)



Detailed selected analysis

COMSOL Model Set Up

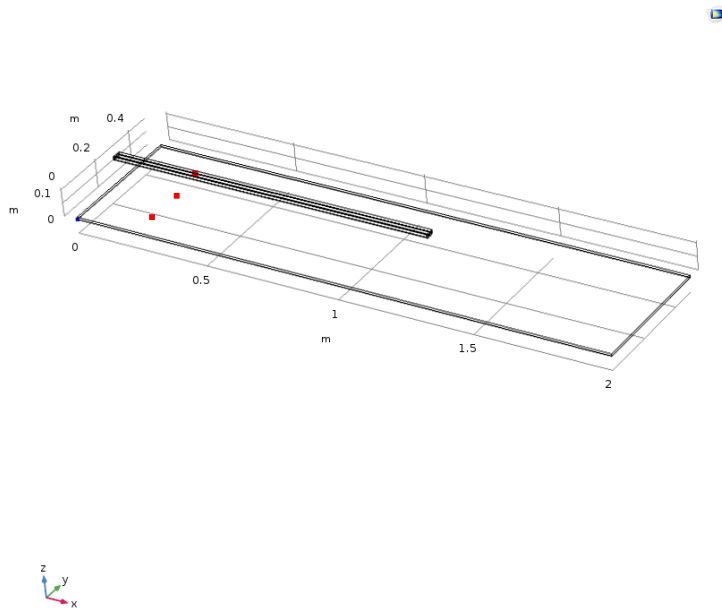


- ▲ **Component 1 (comp1)**
 - ▶ **Definitions**
 - ▶ **Geometry 1**
 - ▶ **Materials**
 - ▲ **Heat Transfer with Surface-to-Surface Radiation (ht)**
 - ▶ **Heat Transfer in Solids 1**
 - ▶ **Initial Values 1**
 - ▶ **Thermal Insulation 1**
 - ▶ **Diffuse Surface 1**
 - ▶ **Heat Flux 1**
 - ▶ **Heizleistung**
 - ▶ **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

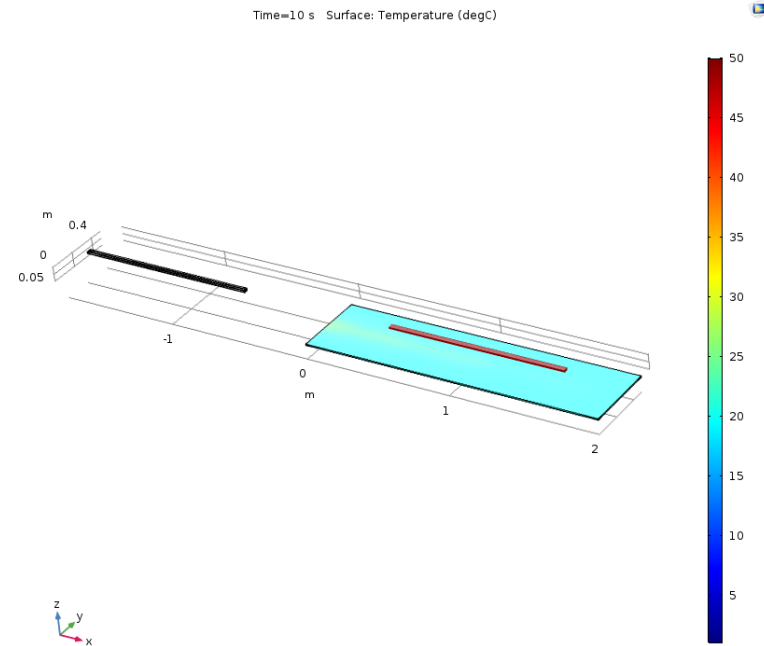
Solid mechanics module: off



Position Thermocouples

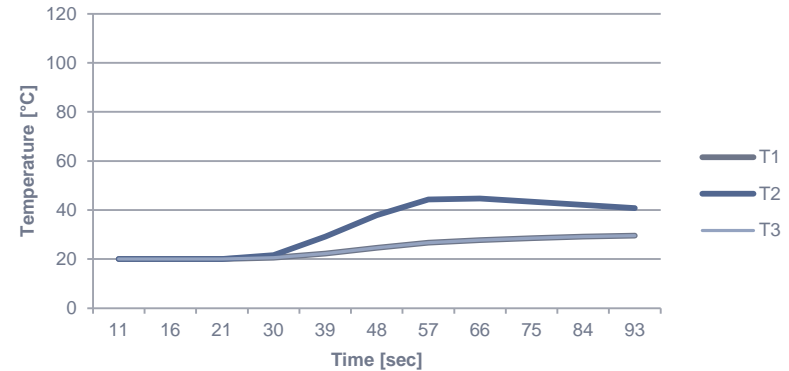
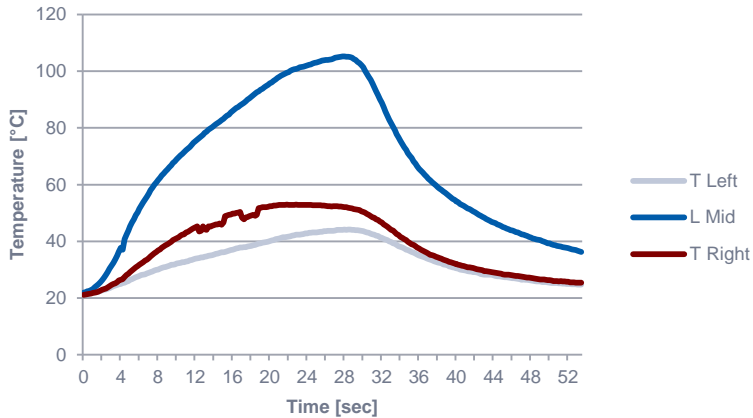
Dynamic approach

Solid mechanics module: on



Moving of IR emitter

Results without bagging material

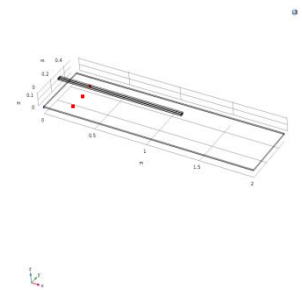


Comparison of moving IR emitter without bagging material

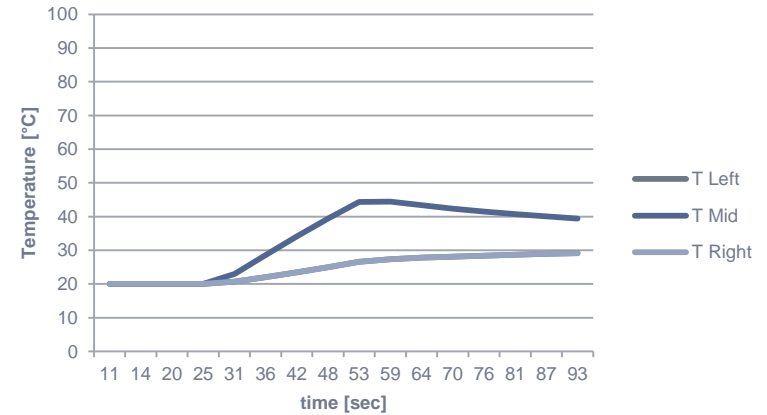
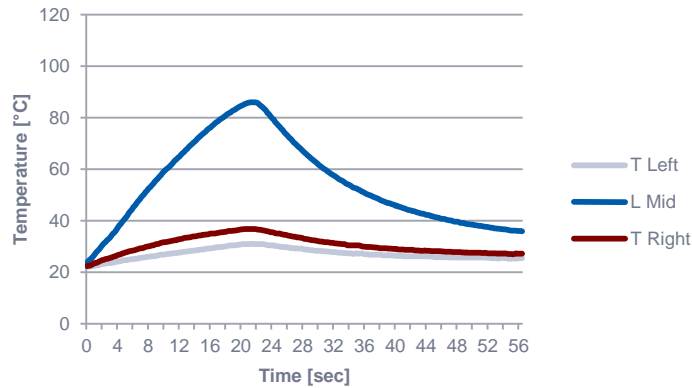
Left: Measured results

Right: Results from COMSOL

→ Reached temperature and cooling rate not comparable



Results including bagging material

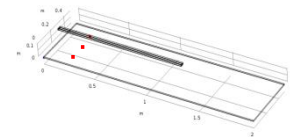


Comparison of moving IR emitter with bagging material

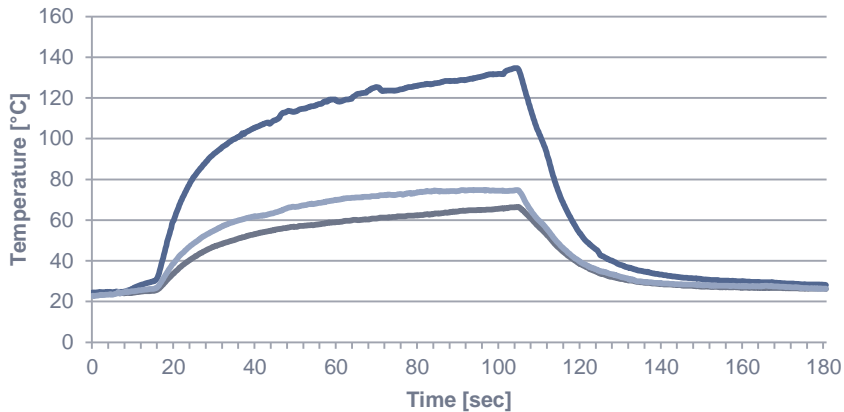
Left: Measured results

Right: Results from COMSOL

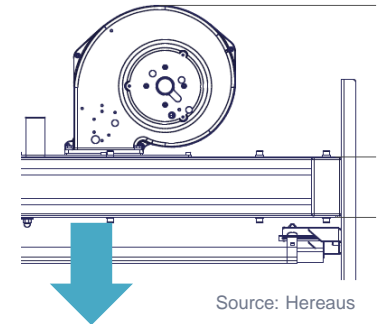
- Reached temperature and cooling rate not comparable
- Second result from Simulation shows higher value compared to simulation without bagging material



Root Cause Analysis

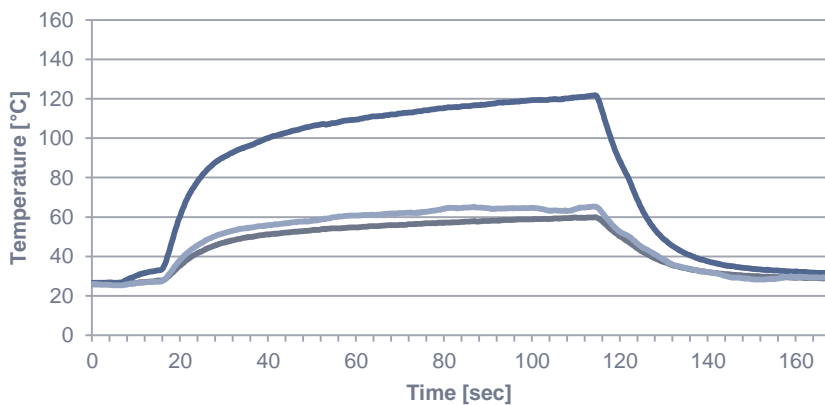


— T Left
— L Mid
— T Right



Upper diagram without cooling fan

Lower diagram including cooling fan

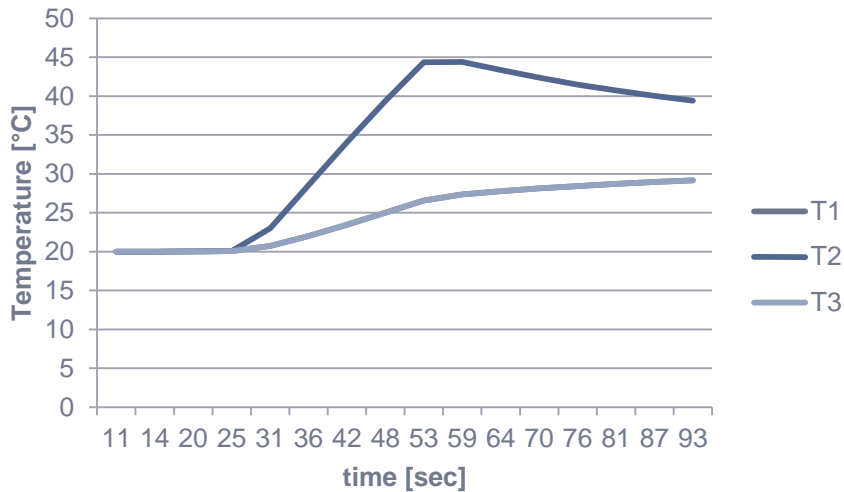


— T Left
— L Mid
— T Right

→ Comparable curve characteristics

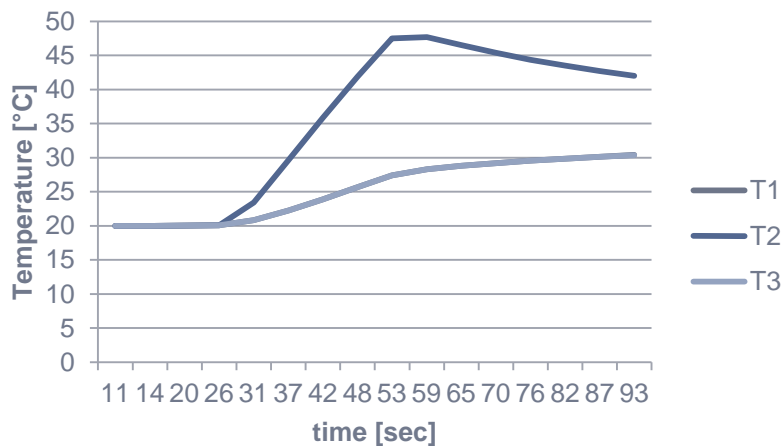
→ Ca. 15°C temperature difference

Root Cause Analysis



Upper diagram with
emission coefficient of
0,75

Lower diagram with
emission coefficient of
0,85



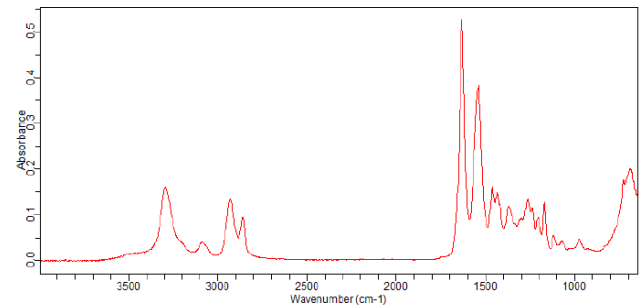
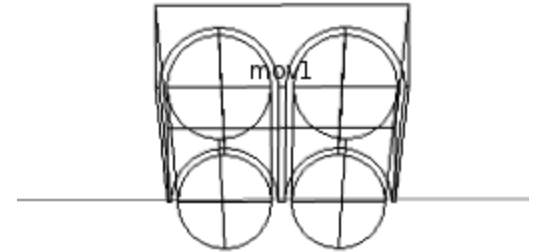
→ Comparable curve
characteristics

→ 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



© CTC GMBH. Alle Rechte vorbehalten. Vertrauliches und geschütztes Dokument.

Dieses Dokument und alle darin enthaltenen Informationen sind das alleinige Eigentum der CTC GMBH. Die Zustellung dieses Dokumentes oder die Offenlegung seines Inhalts begründen keine Rechte am geistigen Eigentum. Dieses Dokument darf ohne die ausdrückliche schriftliche Genehmigung der CTC GMBH nicht vervielfältigt oder einem Dritten gegenüber enthüllt werden. Dieses Dokument und sein Inhalt dürfen nur zu bestimmungsgemäßen Zwecken verwendet werden. Die in diesem Dokument gemachten Aussagen stellen kein Angebot dar. Sie wurden auf der Grundlage der aufgeführten Annahmen und in gutem Glauben gemacht. Wenn die zugehörigen Begründungen für diese Aussagen nicht angegeben sind, ist die CTC GMBH gern bereit, deren Grundlage zu erläutern.



COMPOSITE TECHNOLOGY CENTER STADE

AN AIRBUS COMPANY

© CTC GMBH. All rights reserved. Confidential and proprietary document.
 CTC GmbH is a 100% subsidiary of AIRBUS Operations GmbH

Gefördert durch:



Bundesministerium
 für Wirtschaft
 und Energie

aufgrund eines Beschlusses
 des Deutschen Bundestages



Backup

Material Data:

Name	Value	Unit
Heat capacity at constant pressure	900	J/(kg·K)
Density	2700	kg/m ³
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/cm ³
Thermal conductivity	0.35	W/(m·K)
Surface emissivity	0.75/0.85	1

