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Centre for Polymer and Material Technologies

FACULTY OF ENGINEERING
AND ARCHITECTURE

DEPARTMENT OF MATERIALS, TEXTILES AND CHEMICAL ENGINEERING
CENTRE FOR POLYMER AND MATERIAL TECHNOLOGIES (CPMT)

EXPERIMENTAL AND NUMERICAL OPTIMIZATION OF PROCESSING PARAMETERS FOR HYBRID INJECTION MOULDS

Willem Van De Steene, Stef Boden, Tom Wieme, Ludwig Cardon – 26/03/2019

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CONTENT

General introduction research group

Increasing demand for hybrid injection moulds

Part, mould & simulation design

Materials & methods

Results & discussion

Conclusions & future work

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Prof. Cardon - 3D Printing

- Extrusion based 3D Printing of pellets and filament
- Material development for 3D Printing
- 3D Printing of continuous fibre composites
- Printhead development
- 3D Printing build strategies
- FabLab UGent

Prof. Cardon - Advanced Polymer Processing

- Injection Mould Engineering
- Conductive polymers
- Hybrid Moulds
- Process simulation

Prof. Ragaert - Recycling and Sustainable Use

- Mechanical recycling
- Mixed polymer waste
- Multilayer packaging
- WEEE recycling
- Compounding
- Microfibrillar composites
- Design for & from Recycling
- Degradation effects

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INCREASING DEMAND FOR SMALL SERIES INJECTION MOULDS

Increasing demand for (additively manufactured) hybrid mould inserts for small series production of injection moulding parts from industrial partners.

Faster design iterations of the exact part geometry,
in the **same material** as the final product,
usually at a **smaller cost**

ADDITIVE MANUFACTURING OF HYBRID MOULD INSERTS


AM cavity (Stratasys, 2017)

Thermoset materials (material jetting, vat photopolymerisation)

very accurate, but brittle and expensive

Ceramic/metal/polymer filled resin (binder jetting)

brittle, low strength

Metals (electron beam melting, selective laser melting)

optimal thermal conduction high strength, expensive, post processing

Thermoplastic materials (powder bed fusion /**HP MFJT PA12**, FFF)

accurate, inexpensive, **maximum operating temperature**

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THERMOPLASTIC MOULD INSERTS

Using the HP Multi Jet Fusion Technology

Restrictions for semi-crystalline thermoplastic moulds:

thermal: keep processing temperature below HDT/Vicat softening point

→ **importance of cooling**

→ **Moldex3D**

mechanical: limited injection and clamping pressures

dimensional: higher CTE than metals, should be compensated for

Deformed PA12 insert after use

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PART, MOULD & SIMULATION DESIGN

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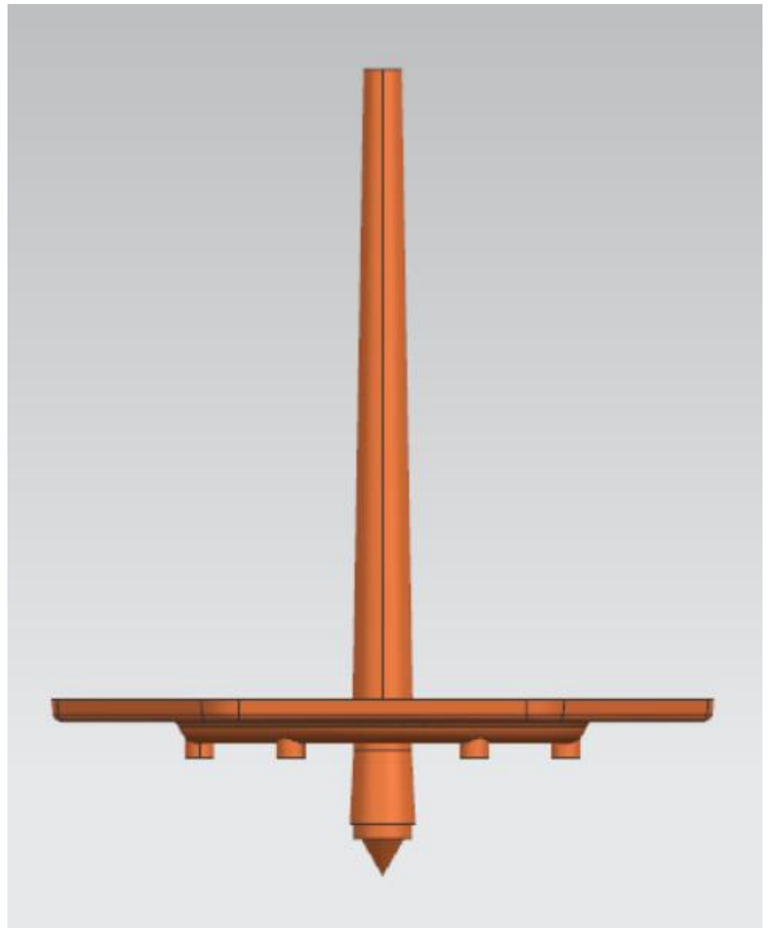
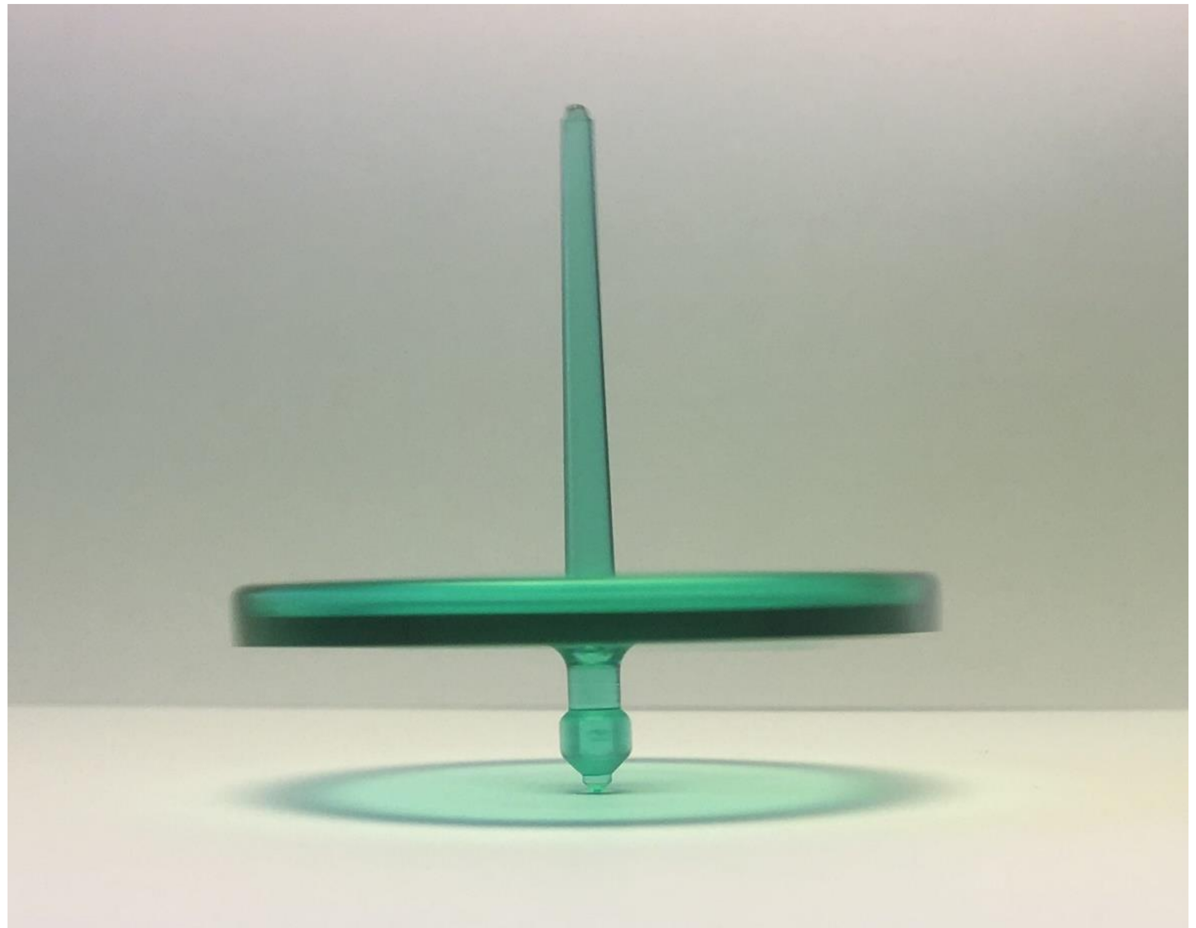
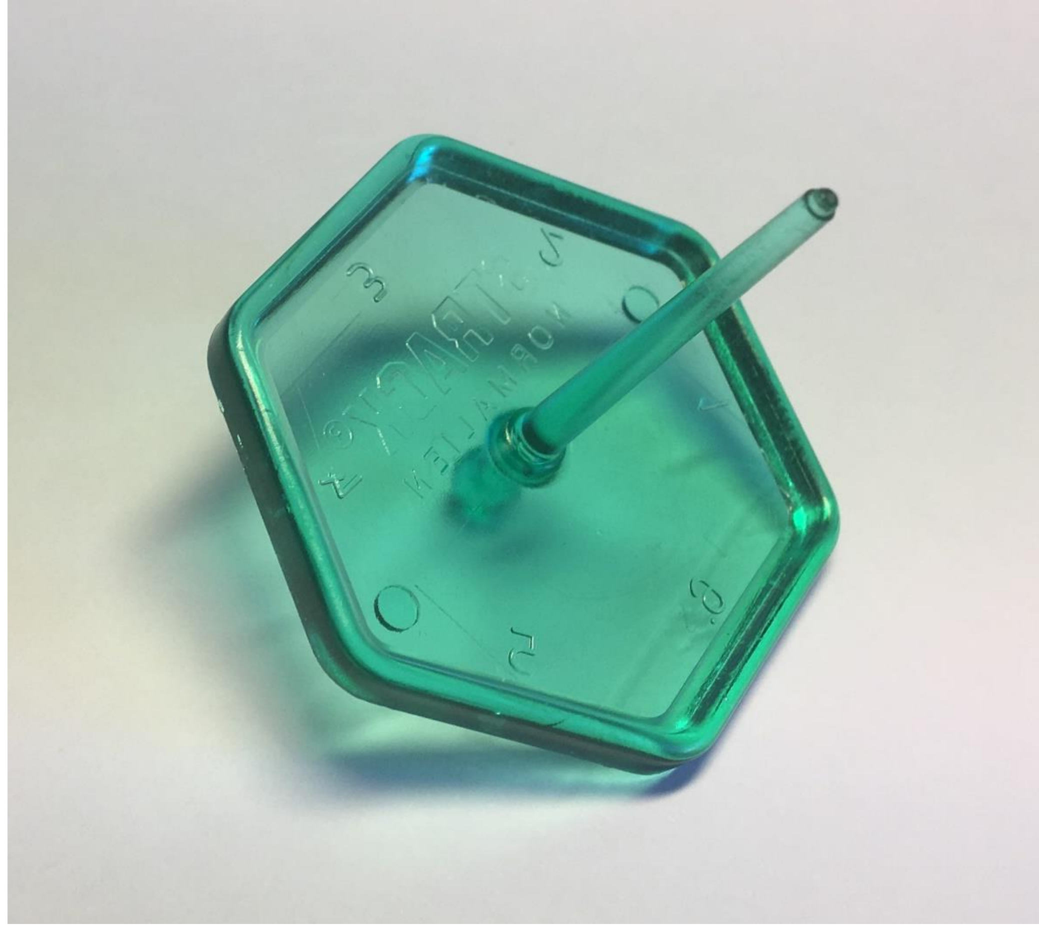
DEMONSTRATOR PART DESIGN







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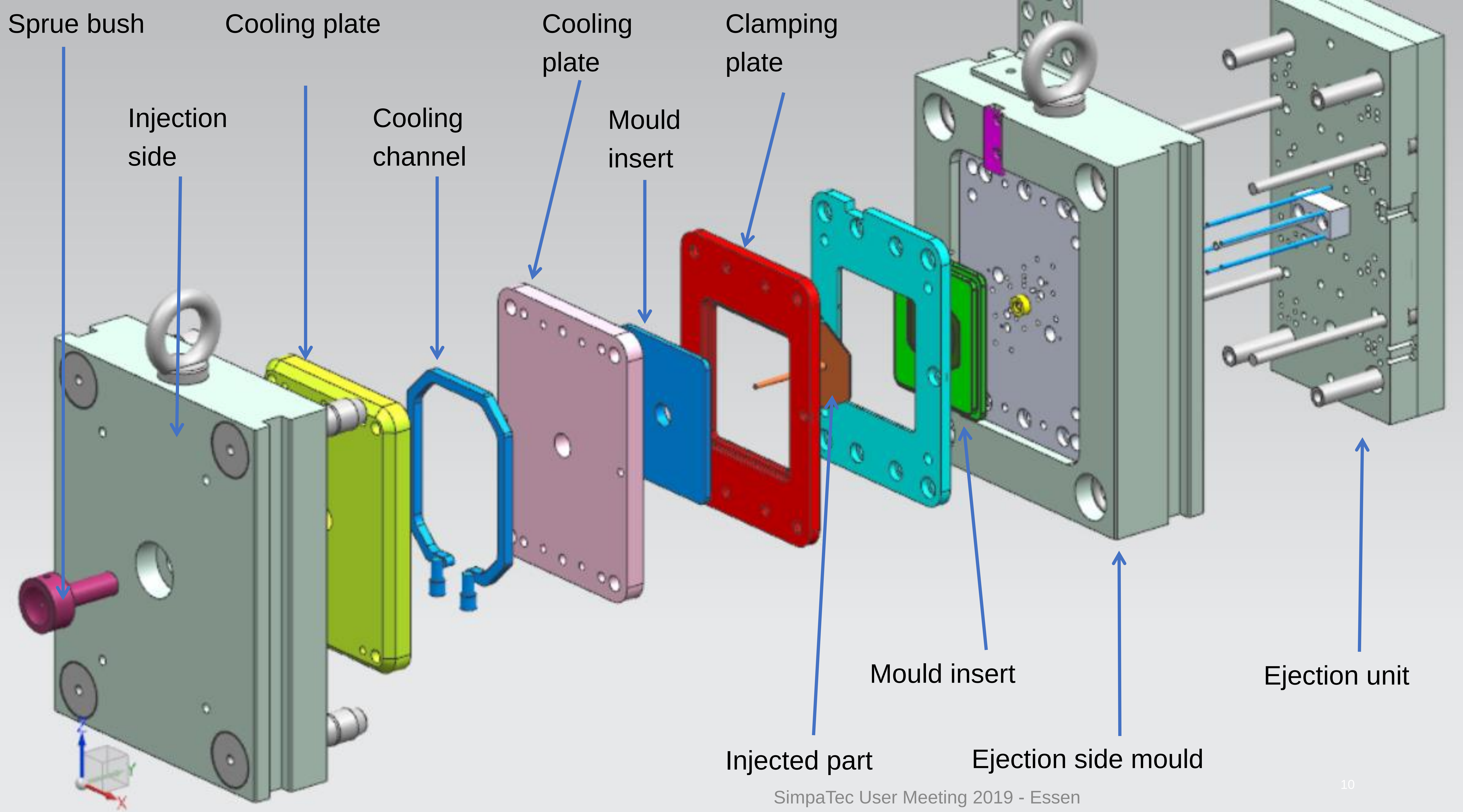
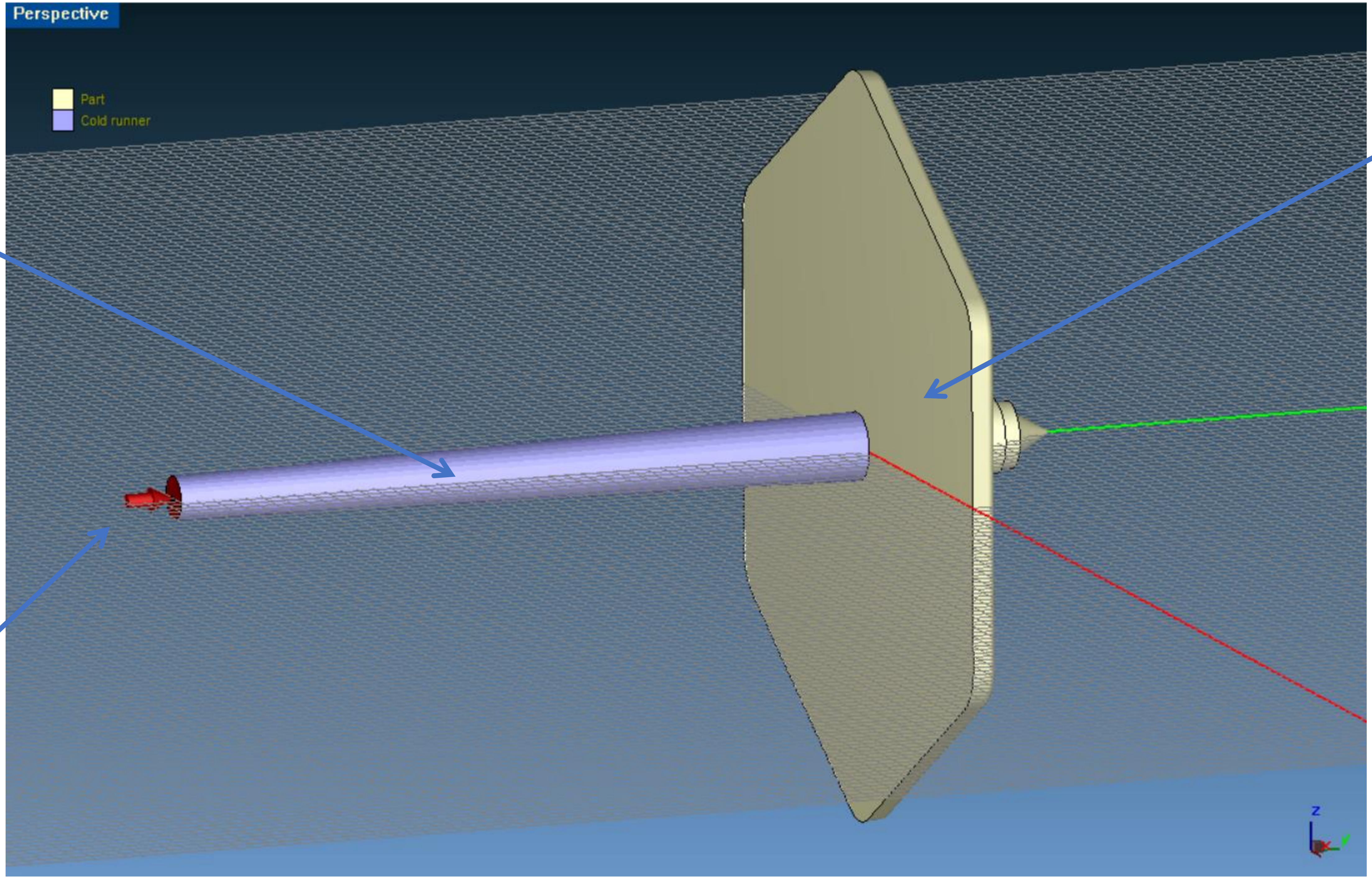

Sprue bush
Cooling plate
Cooling plate
Clamping plate
Injection side
Cooling channel
Mould insert
Mould insert
Ejection unit
Injected part
Ejection side mould

SIMULATION DESIGN

Cold runner with sprue bush

Inlet melt flow

Cavity



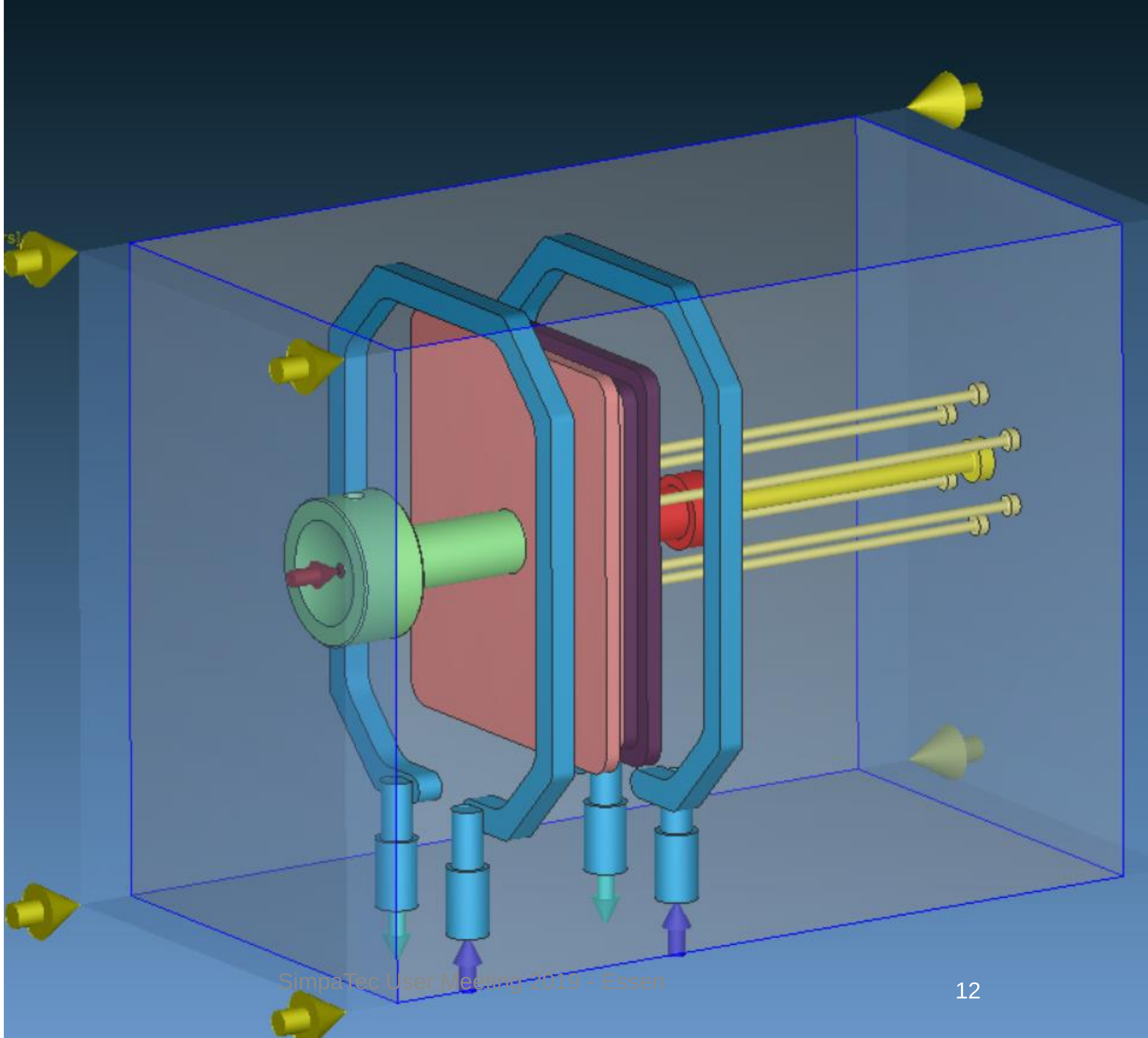
Mould inserts

- Core insert
- Cavity insert
- Sprue bush
- Ejection bush
- Ejector system

Cooling

- Cooling channel
- Cooling inlet
- Cooling outlet

Mould base



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MATERIALS & METHODS

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MATERIALS AND METHODS

PA12 mould inserts: HP Multi Fusion Jetting Technology (MJFT)

Injection machine: Engel E-Victory 28T

Injection part: Sabic PP 575L

Thermal conductivity and heat capacity: Hot Disk TPS 2500S (ISO 22007-2)

Infrared camera: Testo 875

Optical microscopy: Keyence VHX-500F

SURFACE PREPARATION OF THE MOULD INSERTS

PA12 surface after manufacturing

PA12 surface after heat resistant surface coating

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RESULTS

THERMAL & MECHANICAL ANALYSIS

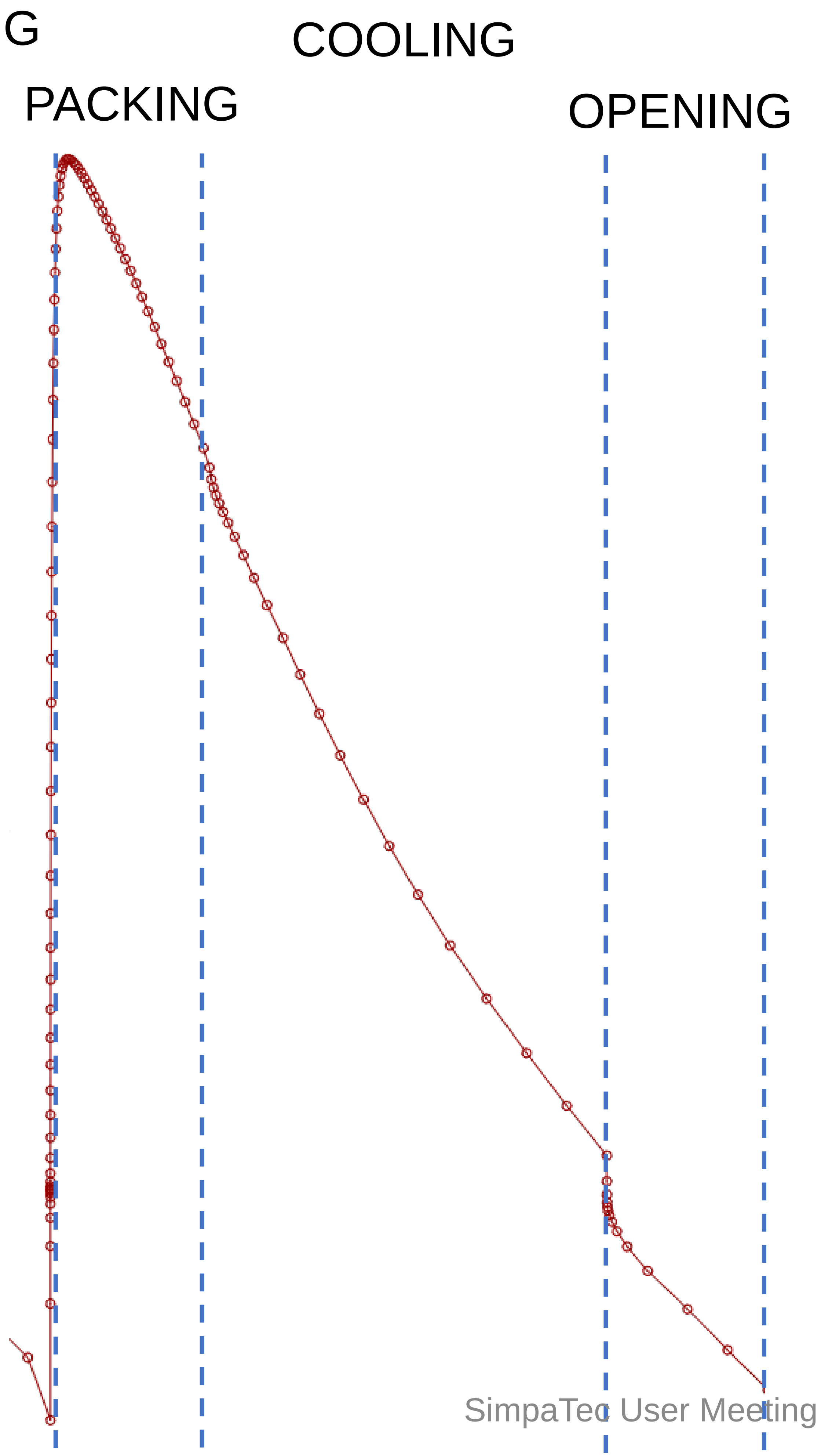
	PA12 (HP MJFT)	1.2311 steel (P20)
Conductivity [W/mK]	**0.3161**	**35**
Heat capacity [J/kgK]	1471	476.0
Density [g/cm³]	1.029	7.850
Young's modulus [GPa]	1.359	204.0
Yield strength [MPa]	**15.35**	**716.0**
Tensile strength [MPa]	42.09	1080

Thermal conductivity of PA12 is a factor 100 lower than that of 1.2311

Yield strength is a factor 50 lower

SIMULATION

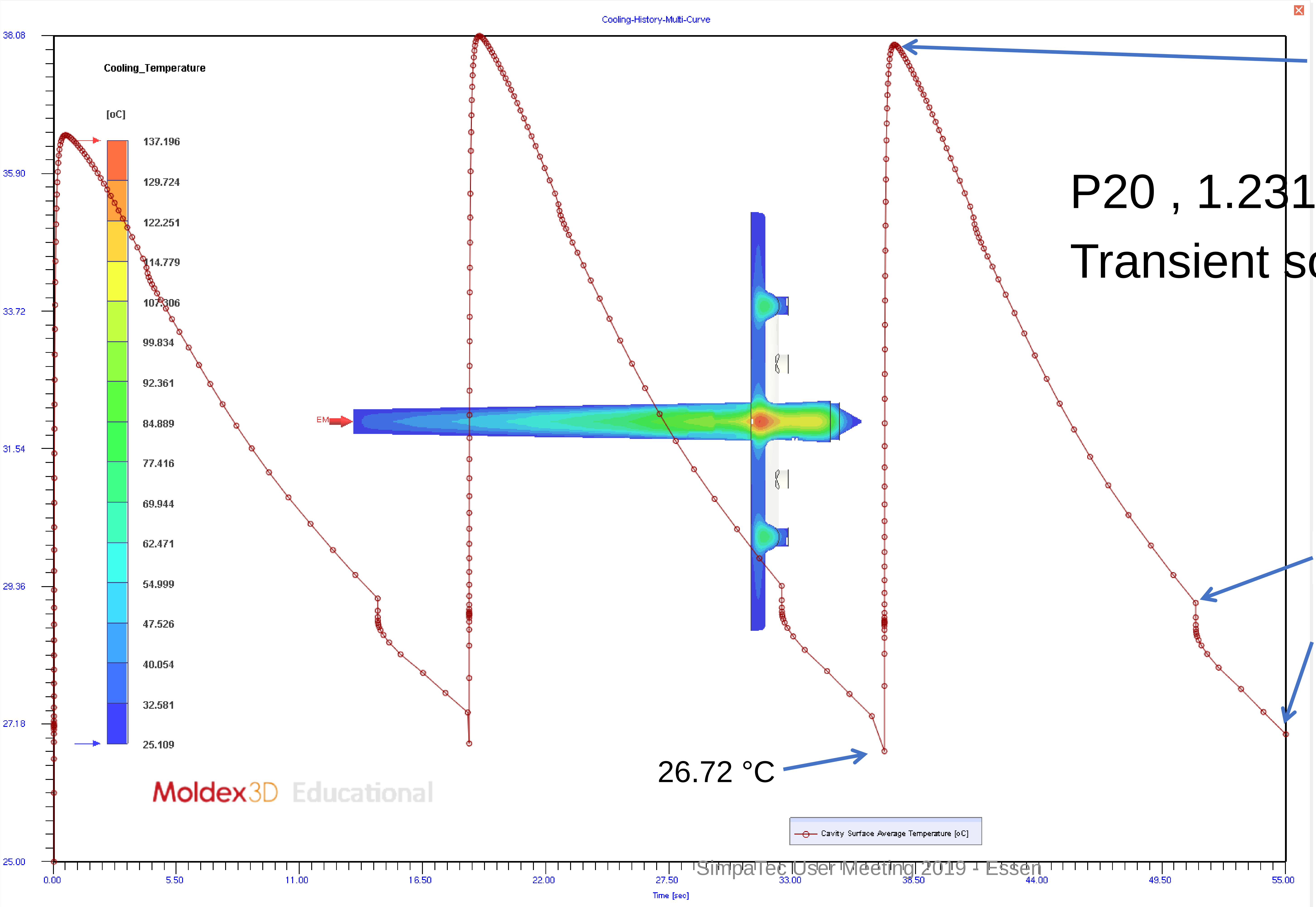
Filling :	0.14 s
Packing :	3.40 s
Cooling :	10.00 s
Opening :	5.00 s



P20, 1.2311 steel

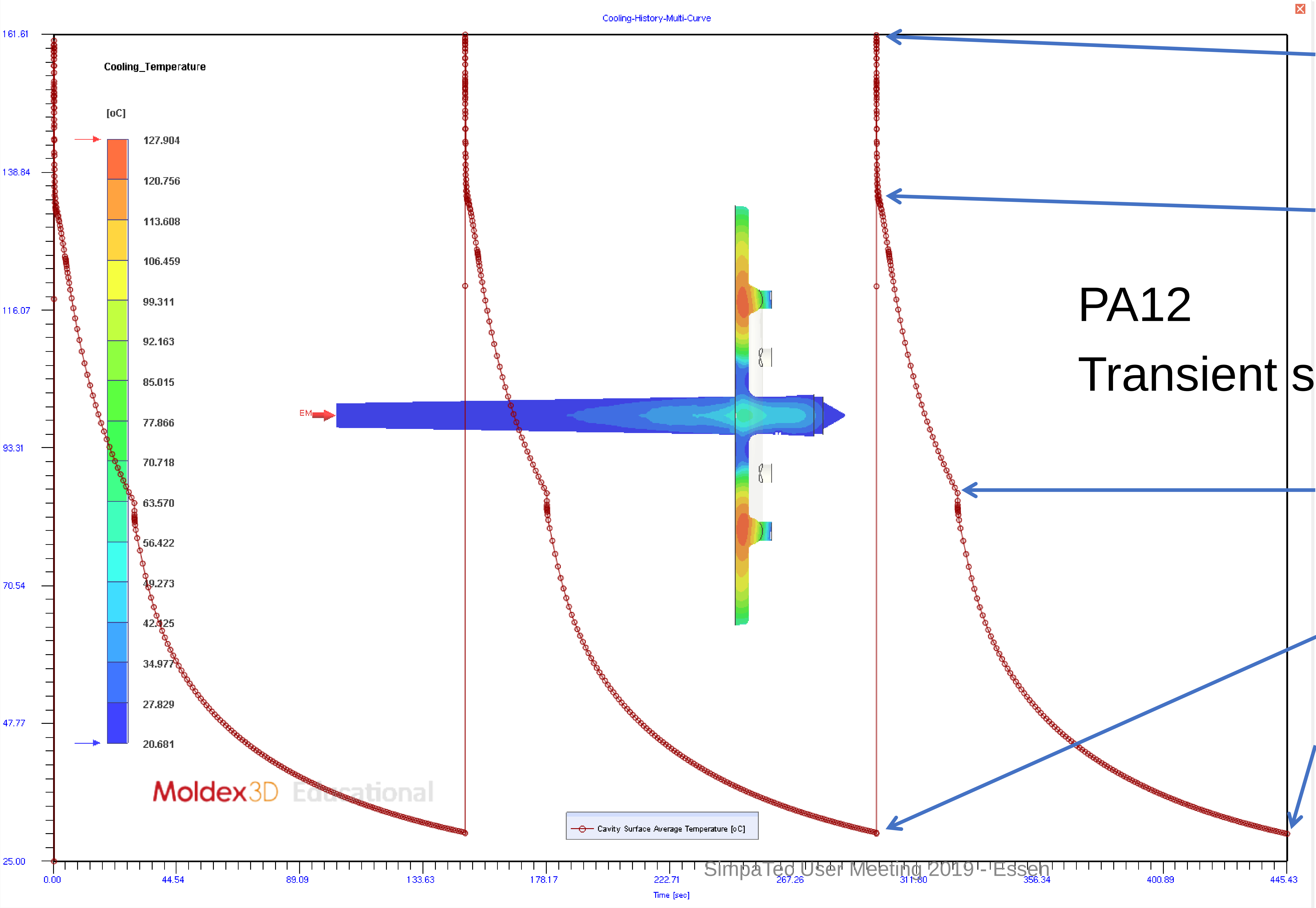
Steady state

P20 , 1.2311 steel
Transient solution



PA12

Transient solution



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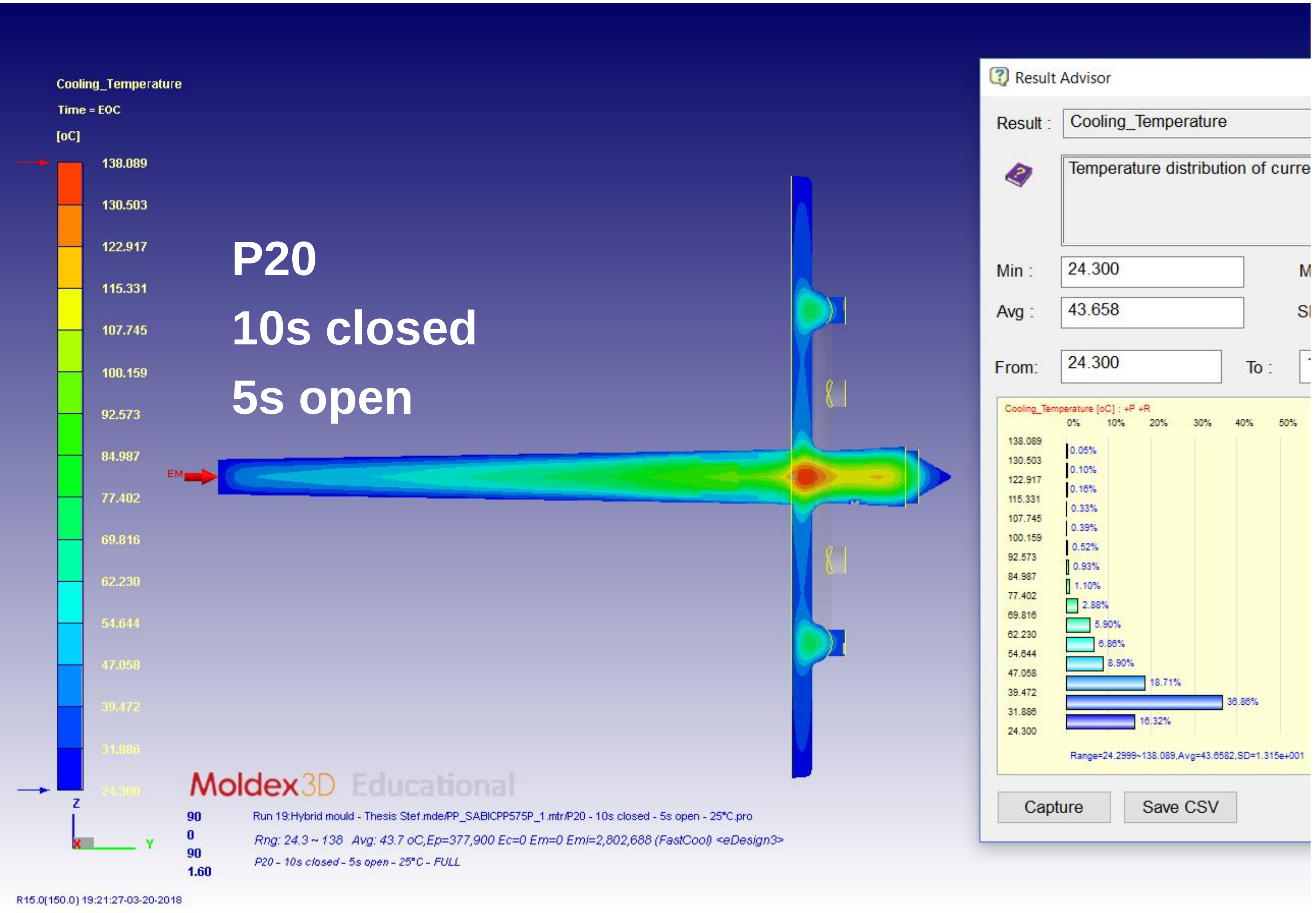
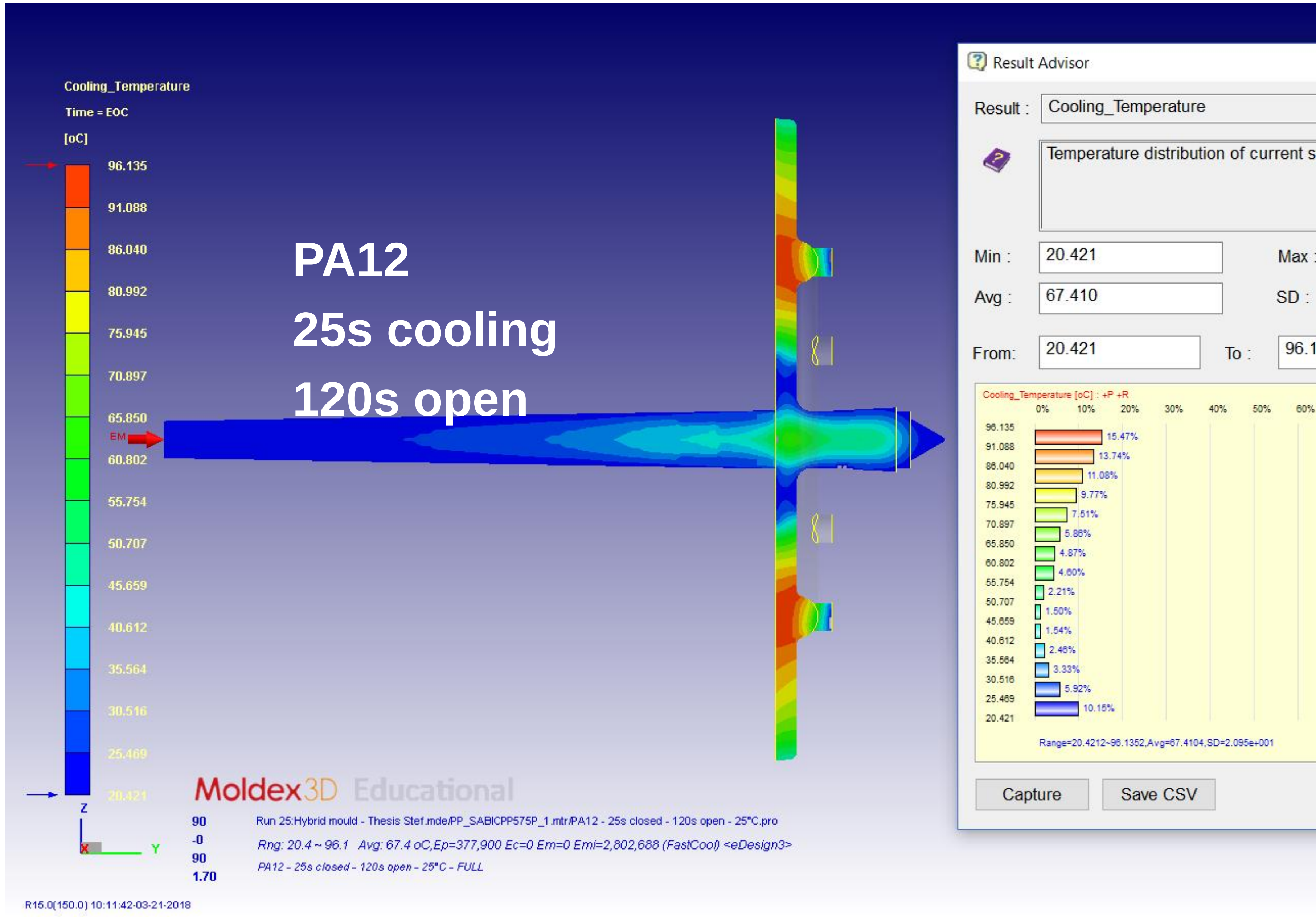
EJECTION TEMPERATURES P20 VS. PA12 INSERTS





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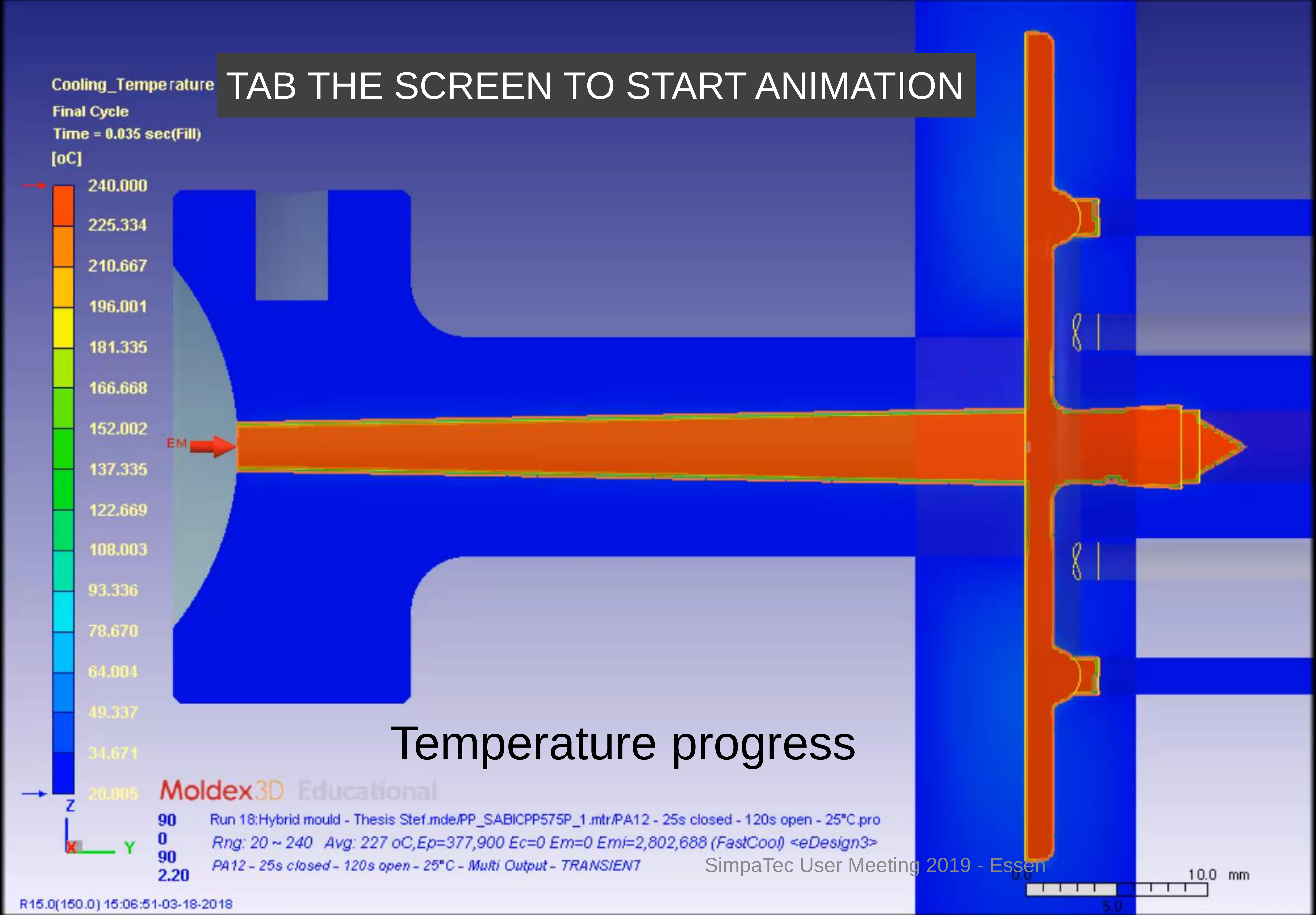
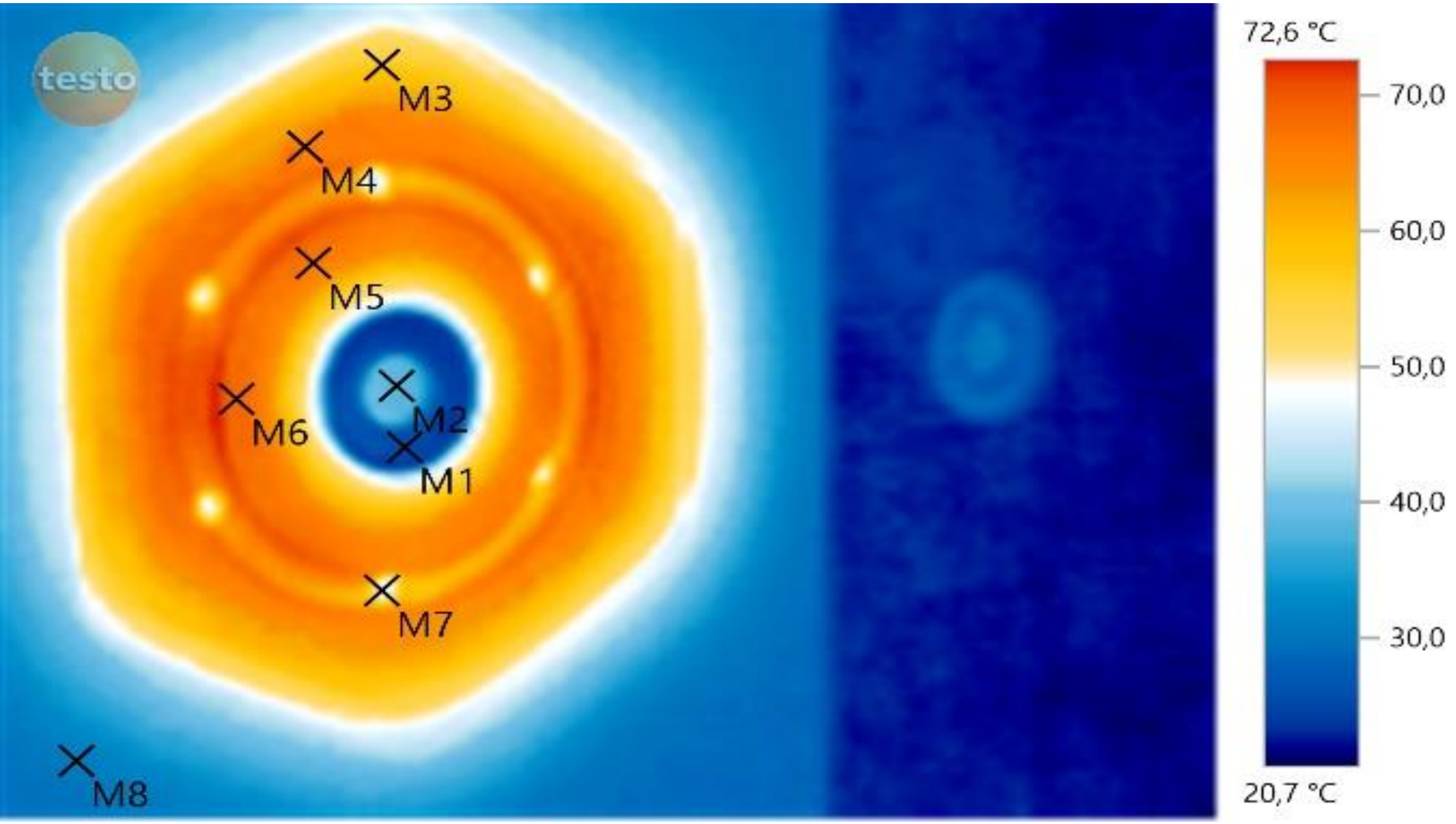
TAB THE SCREEN TO START ANIMATION

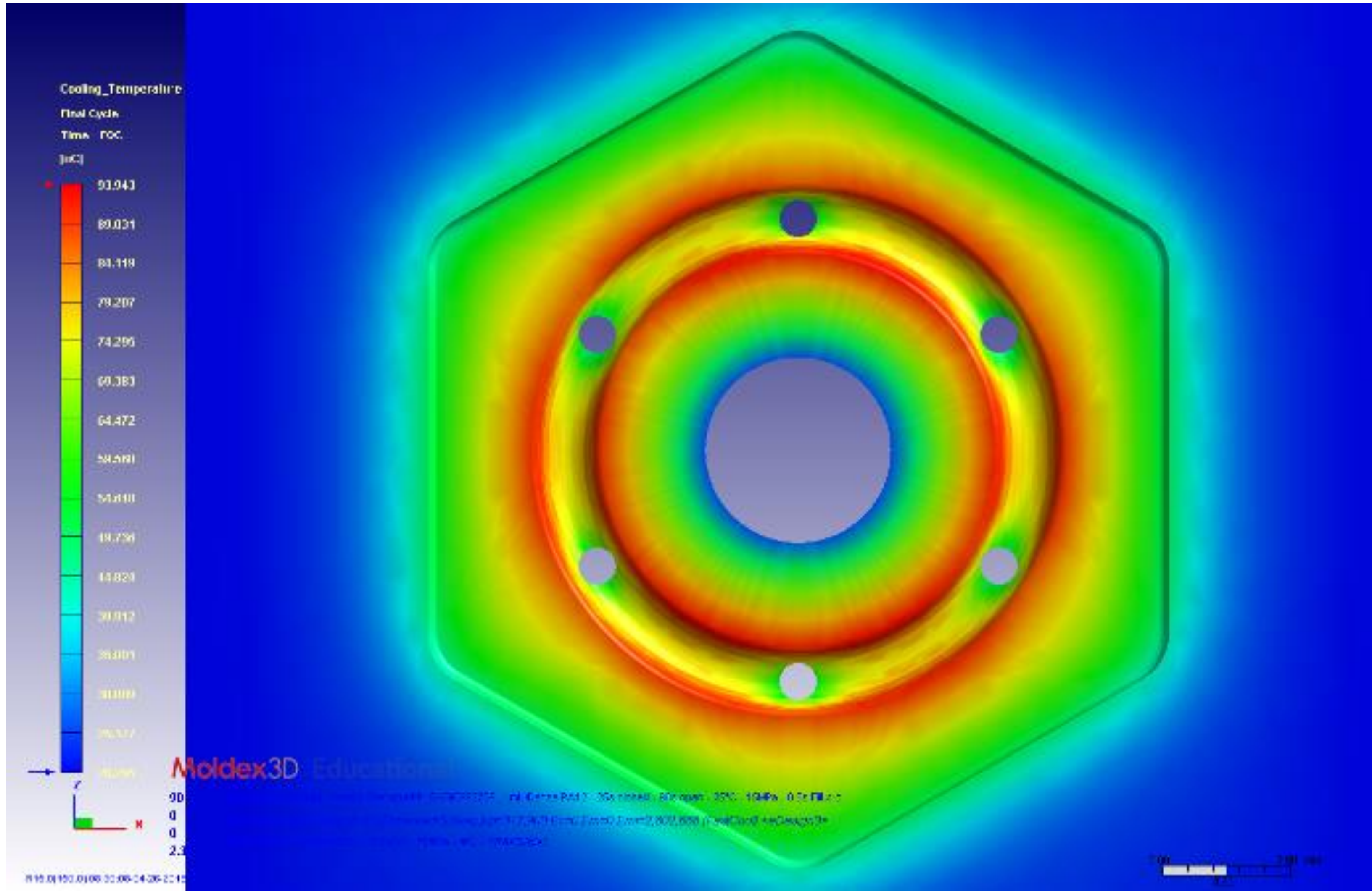
Temperature progress



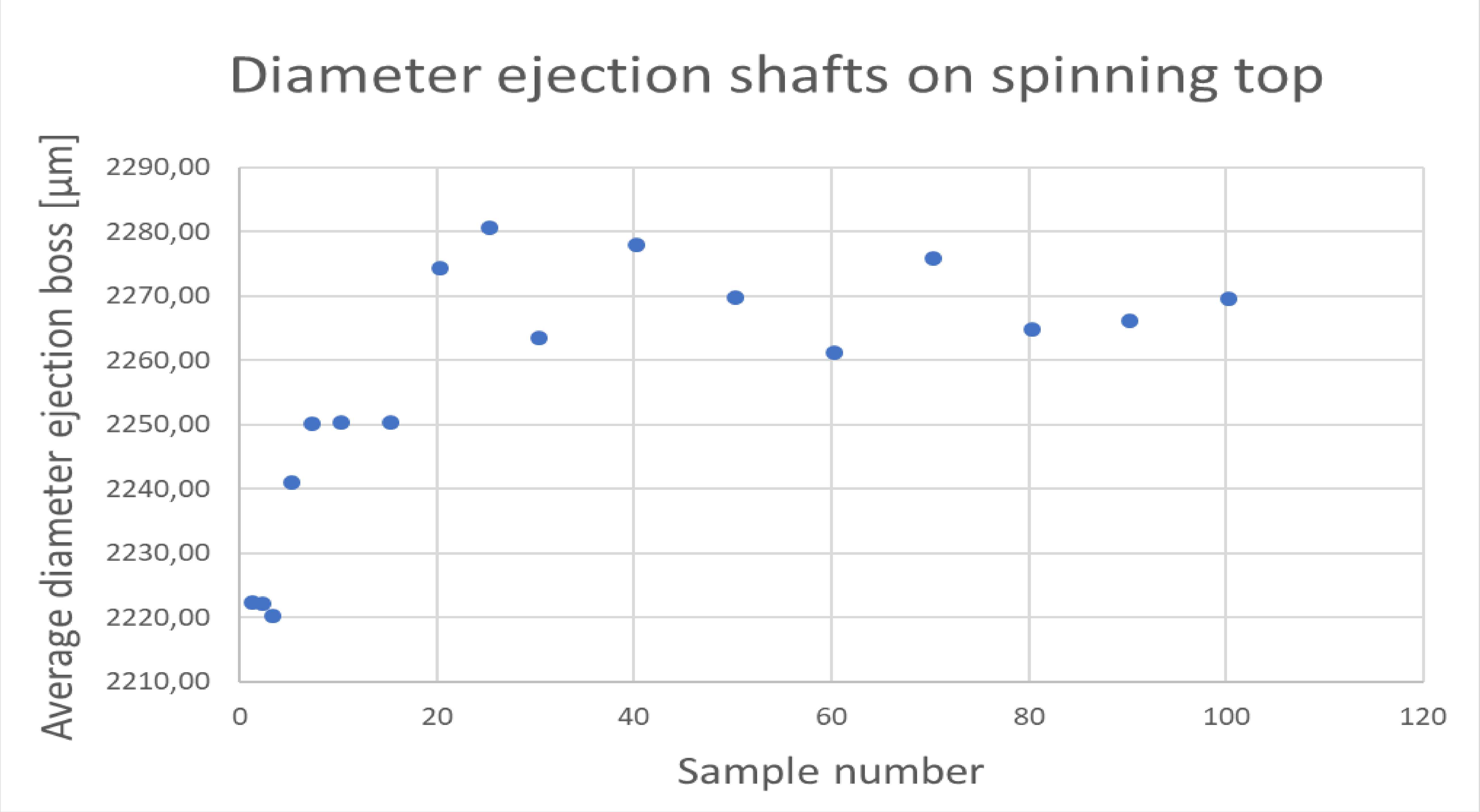
EXPERIMENTAL RESULTS

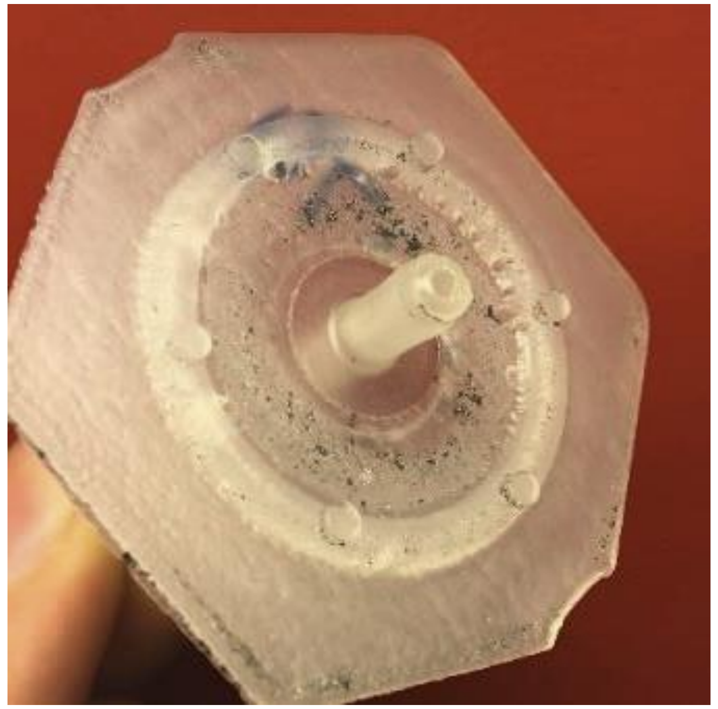
Mould surface temperatures, left: infrared image, right: simulation

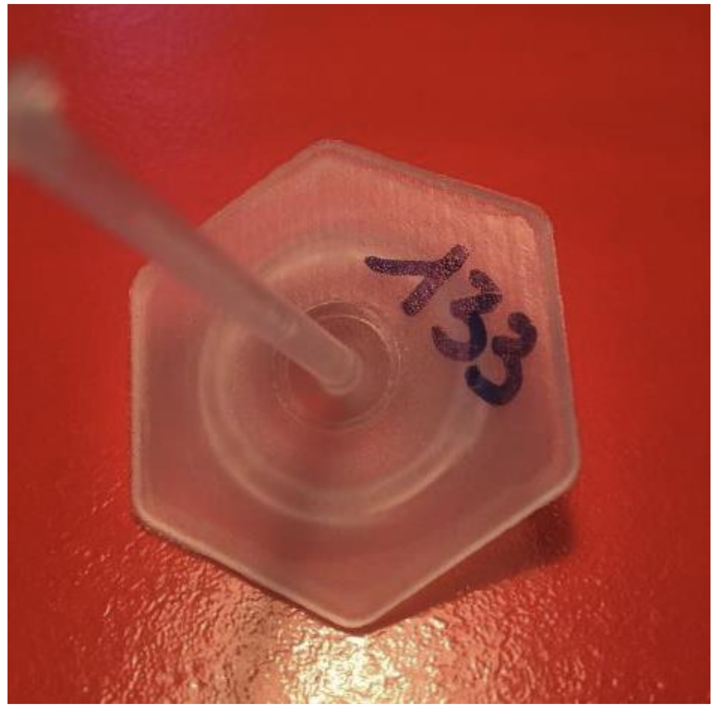




EXPERIMENTAL RESULTS







THEORETICAL & EXPERIMENTAL RESULTS

	Simulated/theoretical	Experimental
Cooling time [s]	25	25
Mould open time [s]	90	90
Injection time [s]	0.5 < t < 2.0	t < 0.5
Clamping force [ton]	1.55 < F < 4.31	2.00
Injection pressure [bar]	110 < p1 < 155	165
Holding pressure [bar]	p2 < 155	30
Holding time [s]	3.0	5.0
Cavity		
Temp after ejection [°C]	70 < T < 80	70 < T < 75
Temperature EOC [°C]	27 < T < 30	32 < T < 35
Core		
Temp after ejection [°C]	75 < T < 85	65 < T < 75
Temperature EOC [°C]	27 < T < 31	32 < T < 35
Moulded part		
Temp after ejection [°C]	**75 < T < 85**	**90 < T < 100**

Due to surface coating?

Overestimation convection?

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CONCLUSIONS & FUTURE WORK

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CONCLUSIONS & FUTURE WORK

HP MFJT PA12 inserts are suitable for injection moulding applications, production of > 130 parts

Integration of so-called “forced surface cooling” to reduce cycle time

Optimise surface coating to lower part adhesion and reduce surface roughness

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ZiggZagg (production mould inserts)

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