Thermoplastic Composites Conference

Mono-Material Sandwich Structures with Honeycomb Core

Thermal Analysis

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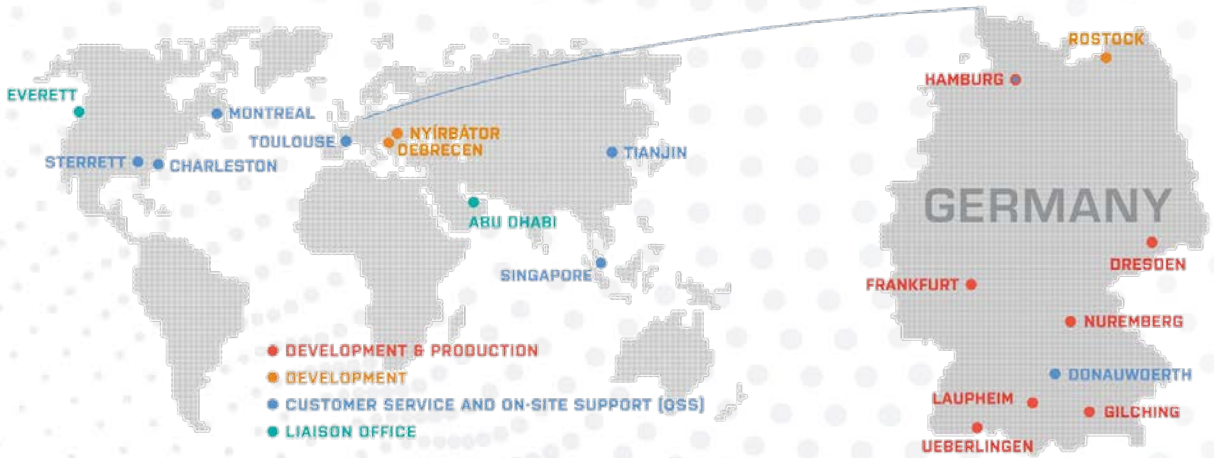
Agenda

- About Diehl Aviation
- Object and concept
- Manufacturing process
- Isothermal process: heat transfer model
- Isothermal process: experiment
- Non-isothermal process: heat transfer model
- Non-isothermal process: experiment
- Combined process: heat transfer model
- Summary and outlook

Diehl Aviation

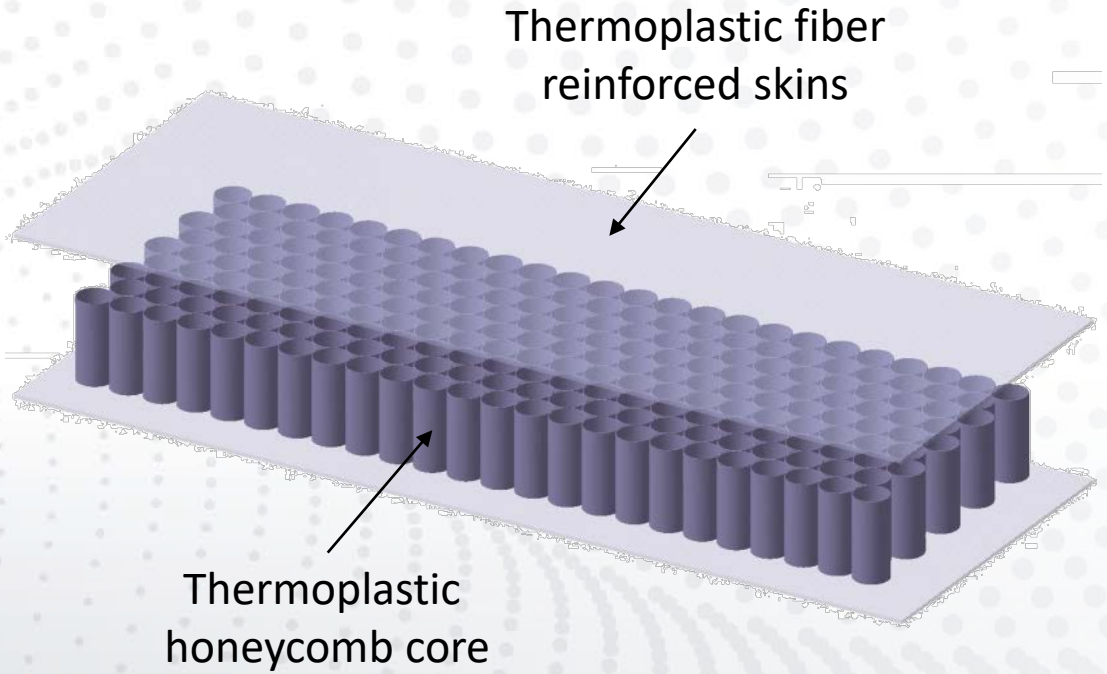


Conventional sandwich structure:

- phenolic/epoxy glass fiber reinforced prepregs
- aramid-phenolic resin paper honeycomb core (NOMEX®)

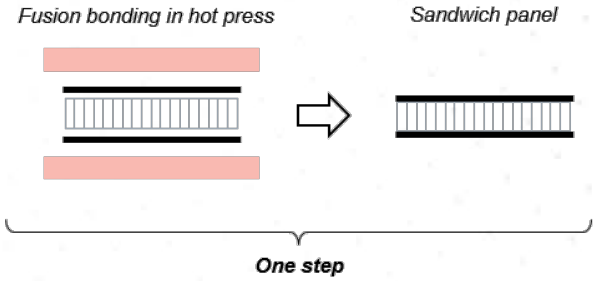
Object and concept

- obtain an adhesion-free thermoplastic sandwich panel
- challenge: to get a sufficient bonding degree between skins and honeycomb core by means of fusion bonding in restricted process window
- define optimal manufacturing process
- investigate formability of thermoplastic sandwich structures, its impact on bonding degree and mechanical properties

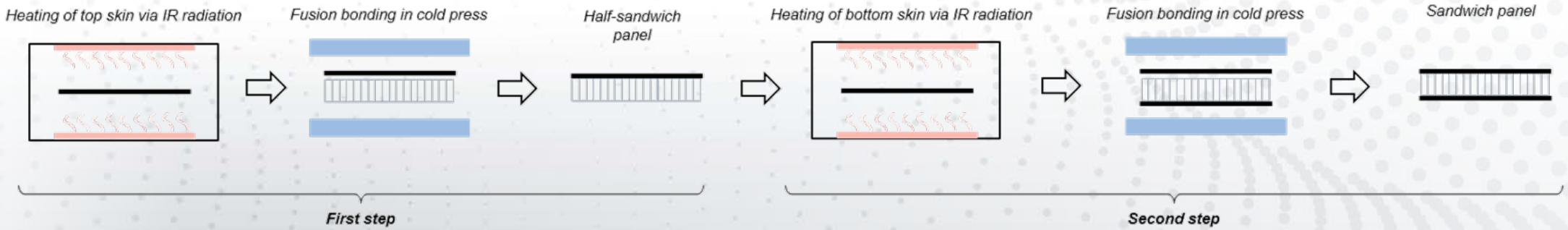


Manufacturing process

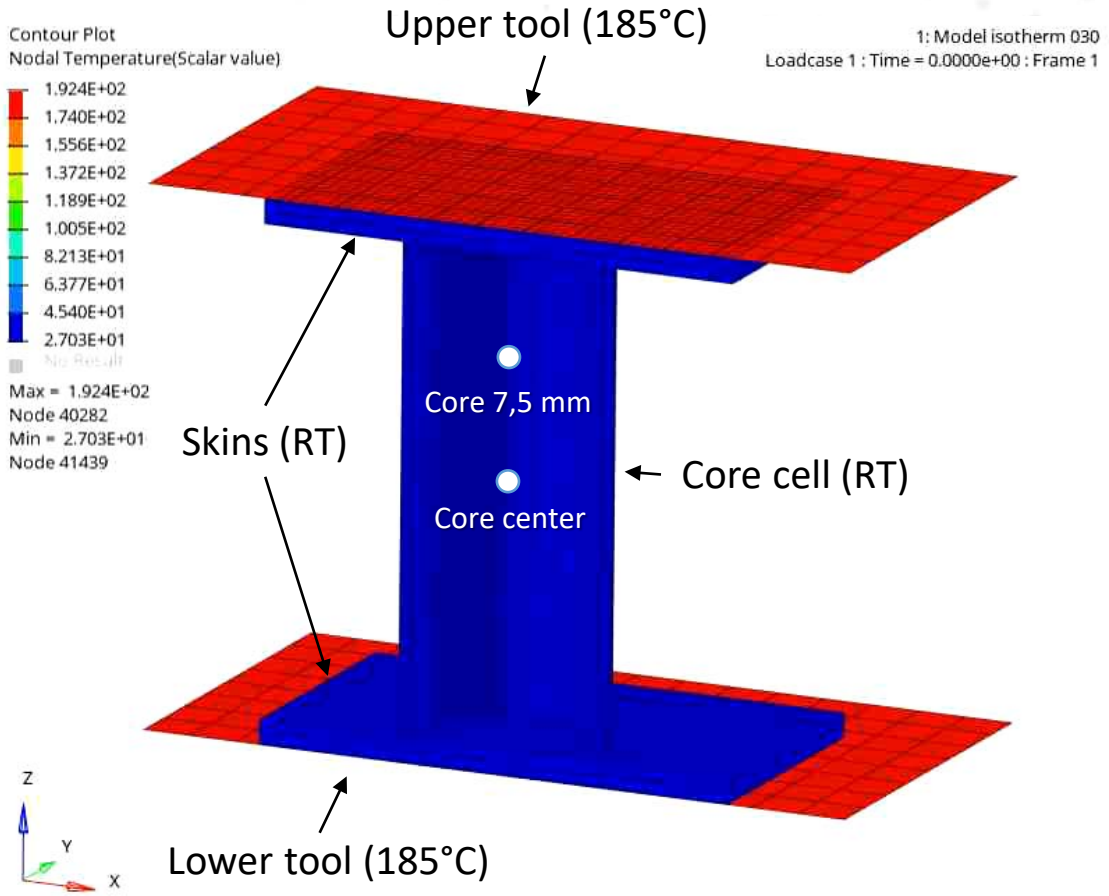
Isothermal process

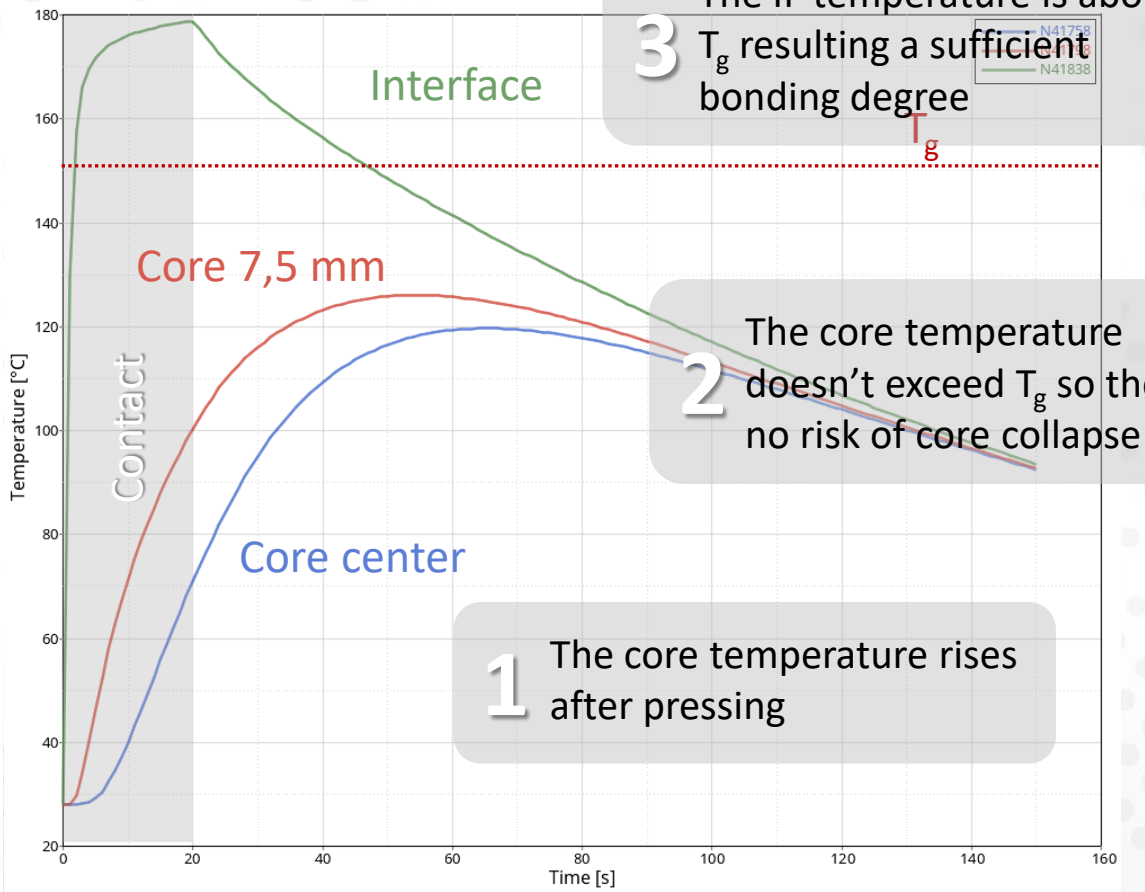


Non-isothermal process



Isothermal process: heat transfer model



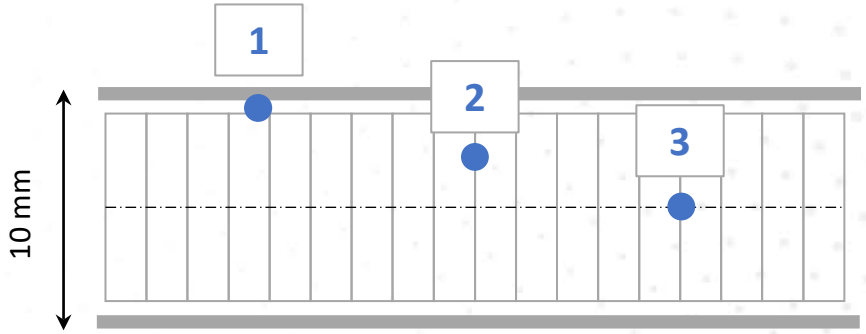


3 The IF temperature is above T_g resulting a sufficient bonding degree

2 The core temperature doesn't exceed T_g so there is no risk of core collapse

1 The core temperature rises after pressing

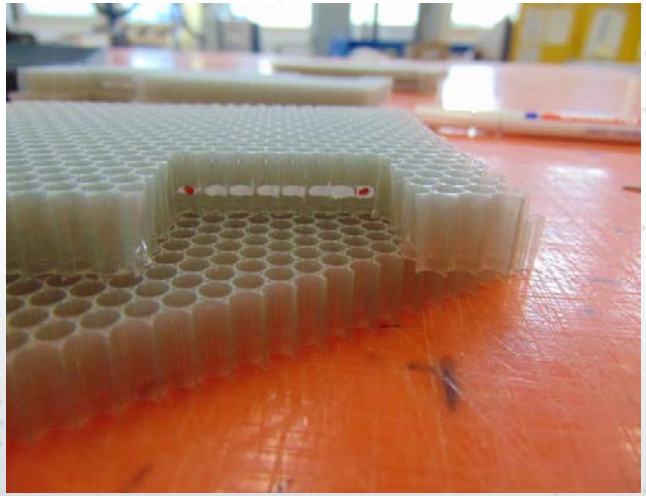
Isothermal process: temperature measurement



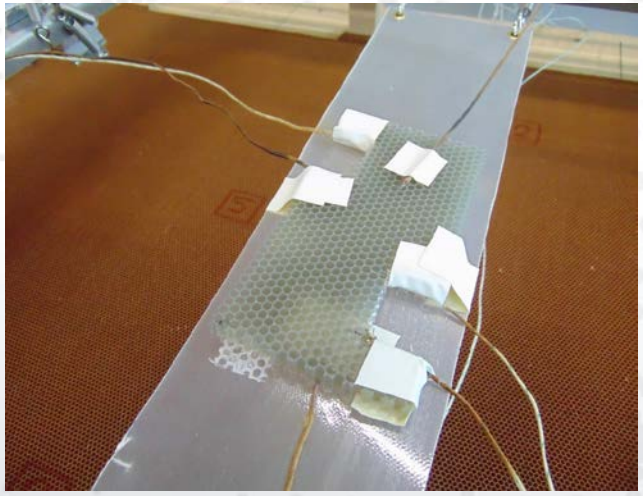
Position of thermocouples in sandwich structure

Position of thermocouples:

1. Interface between skin and core
2. 7,5 mm of core
3. 5 mm (center of core)

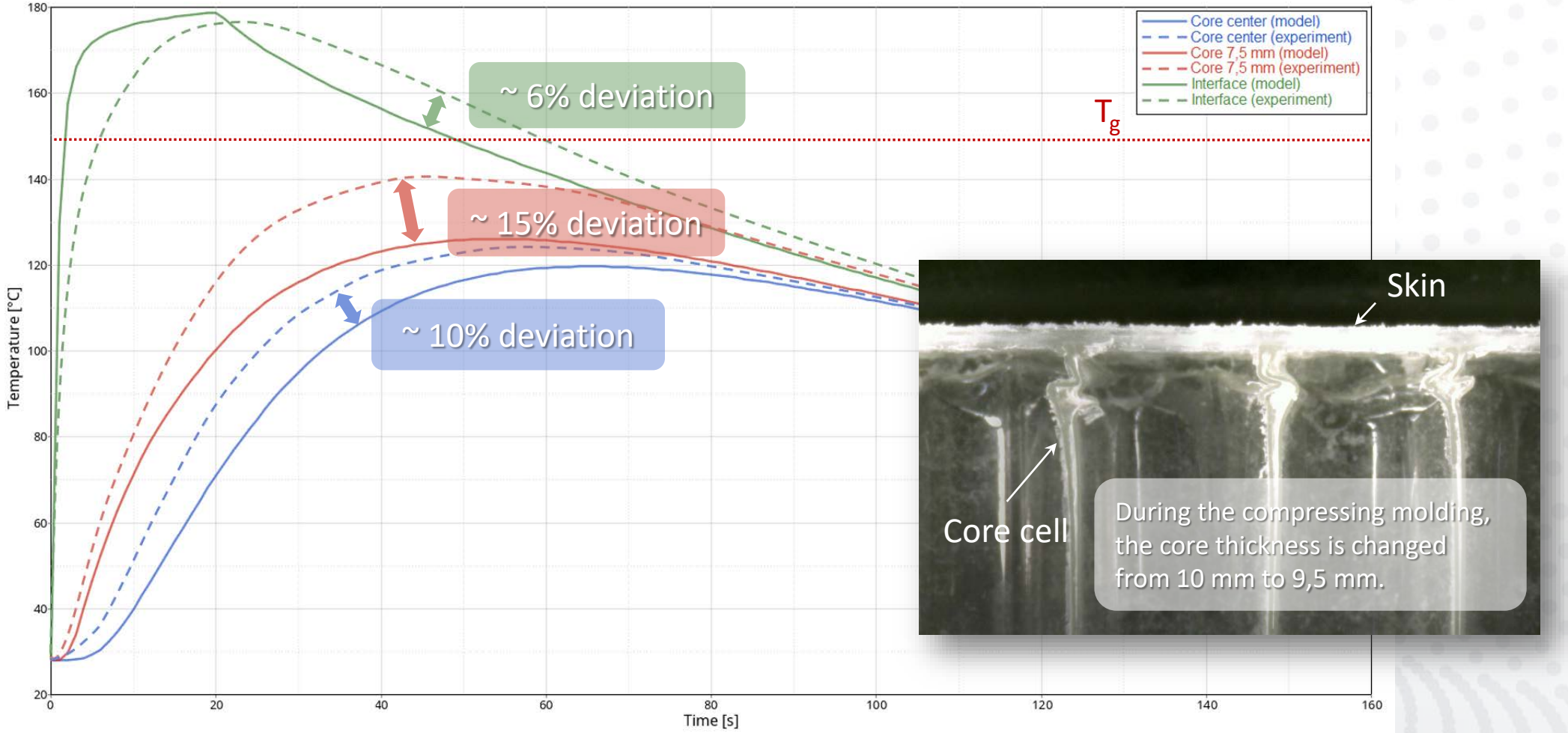


Marking for thermocouples in core

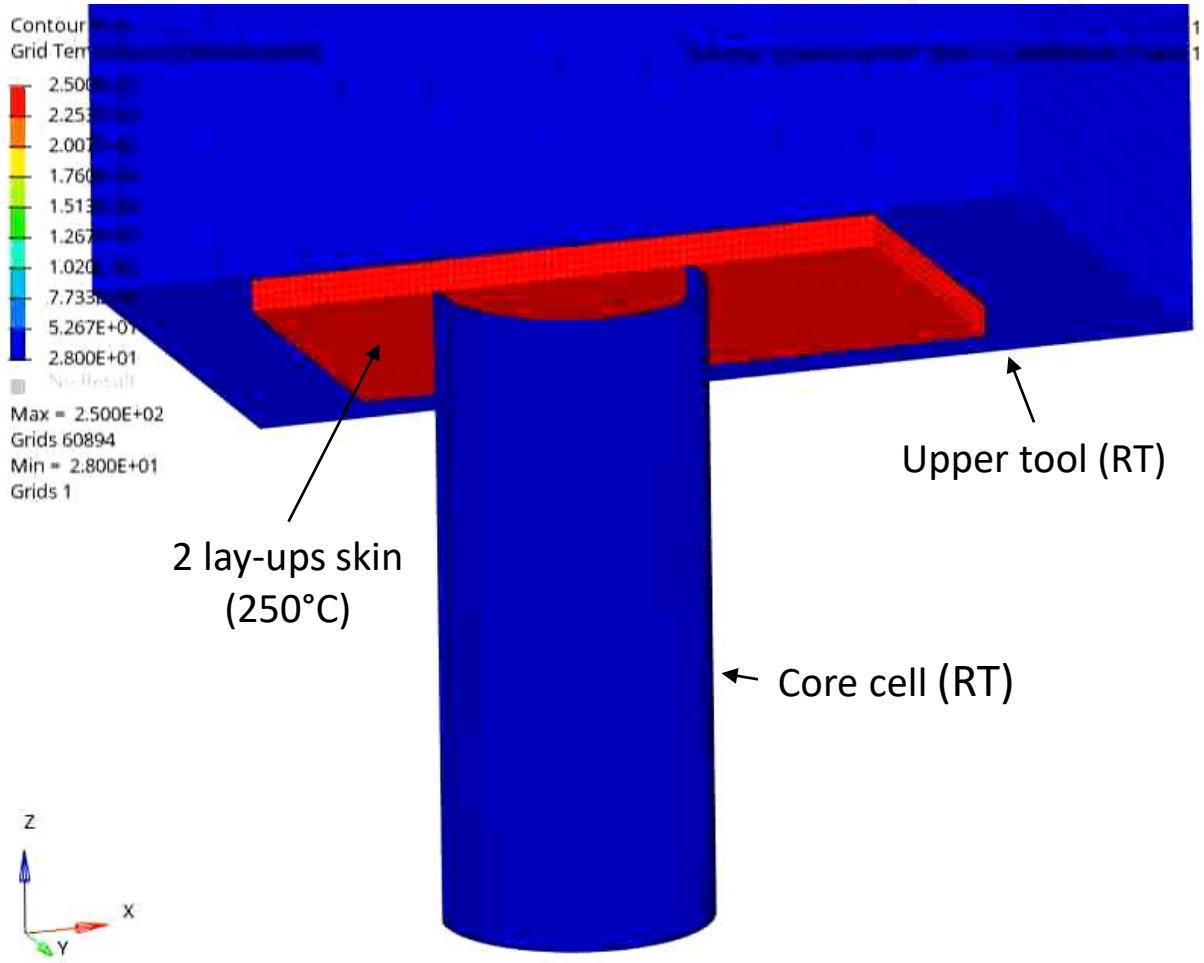


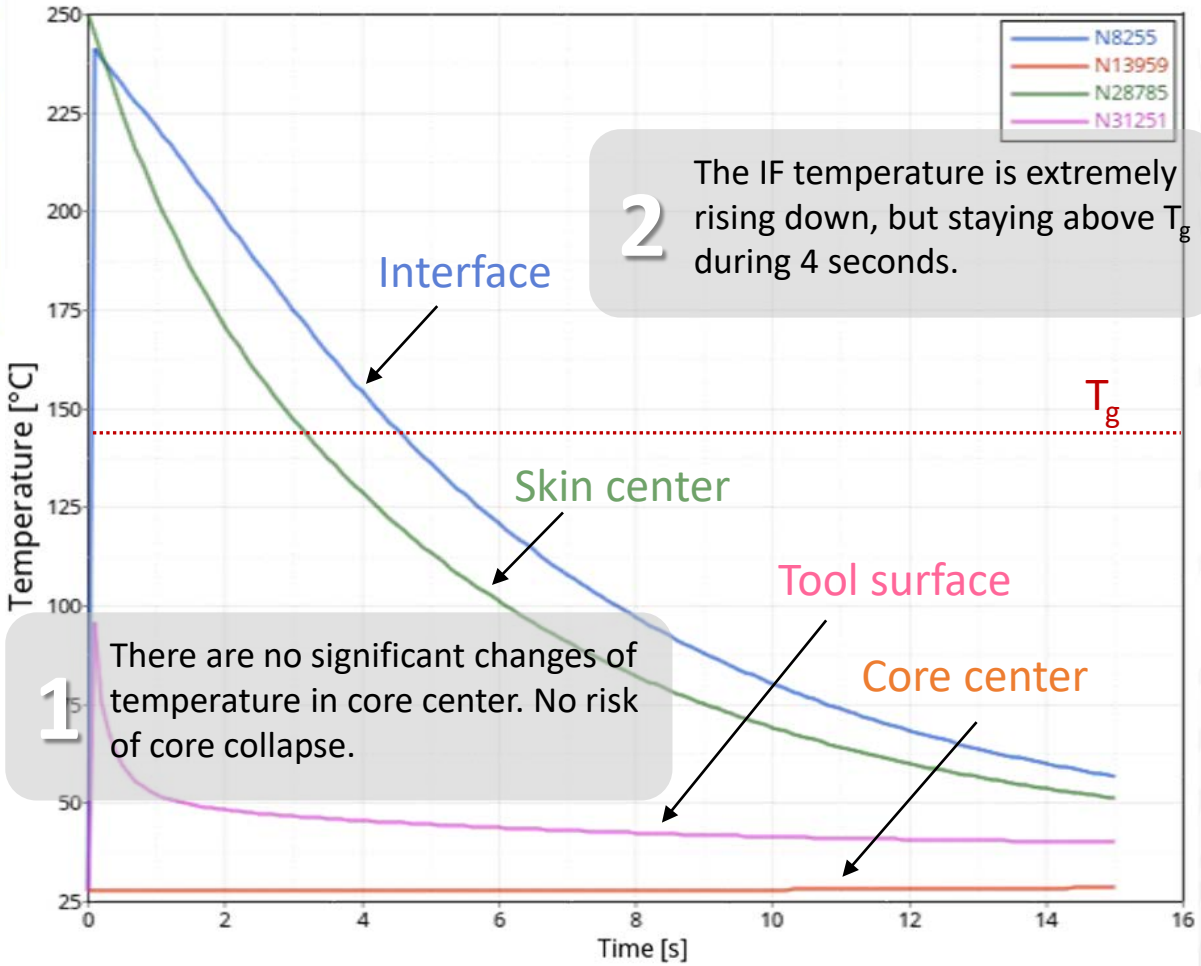
Attached thermocouples to core and skins

Isothermal process: simulation vs. experiment

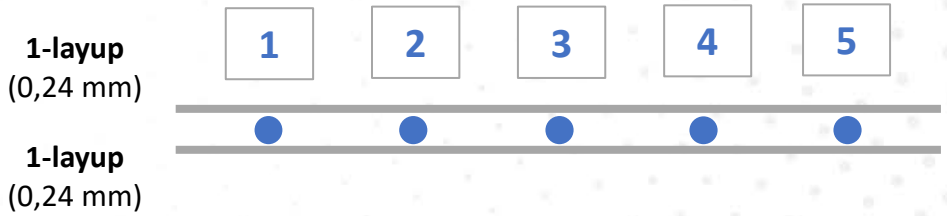


Non-isothermal process: heat transfer model

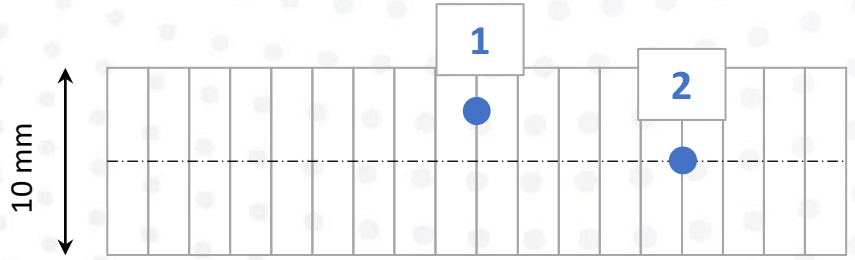




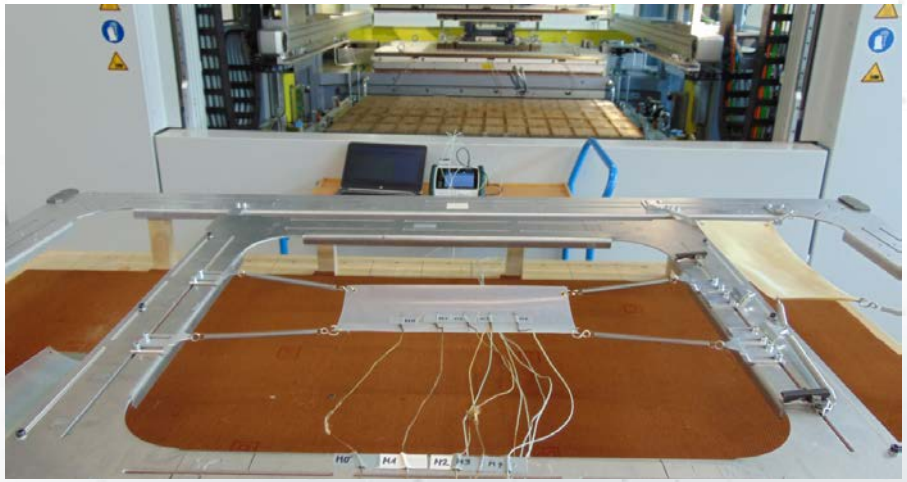
Non-isothermal: temperature measurement



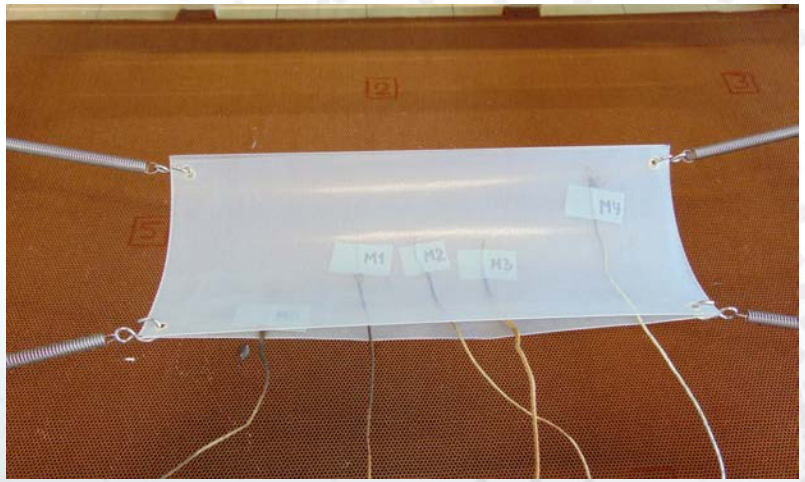
Position of thermocouples between two thin lay-ups



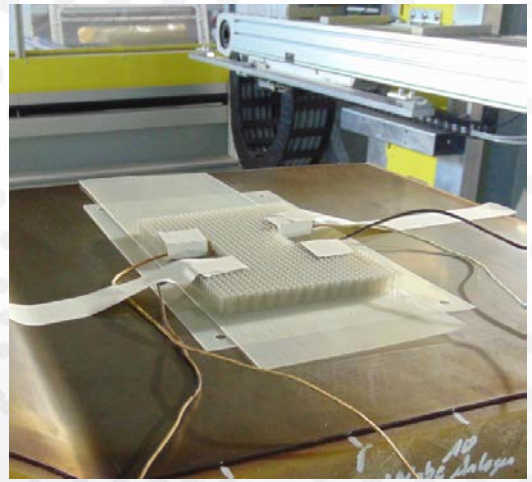
Position of thermocouples in core



Fixation of skin in clamping frame

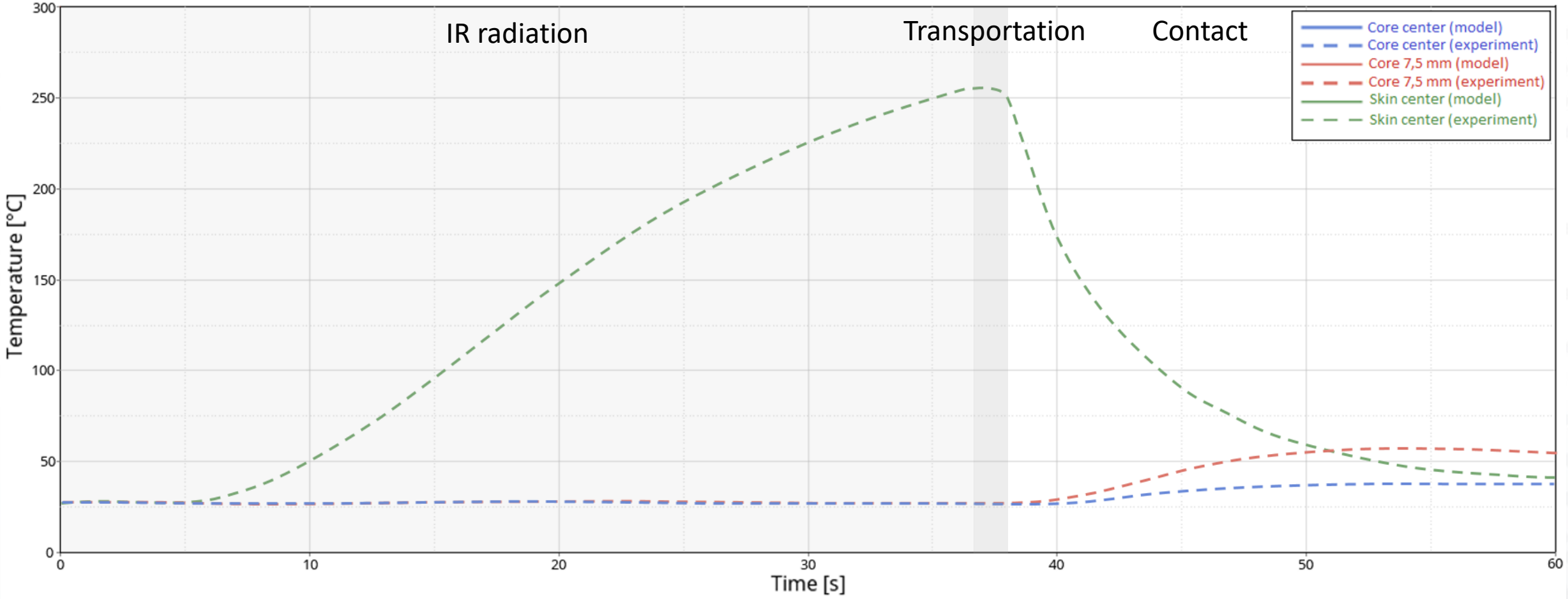


Attached thermocouples between two lay-ups

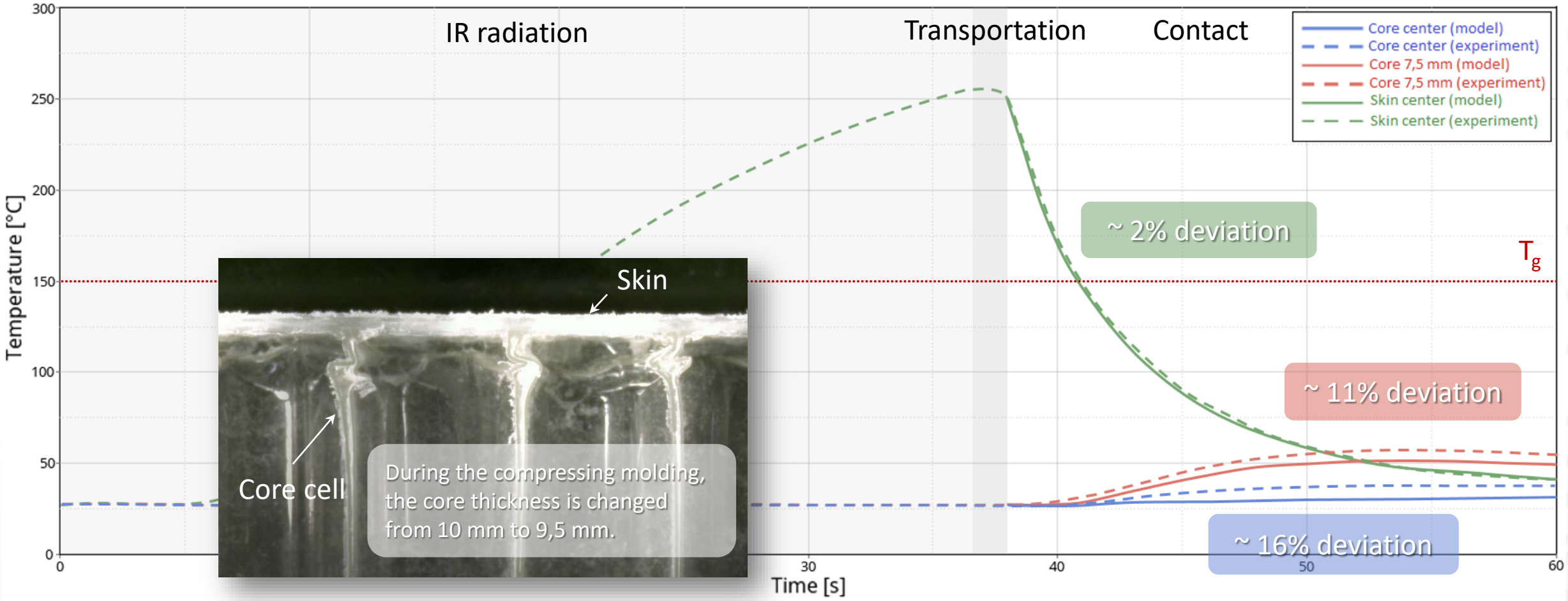


Attached thermocouples in core

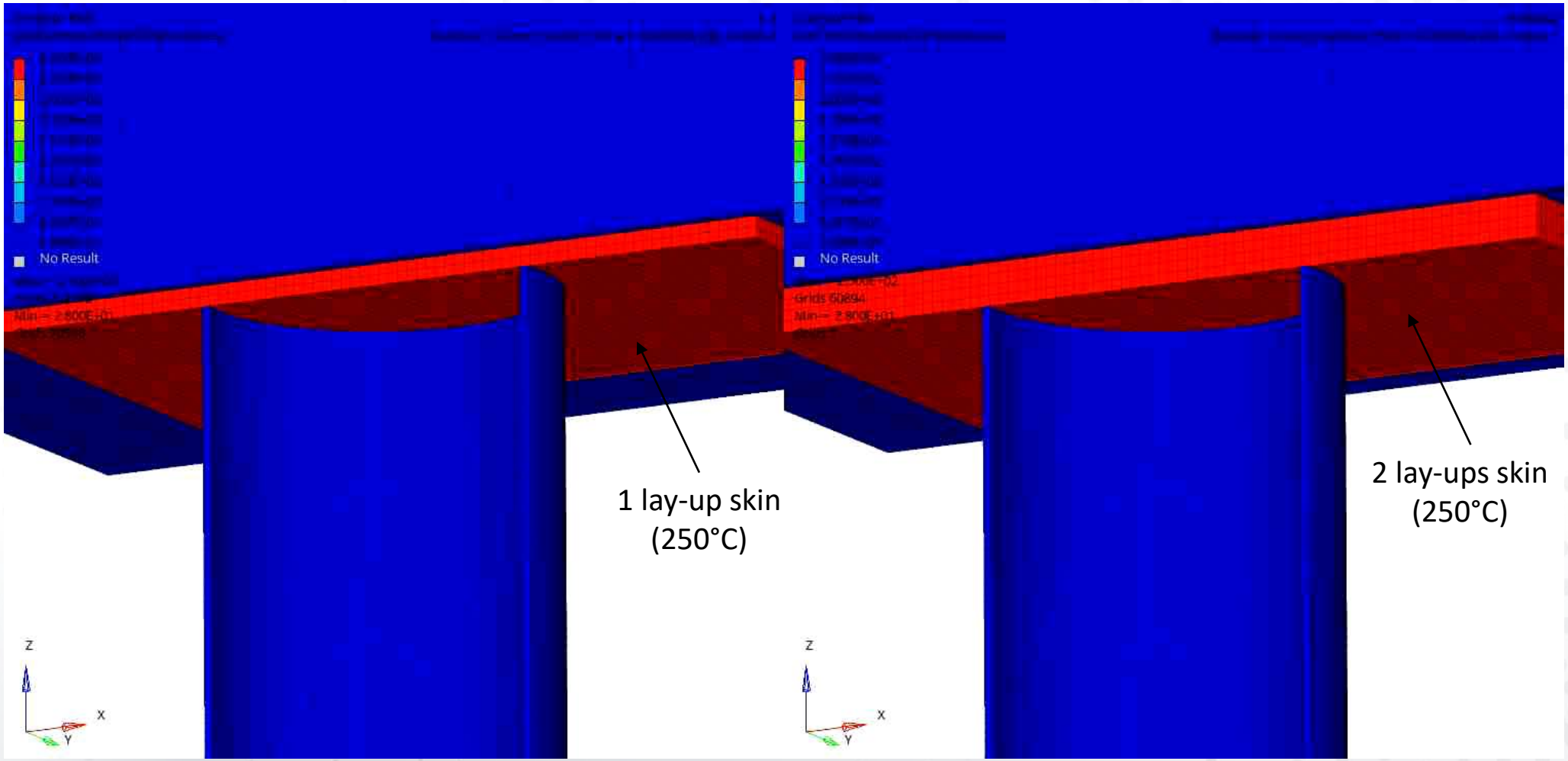
Non-isothermal: temperature measurement



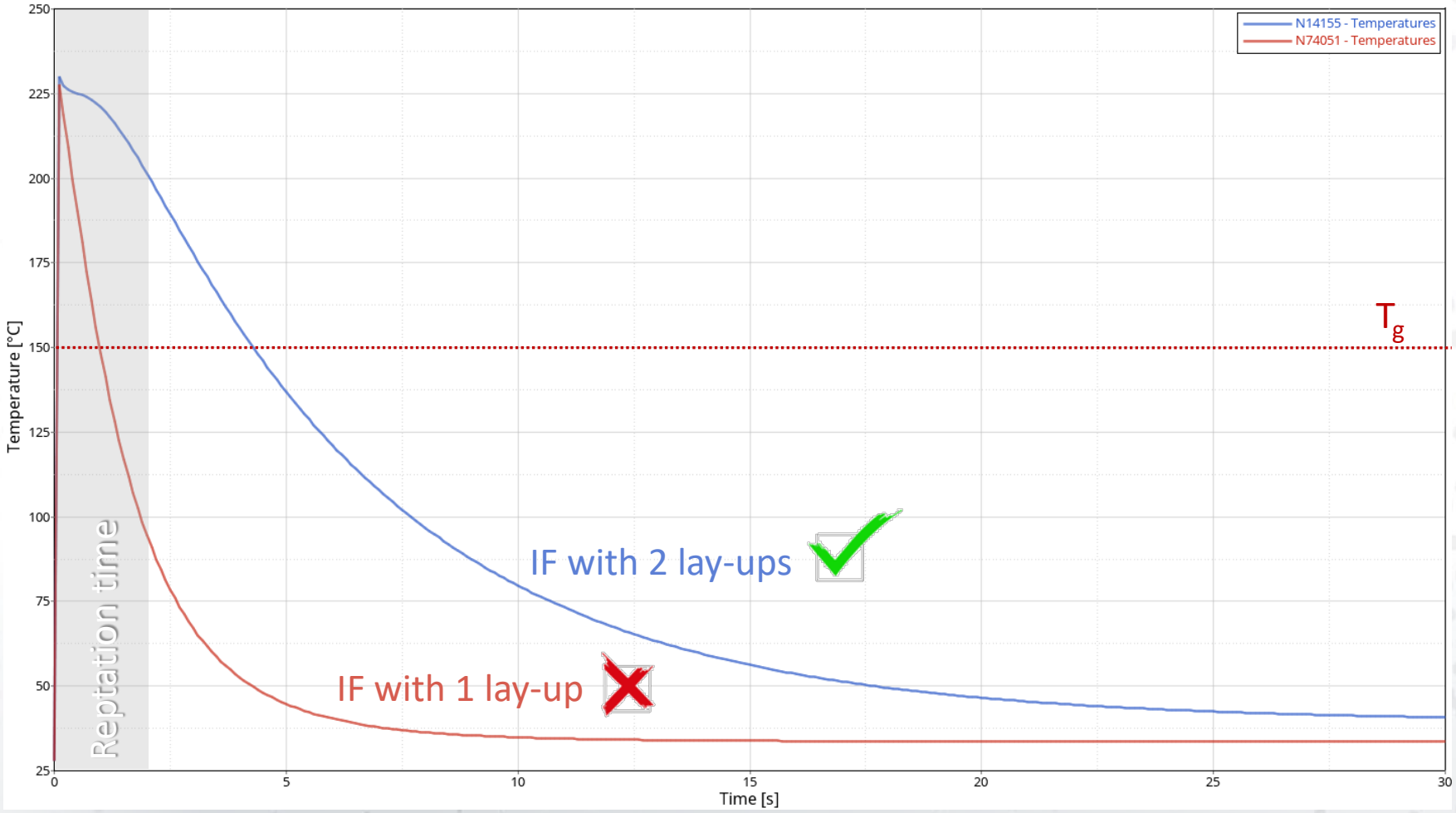
Non-isothermal: simulation vs. experiment



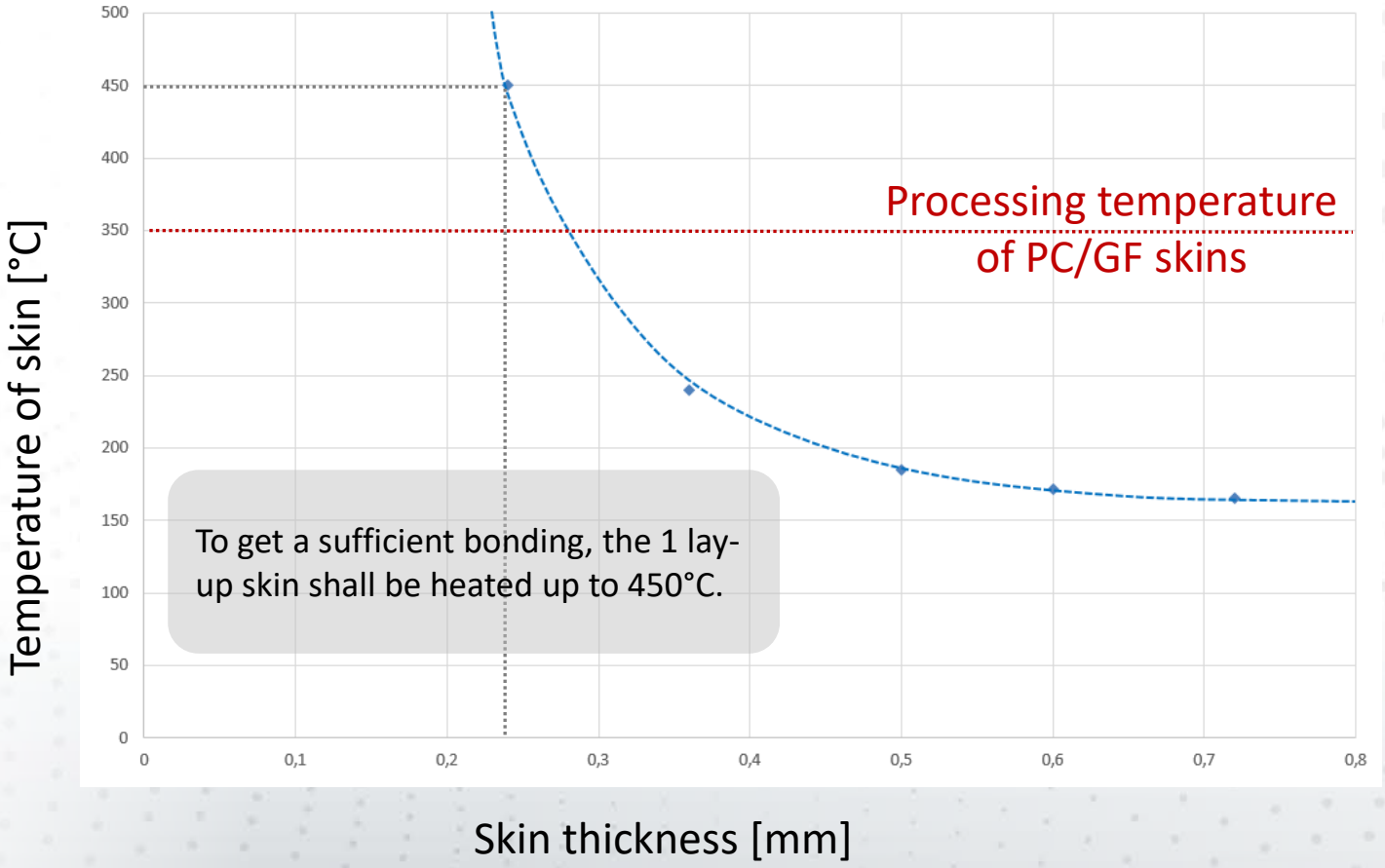
Non-isothermal process: skin thickness



Non-isothermal process: skin thickness



Non-isothermal process: skin thickness

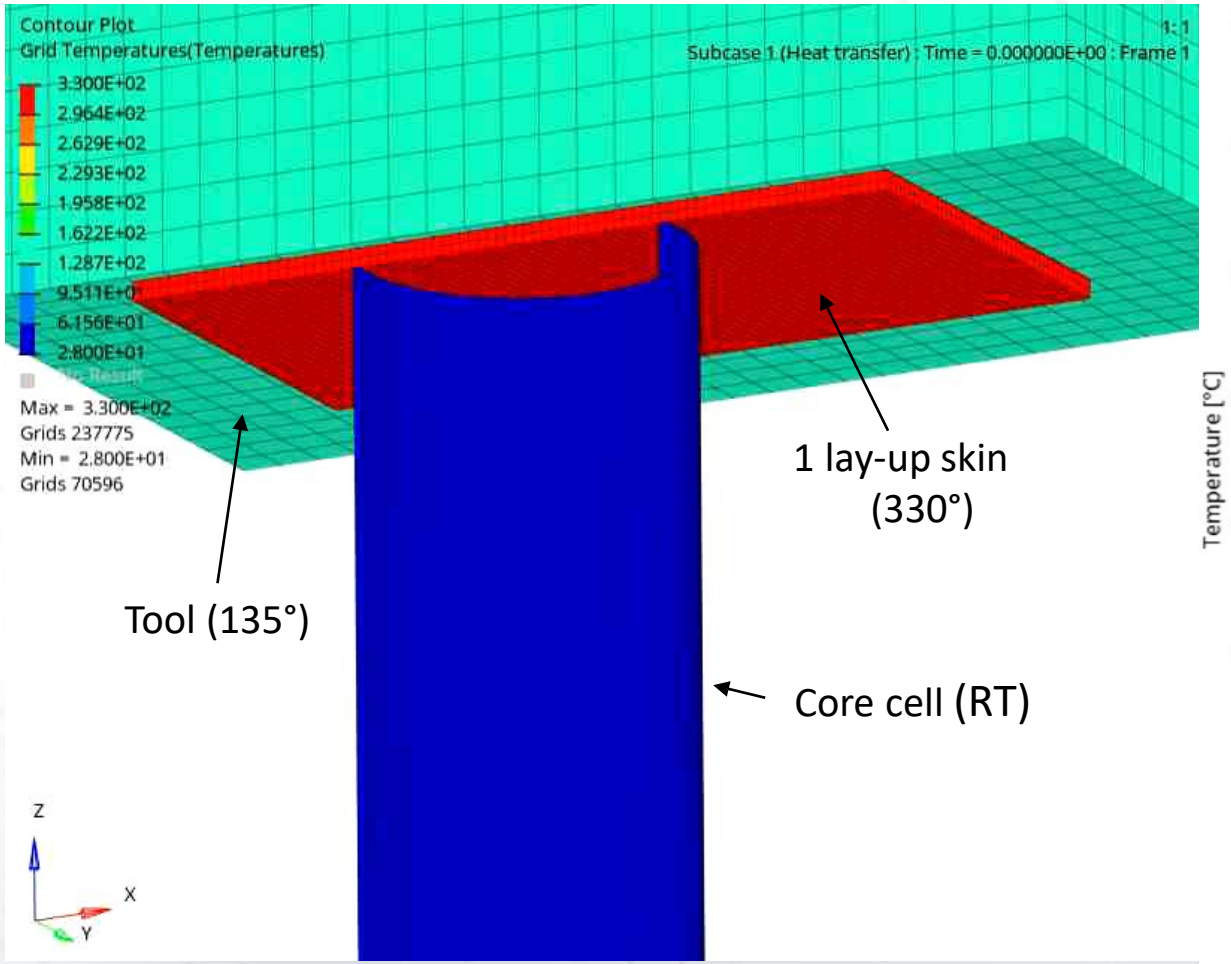


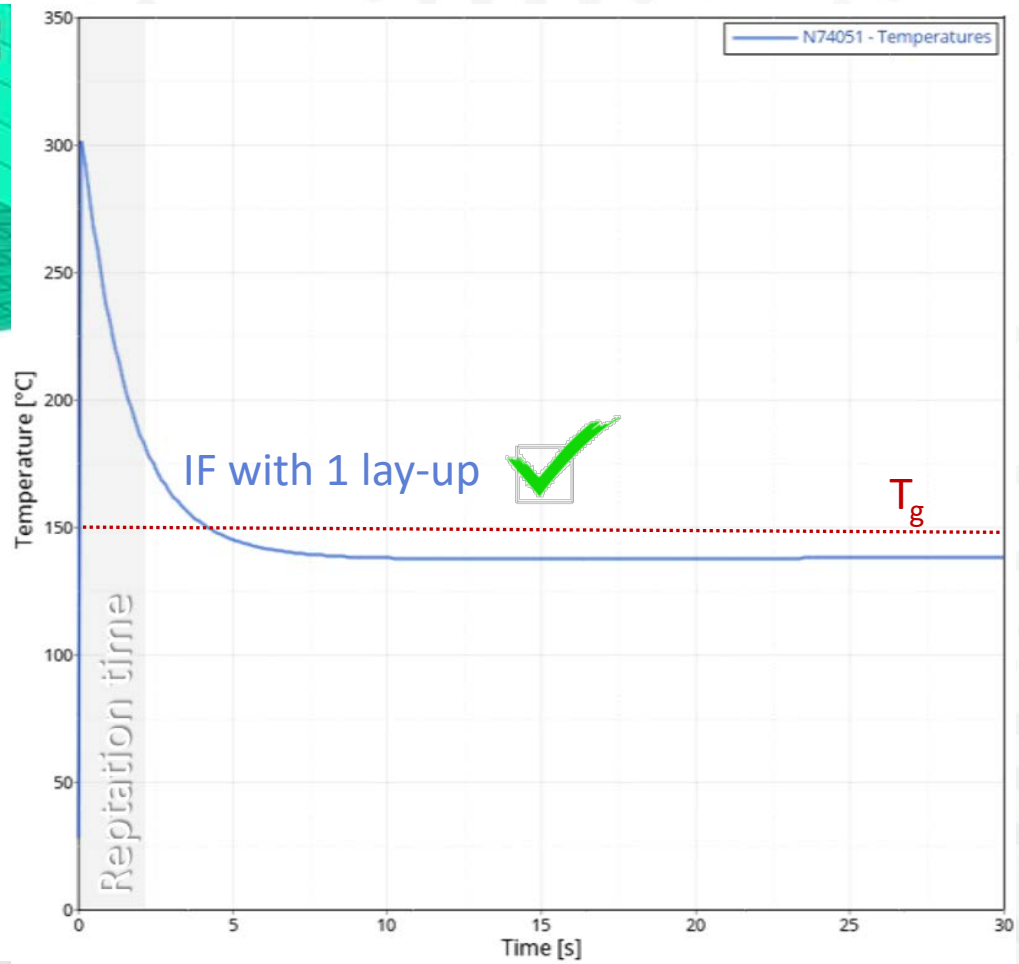
Skin thickness = f (skin temperature) is defined in order to obtain the sufficient bonding degree.

RESULT

Non-isothermal process is workable with skin thickness beginning from 0,28 mm.

Combined process: heat transfer model





Summary and outlook

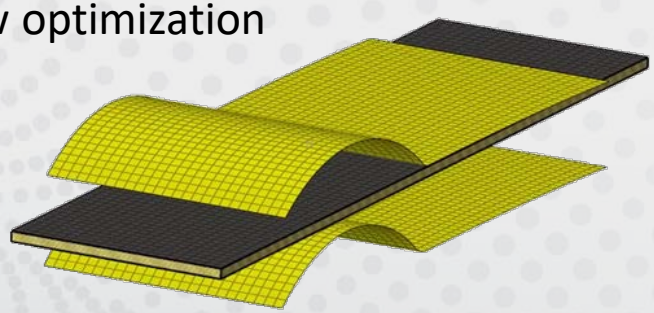
Thermal analysis

Definition of process window for:

- isothermal process ✓
- non-isothermal process ✓ (with restrictions)
- combined process ✓

Thermo-mechanical analysis

- Mechanical behavior during thermoforming process
- Failure modes prediction
- Process window optimization



Thank you!

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