mtc
Manufacturing
Technology Centre

CATAPULT
High Value Manufacturing

Using COMSOL® in a connected virtual factory –thermal RSM for rapid adaptable packaging line

Heather Nute

October 2023

COMSOL
Certified Consultant

Background

- Opened in 2011
- Independent RTO
- To bridge the valley of death
- Prove innovative manufacturing ideas
- Manufacturing system solutions
- Training & Skills

UNIVERSITY OF BIRMINGHAM

Loughborough University

The University of Nottingham

Problem statement

What is the Digital Manufacturing Accelerator (DMA)?

- A project to create purpose built digital and physical testbed facilities and specialist skills and expertise for future requirements of industry

Why was the DMA funded?

- To support companies in identifying, implementing, and de-risking adoption of digital and automation technology solutions to transform businesses and their manufacturing processes

How was modelling used in the DMA?

<u>The Challenge</u>

- To create a rapidly* reconfigurable system of a tablet blister packaging process with quick changeovers

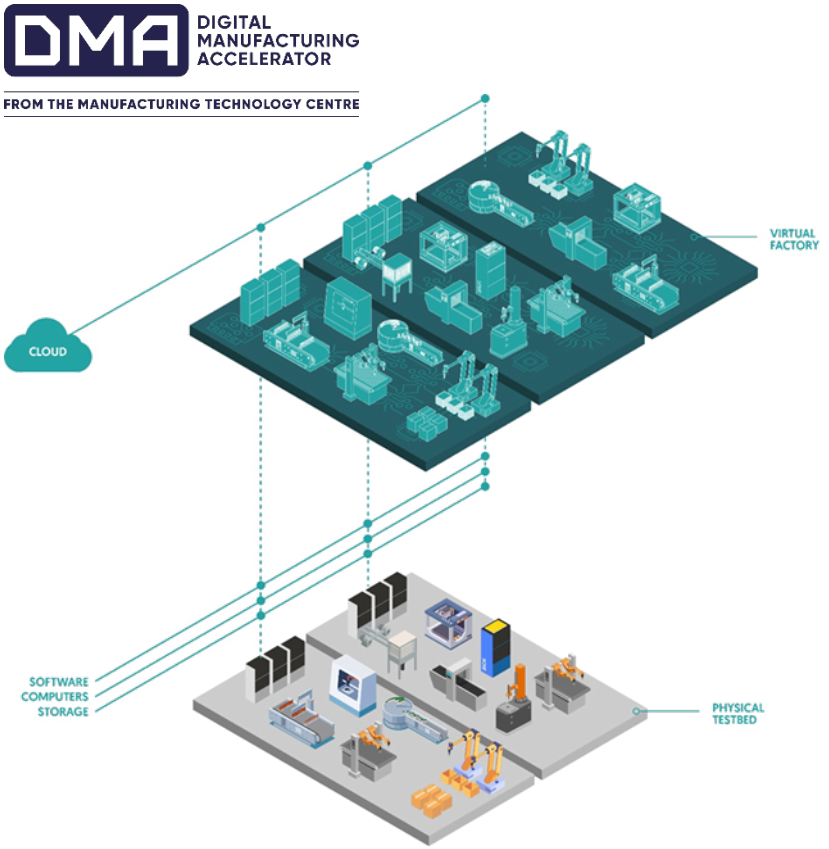
<u>The Objective</u>

- To avoid tablet product quality defects due to exposure to high temperature during blister packaging

<u>MTC's Solution</u>

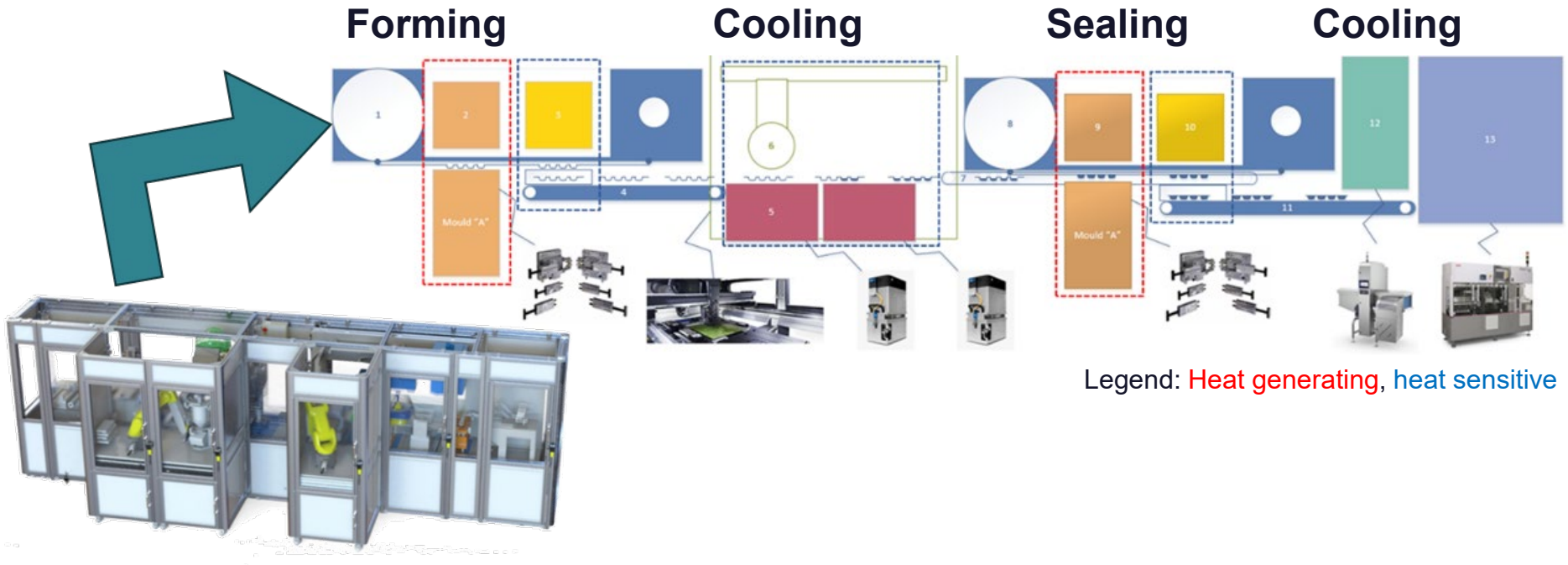
- Develop a COMSOL model of inline blister temperature control to determine time output for informed decision making

**Changeover in 15mins*



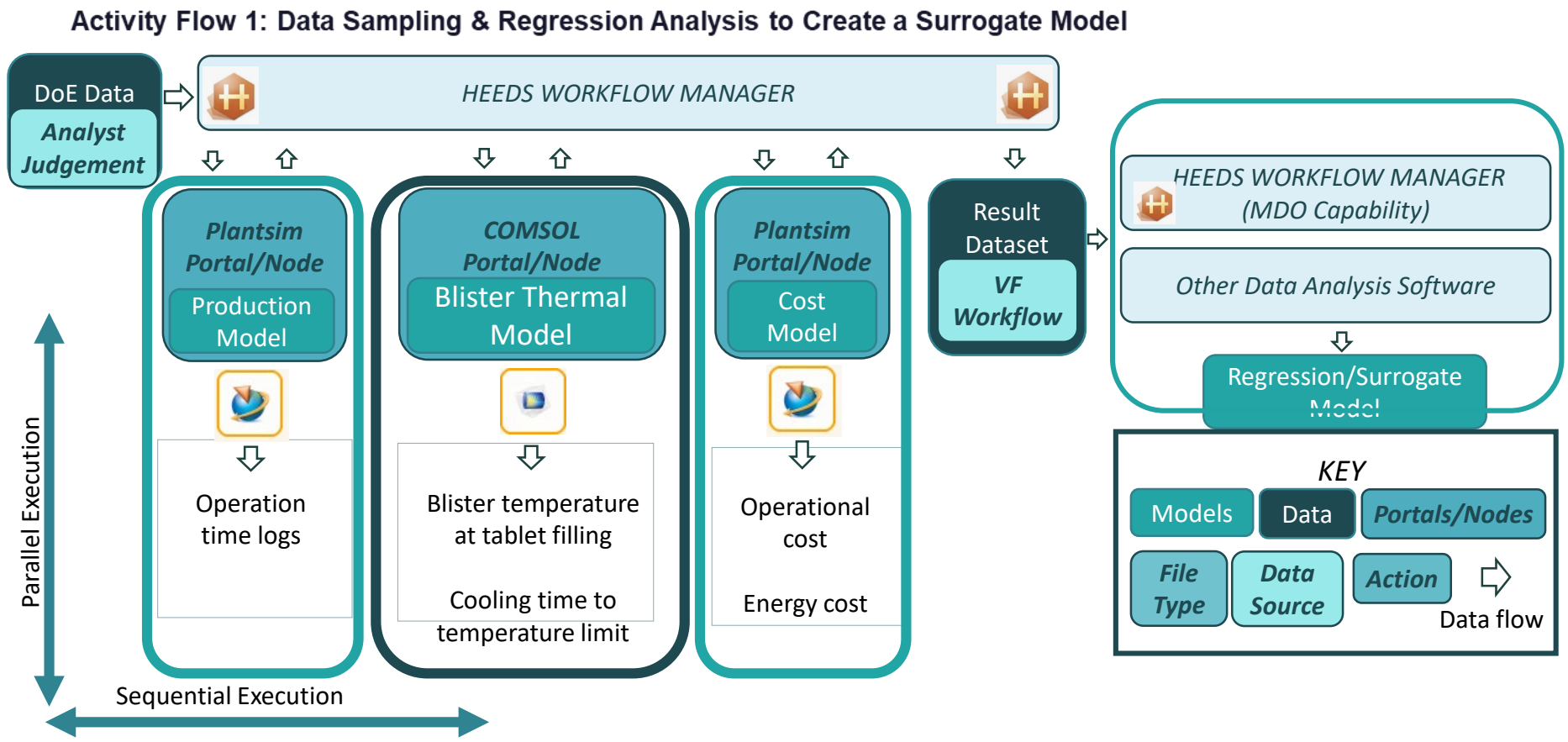
Method: manufacture process map

- Model simulates thermal aspects of a tablet packaging process to evaluate blister cavity temperature over time for selected sub-processes:



Legend: Heat generating, heat sensitive

Virtual Factory Workflow Flow Overview



Method: FEA model

Geometry

- Shell blister cavity + ‘lid’

Materials and Sections

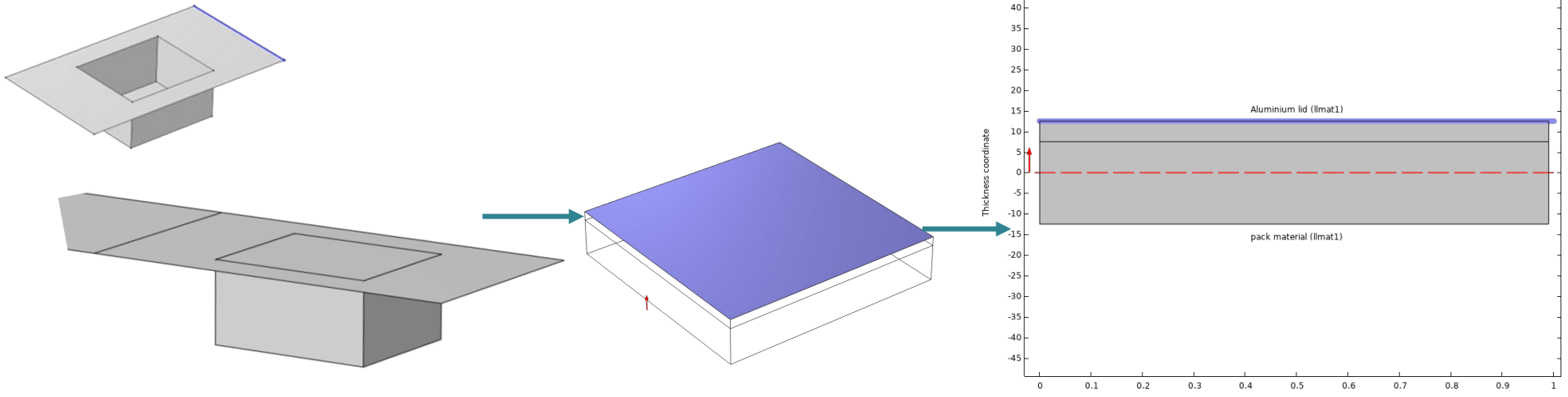
- Layered materials – lid represented by additional layer on base pack material

Step 1: Unlidded cavity

Step 2: Lidded cavity

(lidded) Top surface topology

Layered material thicknesses:



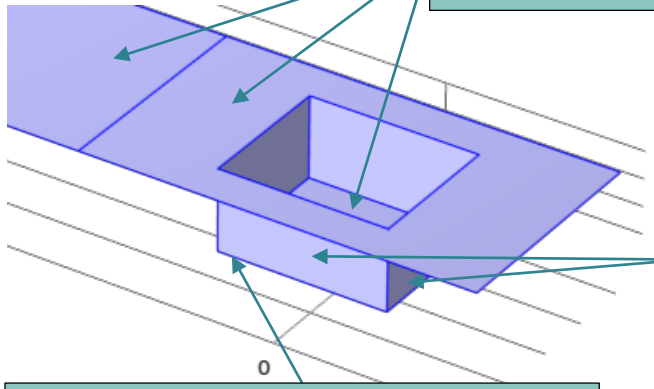
Method: FEA model

Physics and boundary conditions

- Heat transfer in shells and Events

180 W/(m^2. K) heat transfer applied to all surfaces, when active cooling enabled

Step1: Forming + 1st cooling period

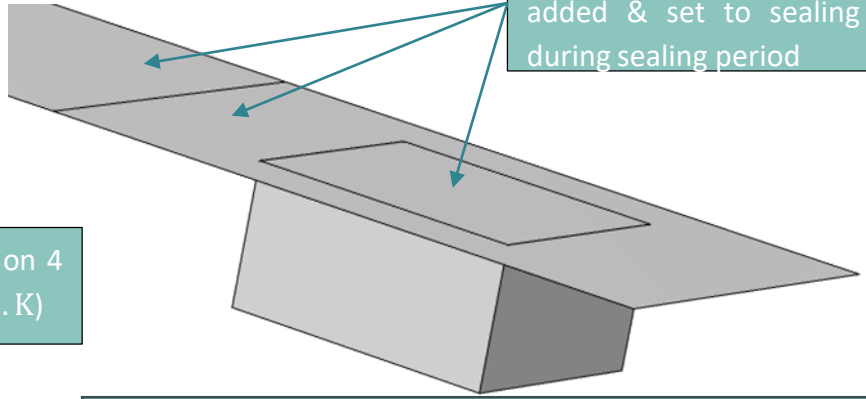


Natural convection on top surfaces (based on characteristic length)

Natural convection on 4 side walls: 5 W/(m^2. K)

10 W/(m^2. K) default heat transfer at base (as assumed in contact with surface)

Step 2: Sealing + 2nd cooling period



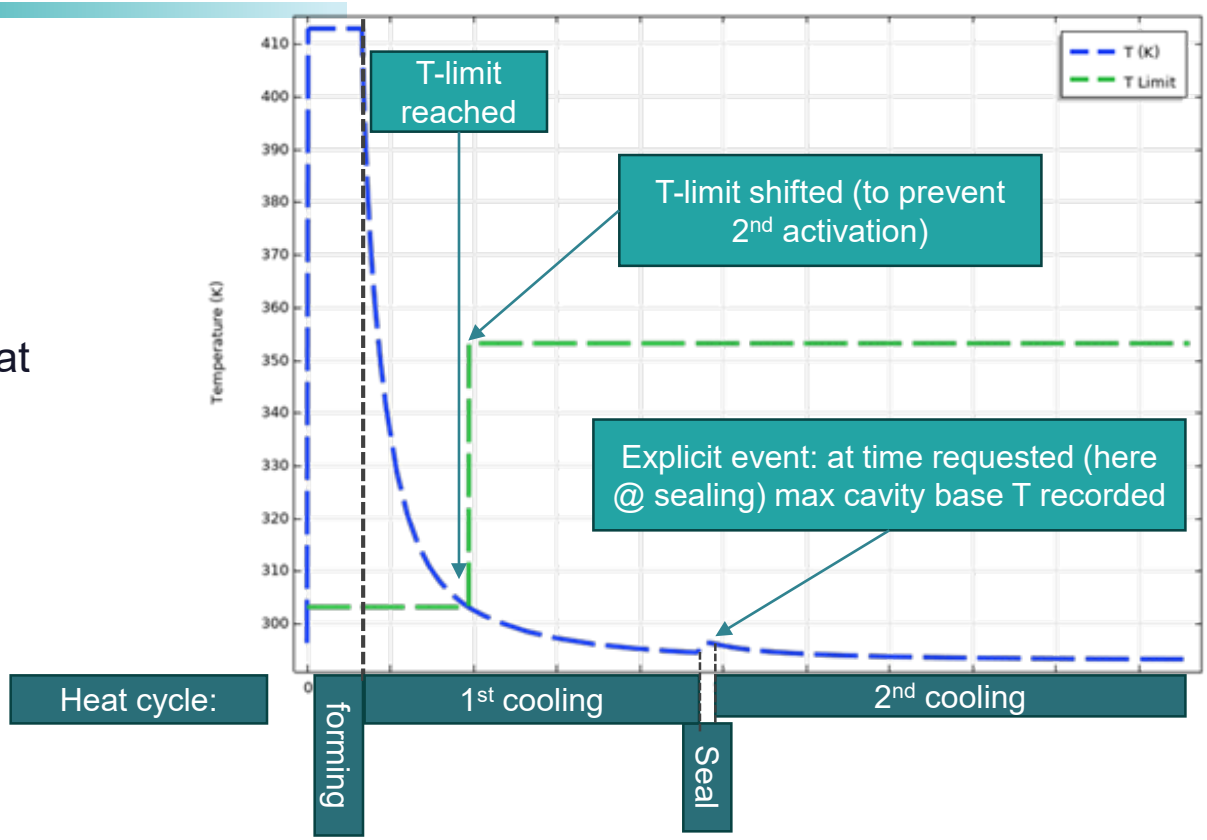
Top aluminium layer is added & set to sealing T, during sealing period

Aluminium lidding T_int = ambient air, the cavity carries through temperature from the end of the prior step, after initial cooling.

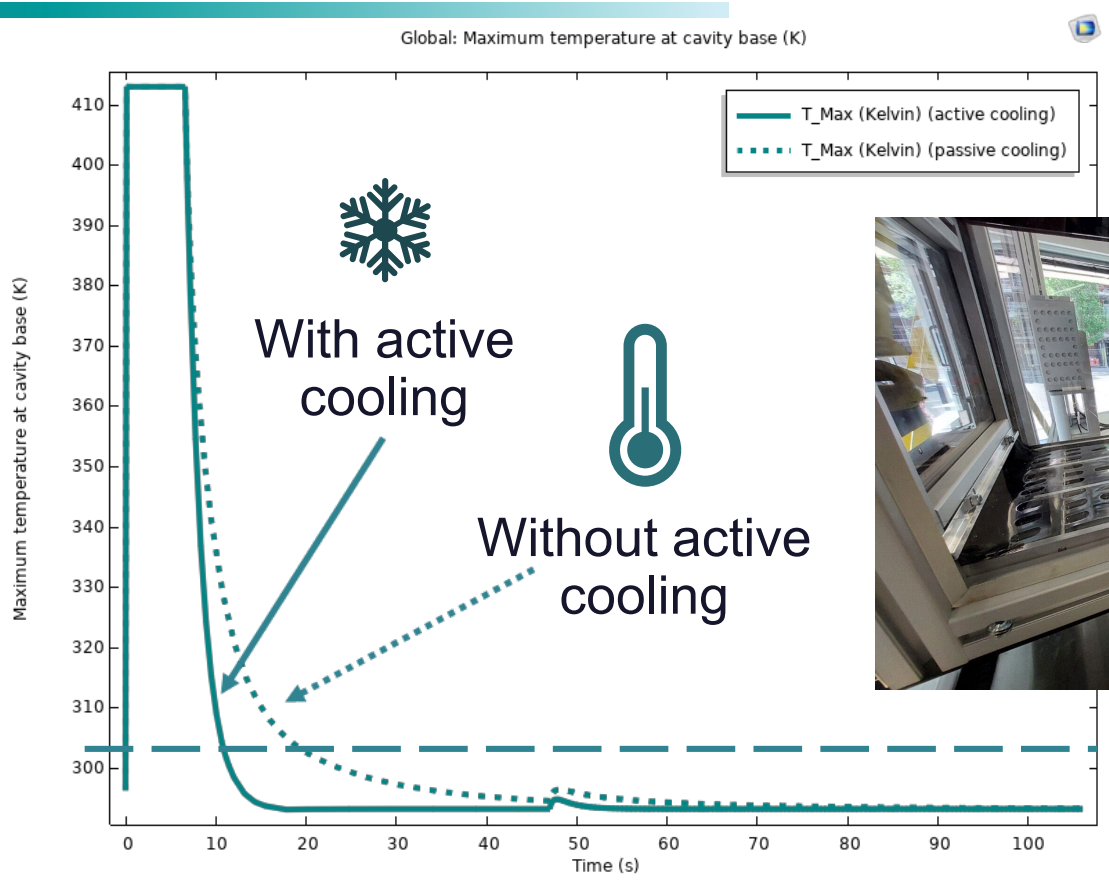
Method (FEA model)

Events

- Switching on/off heating (forming/sealing)
- Recording max temperature at set times
- Recording times when temperature limit is met
- Setting & resetting temperature limit



Example results:



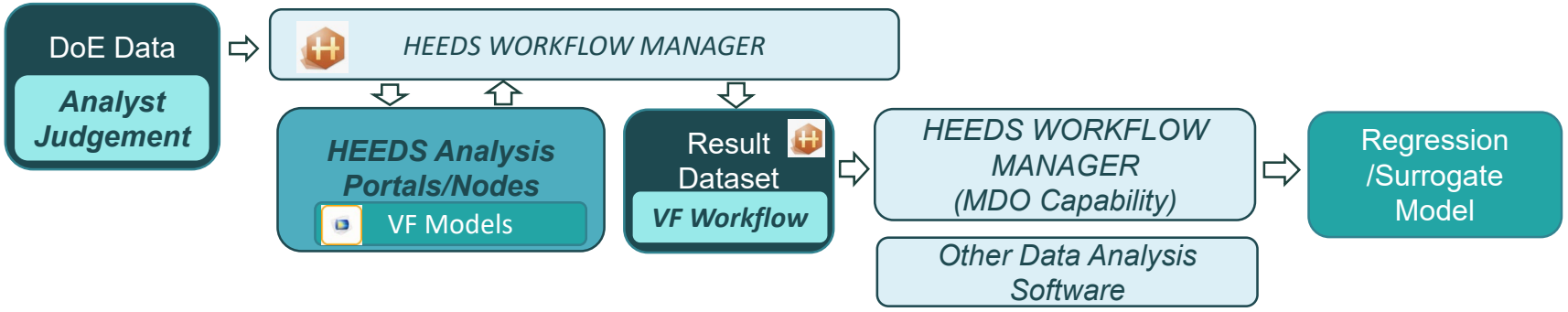
Cooling ‘wand’

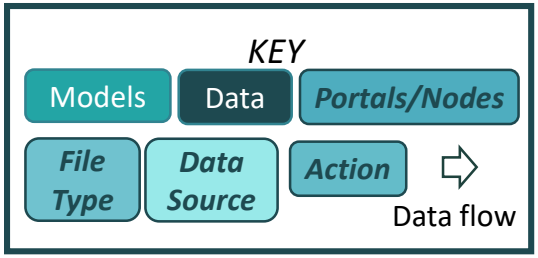
Temperature limit

How is the COMSOL model used in the Virtual factory platform?

Activity Flow 1: Data Sampling & Regression Analysis to Create a Surrogate Model

- COMSOL model as portal node

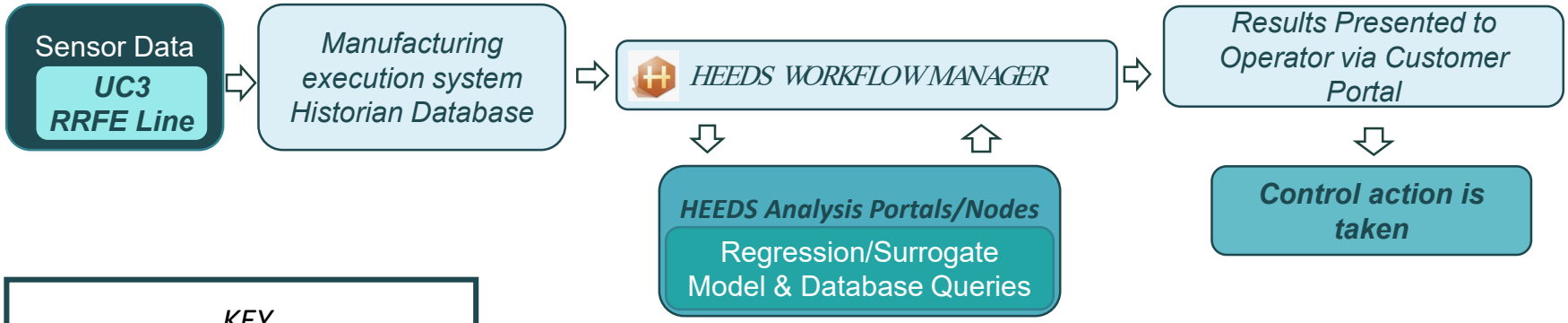




How is the COMSOL model used in the Virtual factory platform?

Activity Flow 2: Deployment of Regression/Surrogate Model

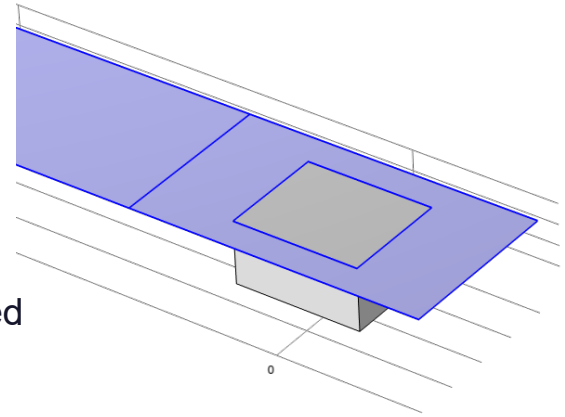
- COMSOL model as portal node



Conclusions

Using COMSOL® in a connected virtual factory

- Simulations can aid line builders to de-risk the design before implementation
- This use case aided decision making on optimising active cooling and scheduling of blister packaging via virtual tools and workflows
- Incorporating COMSOL models within multi-discipline workflows allowed teams of engineers to perform analysis in half the time
- Informed decisions were enabled on a range of scenarios that were linked to a live production line (for initial input data) for queries to be run and predictions to be made, establishing a factory digital twin
- Real-world benefits include:
  - Increase accuracy of line operating time estimates and optimised scheduling
  - Improvements in productivity and product yields
  - Better product quality assurance, reducing defects and rework
  - Reduce risk of accidents and unplanned downtime through failures



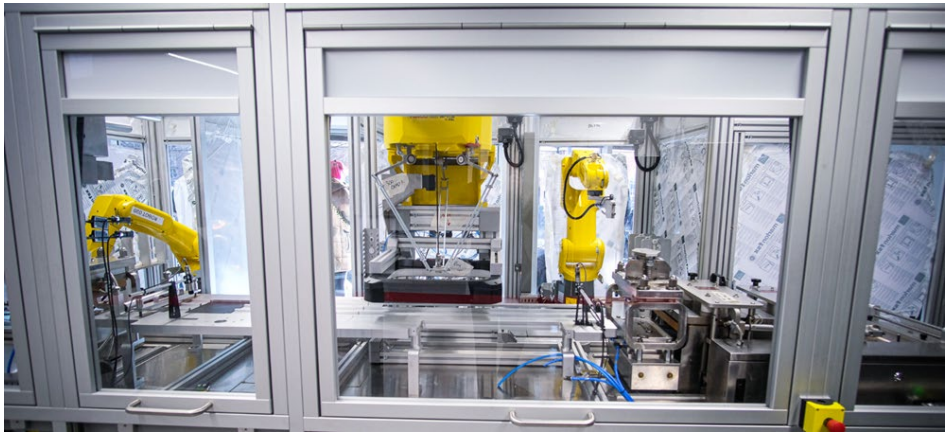
DMA DIGITAL MANUFACTURING ACCELERATOR

FROM THE MANUFACTURING TECHNOLOGY CENTRE

This work was undertaken as part of the Digital Manufacturing Accelerator programme and funded by the Liverpool city region Combined Authority.

Find out more at digitalmanufacturingaccelerator.com

For more information scan here with your camera!



RRFE at the MTC (Liverpool site)

LIVERPOOL CITY REGION COMBINED AUTHORITY

METRO MAYOR LIVERPOOL CITY REGION

NORTHERN POWERHOUSE

Liverpool City Region Local Enterprise Partnership

STRATEGIC INVESTMENT FUND

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THANK YOU