



**SAAB**

# Fast forming of aircraft composite parts

E12\_38859\_FT2019

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# Fast forming of aircraft composite parts

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- Introduction
  - Automated aerospace composite manufacturing – fabrication and inspection
  - Why fast forming?
- Alternative forming process
  - Press forming - pros and cons
- Experimental case study
  - Fluid cell press forming
  - Modified HDF
- Summary

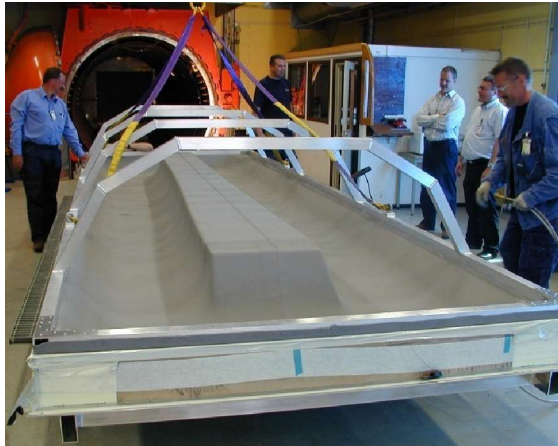


Clean Sky "Breakthrough Laminar Aircraft Demonstrator"  
Composite Wing Panel

# Automated aerospace composite manufacturing



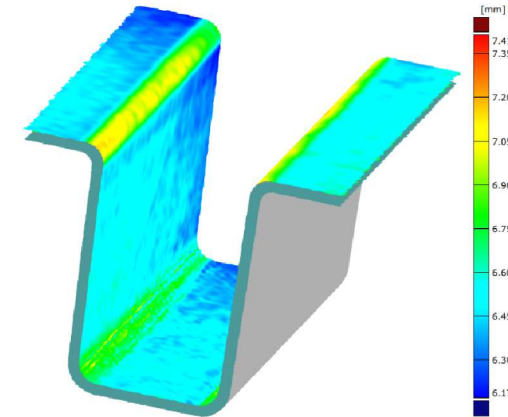
Hand lay-up vs. automated lay-up



Forming



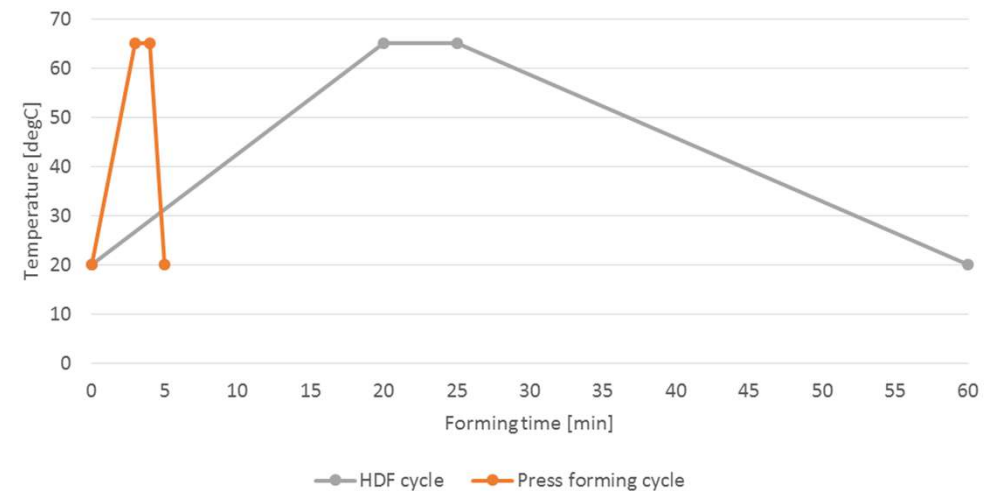
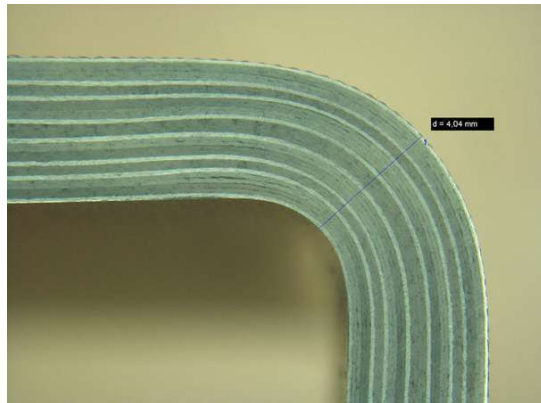
Curing



Inspection

# Alternative forming process – press forming

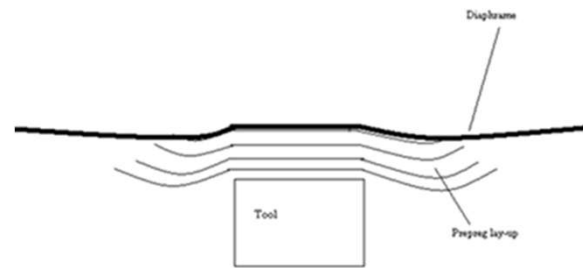
- Expected pros
  - Reduction process time,
  - Improved laminate quality
- Expected cons
  - Risk of fibre wash
  - Risk of fibre damage



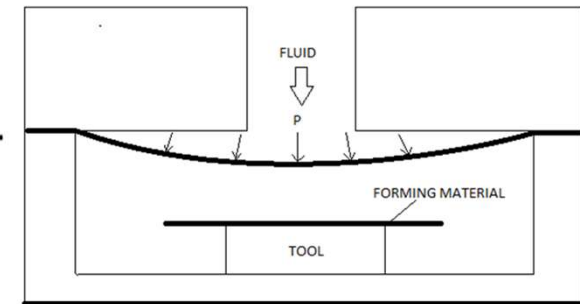
Reduction of cycle time by using press forming

# Experimental case study – press forming

- HDF comparable forming technique
  - Forming with high pressure
- Using steel sheet pressure plates
- Temperature effects
- Manipulating forming behavior with temperature tailoring



Principle of hot drape forming



Principle of fluid cell press forming

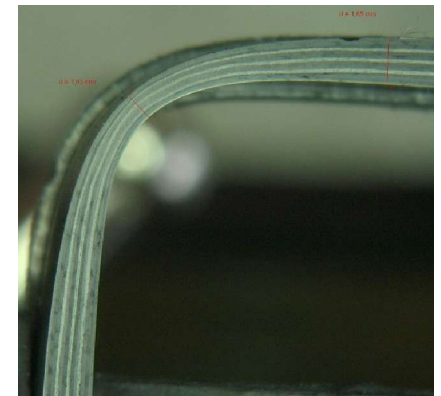
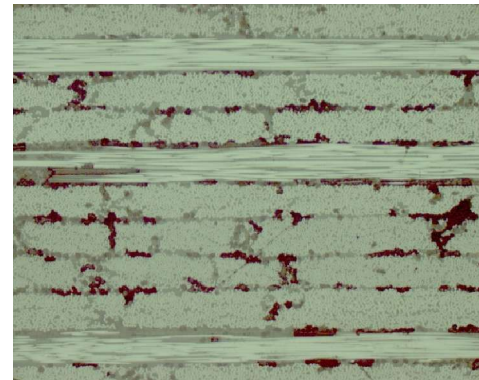
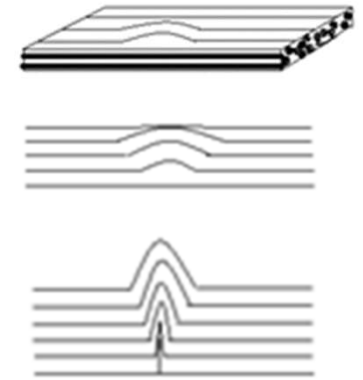
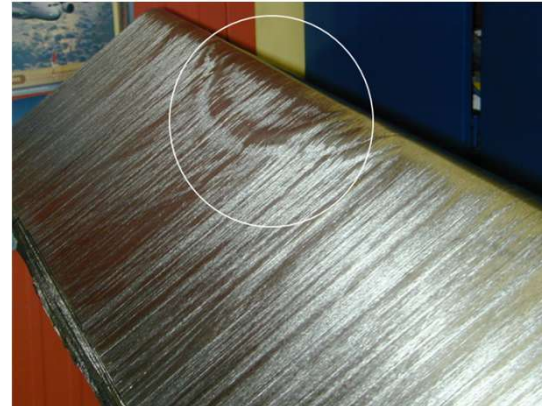


Steel sheet pressure plates

# Evaluations

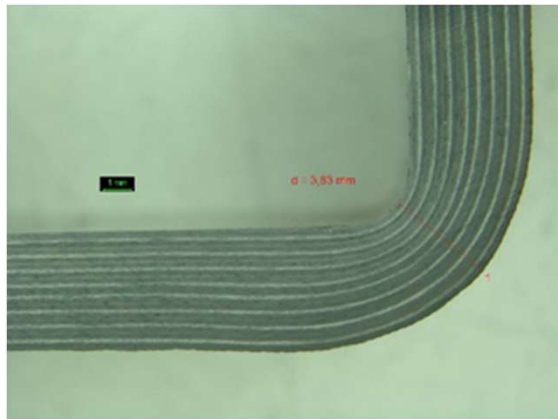
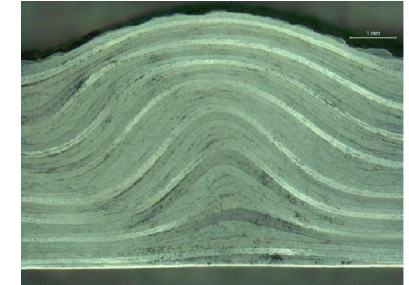
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- Micrographs
  - Wrinkles
  - Porosity
  - Thickness variation
- Effects of steel sheet pressure plates
- Effects of temperature tailoring

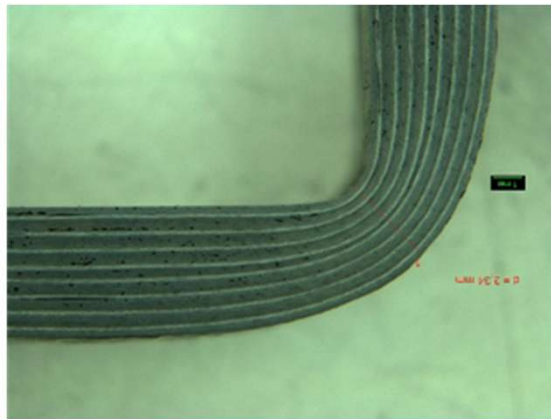


# Wrinkles, porosity and thickness variation

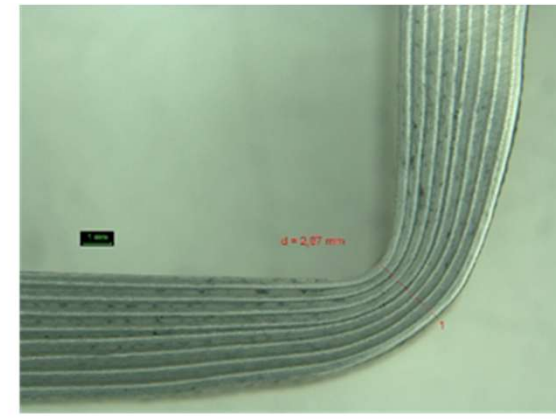
- Press forming study results
- Illustration of Vacuum bag only cure



Hand lay-up



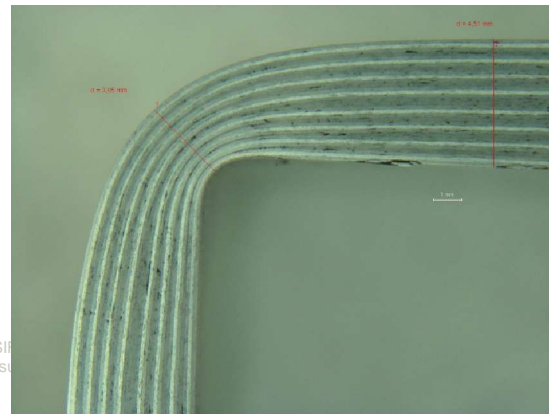
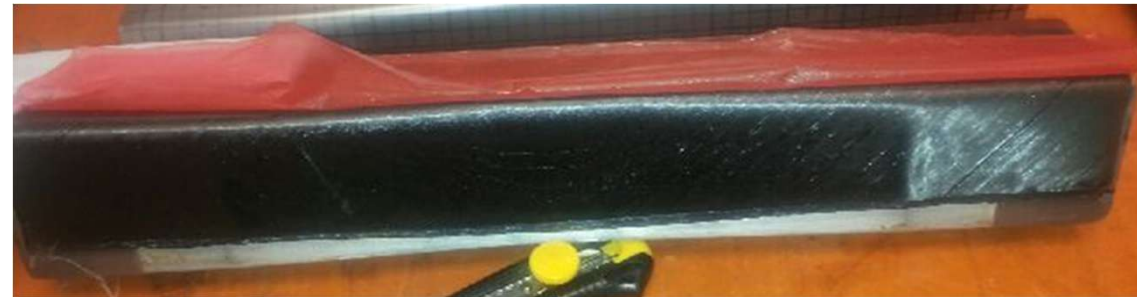
Hot drape forming



Fluid cell press forming

# Effects of steel sheet pressure plates

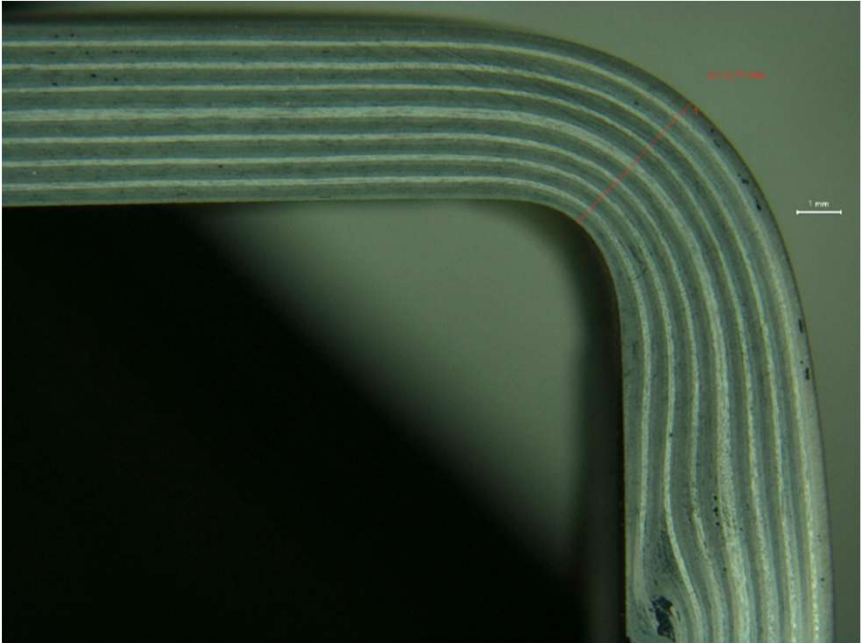
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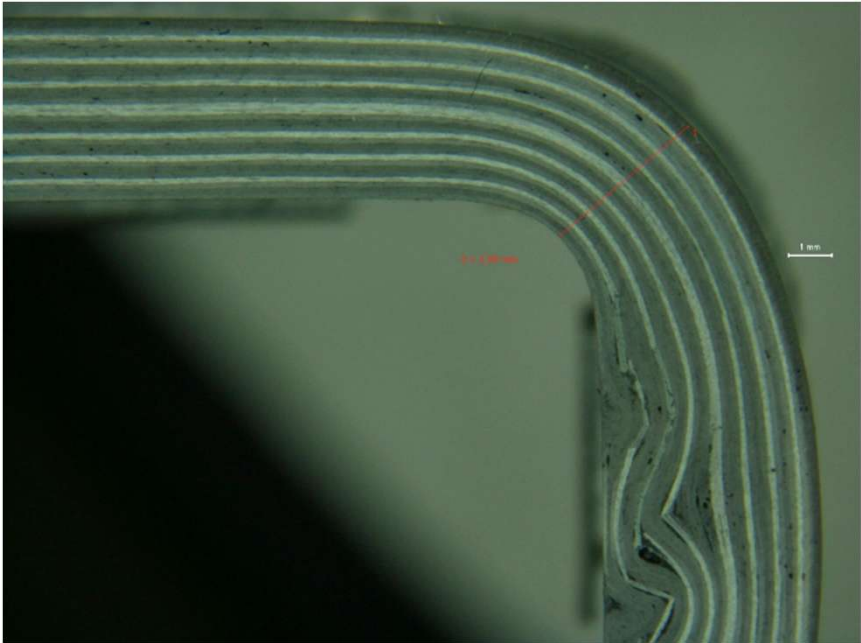


# Temperature Effects

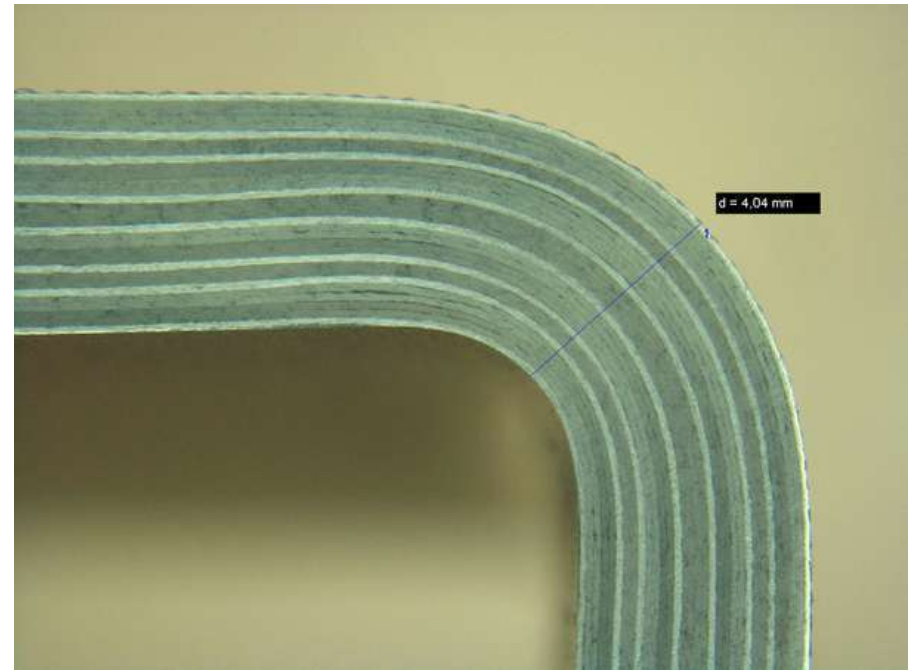
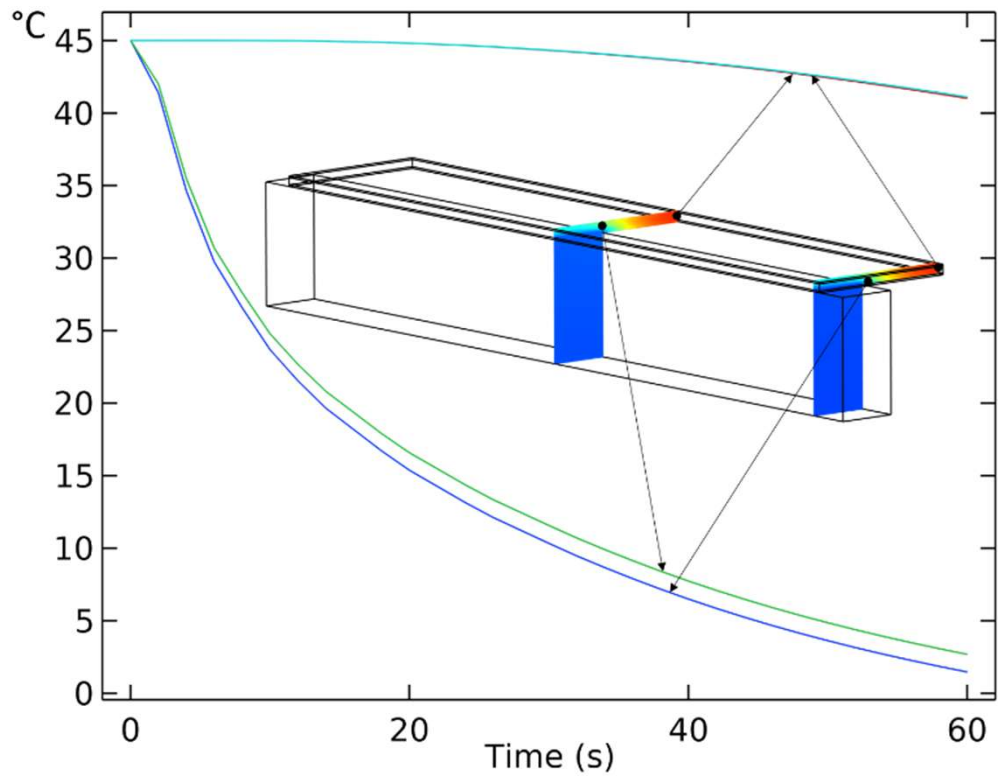
Room temperature forming



-18 °C forming



# Effects of temperature tailoring



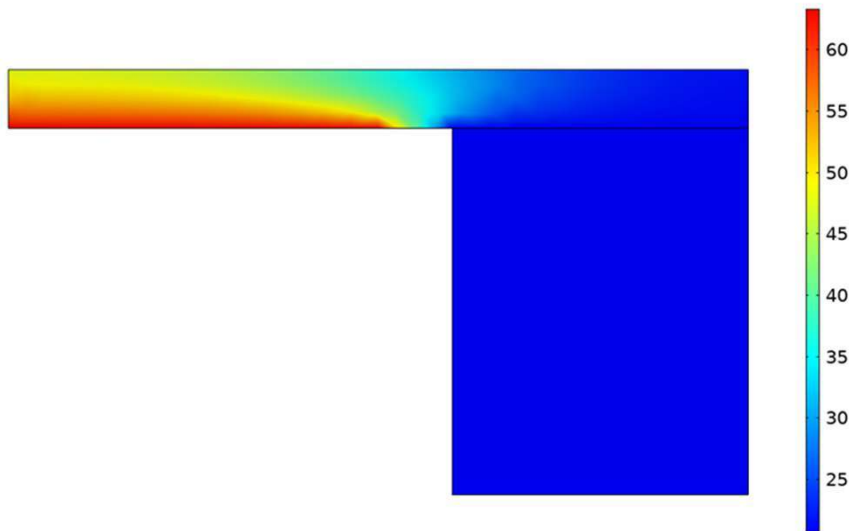
# Experimental case study – modified HDF

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- Heating – where necessary

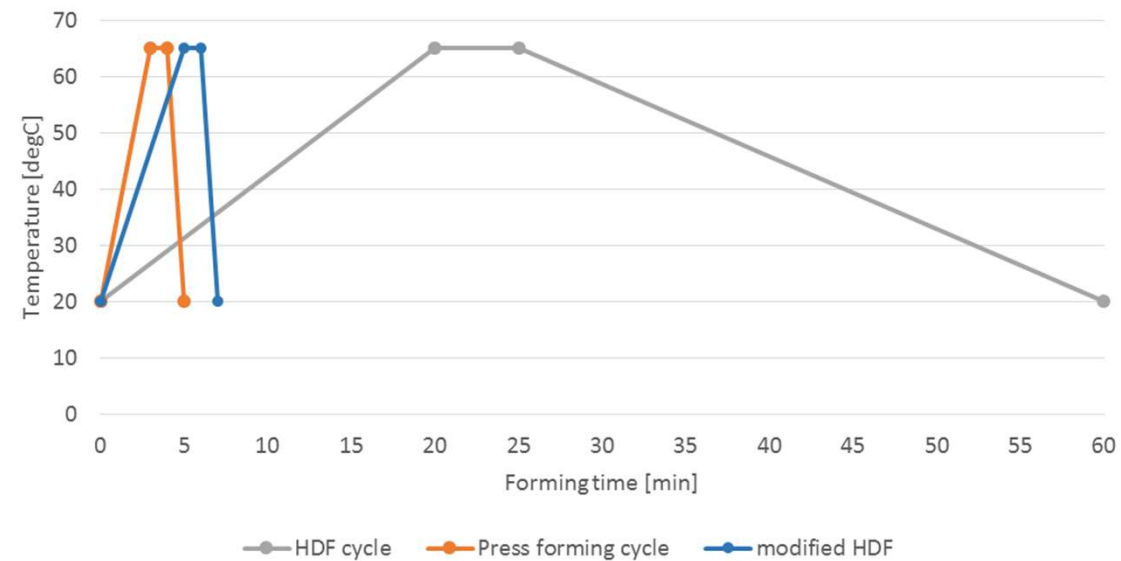
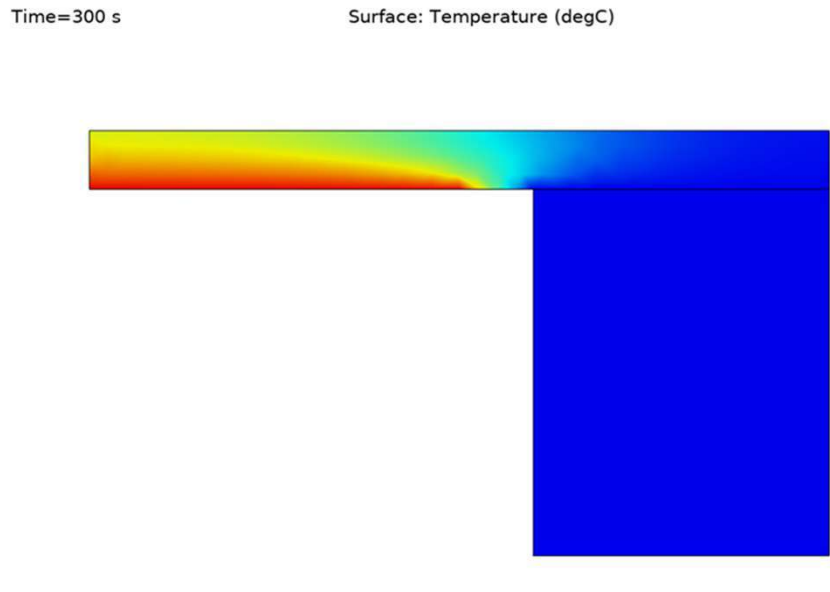
Time=300 s

Surface: Temperature (degC)



# Experimental case study – modified HDF

- Heating – where necessary



# Modified HDF - results and discussion

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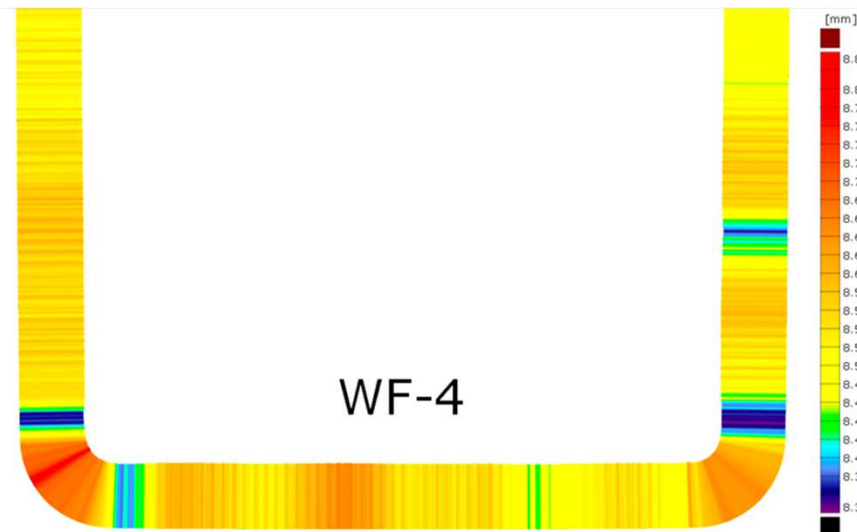
- Wrinkles
- Porosity
- Thickness variation



# Modified HDF - results and discussion

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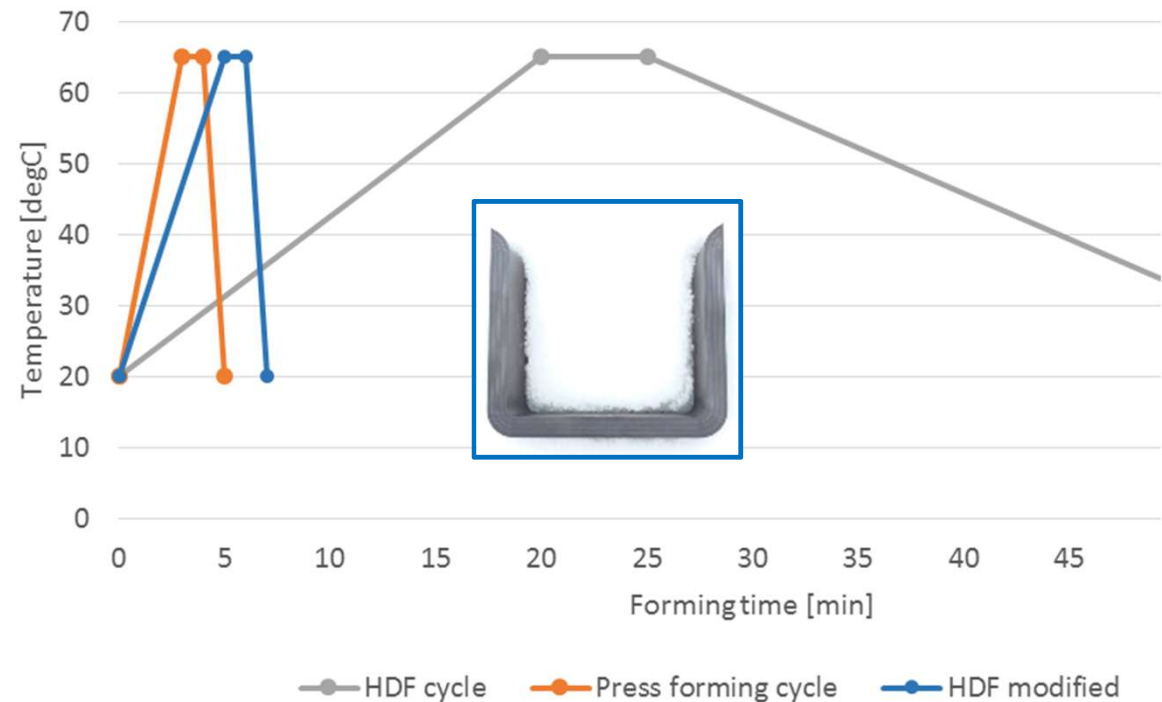
- Wrinkles
- Porosity
- Thickness variation



# Summary

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- High pressure
  - provides fast forming
  - does not necessarily reduce the porosity level
  - induce increased level of squeeze flow
- It is more beneficial to manipulate the temperature distribution
- Low pressure with distributed temperatures will be equally efficient
- A prerequisite for temperature tailoring in HDF is a rapid process cycles
- Tailored temperature distribution enables significantly reduced forming cycles





Thank you for your attention!