ICCM 23
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THERMOPLASTIC MONO-MATERIAL SANDWICH PANELS

Manufacturing for aircraft interiors

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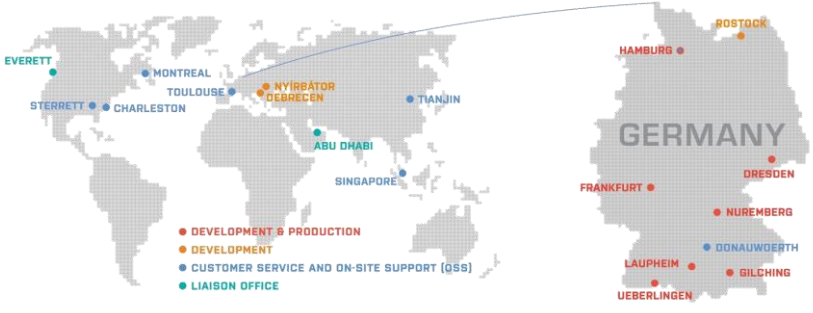
DIEHL
Aviation

AGENDA

- About Diehl Aviation
- Object and concept
- Manufacturing process
- Numerical method
- Isothermal process
- Non-isothermal process
- Combined process
- Bonding degree
- Summary and outlook

DIEHL AVIATION

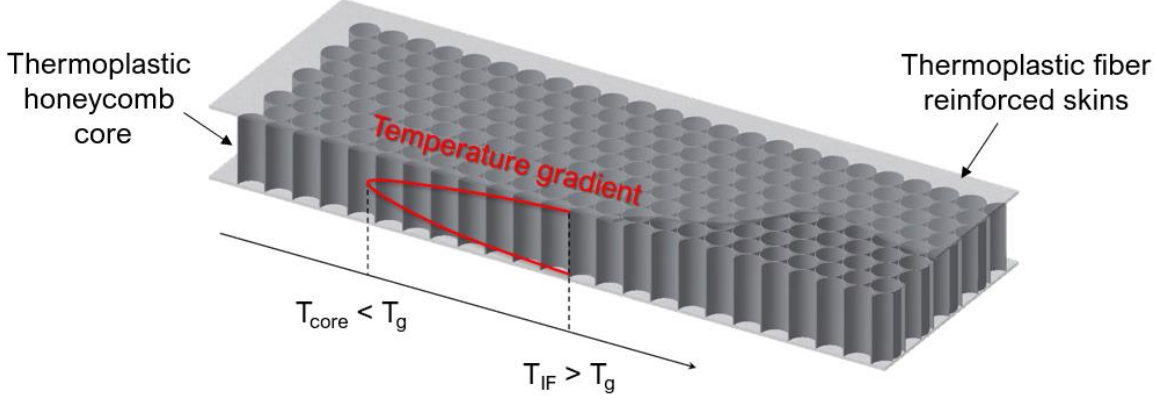


Conventional sandwich structure:

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

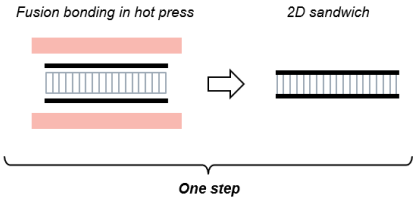
OBJECT AND CONCEPT

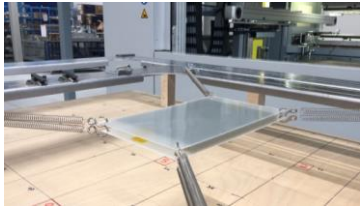
- obtain an adhesion-free thermoplastic sandwich panel
- challenge: to get a sufficient bonding degree between skins and honeycomb core by means of fusion bonding
- define optimal manufacturing process



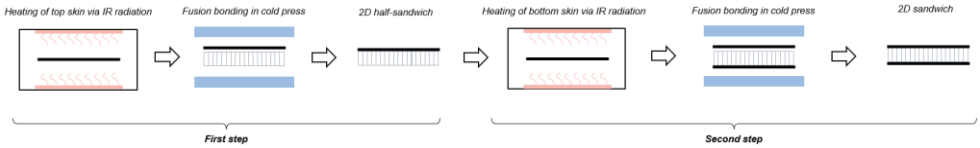
MANUFACTURING PROCESS

- Isothermal process

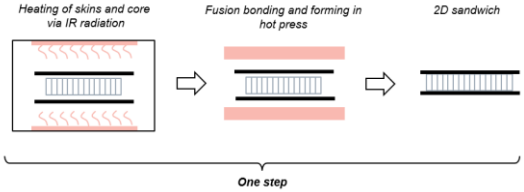


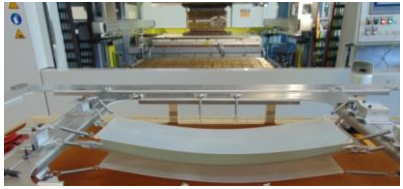


- Non-isothermal process

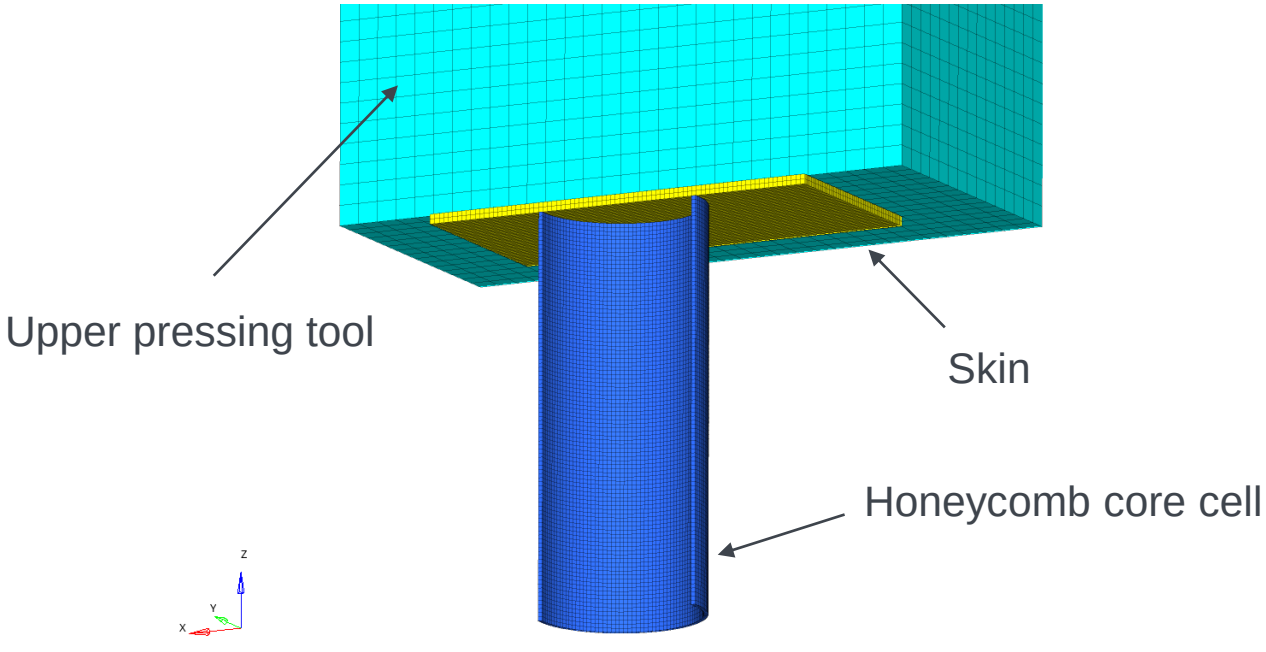


- Combined process

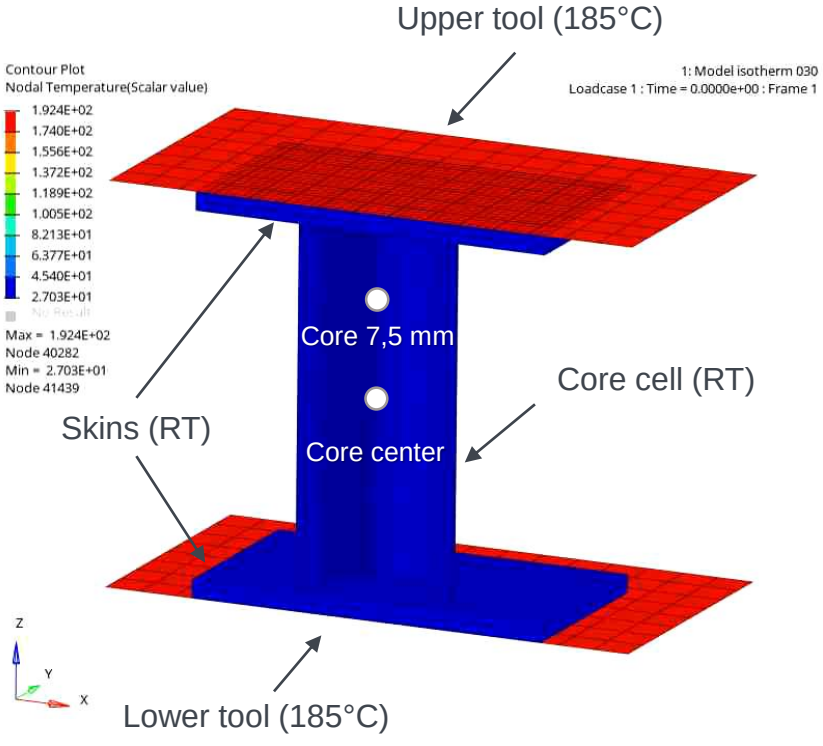


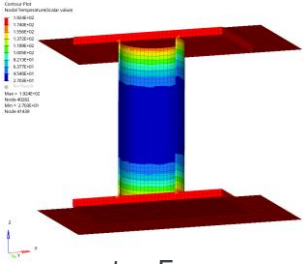


NUMERICAL METHOD



ISOTHERMAL PROCESS





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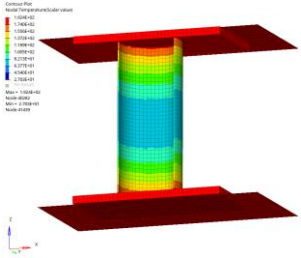

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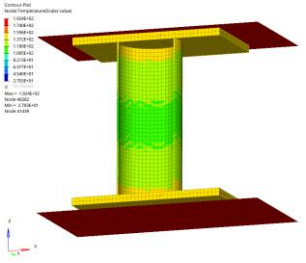

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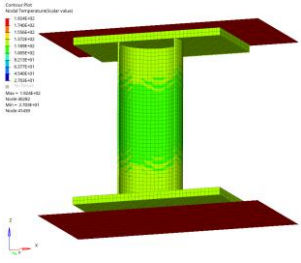

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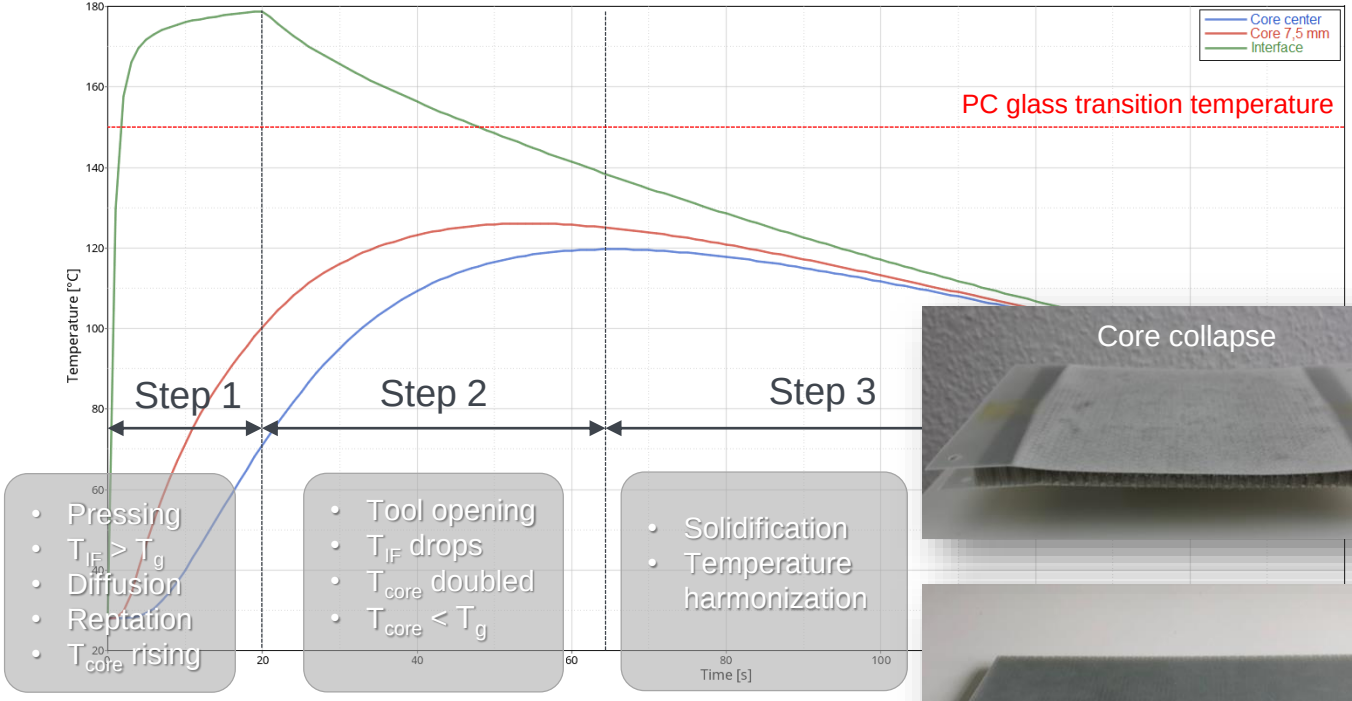
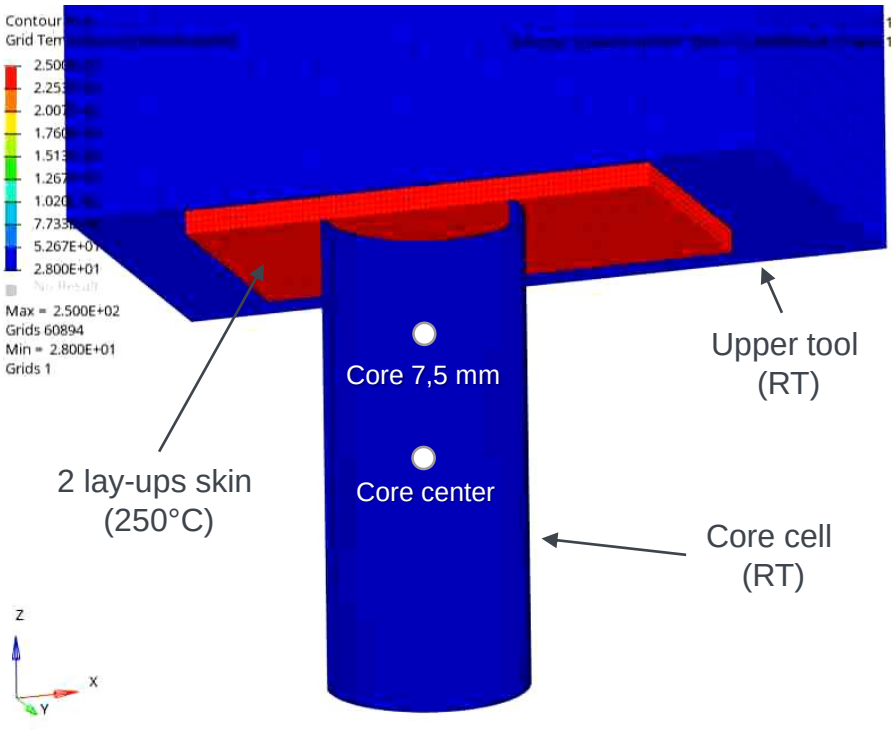
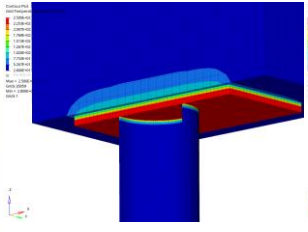
ISOTHERMAL PROCESS

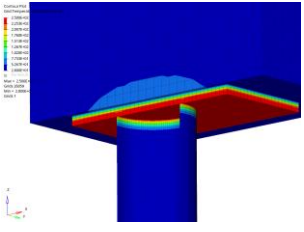


NON-ISOTHERMAL PROCESS

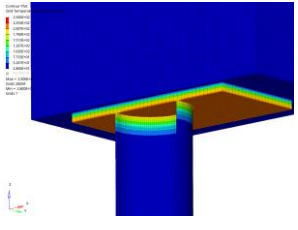




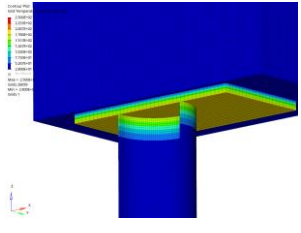
t = 1 s



t = 5 s



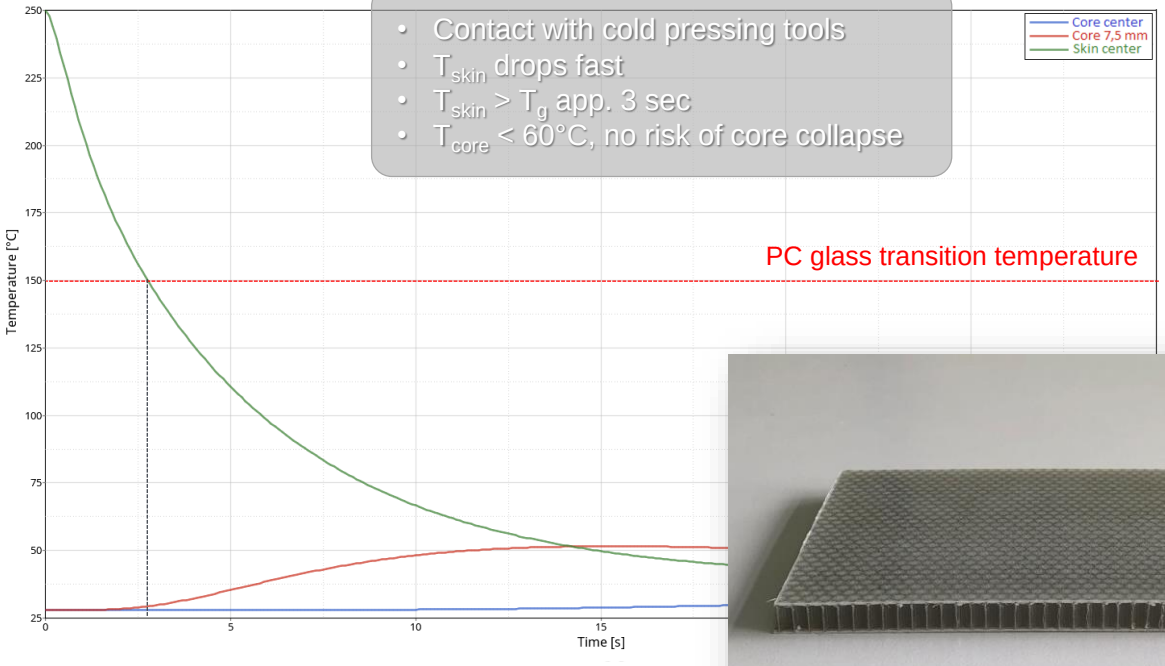
t = 20 s



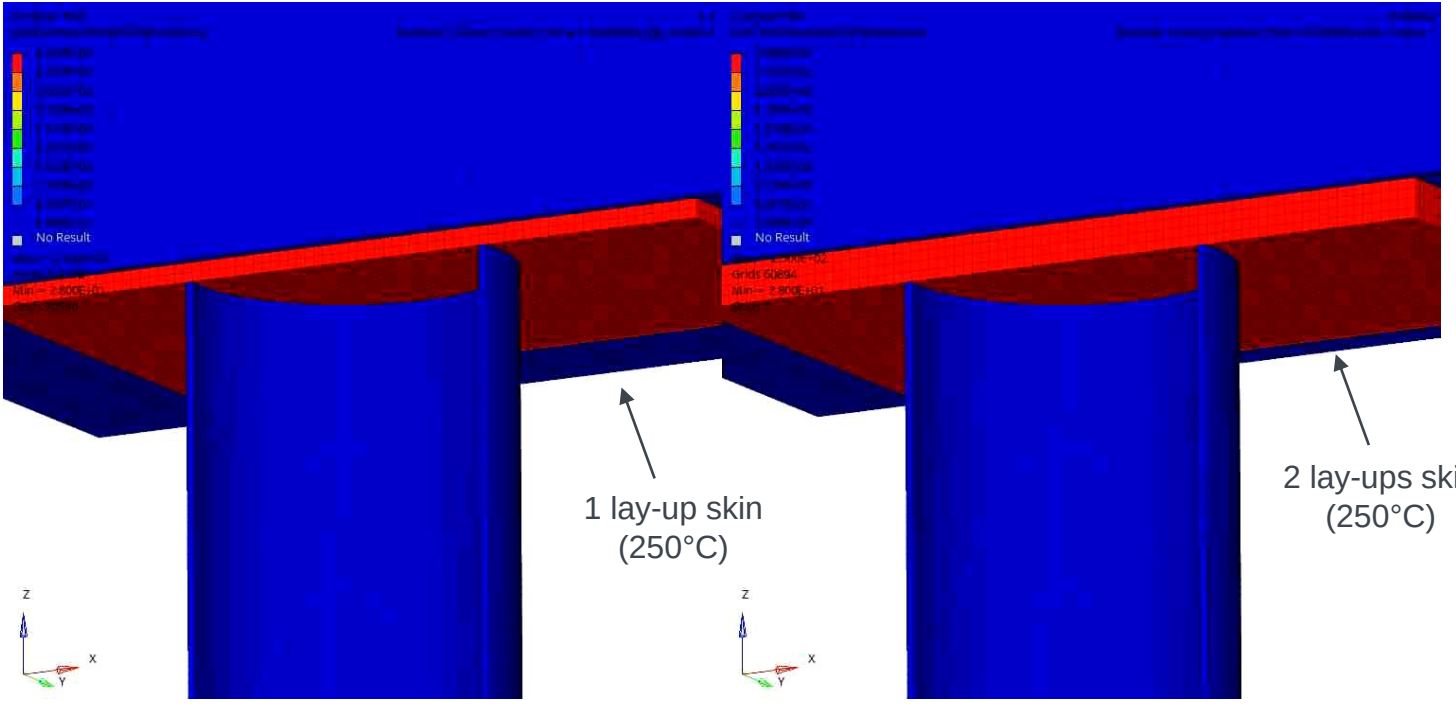
t = 30 s

NON-ISOTHERMAL PROCESS

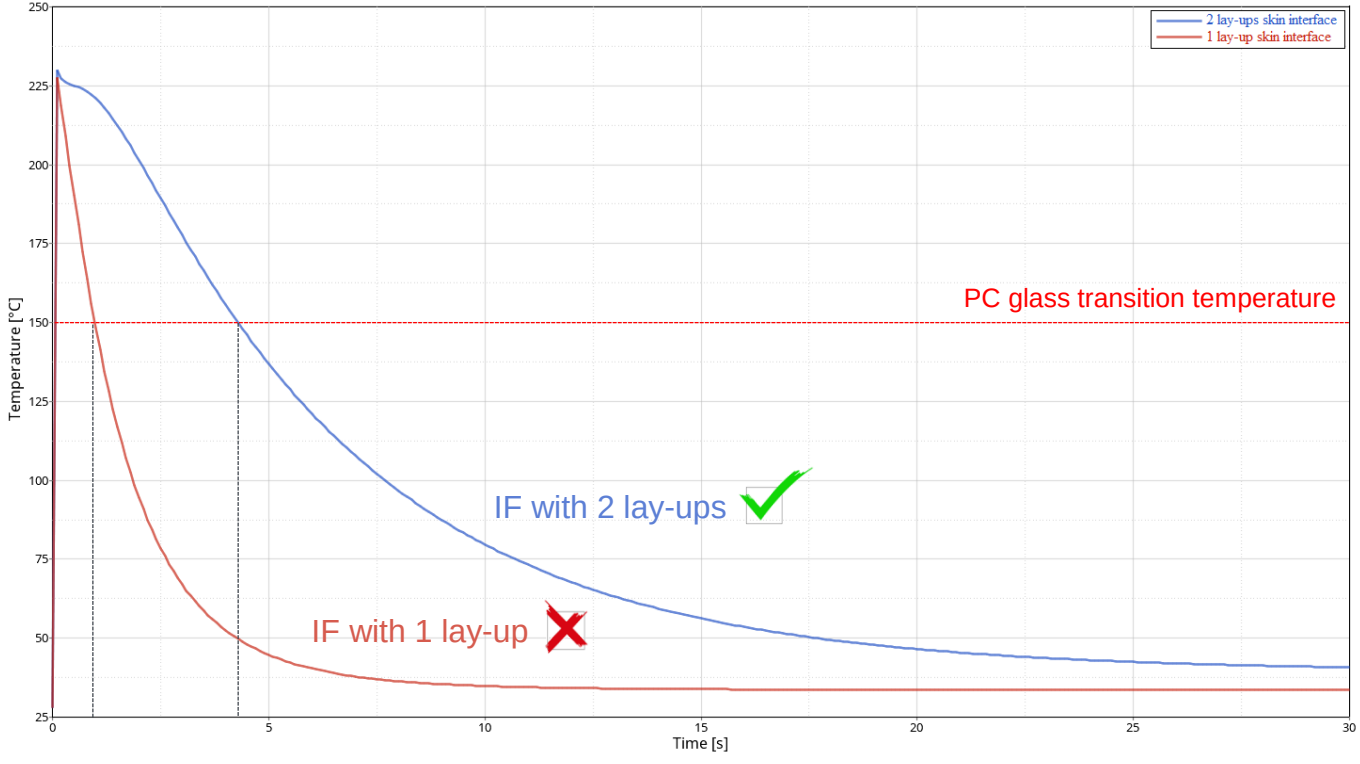
- Contact with cold pressing tools
- T_{skin} drops fast
- $T_{skin} > T_g$ app. 3 sec
- $T_{core} < 60°C$, no risk of core collapse



NON-ISOTHERMAL PROCESS

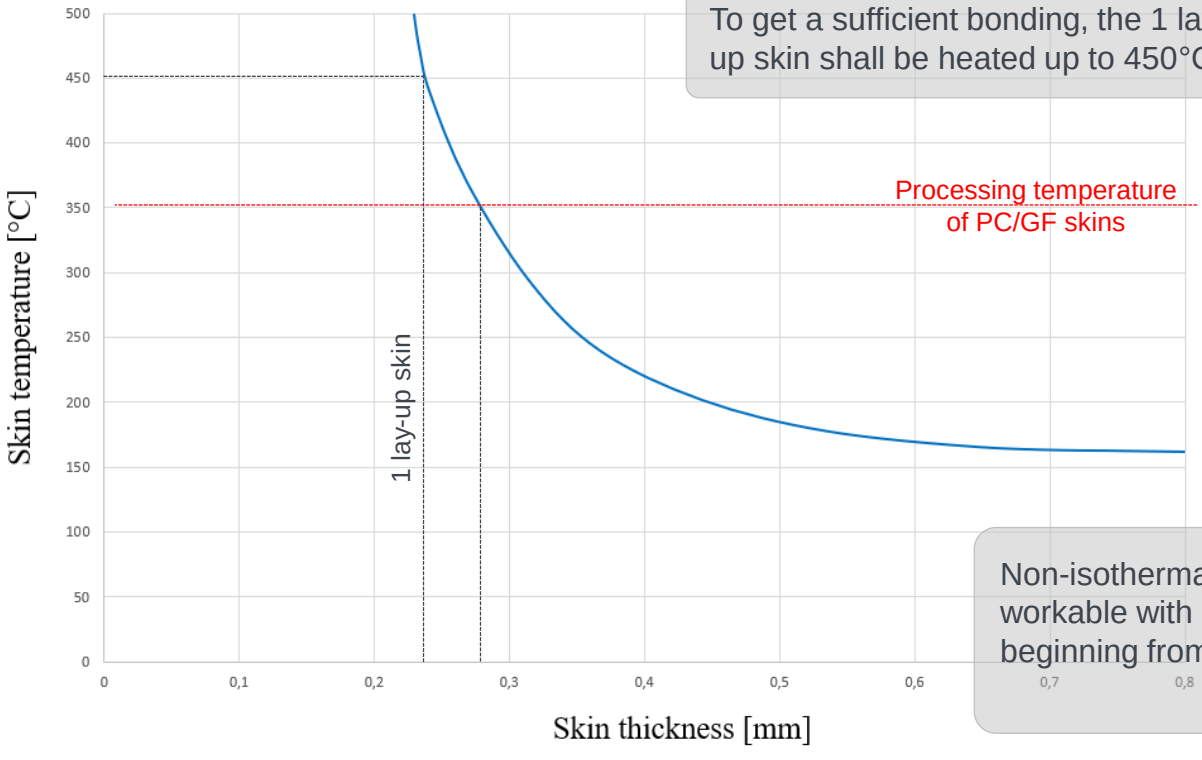


NON-ISOTHERMAL PROCESS



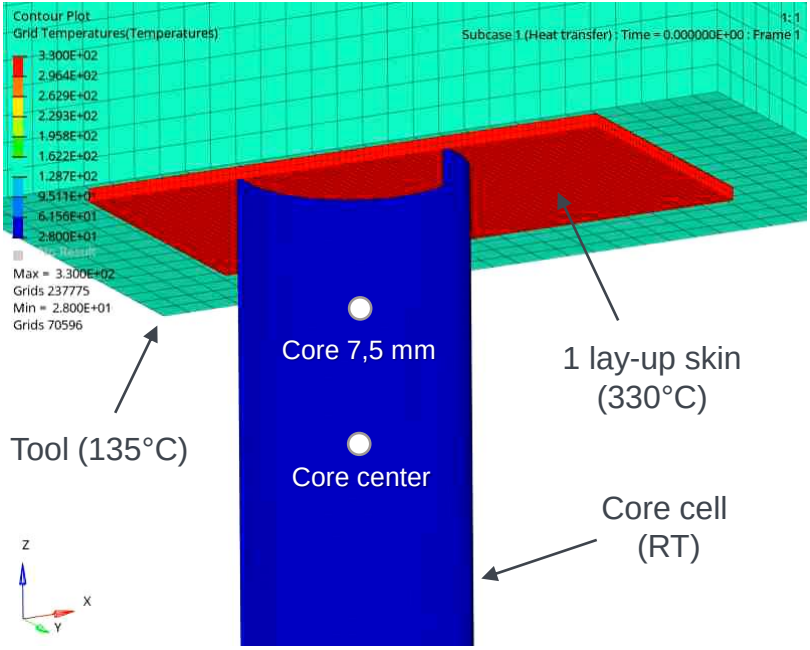
NON-ISOTHERMAL PROCESS

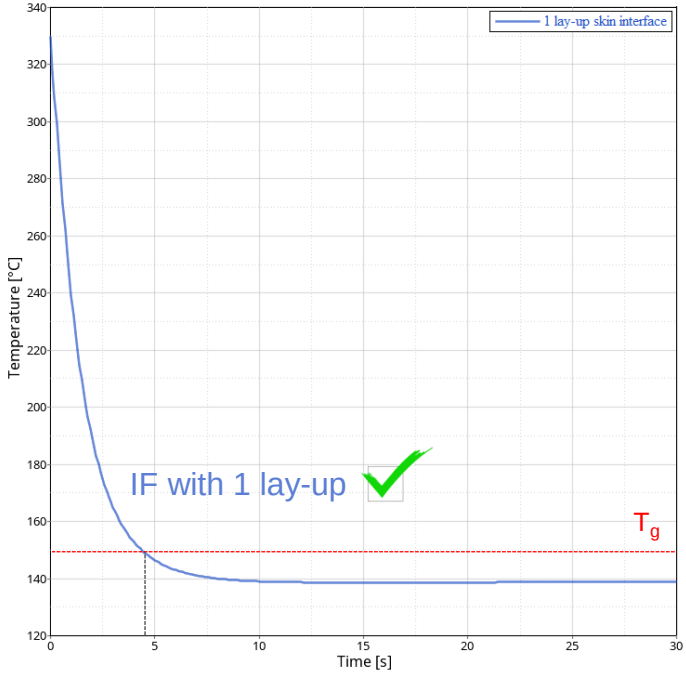
To get a sufficient bonding, the 1 lay-up skin shall be heated up to 450°C.



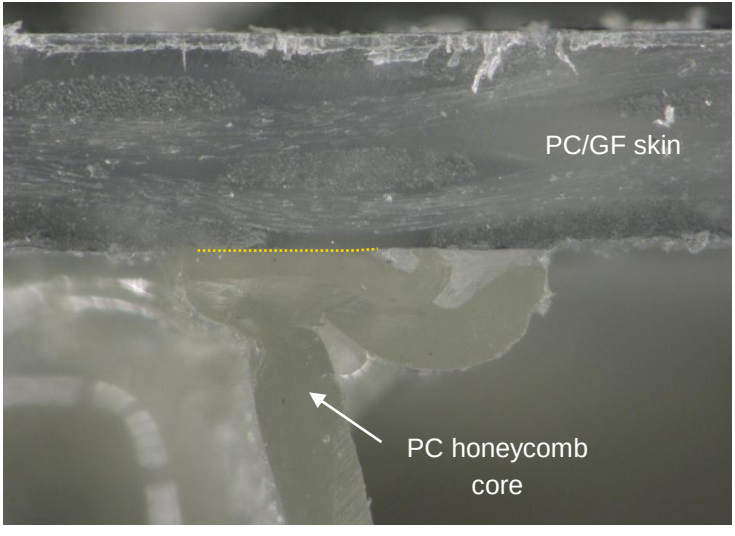
Non-isothermal process workable with skin thickness beginning from 0,28 mm.

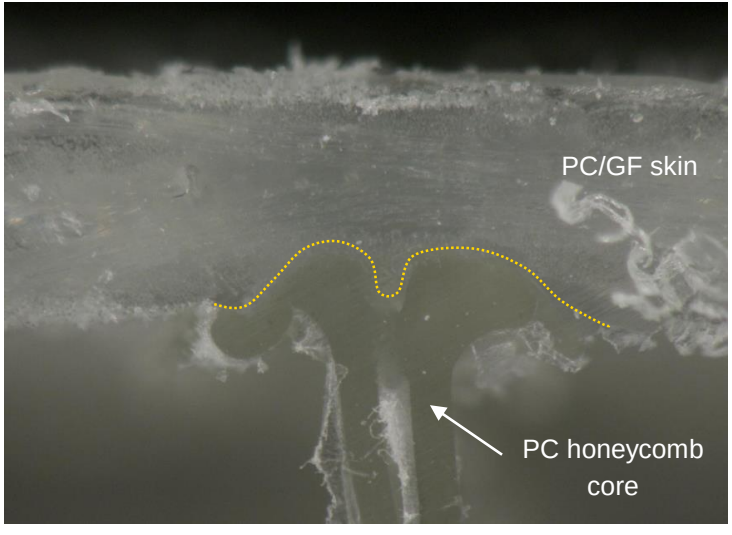
COMBINED PROCESS





MICROSCOPY





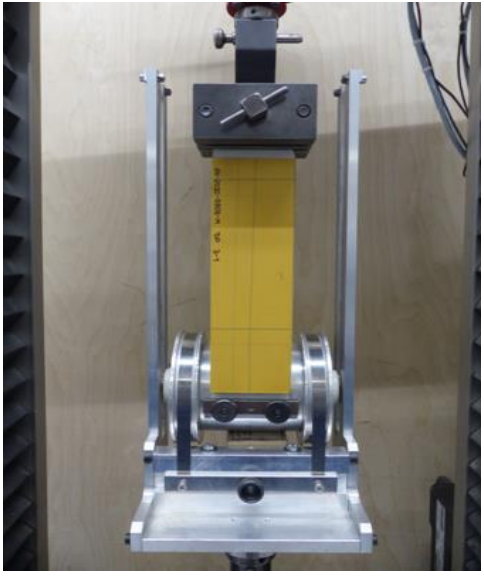
Isothermal process

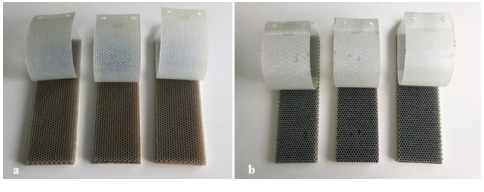
- Core is partially melted and pressed
- Domination of melted part
- Bonding degree is determined by contact surface

Non-isothermal process

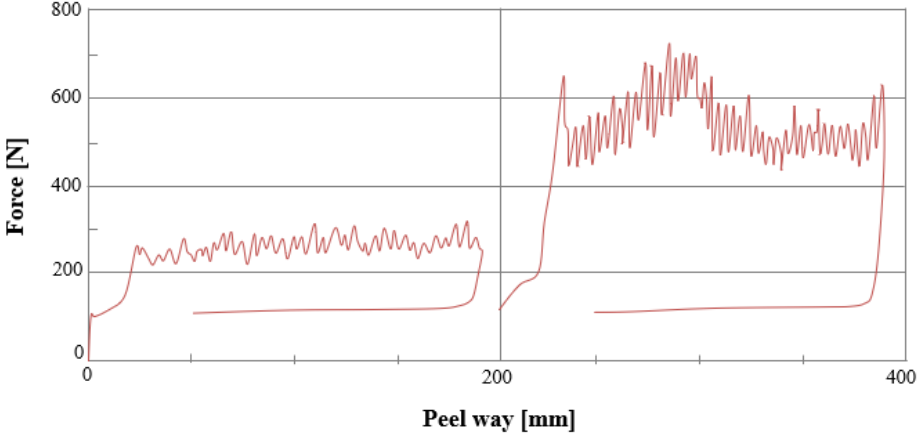
- Skin is heated
- Core penetration in softened skin
- Partial melting of core
- Bonding degree is defined by penetration depth and contact surface

DRUM PEEL TEST





Drum peel test is conducted to determine the bonding quality between a face sheet and honeycomb core of the sandwich compound (ASTM D 1781).



Isothermal process
Peel resistance 2 N/mm

Non-isothermal process
Peel resistance 6 N/mm

SUMMARY AND OUTLOOK

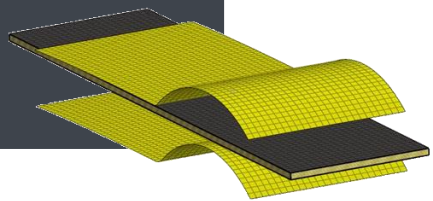
Thermal analysis

Definition of process window for:

1) Isothermal process
2) non-isothermal process (with restriction)
3) Combined process

Thermo-mechanical analysis

1) Mechanical behavior during thermoforming process
2) Failure modes prediction
3) Process window optimization



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Thank you!

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