
MAGMA


International MAGMA User Meeting 2024
October 9-11, 2024
RADISSON BLU – Frankfurt
BE PART OF IT
MAGMA

# MAGMA ECONOMICS

## Workshop Core Making Processes

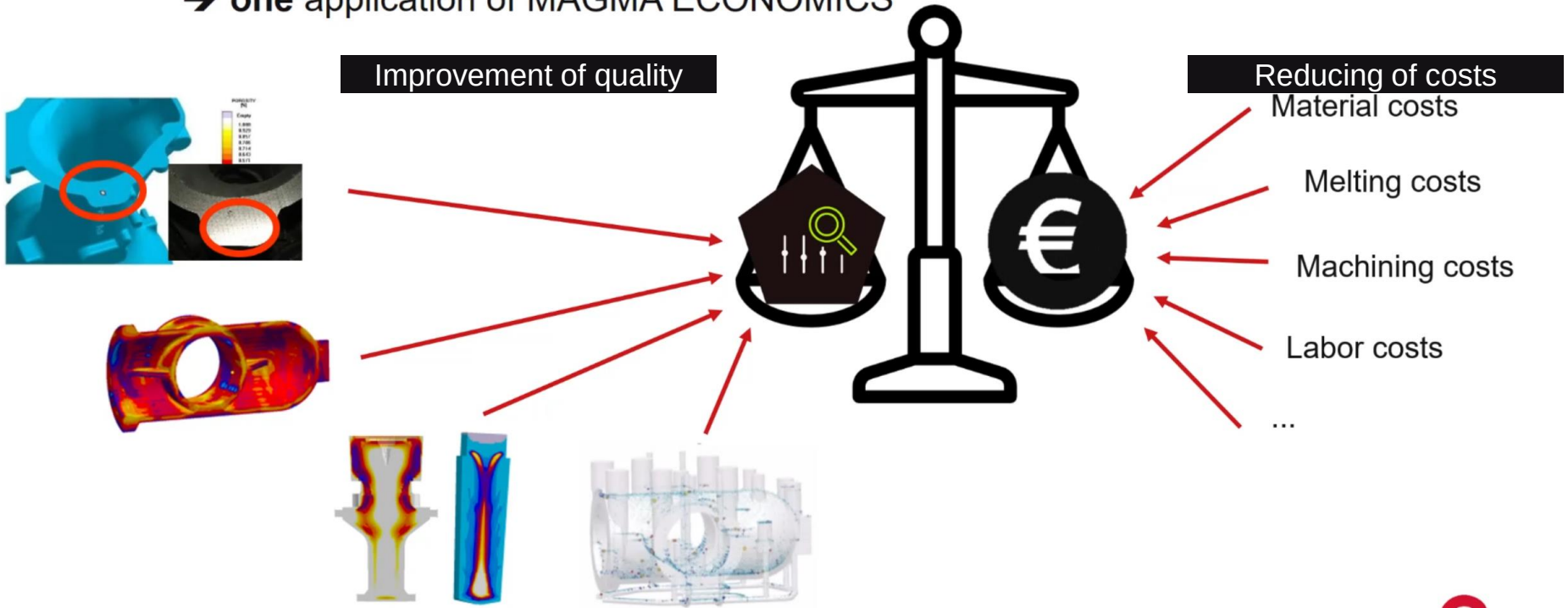

Ľuboš Pavľak

**Frankfurt, October 10th 2024**

# 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 **$CO_2$** emissions estimation for castings

**MAGMA ECONOMICS** provides further criteria – in addition to quality – for evaluating the best solution: **Costs and $CO_2$**.

- **Predefined** basic Cost/$CO_2$ sheets
- We are talking about costs, **NOT** price!
- It is **NOT** a comprehensive **cost-/$CO_2$-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 **$CO_2$ 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 ?

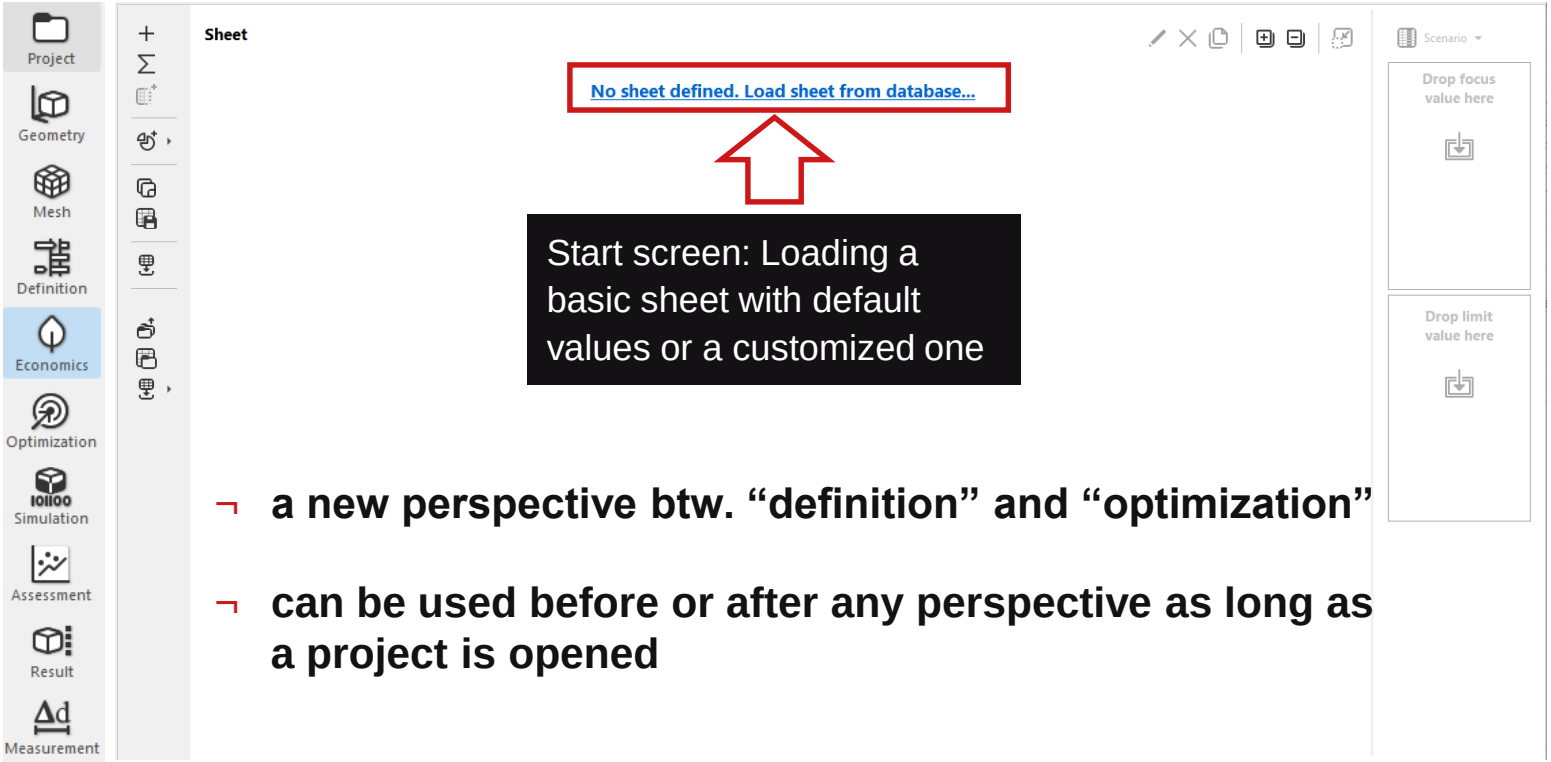
- More **robust**, better and more **sustainable evaluations** & **decisions**…
  - with **additional decision criteria**,
  - by adding **more/different people** in the decision making process and
  - by gains of **knowledge & visualization** the relation btw. **costs/$CO_2$** and **quality**.

- Furthermore **time can be saved** in the development process by
  - **early considerations** of **costs** and **$CO_2$** emissions in the simulation phase and by
  - **avoiding** unnecessary simulations (scenarios).

**Feeling?!** **VERSUS** **Quantitative Values!**

# Introduction of a new Perspective

## The first page

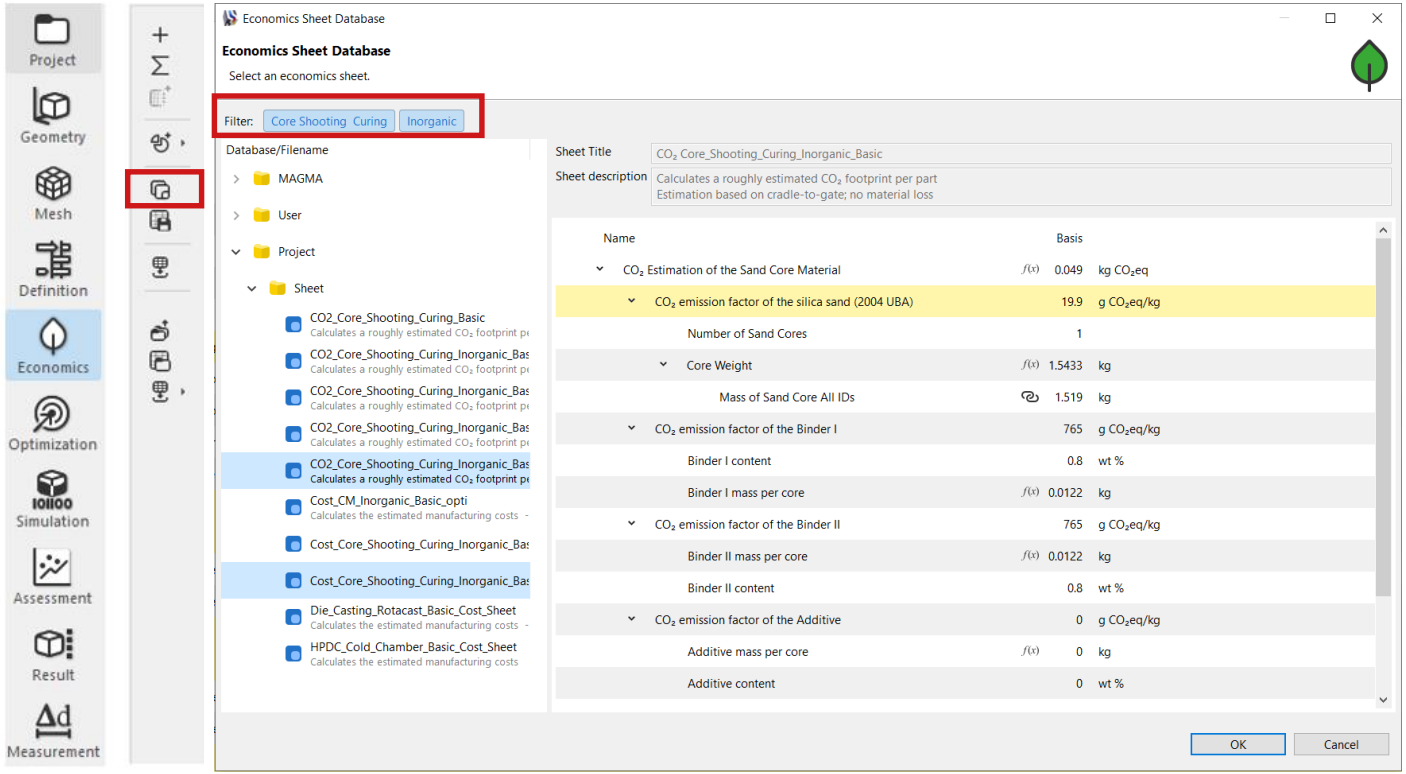



- a new perspective btw. “definition” and “optimization”
- can be used before or after any perspective as long as a project is opened

# Introduction of a new Perspective

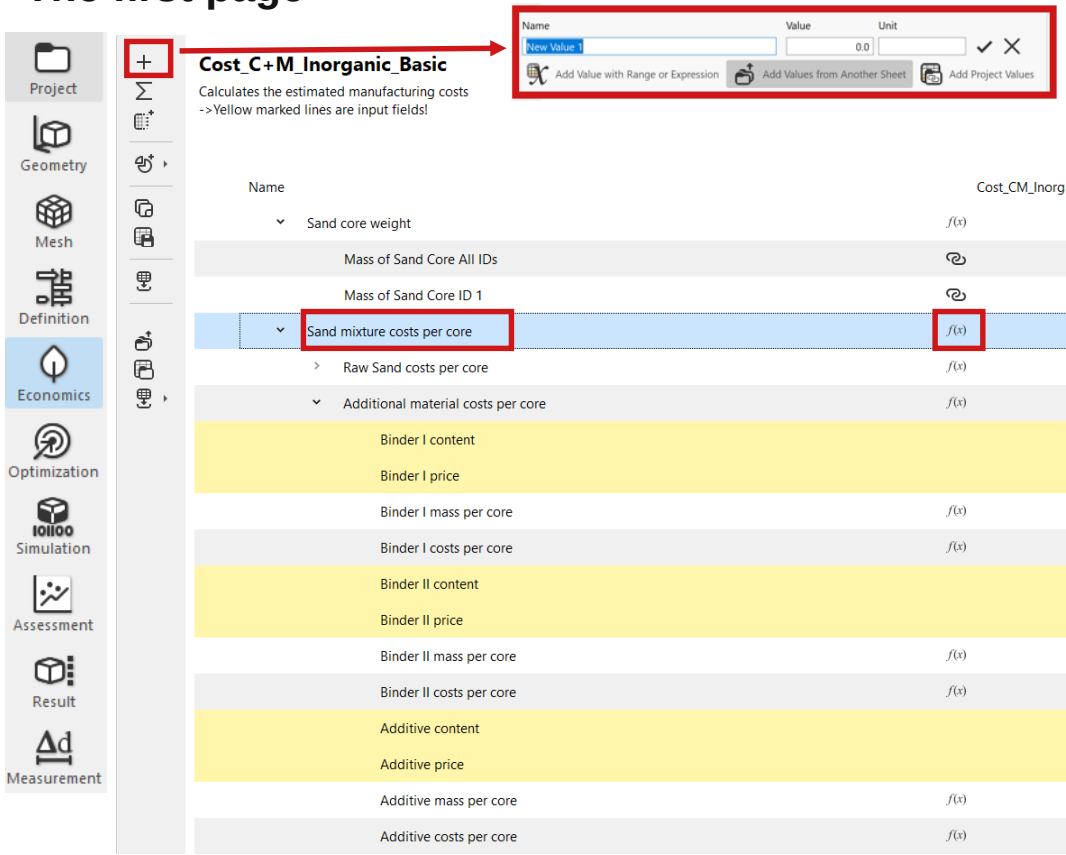
## Open the Economics Database and select a default (Basic) or self-defined sheet

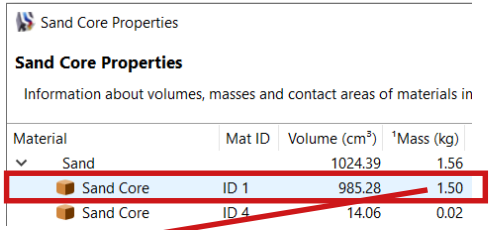
Economics sheet database with filter function for Process mode and Material type: Preview and selection of the desired template



# Cost sheet Inorganic process 1

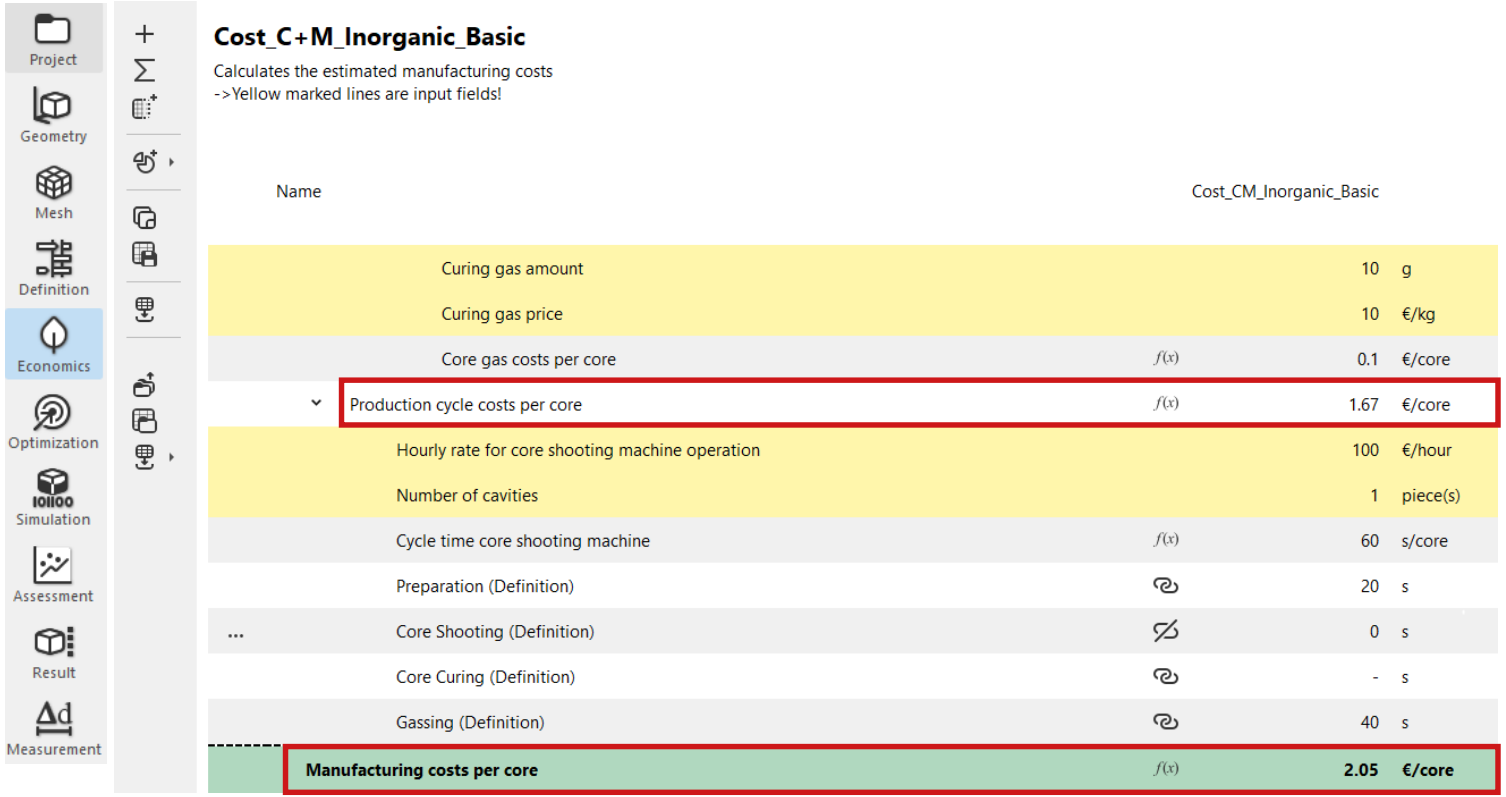
## The first page



# Cost sheet Inorganic process 2

## The first page



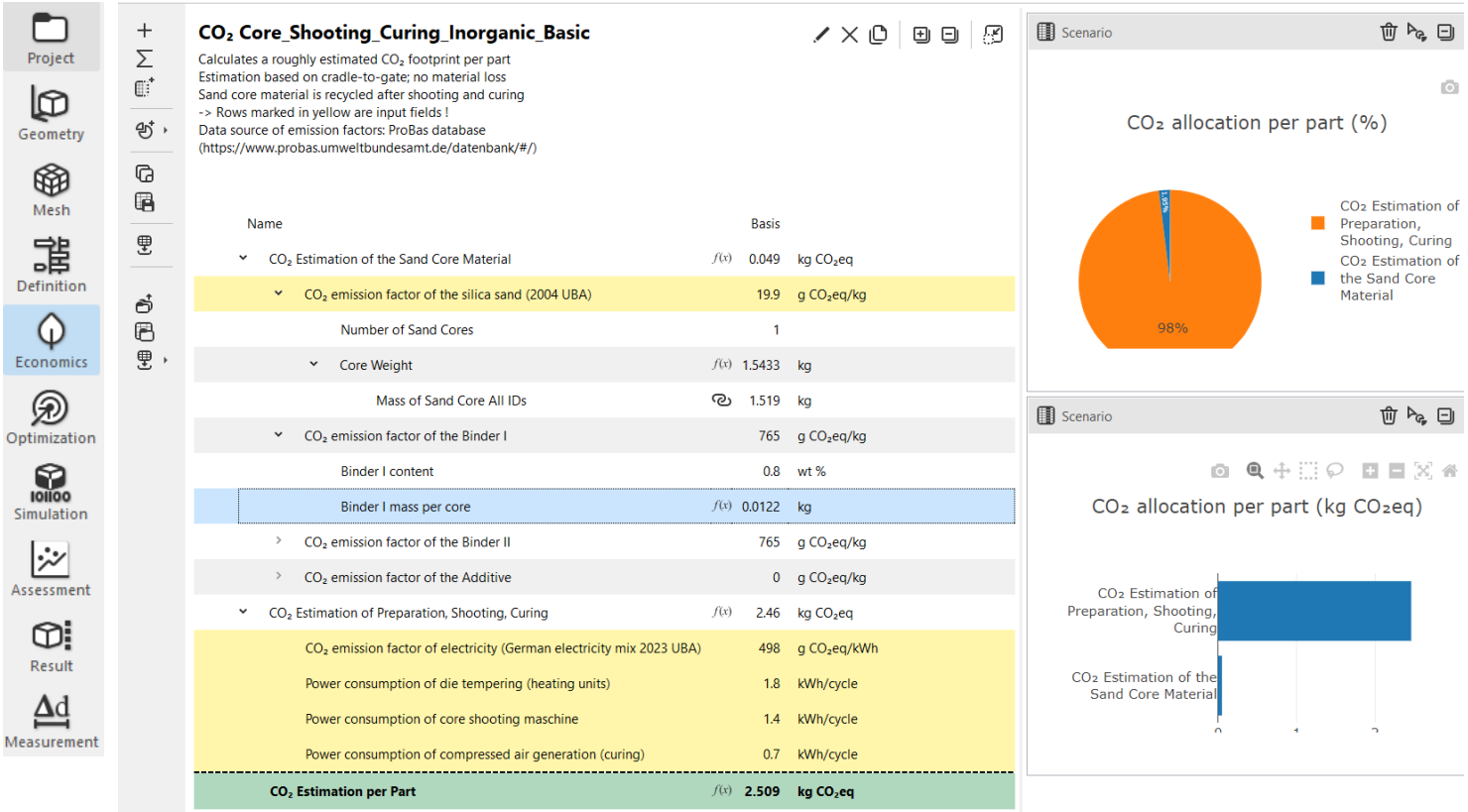

**Cost_C+M_Inorganic_Basic**

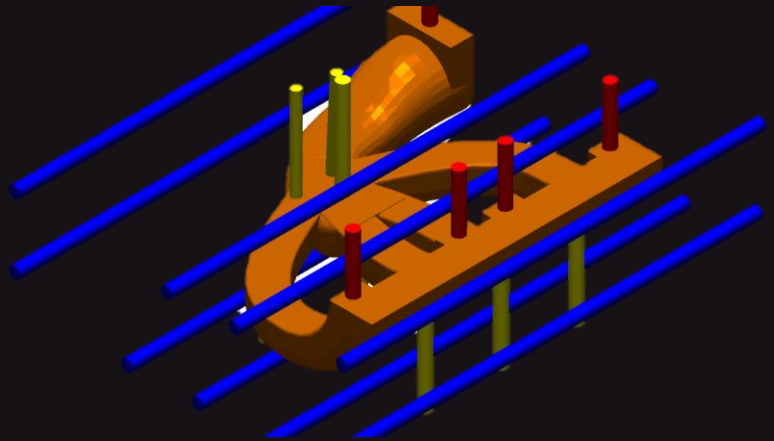
Calculates the estimated manufacturing costs
->Yellow marked lines are input fields!

| Name | | Cost_CM_Inorganic_Basic | |
|---|---|---|---|
| Curing gas amount | | 10 | g |
| Curing gas price | | 10 | €/kg |
| Core gas costs per core | $f(x)$ | 0.1 | €/core |
| Production cycle costs per core | $f(x)$ | 1.67 | €/core |
| Hourly rate for core shooting machine operation | | 100 | €/hour |
| Number of cavities | | 1 | piece(s) |
| Cycle time core shooting machine | $f(x)$ | 60 | s/core |
| Preparation (Definition) | | 20 | s |
| ... Core Shooting (Definition) | | 0 | s |
| Core Curing (Definition) | | - | s |
| Gassing (Definition) | | 40 | s |
| **Manufacturing costs per core** | $f(x)$ | **2.05** | **€/core** |

# $CO_2$ sheet Inorganic process

## The first page



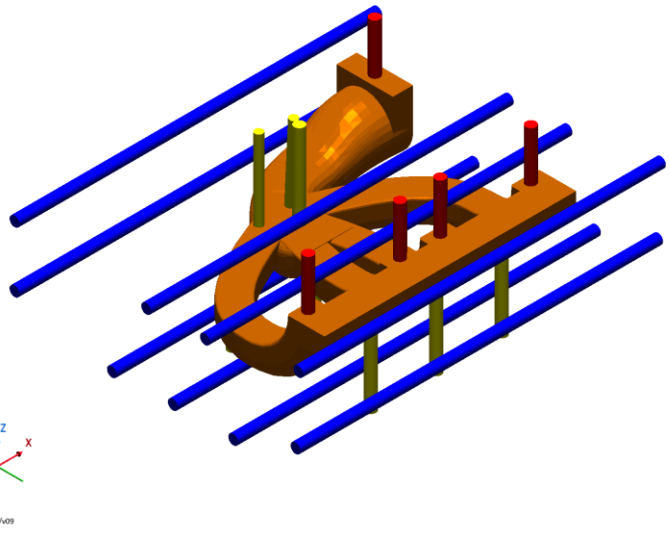


# Inorganic production

## DOE Inorganic curing process

# Geometrical Variables

## Variation/Exchange of heating cartridge/Oil heating




- 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) |
|---|---|---|---|---|
| ☑ | Y0 | 0.0 | 0.0 | 0.0 |
| ☑ | Y1 | 1000.0 | 2000.0 | 1000.0 |
| ☑ | Y2 | 1000.0 | 2000.0 | 1000.0 |
| | Design Variable | | | |
| ☐ | Geometry cyl_015 - active | | | |
| ☐ | Geometry cyl_016 - active | | | |
| | Design Variable | Lower Limit (°C) | Upper Limit (°C) | Step (°C) |
| ☐ | Tempering Channel ID 1 - Initial Temperature | 200.0 | 250.0 | 50.0 |
| | Design Variable | Lower Limit (€/hour) | Upper Limit (€/hour) | Step (€/hour) |
| ☑ | Hourly rate for core shooting machine operation | 100.0 | 120.0 | 20.0 |
| | Design Variable | Dataset List | | |
| ☑ | Tempering Channel Class - Material Data | MAGMA/Oil160<br>MAGMA/TempCart_NiCr8020 | | |
| | Design Variable | | | |
| ☑ | Geometry tc_elektro - active | | | |
| ☑ | 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 maschine 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

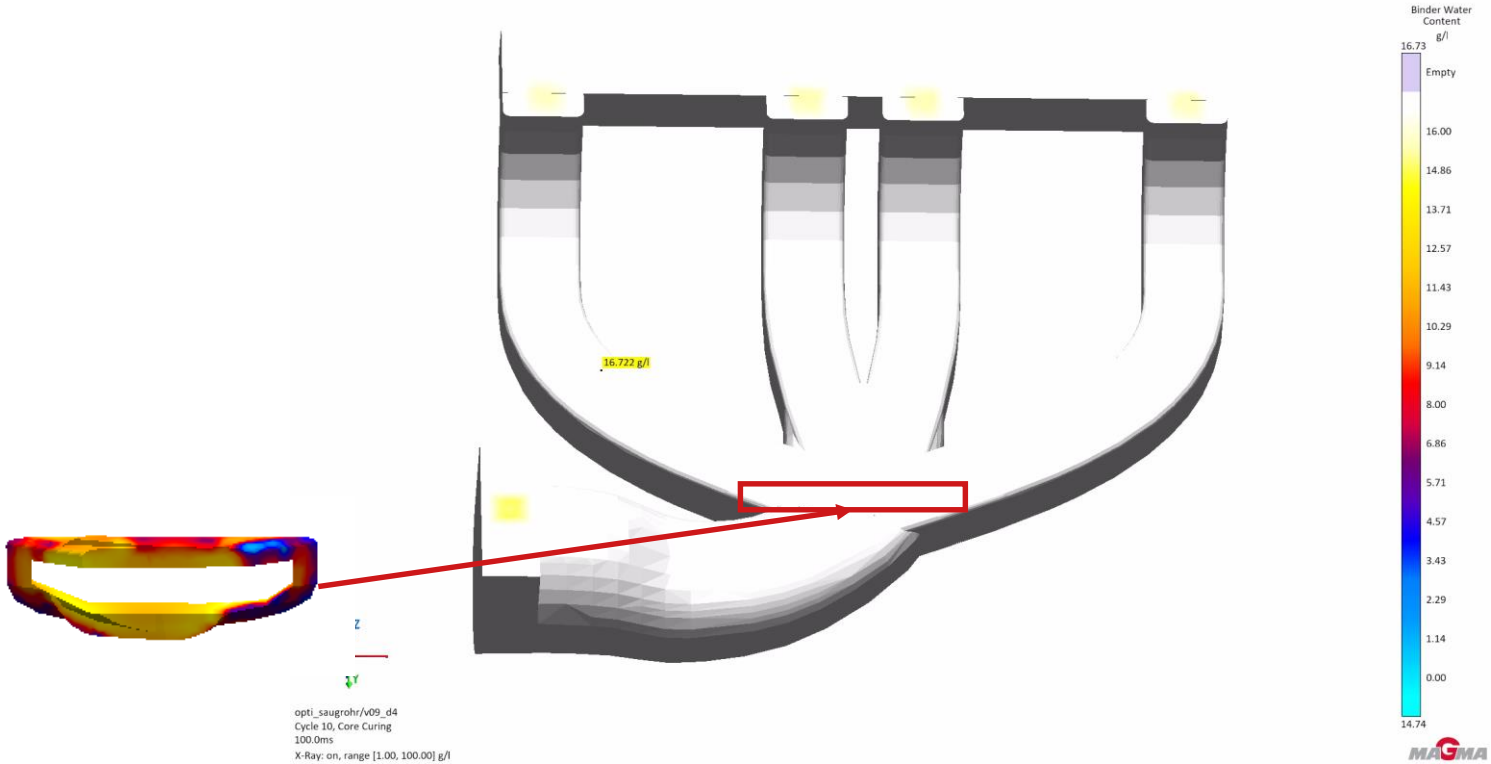
| | Name | Type | Value | Expression |
|---|---|---|---|---|
| ☑ | Core gas costs per core | Minimize | | {Core gas costs per core} |
| ☑ | Water Vapor Mass Flow Curve - All Vents | Maximize | | {Cycle 10/Gassing/Water Vapor Mass Flow Curve - All Vents/Max/Max of Water Vapor Mass Flow Curve - All Vents} |
| ☑ | Manufacturing costs per core | Minimize | | {Manufacturing costs per core} |
| ☑ | Cycle time core shooting machine | Minimize | | {Cycle time core shooting machine} |
| ☑ | Manufacturing costs per core 40s | Minimize | | {Manufacturing costs per core 40s} |
| ☑ | Manufacturing costs per core 50s | Minimize | | {Manufacturing costs per core 50s} |
| ☑ | Manufacturing costs per core 60s | Minimize | | {Manufacturing costs per core 60s} |
| ☑ | Binder Water Content_40s | Minimize | | {Cycle 10/Gassing/Binder Water Content/at 20.0 s/Max/Sand Core ID 4} |
| ☑ | Binder Water Content_50s | Minimize | | {Cycle 10/Gassing/Binder Water Content/at 30.0 s/Max/Sand Core ID 4} |
| ☑ | Binder Water Content_60s | Minimize | | {Cycle 10/Gassing/Binder Water Content/at 40.0 s/Max/Sand Core ID 4} |
| ☑ | $CO_2$ Estimation of Preparation, Shooting, Curing | Minimize | | {$CO_2$ Estimation of Preparation, Shooting, Curing} |

Low manufacturing costs

Good cured core in shortest time

# Binder Water Content

## Curing Quality Criteria

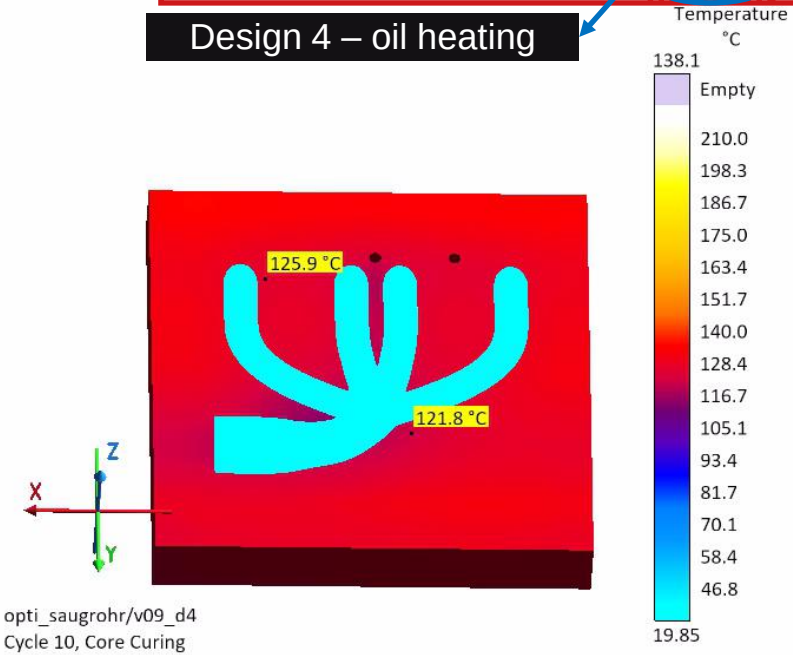


# Comparison Electric heating vs. Oil heating

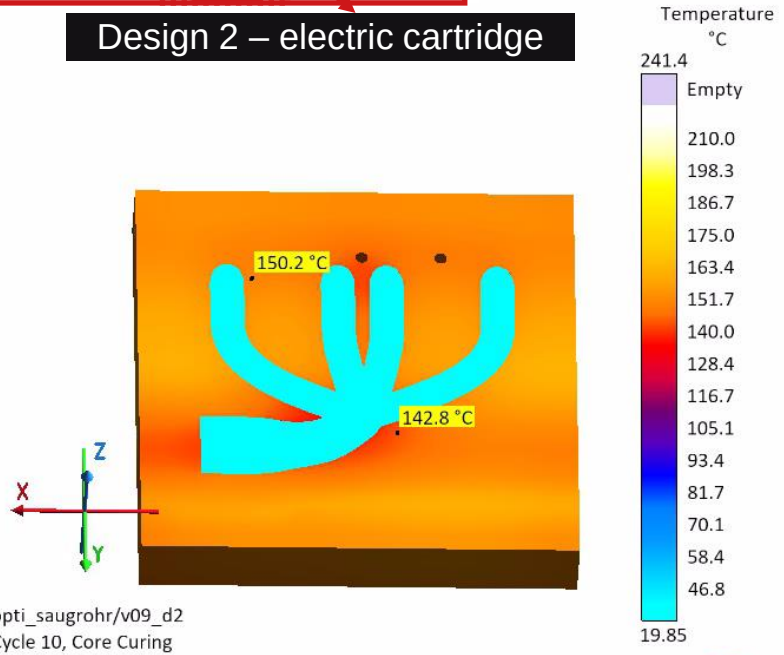
## Mold/Core Temperature

| Name | Design 4 | Design 3 | Design 2 | Design 1 |
|---|---|---|---|---|
| Gassing - Pressure Curve Variation, 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



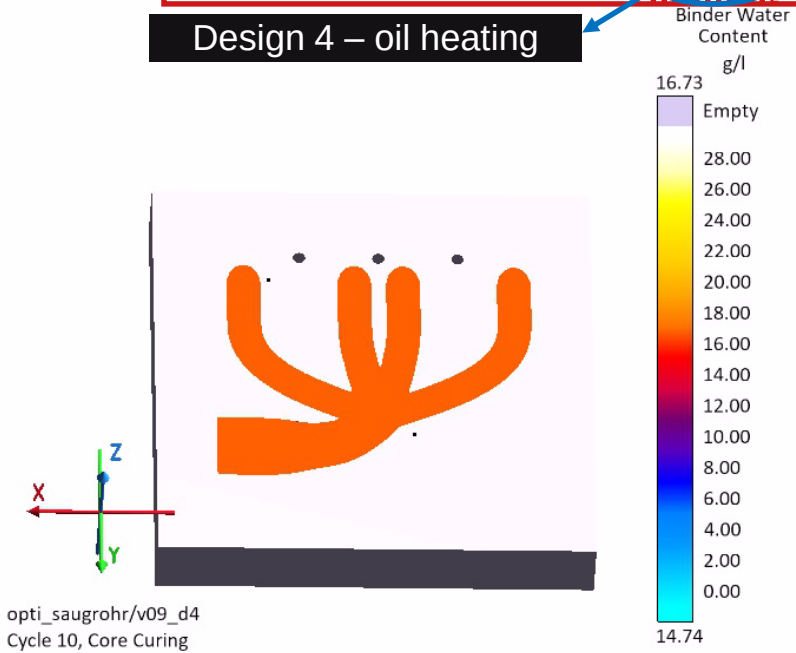
# Comparison Oil heating vs. Electric heating

## Binder water content

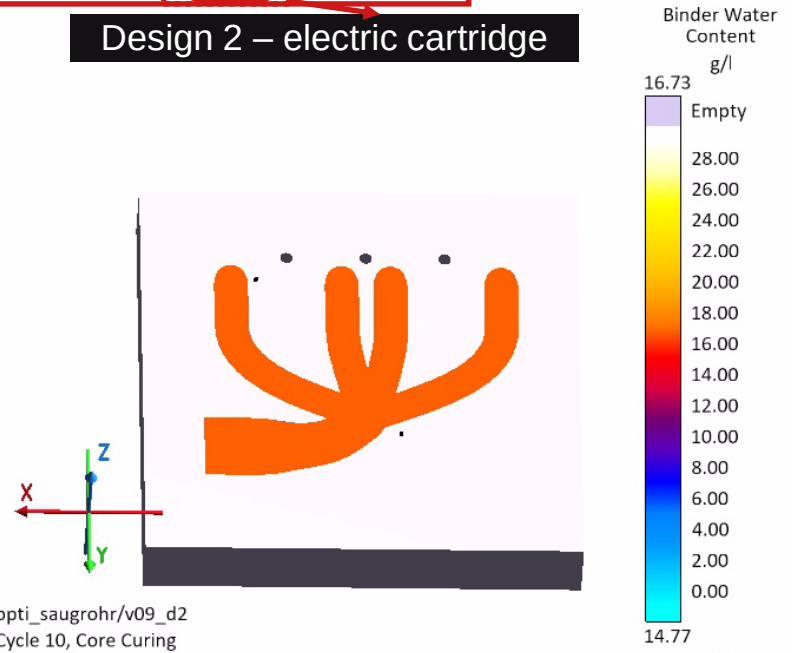
| Name | Design 4 | Design 3 | Design 2 | Design 1 |
|---|---|---|---|---|
| Gassing - Pressure Curve Variation, Y2 | 2,000 mbar | 1,000 mbar | 2,000 mbar | 1,000 mbar |
| Hourly rate for core shooting machine operation | 100 €/hour | 100 €/hour | 120 €/hour | 120 €/hour |
| Manufacturing costs per core 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

Design 2 – electric cartridge




opti_saugrohr/v09_d4
Cycle 10, Core Curing
100.0ms
X-Ray: on, range [3.00, 40.03] g/l



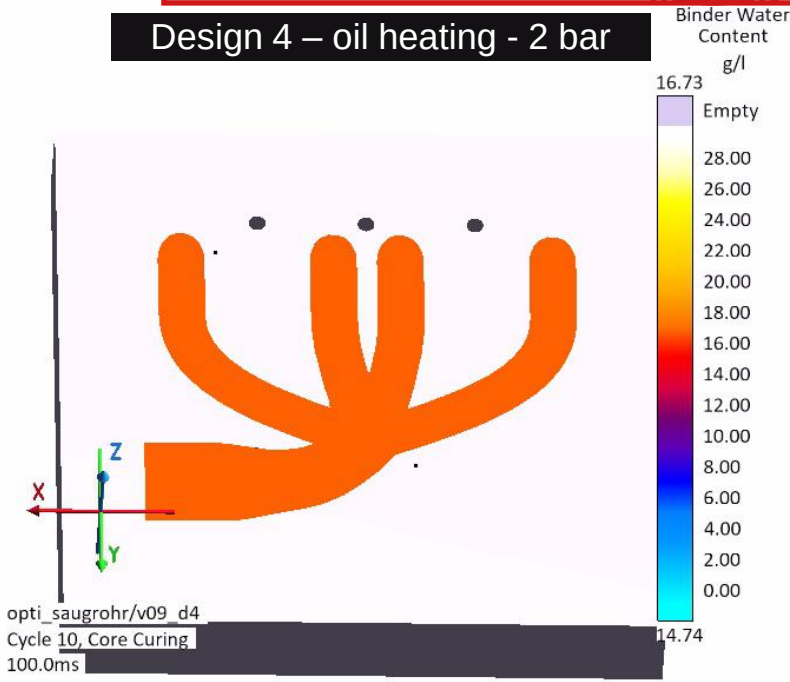

opti_saugrohr/v09_d2
Cycle 10, Core Curing
100.1ms
X-Ray: on, range [3.00, 40.03] g/l

# Comparison Air Pressure 2 bar vs. 1 bar

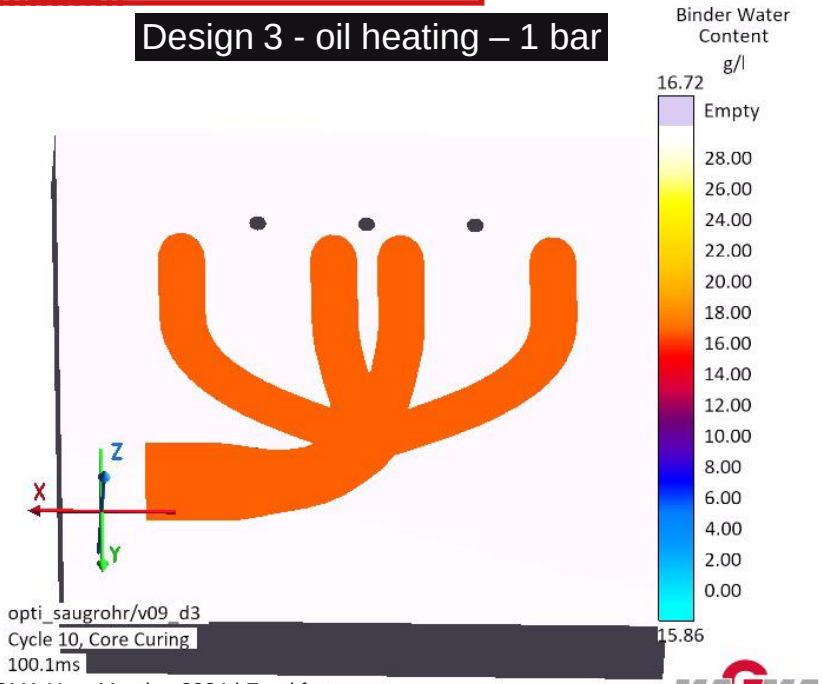
## Oil heating

| 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




Design 3 - oil heating – 1 bar

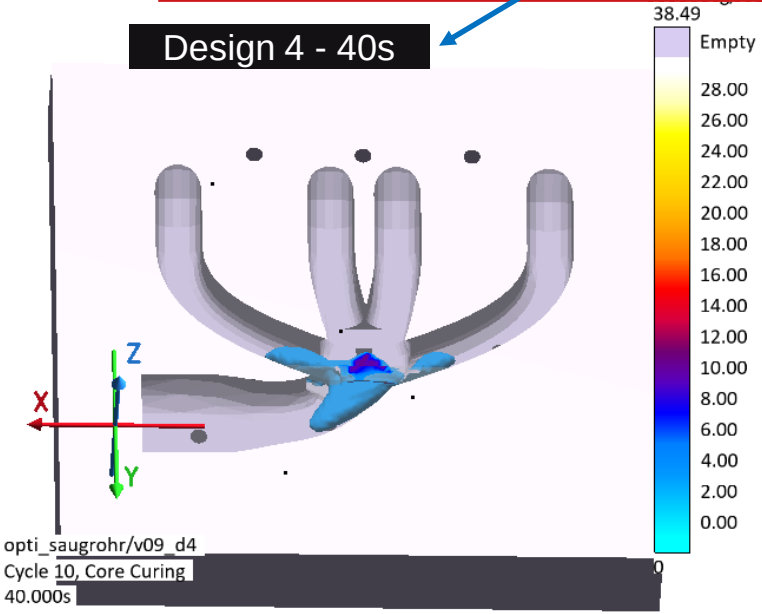


# Comparison Curing time 40s vs. 30s

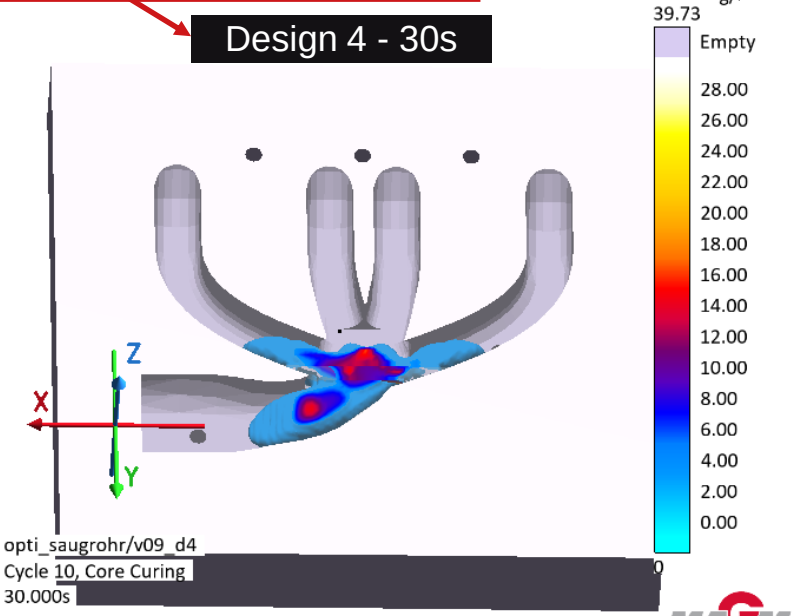
## Oil Heating

| 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 | 40.8015 | 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 |

Design 4 - 40s




Design 4 - 30s

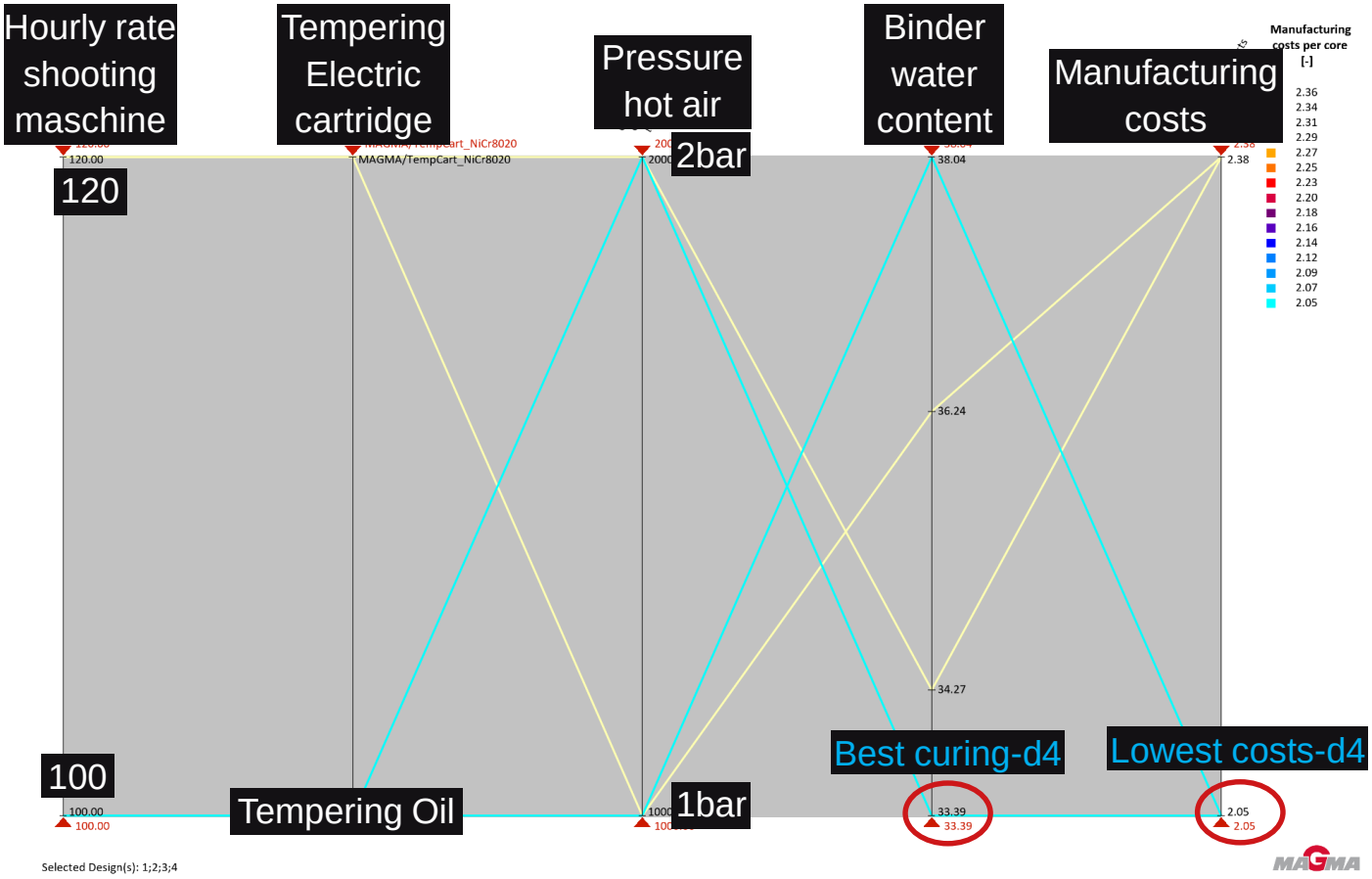


# Assessment – Comparison of Designs

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 | **1.69** | €/core | 1.69 | €/core | 2.03 | €/core | 2.03 | €/core |
| Production cycle costs per core 40s | **1.11** | €/core | 1.11 | €/core | 1.33 | €/core | 1.33 | €/core |
| Production cycle costs per core 50s | **1.39** | €/core | 1.39 | €/core | 1.67 | €/core | 1.67 | €/core |
| Production cycle costs per core 60s | **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 | **2.07** | €/core | 2.07 | €/core | 2.41 | €/core | 2.41 | €/core |
| Manufacturing costs per core 40s | **1.49** | €/core | 1.49 | €/core | 1.71 | €/core | 1.71 | €/core |
| 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 |
| 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.

Ľuboš Pavľak

MAGMA Gießereitechnologie GmbH

**l.pavlak@magmasoft.de**