

**MAGMA**

# International MAGMA User Meeting 2024

October 9-11, 2024

RADISSON BLU – Frankfurt

BE  
PART  
OF  
IT

The logo for MAGMA, featuring the word "MAGMA" in a bold, sans-serif font. The letter "G" is stylized with a red circular element around it.

# MAGMA ECONOMICS

## Workshop Core Making Processes

L'uboš Pavlák

Frankfurt, October 10<sup>th</sup> 2024

### International MAGMA User Meeting 2024

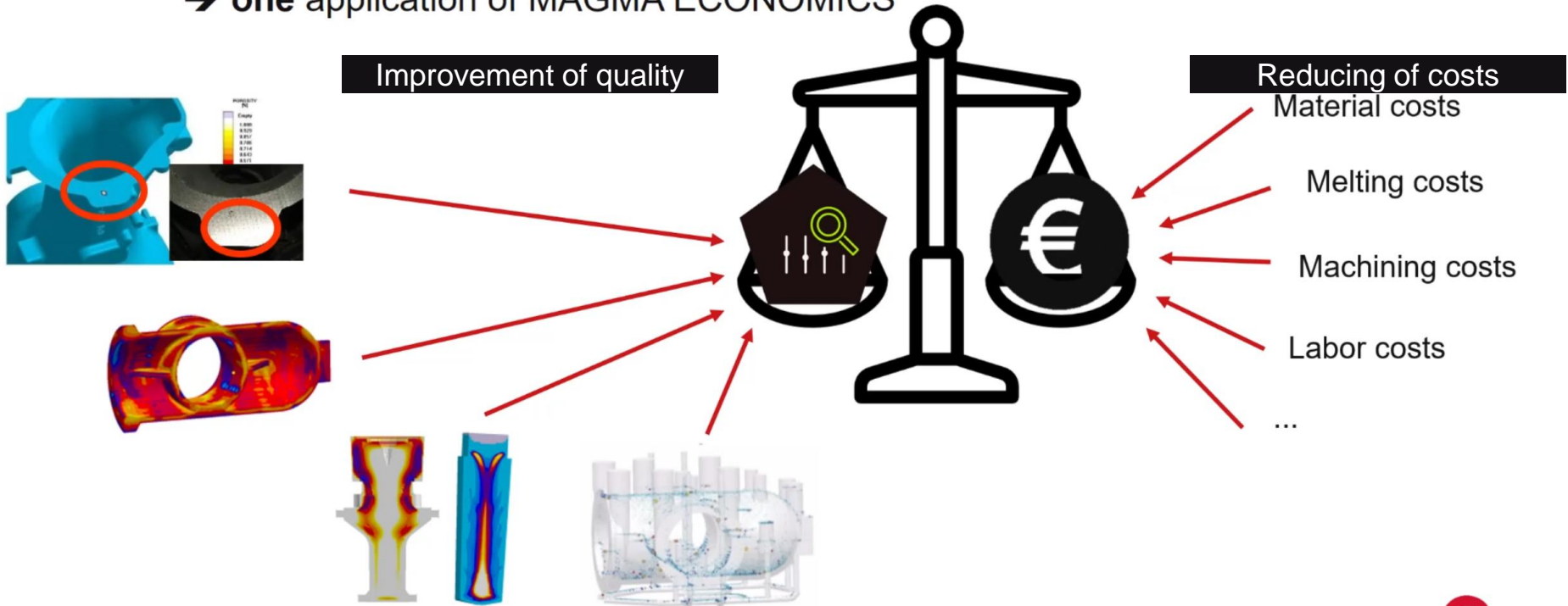
October 9-11, Frankfurt



# MAGMA ECONOMICS

## Simultaneous Evaluation of Quality and Costs

- Adding and assessing quantified costs and weighting them against quality  
→ **one** application of MAGMA ECONOMICS



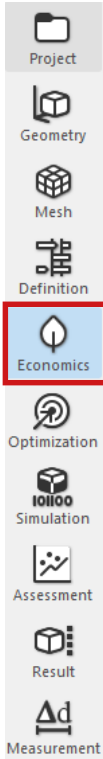
# MAGMA ECONOMICS

## What is it ?

- a new, additional **perspective** in MAGMASOFT®
- **easy to use & free** of charge
- **production costs** and/or **CO<sub>2</sub>** emissions estimation for castings

**MAGMA ECONOMICS** provides further criteria – in addition to quality – for evaluating the best solution: **Costs and CO<sub>2</sub>**.

- **Predefined** basic Cost/CO<sub>2</sub> sheets
- We are talking about costs, **NOT** price!
- It is **NOT** a comprehensive **cost-/CO<sub>2</sub>-calculation program!**
- **Not replace** your own cost calculation software



# MAGMA ECONOMICS

## How does it work ?

- With support from the **cost sheets** ...
- ...and the **already available information** in MAGMASOFT® simulation projects  
(weights, volumes, process times...)
- ...and **without any further input**
- ...estimations of **costs** and/or **CO<sub>2</sub> emissions** are automatically calculated  
(predefined cost sheets use data available in databases like Probas...)
- Including **DoEs**  
(all defined costs are available as variable or objectives in optimization perspective)

# MAGMA ECONOMICS

## What is the benefit ?

- More **robust**, better and more **sustainable evaluations & decisions...**
  - with **additional decision criteria**,
  - by adding **more/different people** in the decision making process and
  - by gains of **knowledge & visualization** the relation btw. **costs/CO<sub>2</sub>** and **quality**.
- Furthermore **time can be saved** in the development process by
  - **early considerations** of **costs** and **CO<sub>2</sub>** emissions in the simulation phase and by
  - **avoiding** unnecessary simulations (scenarios).

Feeling?!

VERSUS

Quantitative Values!

# Introduction of a new Perspective

## The first page

The screenshot shows the MAGMA software interface. On the left, a sidebar contains icons for different perspectives: Project, Geometry, Mesh, Definition, **Economics** (highlighted), Optimization, Simulation, Assessment, Result, and Measurement. The main workspace is titled 'Sheet' and displays a message in a red-bordered box: 'No sheet defined. Load sheet from database...'. A red arrow points from a black text box below to this message. The black box contains the text: 'Start screen: Loading a basic sheet with default values or a customized one'. On the right, there are two sections: 'Drop focus value here' and 'Drop limit value here', each with a download icon. The top right of the interface has various tool icons and a 'Scenario' dropdown menu.

Start screen: Loading a basic sheet with default values or a customized one

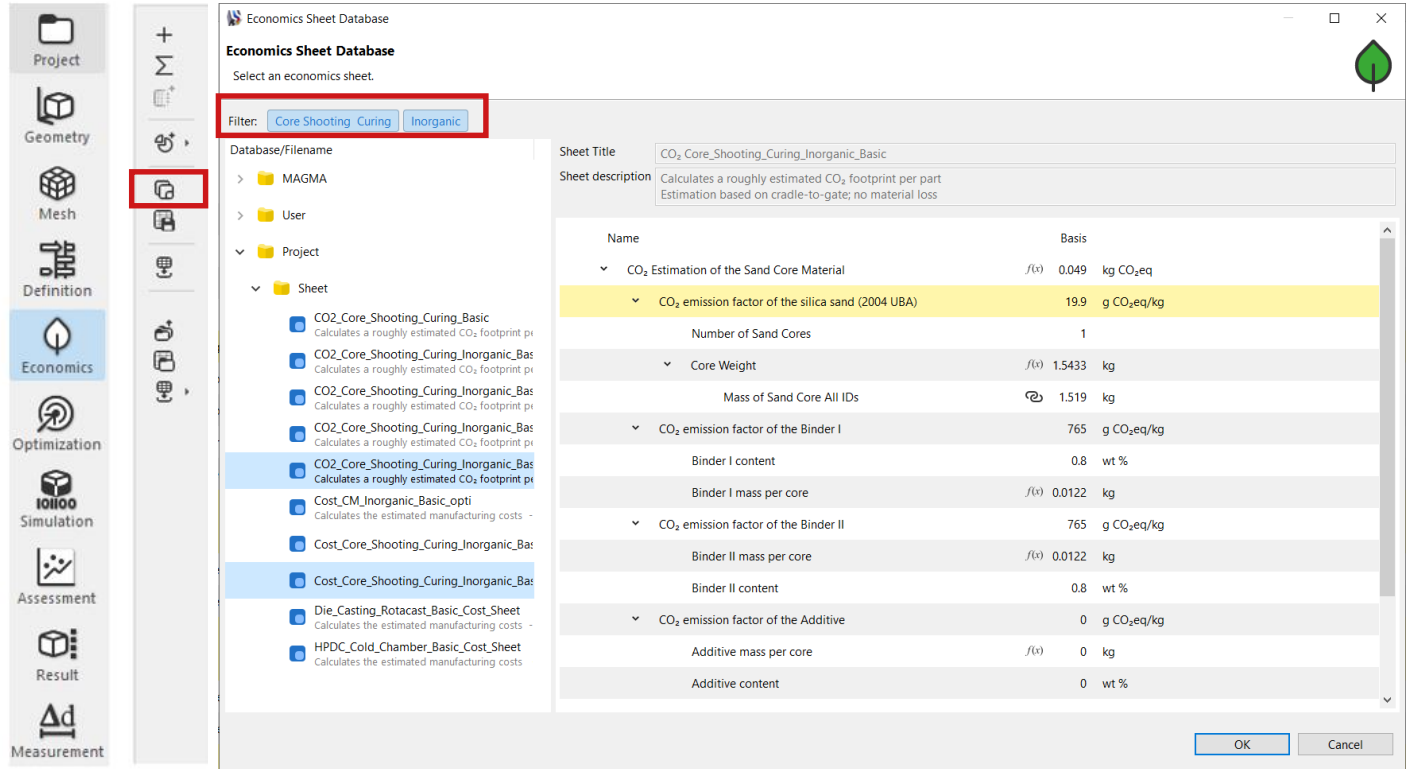
- a new perspective btw. “definition” and “optimization”
- can be used before or after any perspective as long as a project is opened



# Introduction of a new Perspective

Open the Economics Database and select a default (Basic) or self-defined sheet

Economics sheet database with filter function for Process mode and Material type: Preview and selection of the desired template

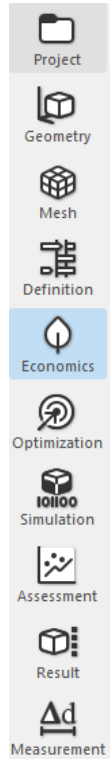


The screenshot shows the 'Economics Sheet Database' window. On the left, a vertical toolbar contains icons for Project, Geometry, Mesh, Definition, Economics (highlighted), Optimization, Simulation, Assessment, Result, and Measurement. The 'Economics' icon is highlighted with a red box. The main window has a 'Filter' section with two buttons: 'Core Shooting Curing' and 'Inorganic', both highlighted with a red box. Below the filter, a tree view shows the database structure: MAGMA > User > Project > Sheet. Under 'Sheet', several templates are listed, including 'CO2\_Core\_Shooting\_Curing\_Basic', 'CO2\_Core\_Shooting\_Curing\_Inorganic\_Basic', 'Cost\_CM\_Inorganic\_Basic\_opti', 'Cost\_Core\_Shooting\_Curing\_Inorganic\_Basic', 'Die\_Casting\_Rotacast\_Basic\_Cost\_Sheet', and 'HPDC\_Cold\_Chamber\_Basic\_Cost\_Sheet'. The 'CO2\_Core\_Shooting\_Curing\_Inorganic\_Basic' template is selected. The right pane shows the 'Sheet Title' as 'CO2\_Core\_Shooting\_Curing\_Inorganic\_Basic' and the 'Sheet description' as 'Calculates a roughly estimated CO2 footprint per part Estimation based on cradle-to-gate; no material loss'. Below this, a table displays the 'Name' and 'Basis' for various components.

Name	Basis
CO <sub>2</sub> Estimation of the Sand Core Material	f(x) 0.049 kg CO <sub>2</sub> eq
CO <sub>2</sub> emission factor of the silica sand (2004 UBA)	19.9 g CO <sub>2</sub> eq/kg
Number of Sand Cores	1
Core Weight	f(x) 1.5433 kg
Mass of Sand Core All IDs	1.519 kg
CO <sub>2</sub> emission factor of the Binder I	765 g CO <sub>2</sub> eq/kg
Binder I content	0.8 wt %
Binder I mass per core	f(x) 0.0122 kg
CO <sub>2</sub> emission factor of the Binder II	765 g CO <sub>2</sub> eq/kg
Binder II mass per core	f(x) 0.0122 kg
Binder II content	0.8 wt %
CO <sub>2</sub> emission factor of the Additive	0 g CO <sub>2</sub> eq/kg
Additive mass per core	f(x) 0 kg
Additive content	0 wt %

# Cost sheet Inorganic process 1

## The first page



### Cost\_C+M\_Inorganic\_Basic

Calculates the estimated manufacturing costs  
->Yellow marked lines are input fields!

Name:  Value:  Unit:  ☒ ☐ ☐

Name		Cost_CM_Inorganic_Basic
▼ Sand core weight	$f(x)$	1.4976 kg
Mass of Sand Core All IDs	$f(x)$	1.519 kg
Mass of Sand Core ID 1	$f(x)$	1.4976 kg
▼ Sand mixture costs per core	$f(x)$	0.38 €/core
> Raw Sand costs per core	$f(x)$	0.19 €/core
▼ Additional material costs per core	$f(x)$	0.19 €/core
Binder I content		0.8 wt %
Binder I price		2.6 €/kg
Binder I mass per core	$f(x)$	0.012 kg
Binder I costs per core	$f(x)$	0.0312 €/core
Binder II content		0.7 wt %
Binder II price		3.04 €/kg
Binder II mass per core	$f(x)$	0.0105 kg
Binder II costs per core	$f(x)$	0.0319 €/core
Additive content		0.5 wt %
Additive price		3 €/kg
Additive mass per core	$f(x)$	0.0075 kg
Additive costs per core	$f(x)$	0.0225 €/core

Sand Core Properties

**Sand Core Properties**

Information about volumes, masses and contact areas of materials in

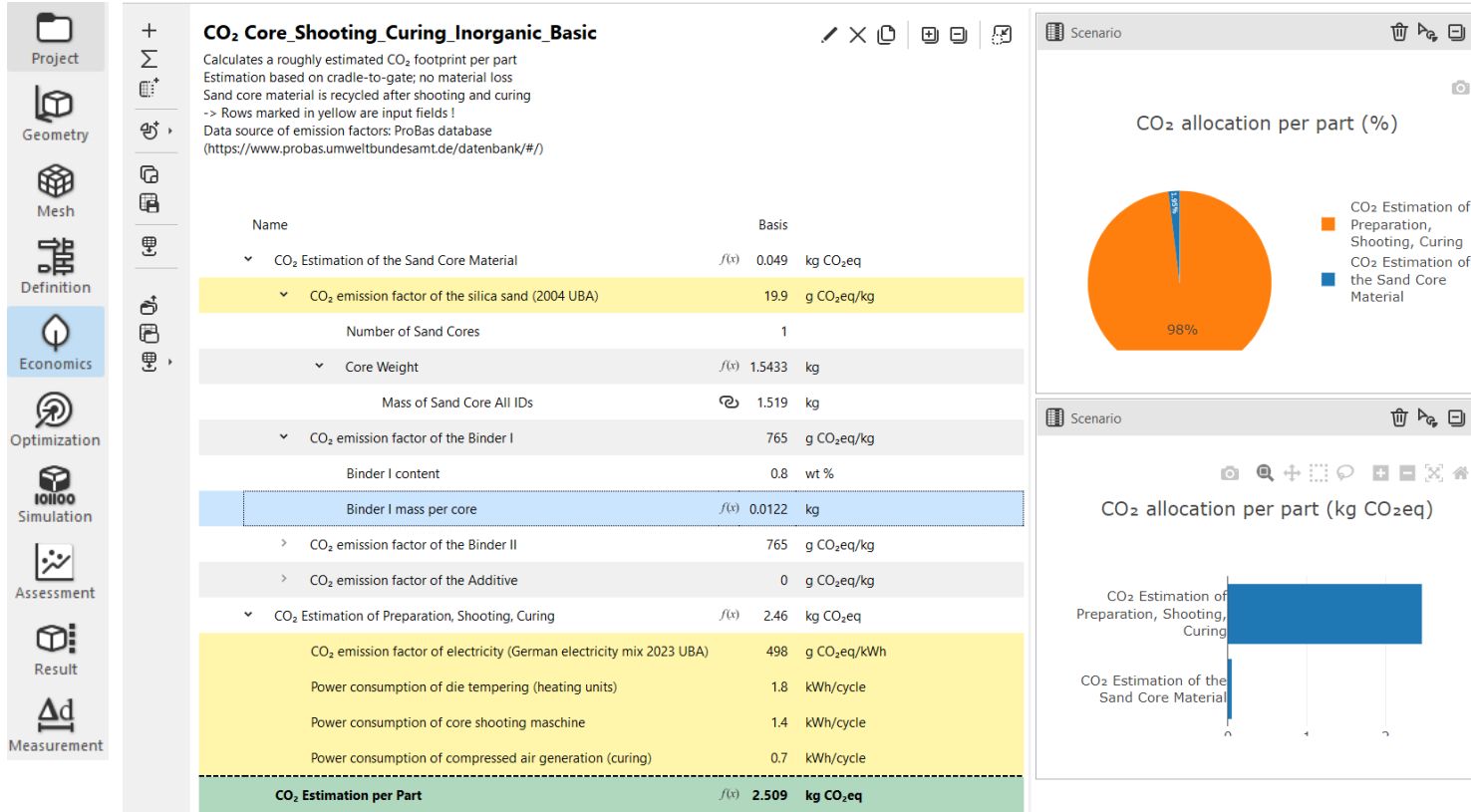
Material	Mat ID	Volume (cm <sup>3</sup> )	Mass (kg)
▼ Sand		1024.39	1.56
Sand Core	ID 1	985.28	1.50
Sand Core	ID 4	14.06	0.02

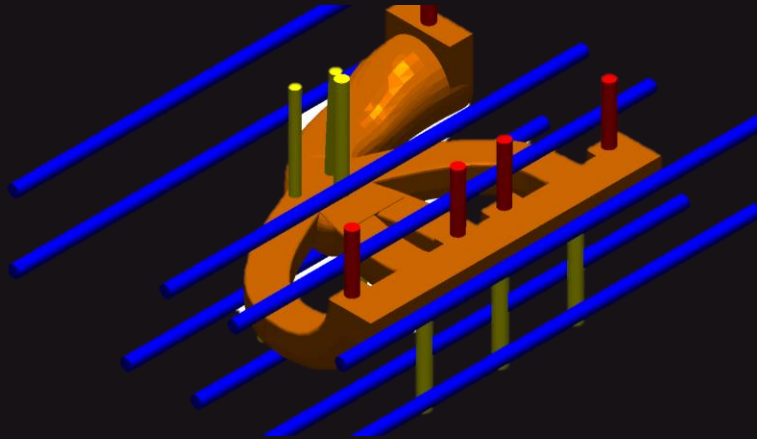
## The first page



# CO<sub>2</sub> sheet Inorganic process

## The first page



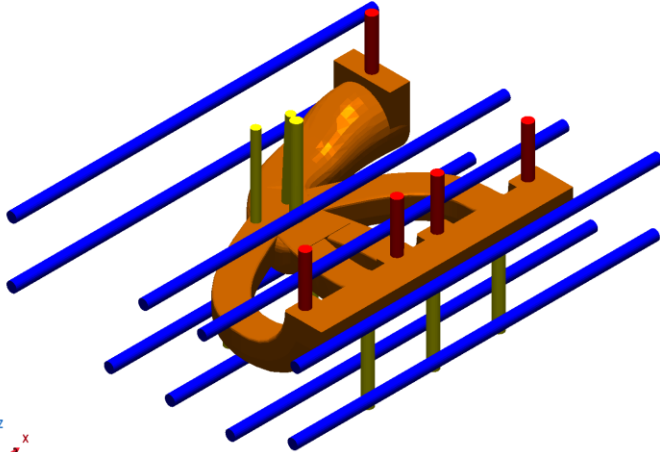


# Inorganic production

DOE Inorganic curing process

# Geometrical Variables

## Variation/Exchange of heating cartridge/Oil heating



opti\_singh/409  
Geometry

- Exchange/Comparison of heating cartridge vs. Oil heating
- **Oil heating:**
  - Starting temperature 300°C
  - HTC 1500
  - Running nonstop
- **Tempering cartridge:**
  - 9 Cartridges each with 1500W Power
  - HTC 1500
  - Start: TC below 150°C, Stop TC above 155°C

# Variables

## Air Pressure of Hot Air, Costs, Heating and production times

### Design Variables

Variation Parameter	Lower Limit (mbar)	Upper Limit (mbar)	Step (mbar)
<input checked="" type="checkbox"/> Y0	0.0	0.0	0.0
<input checked="" type="checkbox"/> Y1	1000.0	2000.0	1000.0
<input checked="" type="checkbox"/> Y2	1000.0	2000.0	1000.0
Design Variable			
<input type="checkbox"/> Geometry cyl_015 - active			
<input type="checkbox"/> Geometry cyl_016 - active			
Design Variable			
<input type="checkbox"/> Tempering Channel ID 1 - Initial Temperature	200.0	250.0	50.0
Design Variable			
<input checked="" type="checkbox"/> Hourly rate for core shooting machine operation	100.0	120.0	20.0
Design Variable			
<input checked="" type="checkbox"/> Tempering Channel Class - Material Data	MAGMA/Oil160 MAGMA/TempCart_NiCr8020		
Design Variable			
<input checked="" type="checkbox"/> Geometry tc_elektro - active			
<input checked="" type="checkbox"/> Geometry tc_oil - active			

Manufacturing costs per core		f(x)	2.05 €/core
Manufacturing costs per core 40s		f(x)	1.49 €/core
Manufacturing costs per core 50s		f(x)	1.77 €/core
Manufacturing costs per core 60s		f(x)	2.05 €/core



- Hot air Pressure:
  - 1000 mbar
  - 2000 mbar
- Hourly rate for core shooting machine operation:
  - Oil Heating: 100€/hour
  - Electrical Tempering cartridge: 120€/hour
- Curing time check:
  - 40s, 50s and 60s totally time to analyze costs

# Calculated DOE

## 4 Designs



### Start Sequence

Design ID	Gassing - Pressure Curve Variation, Y2 (mbar)	Hourly rate for core shooting machine operation (€/hour)	Tempering Channel Class - Material Data	Geometry tc_elektro - active
1	1000.0	120.0	MAGMA/TempCart_NiCr8020	1.0
2	2000.0	120.0	MAGMA/TempCart_NiCr8020	1.0
3	1000.0	100.0	MAGMA/Oil160	0.0
4	2000.0	100.0	MAGMA/Oil160	0.0



# Objectives

## Objectives

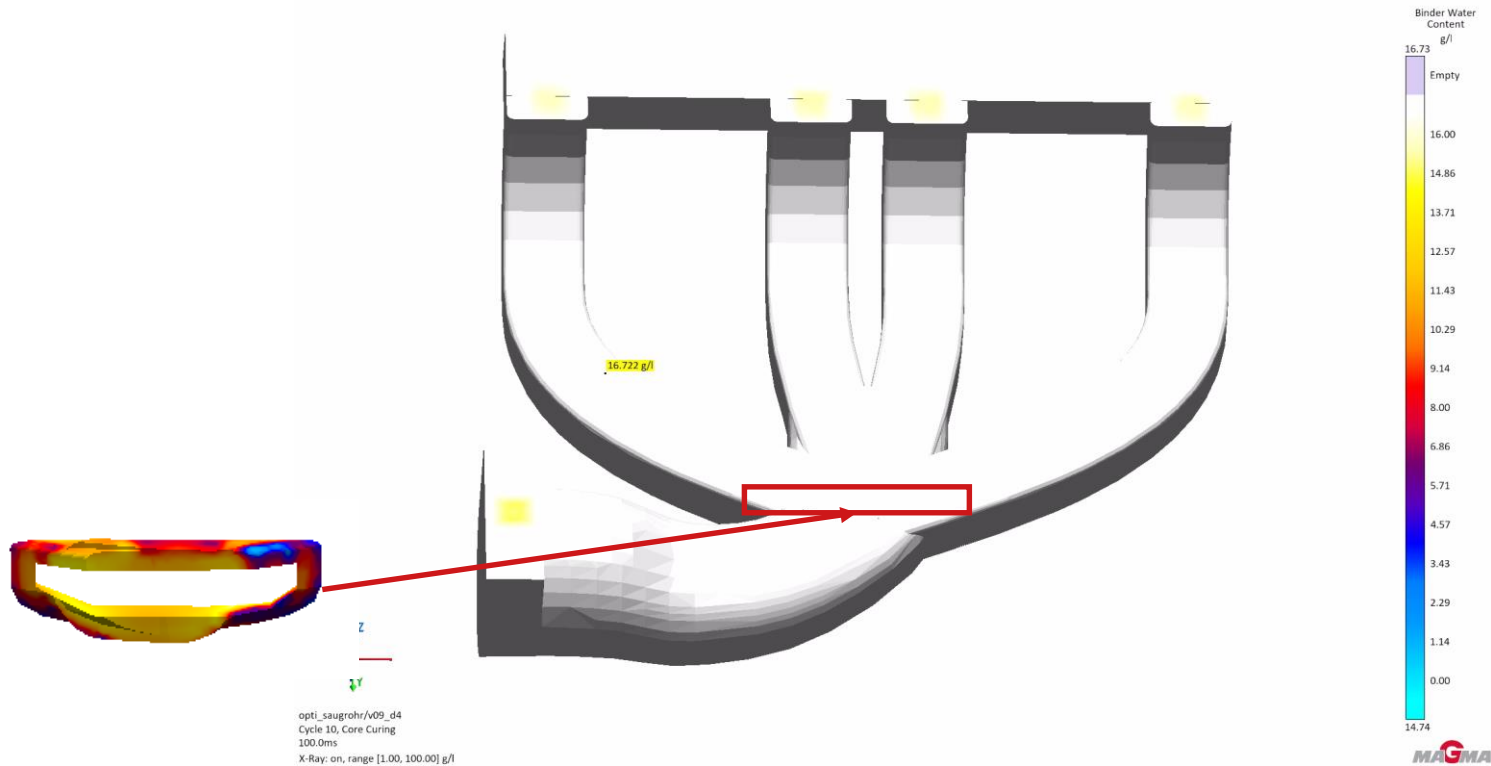
	Name	Type	Value	Expression
<input checked="" type="checkbox"/>	Core gas costs per core	Minimize	▼	{Core gas costs per core}
<input checked="" type="checkbox"/>	Water Vapor Mass Flow Curve - All Vents	Maximize	▼	{Cycle 10/Gassing/Water Vapor Mass Flow Curve - All Vents/Max/Max of Water Vapor Mass Flow Curve - All Vents}
<input checked="" type="checkbox"/>	Manufacturing costs per core	Minimize	▼	{Manufacturing costs per core}
<input checked="" type="checkbox"/>	Cycle time core shooting machine	Minimize	▼	{Cycle time core shooting machine}
<input checked="" type="checkbox"/>	Manufacturing costs per core 40s	Minimize	▼	{Manufacturing costs per core 40s}
<input checked="" type="checkbox"/>	Manufacturing costs per core 50s	Minimize	▼	{Manufacturing costs per core 50s}
<input checked="" type="checkbox"/>	Manufacturing costs per core 60s	Minimize	▼	{Manufacturing costs per core 60s}
<input checked="" type="checkbox"/>	Binder Water Content_40s	Minimize	▼	{Cycle 10/Gassing/Binder Water Content/Max 20.0 s/Max/Sand Core ID 4}
<input checked="" type="checkbox"/>	Binder Water Content_50s	Minimize	▼	{Cycle 10/Gassing/Binder Water Content/Max 30.0 s/Max/Sand Core ID 4}
<input checked="" type="checkbox"/>	Binder Water Content_60s	Minimize	▼	{Cycle 10/Gassing/Binder Water Content/Max 40.0 s/Max/Sand Core ID 4}
<input checked="" type="checkbox"/>	CO <sub>2</sub> Estimation of Preparation, Shooting, Curing	Minimize	▼	{CO <sub>2</sub> Estimation of Preparation, Shooting, Curing}

Low manufacturing costs

Good cured core in shortest time

# Binder Water Content

## Curing Quality Criteria



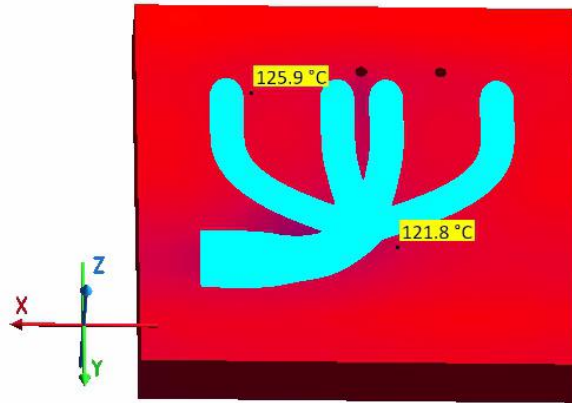
# Comparison Electric heating vs. Oil heating

## Mold/Core Temperature

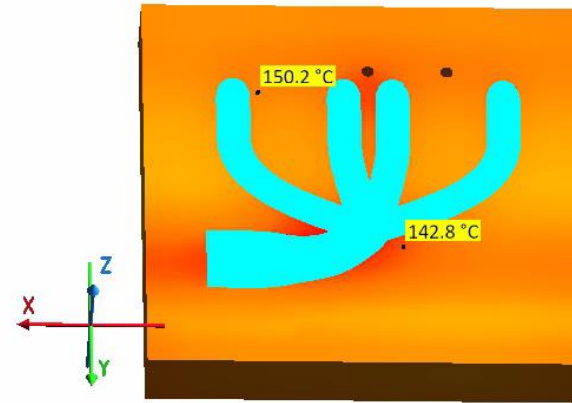
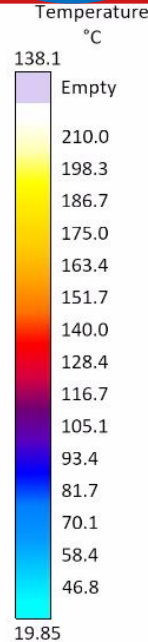
Name	Design 4	Design 3	Design 2	Design 1
Gassing - Pressure Curve Variation, V2	2,000 mbar	1,000 mbar	2,000 mbar	1,000 mbar
Hourly rate for core shooting machine operation	100 €/hour	100 €/hour	120 €/hour	120 €/hour
Manufacturing costs per core 60s	2.05 €/core	2.05 €/core	2.38 €/core	2.38 €/core
Cycle 10/Gassing/Binder Water Content/at 40.0 s/Max/Sand Core ID 4	33.3867 g/l	38.04 g/l	34.2747 g/l	36.2417 g/l

Design 4 – oil heating

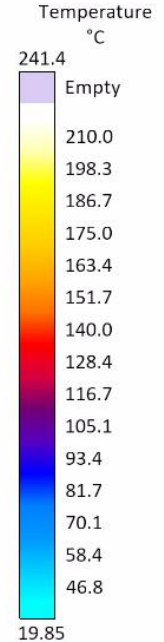
Design 2 – electric cartridge



opti\_saugrohr/v09\_d4  
Cycle 10, Core Curing  
100.0ms, 0.00 %  
10.10.2024



opti\_saugrohr/v09\_d2  
Cycle 10, Core Curing  
100.1ms, 0.00 %



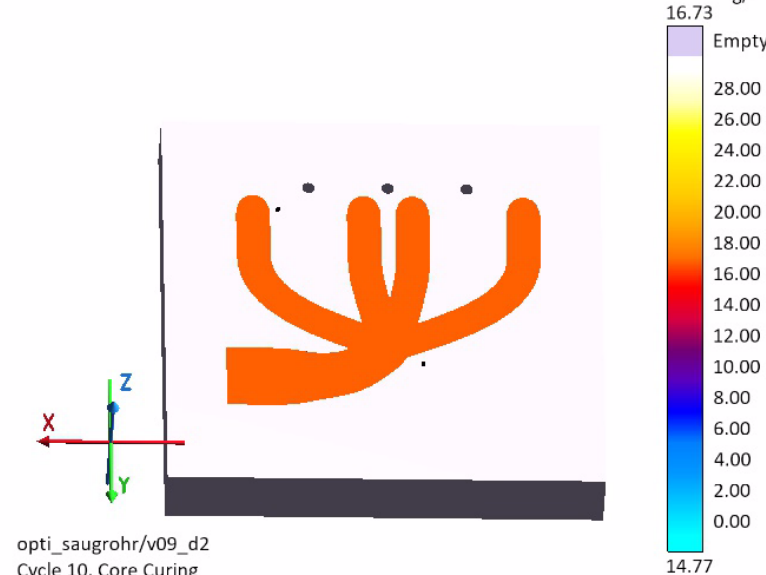
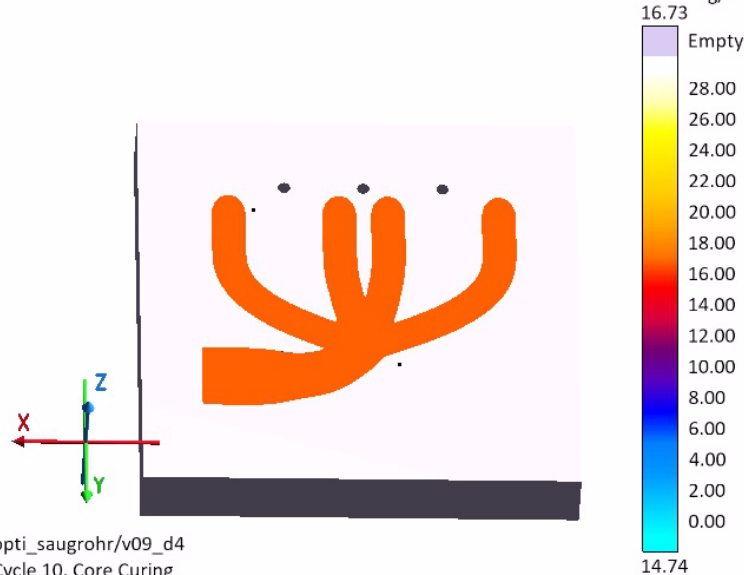
# Comparison Oil heating vs. Electric heating

## Binder water content

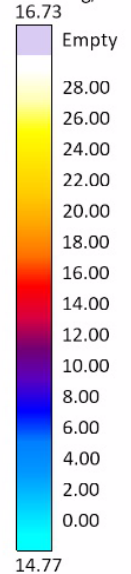
Name	Design 4	Design 3	Design 2	Design 1
Gasping - Pressure Curve Variation, Y2	2,000 mbar	1,000 mbar	2,000 mbar	1,000 mbar
Hourly rate for core shooting machine operation	100 €/hour	100 €/hour	120 €/hour	120 €/hour
Manufacturing costs per core 60s	2.05 €/core	2.05 €/core	2.38 €/core	2.38 €/core
Cycle 10/Gassing/Binder Water Content/at 40.0 s/Max/Sand Core ID 4	33.3867 g/l	38.04 g/l	34.2747 g/l	36.2417 g/l

Design 4 – oil heating

Design 2 – electric cartridge



Binder Water Content  
g/l



# Comparison Air Pressure 2 bar vs. 1 bar

## Oil heating

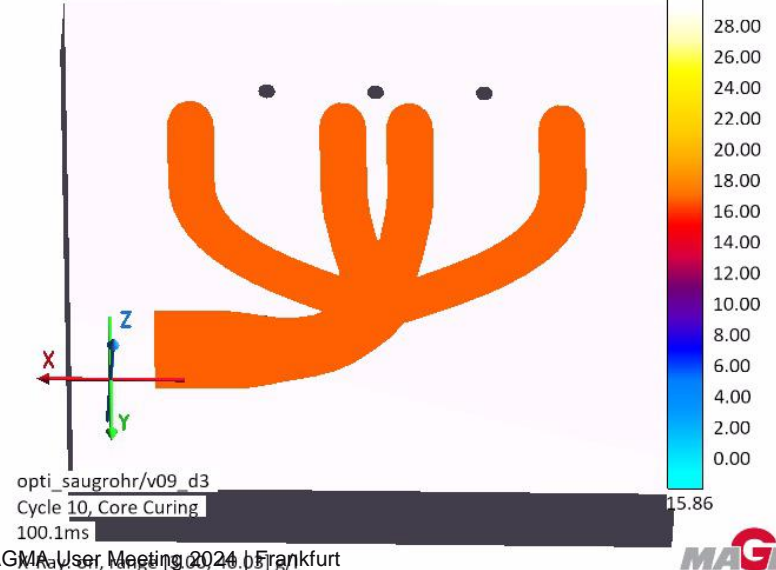
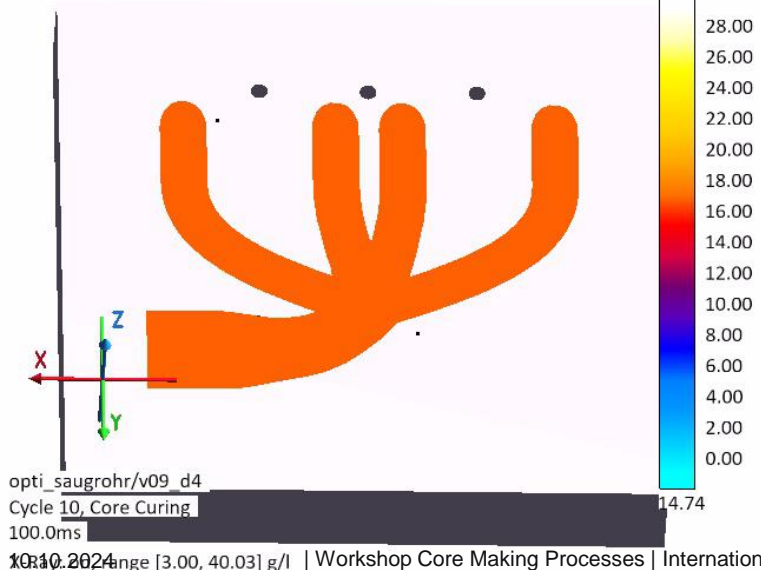
Name	Design 4	Design 3	Design 2	Design 1
Gassing - Pressure Curve Variation, Y2	2,000 mbar	1,000 mbar	2,000 mbar	1,000 mbar
Hourly rate for core shooting machine operation	100 €/hour	100 €/hour	120 €/hour	120 €/hour
Manufacturing costs per core 60s	2.05 €/core	2.05 €/core	2.38 €/core	2.38 €/core
Cycle 10/Gassing/Binder Water Content/at 40.0 s/Max/Sand Core ID 4	33.3867 g/l	38.04 g/l	34.2747 g/l	36.2417 g/l

Design 4 – oil heating - 2 bar

Binder Water Content  
g/l

Design 3 - oil heating – 1 bar

Binder Water Content  
g/l

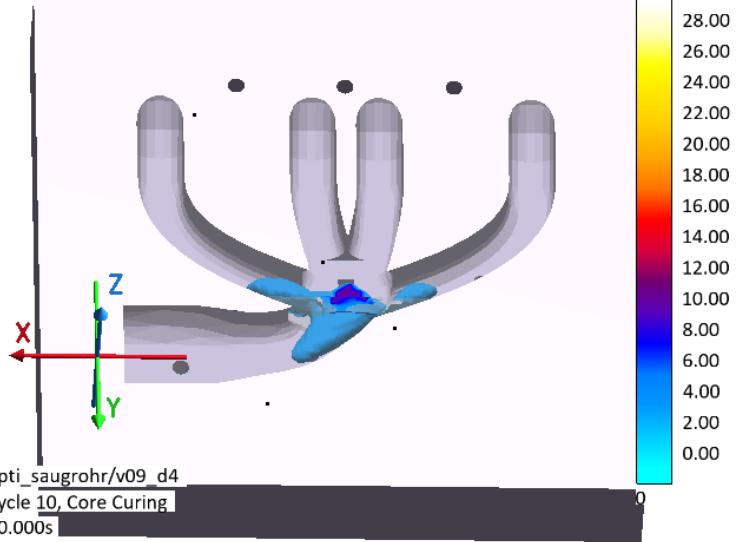


# Comparison Curing time 40s vs. 30s

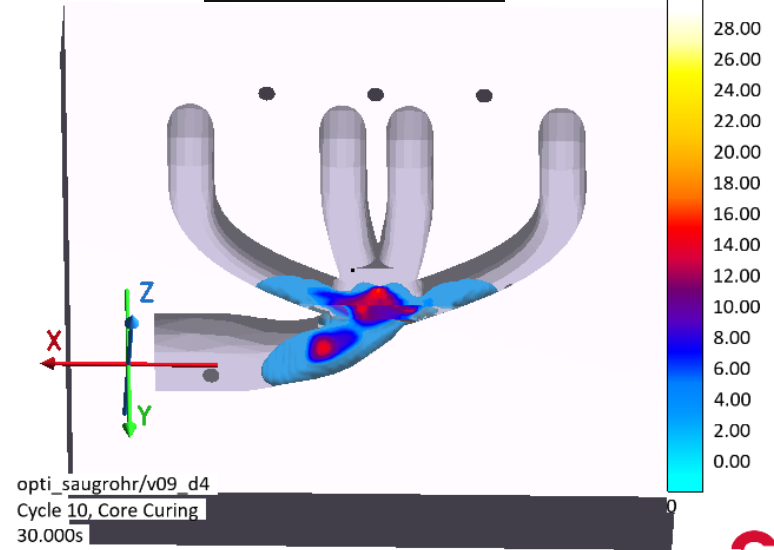
## Oil Heating

Name	Design 4	Design 3	Design 2	Design 1
Gassing - Pressure Curve Variation, Y2	2,000 mbar	1,000 mbar	2,000 mbar	1,000 mbar
Hourly rate for core shooting machine operation	100 €/hour	100 €/hour	120 €/hour	120 €/hour
Manufacturing costs per core 50s	1.77 €/core	1.77 €/core	2.05 €/core	2.05 €/core
Manufacturing costs per core 60s	2.05 €/core	2.05 €/core	2.38 €/core	2.38 €/core
Cycle 10/Gassing/Binder Water Content/at 30.0 s/Max/Sand Core ID 4	36.1872 g/l	40.8615 g/l	36.4314 g/l	39.3429 g/l
Cycle 10/Gassing/Binder Water Content/at 40.0 s/Max/Sand Core ID 4	33.3867 g/l	38.04 g/l	34.2747 g/l	36.2417 g/l

Design 4 - 40s



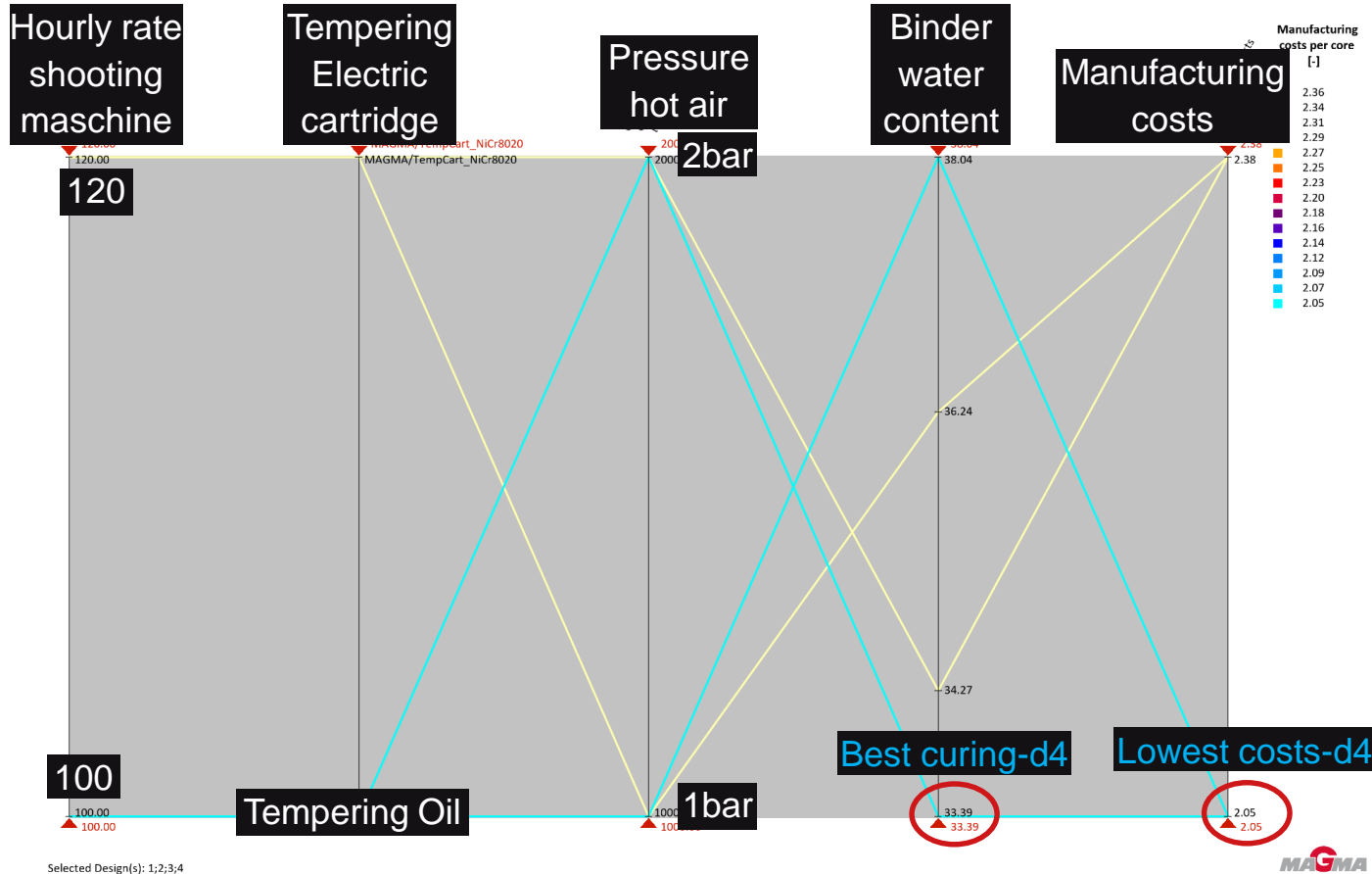
Design 4 - 30s



# Assessment – Comparison of Designs

		Best design			
Name		Design 4	Design 3	Design 2	Design 1
▼ Design Variables					
Geometry tc_oil - active		1	1	0	0
Geometry tc_elektro - active		0	0	1	1
Hourly rate for core shooting machine operation		100 €/hour	100 €/hour	120 €/hour	120 €/hour
Gassing - Pressure Curve Variation, Y2		2,000 mbar	1,000 mbar	2,000 mbar	1,000 mbar
Gassing - Pressure Curve Variation, Y1		2,000 mbar	1,000 mbar	2,000 mbar	1,000 mbar
Objectives					
Output Values					
Constraints					
▼ Economics					
Production cycle costs per core	f(x)	1.69 €/core	1.69 €/core	2.03 €/core	2.03 €/core
Production cycle costs per core 40s	f(x)	1.11 €/core	1.11 €/core	1.33 €/core	1.33 €/core
Production cycle costs per core 50s	f(x)	1.39 €/core	1.39 €/core	1.67 €/core	1.67 €/core
Production cycle costs per core 60s	f(x)	1.67 €/core	1.67 €/core	2 €/core	2 €/core
Hourly rate for core shooting machine operation		100 €/hour	100 €/hour	120 €/hour	120 €/hour
Manufacturing costs per core	f(x)	2.07 €/core	2.07 €/core	2.41 €/core	2.41 €/core
Manufacturing costs per core 40s	f(x)	1.49 €/core	1.49 €/core	1.71 €/core	1.71 €/core
Manufacturing costs per core 50s	f(x)	1.77 €/core	1.77 €/core	2.05 €/core	2.05 €/core
Manufacturing costs per core 60s	f(x)	2.05 €/core	2.05 €/core	2.38 €/core	2.38 €/core
Production Cycle/Core Curing		40.0001 s	40.0001 s	40.0001 s	40.0003 s
Cycle 10/Gassing/Binder Water Content/at 20.0 s/Max/Sand Core ID 4		38.5455 g/l	39.1223 g/l	42.5425 g/l	43.325 g/l
Cycle 10/Gassing/Binder Water Content/at 30.0 s/Max/Sand Core ID 4		36.1872 g/l	40.8015 g/l	36.4314 g/l	39.3429 g/l
Cycle 10/Gassing/Binder Water Content/at 40.0 s/Max/Sand Core ID 4		33.3867 g/l	38.04 g/l	34.2747 g/l	36.2417 g/l

# Assessment – Parallel coordinates





# Thank you for your attention.

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