

International MAGMA User Meeting 2024

October 9-11, 2024

RADISSON BLU – Frankfurt

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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.

The Economics Perspective in MAGMASOFT 6.1

Workshop

T. Wilden

Frankfurt a. M.

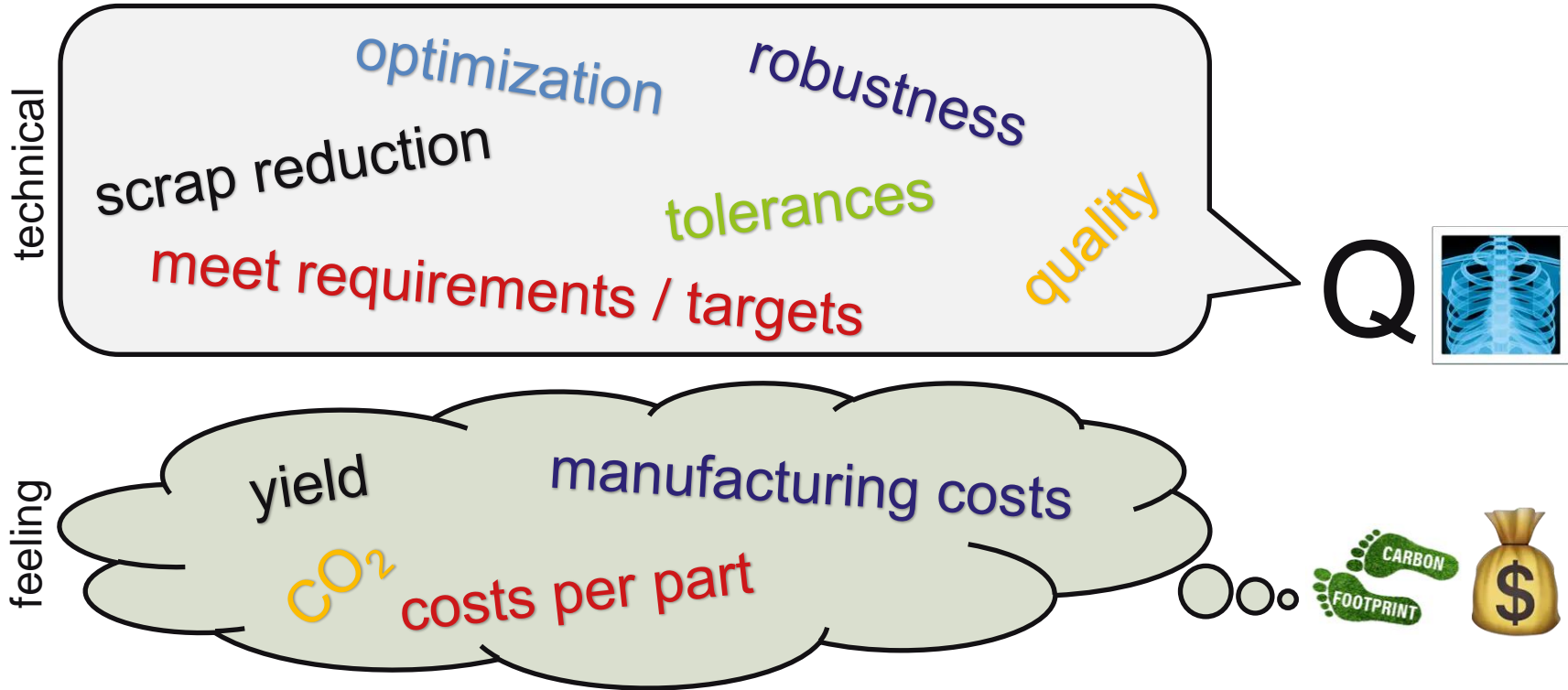
International MAGMA User Meeting 2024

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Motivation of ECONOMICS

Status Quo



MAGMA ECONOMICS

What is it ?

- a new, additional **perspective** in MAGMASOFT®
- **easy to use & free** of charge.
- **production costs** and/or **CO₂** emissions estimation for castings

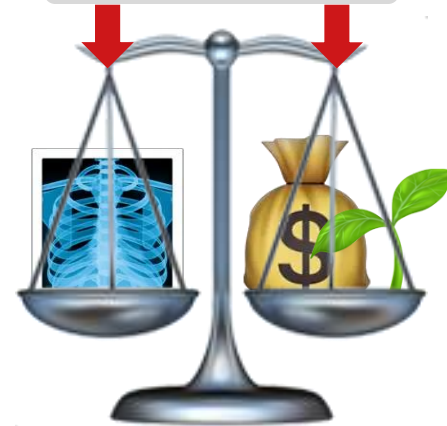
MAGMA ECONOMICS provides further criteria – in addition to quality – for evaluating the best solution: **costs and CO₂**.

- We are talking about costs, **NOT** price!
- It is **NOT** a comprehensive **cost-/CO₂-calculation program!**



MAGMASOFT®
autonomous engineering

project information



MAGMA ECONOMICS

How does it work ?

- With support from the **cost sheets** ...
- ...and the **already available information** in MAGMASOFT® simulation projects
- ...and **without any further input**
- ...estimations of **costs** and/or **CO₂ emissions** are automatically calculated.
- Including **DoEs**

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/CO₂** and **quality**.
- Furthermore **time can be saved** in the development process by
 - **early considerations** of **costs** and **CO₂** emissions in the simulation phase and by
 - **avoiding** unnecessary simulations.

Feeling?!

VERSUS

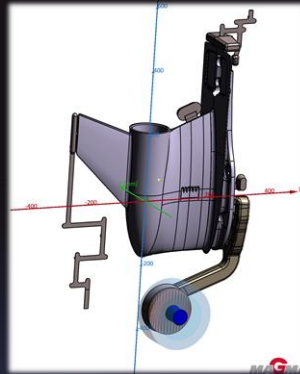
Quantitative Values!

Live Demo

Combine 3 dimensions

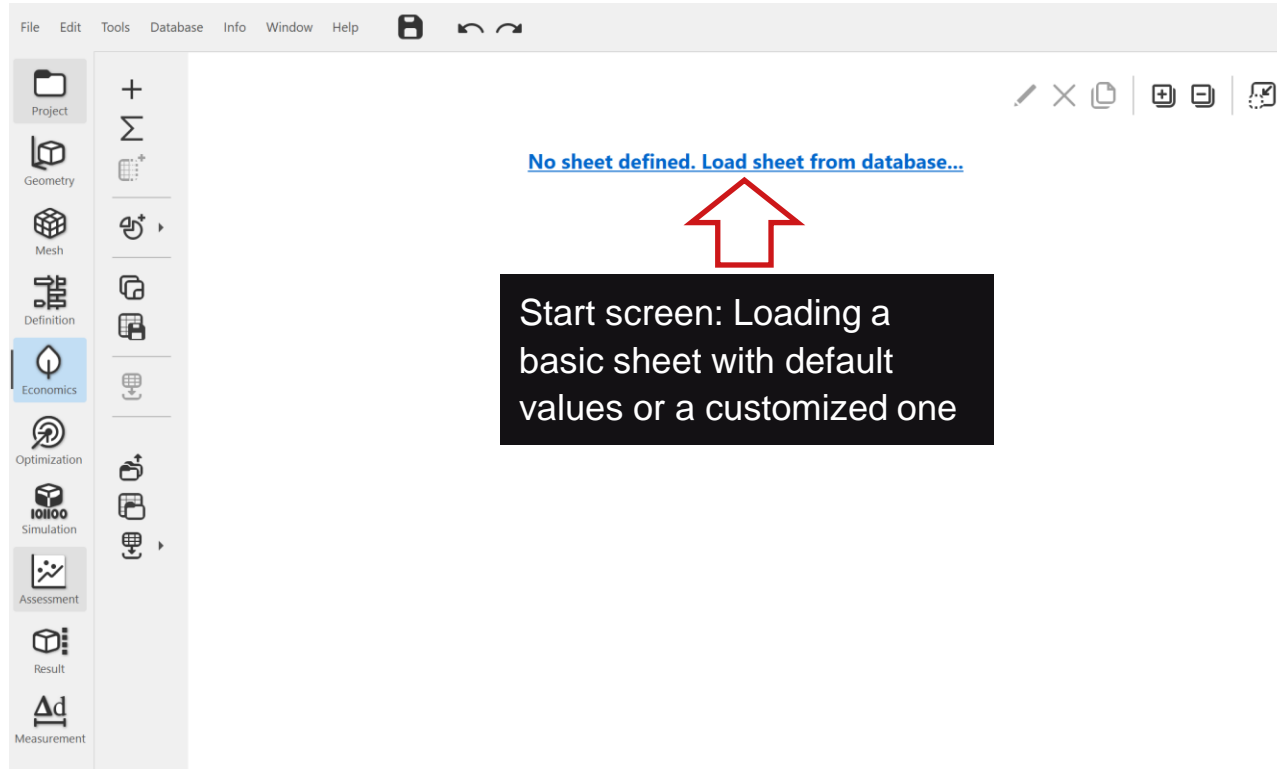
- quality
- manufacturing costs
- carbon footprint per part)

and determine your optimum with
MAGMASOFT 6.1 ECONOMICS



Economics Workflow using the example of a DoE

Open Economics Perspective to load a sheet from database



Economics Workflow using the example of a DoE

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. At the top, it says 'Select an economics sheet.' Below this, there are two filter buttons: 'HPDC - Cold Chamber' and 'Aluminum'. The left pane shows a tree structure with 'MAGMA' and 'Sheet' folders. Under 'Sheet', several templates are listed, including 'CO2_HPDC_Cold_Chamber_Basic', 'Cost_HPDC_Cold_Chamber_Basic' (which is highlighted with a red arrow), 'Finance_at_Company', 'FUNCTION_IF_ELSE-IF_ELSE_example', 'FUNCTION_IF_example', 'FUNCTION_SWITCH_example', and 'HPDC_Cold_Chamber_Cost_Sheet_and'. The right pane shows the details for the selected template, 'Cost_HPDC_Cold_Chamber_Basic'. It includes a 'Sheet Title' and a 'Sheet description'. Below this is a table with columns 'Name', 'Basis', and 'Value'. The table contains several rows of data, including 'Total cost of cast alloy', 'Unit cost of cast alloy per kg', 'Number of Casting Materials', 'Shot weight', 'Mass of Casting All IDs', 'Casting system', 'Mass of Biscuit All IDs', 'Mass of Runner All IDs', 'Mass of Gate All IDs', and 'Mass of Overflow All IDs'. At the bottom right, there are 'OK' and 'Cancel' buttons.

Name	Basis	Value
▼ Total cost of cast alloy	$f(x)$	28,18 €/part
Unit cost of cast alloy per kg		3 €/kg
Number of Casting Materials		1
▼ Shot weight	$f(x)$	14.5512 kg
Mass of Casting All IDs		9.3933 kg
▼ Casting system	$f(x)$	5.1579 kg
Mass of Biscuit All IDs		1.7581 kg
Mass of Runner All IDs		2.2977 kg
Mass of Gate All IDs		0.0259 kg
Mass of Overflow All IDs		1.0761 kg

Economics Workflow using the example of a DoE

Linking a cost sheet with values from another sheet (e.g. to pre-calculate a PCF)

The screenshot displays the Mercury Economics software interface. On the left, a sidebar contains icons for Geometry, Mesh, Definition, Economics (highlighted), Optimization, Simulation, Assessment, Result, and Measurement. The main window shows a cost sheet with columns for Name, Basis, and Value. A red box highlights the top-left corner of the cost sheet, specifically the area where a new value can be added. A red arrow points to this area. A black text box with white text is overlaid on the cost sheet, stating: "Linking two separate sheets with their values and calculation formulas: '+' symbol on top left and selection 'Add values from another sheet'". The cost sheet lists various costs, including Total cost of cast alloy, Unit cost of cast alloy per kg, Shot weight, Casting system, Mass of Biscuit All IDs, Mass of Runner All IDs, Mass of Gate All IDs, Mass of Overflow All IDs, Total cost of melting, Hourly rate for melting operation, Melting performance per hour, Total cost of preparation, filling, solidification, Hourly rate for casting machine operation, Production cycle time die casting machine per part, Production Cycle/Preparation, Production Cycle/Filling, Production Cycle/Solidification & Cooling until Eject, and Manufacturing costs per part. The Manufacturing costs per part is 43.17 €/part. On the right, two charts are displayed. The top chart is a pie chart titled "Cost allocation per part (%)" showing the distribution of costs: Basis (65.3%), Total cost of cast alloy (27%), and Total cost of preparation, filling, solidification (7.96%). The bottom chart is a horizontal bar chart titled "Cost allocation per part (€)" showing the total cost of preparation, filling, solidification (approx. 3.35), Total cost of melting (approx. 11.64), and Total cost of cast alloy (approx. 28.18).

Linking two separate sheets with their values and calculation formulas: "+" symbol on top left and selection "Add values from another sheet"

Cost allocation per part (%)

Category	Percentage
Basis	65.3%
Total cost of cast alloy	27%
Total cost of preparation, filling, solidification	7.96%

Cost allocation per part (€)

Category	Value (€)
Total cost of preparation, filling, solidification	3.35
Total cost of melting	11.64
Total cost of cast alloy	28.18

Manufacturing costs ...
43.17 €/part

Economics Workflow using the example of a DoE

Integrate all values from the carbon footprint calculation into the existing sheet

Mercury Economics DoE Quality+Costs+CO2/v42 - HPDC - Cold Chamber, Aluminum - MAGMASOFT 6.1 RC03

File Edit Tools Database Info Window Help

Project
Geometry
Mesh
Definition
Economics
Optimization
Simulation
Assessment
Result
Measurement

Add Dataset Values

Database/File Name

- MAGMA
- User
- Sheet
- CO2_HPDC_Cold_Chamber_Basic
Calculates a roughly estimated CO2 footprint per part
- CO2_HPDC_Hot_Chamber_Basic
Calculates a roughly estimated CO2 footprint per part
- CO2_Semi_Solid_Basic
Calculates a roughly estimated CO2 footprint per part
- Cost_HPDC_Cold_Chamber_Basic
Calculates the roughly estimated manufacturing costs
- Cost_HPDC_Hot_Chamber_Basic
Calculates the roughly estimated manufacturing costs
- Cost_Semi_Solid_Basic
Calculates the roughly estimated manufacturing costs
- Materialkosten

Select / Unselect All

Name	Basis
<input checked="" type="checkbox"/> CO2 Estimation of the Cast Material	f(x) 50.705 kg CO ₂ /eq/part
<input checked="" type="checkbox"/> CO2 footprint of the cast alloy	5,398 g CO ₂ /eq/kg
<input checked="" type="checkbox"/> CO2 footprint of the casting system (recycled)	f(x) 0 g CO ₂ /eq/kg
<input checked="" type="checkbox"/> Number of Casting Materials	1
<input checked="" type="checkbox"/> Shot weight	f(x) 14.5512 kg
<input checked="" type="checkbox"/> Mass of Casting All IDs	9.3933 kg
<input checked="" type="checkbox"/> Casting system	f(x) 5.1579 kg
<input checked="" type="checkbox"/> Mass of Biscuit All IDs	1.7581 kg
<input checked="" type="checkbox"/> Mass of Runner All IDs	2.2977 kg
<input checked="" type="checkbox"/> Mass of Gate All IDs	0.0259 kg
<input checked="" type="checkbox"/> Mass of Overflow All IDs	1.0761 kg
<input checked="" type="checkbox"/> CO2 Estimation of Melting	f(x) 4.377 kg CO ₂ /eq/part
<input checked="" type="checkbox"/> CO2 emission factor of gas	227.561 g CO ₂ /eq/kWh
<input checked="" type="checkbox"/> Concentration of melting furnace	1.2 MAFS
<input checked="" type="checkbox"/> CO2	

Import

The sheet already contains 8 of your selected values.

Overwrite all Skip all Decide for each value

OK Cancel

Production Cycle/Solidification & Cooling until Eject 35 s

Manufacturing costs per part f(x) 43.17 €/part

Total cost of cast alloy

0 5 10 15

Basis

Selection of the desired CO2-sheet. Either selection of individual values/calculations or overall selection. Redundant values can simply be overwritten.

Economics Workflow using the example of a DoE

Define the objectives and/or design variables for the DoE in the merged sheet

By right-clicking on the desired row and then defining it as an “Objective” or “Design Variable” with a left mouse click, any number of values can be added to the optimization perspective. After each selection, information windows appear, which are confirmed with “Close”.

Economics Workflow using the example of a DoE

Definition Overview in Optimization Perspective and preparation for the DoE

The screenshot displays the Magma Economics software interface. The left sidebar shows a tree view of the project structure, including Definition Overview, Design Variables, Measured Data, Objectives, Constraints, and Settings Overview. The main window is divided into two panes: Design Variables and Objectives.

Design Variables

Design Variable	Selection
<input checked="" type="checkbox"/> Geometry geometry_exchange_001 - Activated item	1 Runner-A-(like-die) 2 Runner-B 3 Runner-C 4 Runner-D-(Final Version)
<input checked="" type="checkbox"/> Geometry Bohne-1 - active	
<input type="checkbox"/> Geometry Bohne-2 - active	
<input checked="" type="checkbox"/> Geometry Bohnen 2 und 3 - active	
<input checked="" type="checkbox"/> Total power consumption of die casting cell	

Objectives

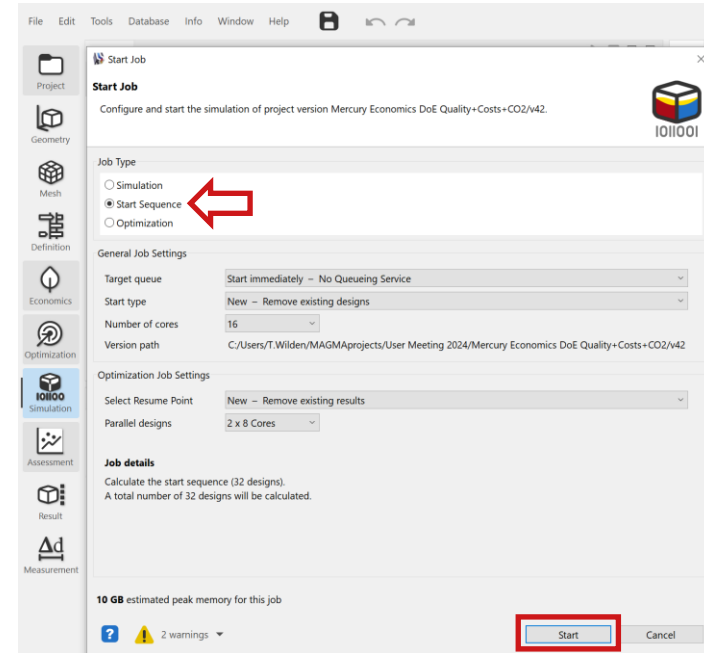
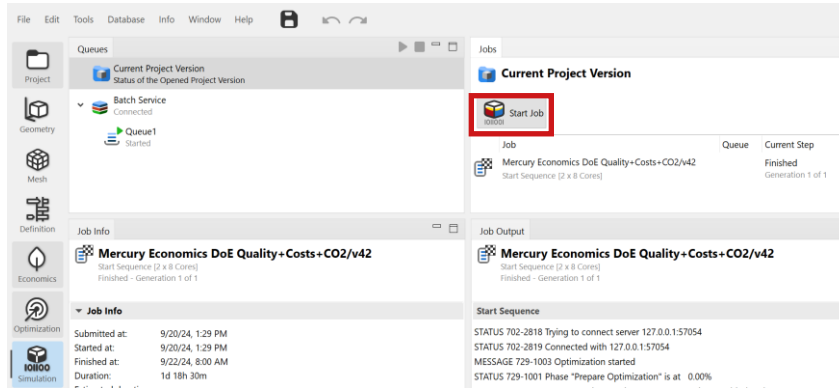
Name	Type	Value	Expression
<input checked="" type="checkbox"/> Porosity gesamt	Minimize	▼	(Cycle 2/Solidification & Cooling until Eject/Porosity/End of S...
<input checked="" type="checkbox"/> Lufteinschlüsse gesamt	Minimize	▼	(Cycle 2/Filling/Air/End of Filling/Avg/Casting ID 1)
<input checked="" type="checkbox"/> Smooth Filling	Minimize	▼	(Cycle 2/Filling/VOF/Max Free Surface of Cast Alloy Class)
<input checked="" type="checkbox"/> Manufacturing costs per part	Minimize	▼	(Manufacturing costs per part)
<input checked="" type="checkbox"/> CO ₂ Estimation per Part	Minimize	▼	(CO ₂ Estimation per Part)

In this example, all objectives are to be minimized. Design variables were defined for the gating and venting system as well as for a variation of casting cells with different power consumption. Total number of designs in this case: 32

Economics Workflow using the example of a DoE

Start sequence (DoE) to calculate a total number of different designs

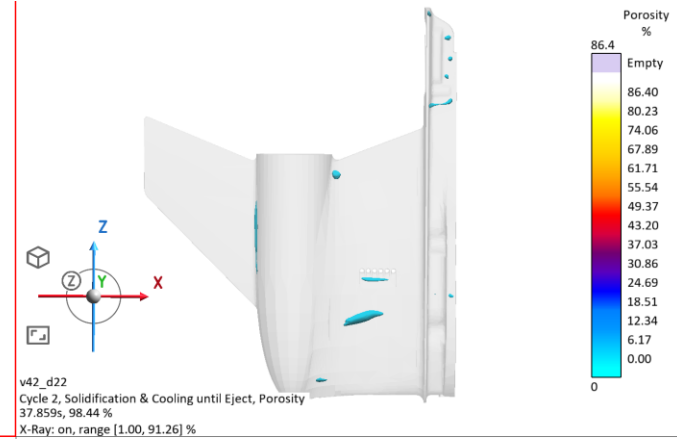
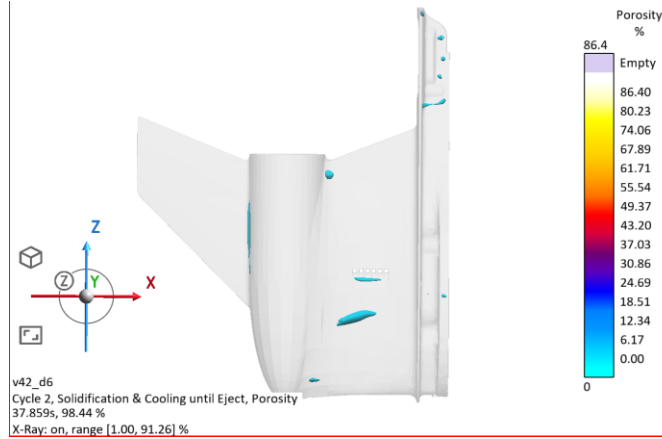
Press “Start Job” in the simulation perspective and select “Start Sequence” in the context window. Then run the DoE by pressing the “Start” button.



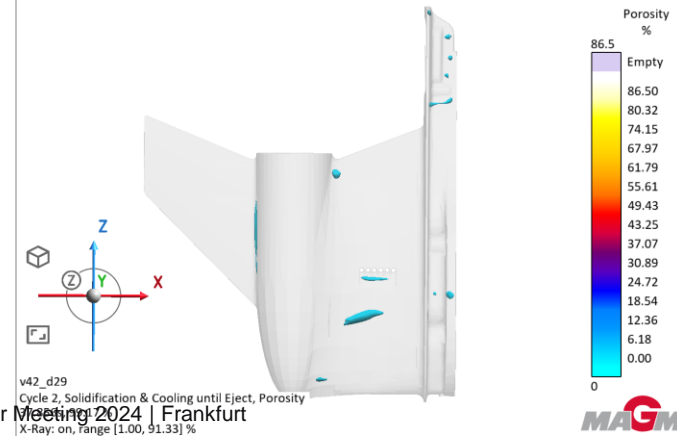
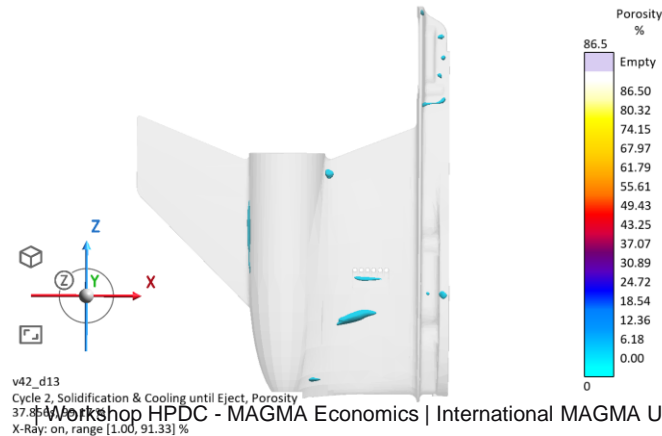
Economics Workflow using the example of a DoE

Porosity results – 2 best and 2 worst designs

Best
Porosity
designs:
D6 / D22



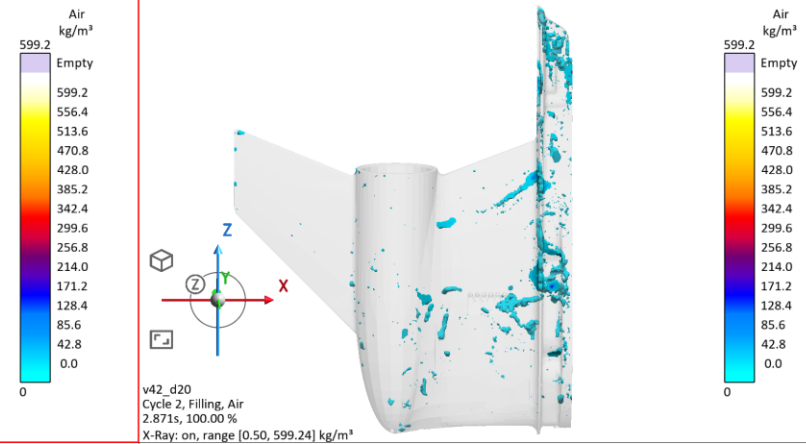
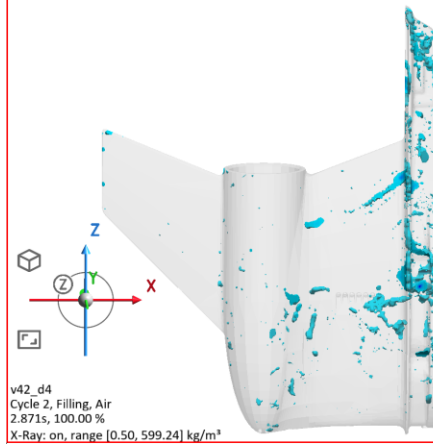
Worst
Porosity
designs:
D13 / D29



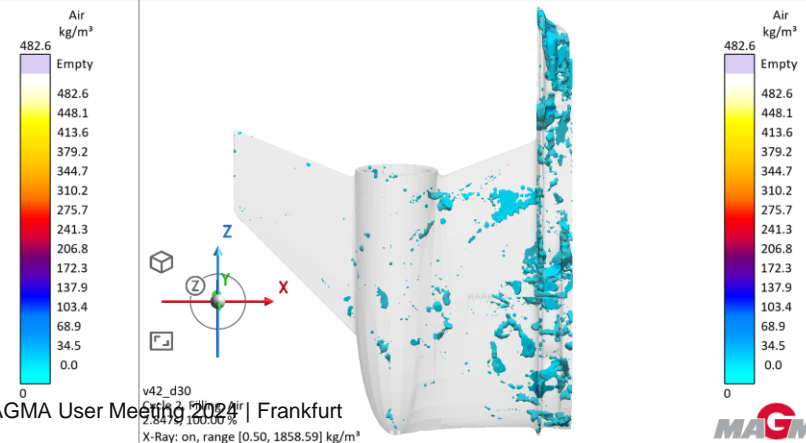
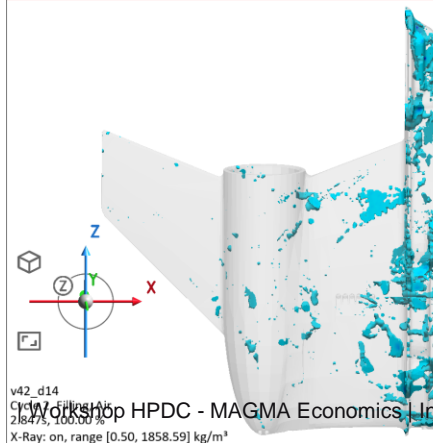
Economics Workflow using the example of a DoE

Air results – 2 best and 2 worst designs

Best Air
designs:
D4 / D20



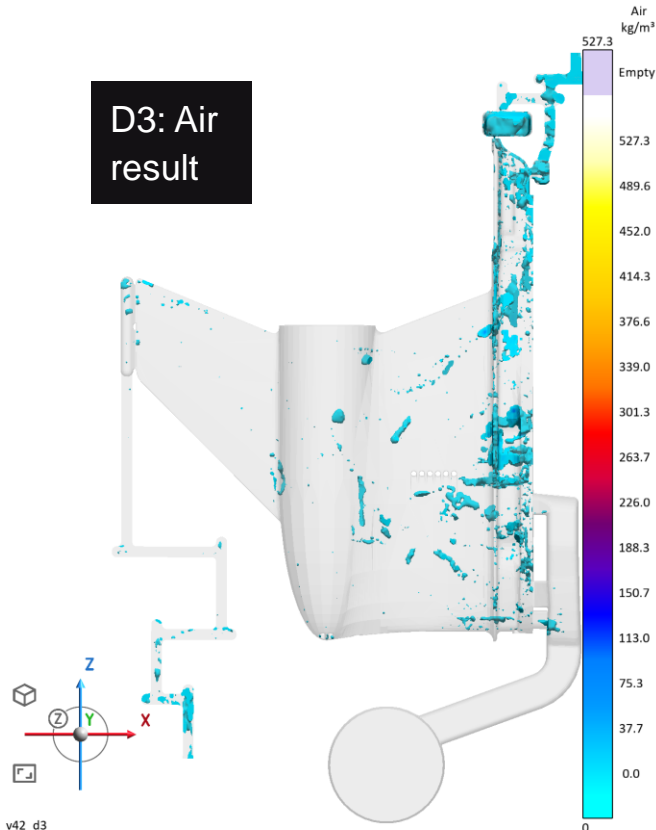
Worst Air
designs:
D14 / D30



Economics Workflow using the example of a DoE

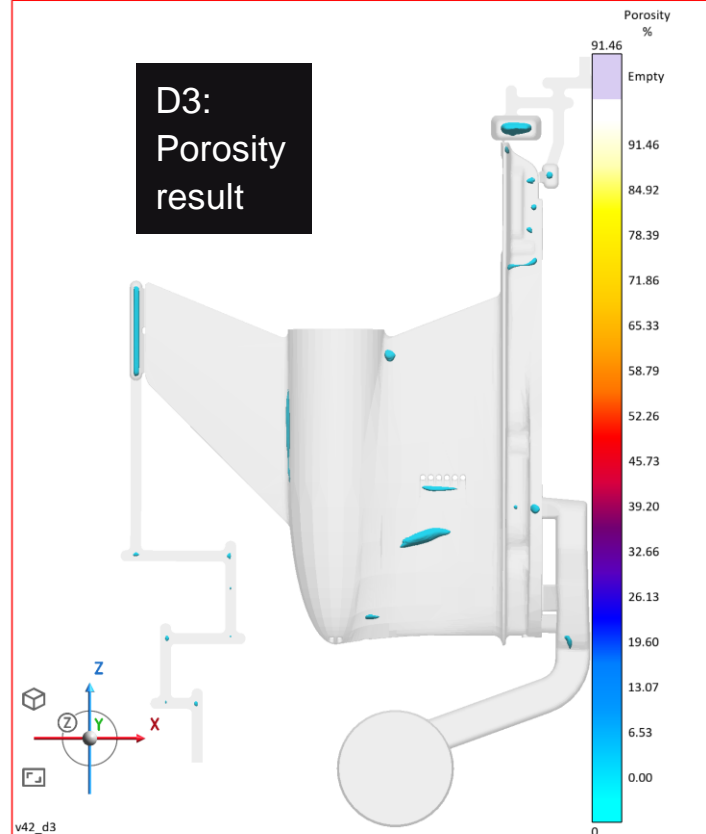
Design 3 as optimum compromise between quality, costs and carbon footprint

D3: Air
result



v42_d3
Cycle 2: Filling Air
2.879% Volume
X-Ray: on, range [0.50, 527.30] kg/m³

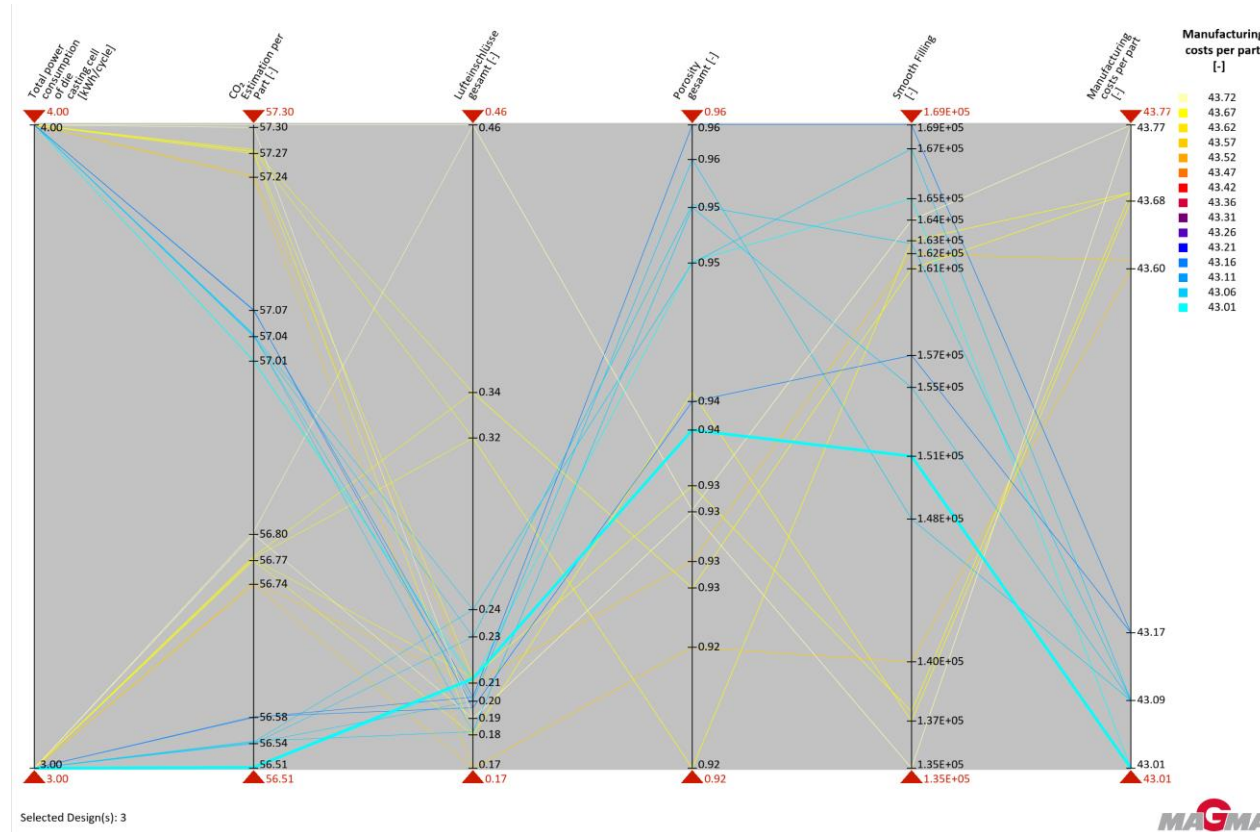
D3:
Porosity
result



v42_d3
Cycle 2: Solidification & Cooling until Eject, Porosity
Volume 2024 | Frankfurt
X-Ray: on, range [1.00, 91.46] %

Economics Workflow using the example of a DoE

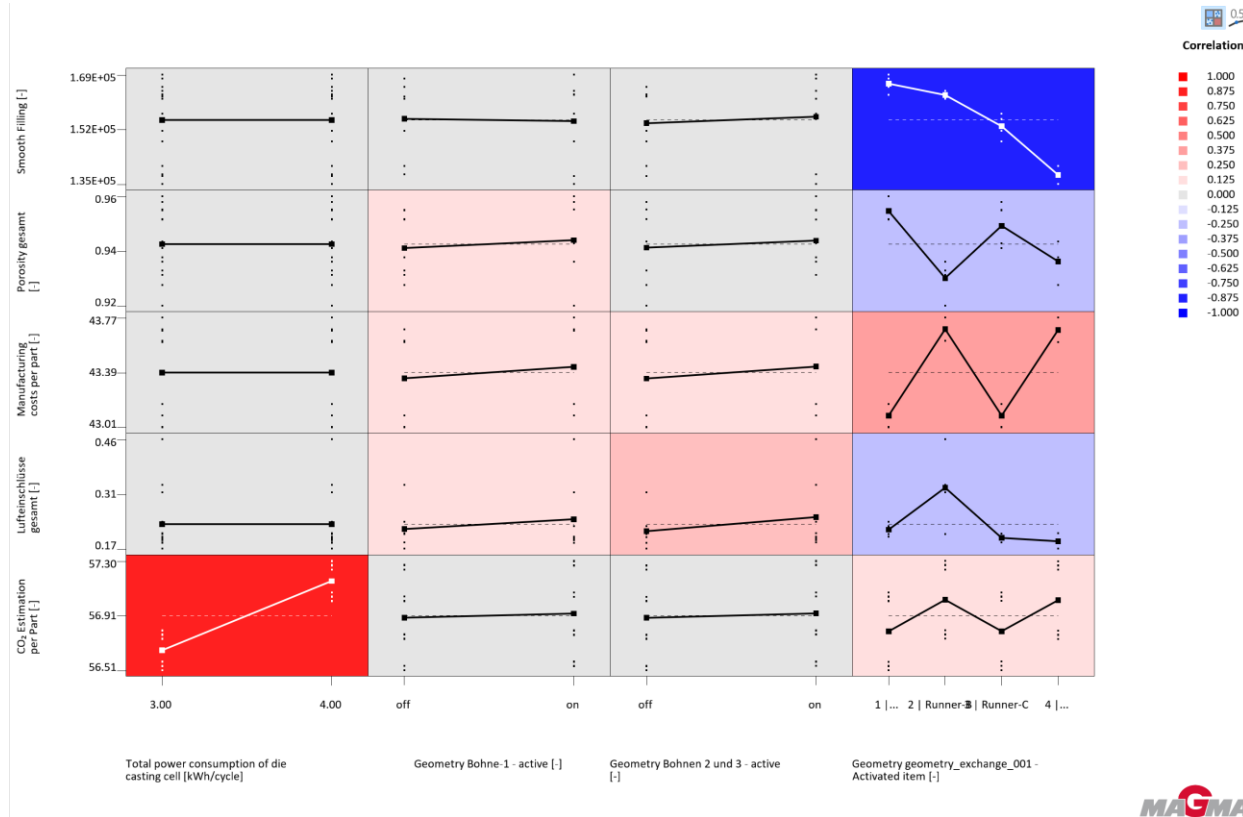
Display of results using Parallel Coordinates



Presentation of DoE-Results: Design 3 on the energy-efficient machine is the best compromise between quality, manufacturing costs and carbon footprint per part !


Economics Workflow using the example of a DoE

Presentation of results as a Main Effect Matrix



Economics Workflow using the example of a DoE

Presentation of results as a Data Table with equal weighting of all variables



Rank	Design	Total power consu...	Geometry Bohne-1...	Geometry Bohnen ...	Geometry geomet...	CO ₂ Estimation per...	Luftteinschlüsse ge...	Manufacturing cos...	Porosity gesamt (-)	Smooth Filling (-)
Rank 1	Design 3	3.0	0.0	0.0	3 Runner-C	56.51	0.209	43.01	0.939	151206.7
Rank 2	Design 4	3.0	0.0	0.0	4 Runner-D-(Final ...	56.74	0.169			
Rank 3	Design 7	3.0	1.0	0.0	3 Runner-C	56.54	0.199			
Rank 4	Design 15	3.0	1.0	1.0	3 Runner-C	56.58	0.196			
Rank 5	Design 11	3.0	0.0	1.0	3 Runner-C	56.55	0.185			
Rank 6	Design 19	4.0	0.0	0.0	3 Runner-C	57.01	0.209			
Rank 7	Design 1	3.0	0.0	0.0	1 Runner-A-(like-...	56.51	0.207			
Rank 8	Design 16	3.0	1.0	1.0	4 Runner-D-(Final ...	56.8	0.191			
Rank 9	Design 12	3.0	0.0	1.0	4 Runner-D-(Final ...	56.77	0.209			
Rank 10	Design 8	3.0	1.0	0.0	4 Runner-D-(Final ...	56.77	0.184			
Rank 11	Design 5	3.0	1.0	0.0	1 Runner-A-(like-...	56.54	0.228			
Rank 12	Design 20	4.0	0.0	0.0	4 Runner-D-(Final ...	57.24	0.169			
Rank 13	Design 9	3.0	0.0	1.0	1 Runner-A-(like-...	56.55	0.24			
Rank 14	Design 23	4.0	1.0	0.0	3 Runner-C	57.04	0.199			
Rank 15	Design 31	4.0	1.0	1.0	3 Runner-C	57.08	0.196			
Rank 16	Design 27	4.0	0.0	1.0	3 Runner-C	57.04	0.185			
Rank 17	Design 2	3.0	0.0	0.0	2 Runner-B	56.74	0.207			
Rank 18	Design 13	3.0	1.0	1.0	1 Runner-A-(like-...	56.58	0.201			
Rank 19	Design 17	4.0	0.0	0.0	1 Runner-A-(like-...	57.01	0.207			
Rank 20	Design 32	4.0	1.0	1.0	4 Runner-D-(Final ...	57.3	0.191			
Rank 21	Design 28	4.0	0.0	1.0	4 Runner-D-(Final ...	57.27	0.209			
Rank 22	Design 24	4.0	1.0	0.0	4 Runner-D-(Final ...	57.27	0.184			
Rank 23	Design 6	3.0	1.0	0.0	2 Runner-B	56.77	0.317			
Rank 24	Design 21	4.0	1.0	0.0	1 Runner-A-(like-...	57.04	0.228			
Rank 25	Design 25	4.0	0.0	1.0	1 Runner-A-(like-...	57.04	0.24			
Rank 26	Design 10	3.0	0.0	1.0	2 Runner-B	56.77	0.338			
Rank 27	Design 18	4.0	0.0	0.0	2 Runner-B	57.24	0.207			
Rank 28	Design 29	4.0	1.0	1.0	1 Runner-A-(like-...	57.07	0.201			
Rank 29	Design 22	4.0	1.0	0.0	2 Runner-B	57.27	0.317			
Rank 30	Design 26	4.0	0.0	1.0	2 Runner-B	57.27	0.338			
Rank 31	Design 14	3.0	1.0	1.0	2 Runner-B	56.8	0.458			
Rank 32	Design 30	4.0	1.0	1.0	2 Runner-B	57.3	0.458			

Presentation of results as data table:

With 100% equal weighting of all optimization objectives, Design 3 is recommended as the best solution.

In this example, the porosity results of all calculated designs in particular lie within a very narrow range.

This trade-off is solved using the roughly estimated manufacturing costs and the carbon footprint per part.

Economics Workflow using the example of a DoE

Detailed view of all calculated designs and their values using the Compare Dialog

MAGMASOFT 6.1 RC23

Overview X Design Variables Plots Data Table Material Definitions Start Sequence Measured Data

All designs
vPseudo Set
Marked

Select the desired designs. Then right mouse button and "Compare" from the context menu.

Rank Design CO₂

Rank 1	Design 3	56.51
Rank 2	Design 4	56.73
Rank 3	Design 7	56.54
Rank 4	Design 15	56.56
Rank 5	Design 11	56.55
Rank 6	Design 19	57.01
Rank 7	Design 1	56.51
Rank 8	Design 16	56.8
Rank 9	Design 12	56.77
Rank 10	Design 8	56.77
Rank 11	Design 5	56.54
Rank 12	Design 20	57.24
		56.55
		57.04
		57.08
		57.04
		56.74
		56.52
		57.01
		57.3
		57.27
		57.27
		56.77
		57.04
		57.04
		56.77
		57.24
		57.01
		57.27
		57.27
		56.8
		57.3
		57.3

Design Information...
Exclude from Assessment
Open Result Perspective for Selected Designs
Mark As
Unmark
Mark All As
Unmark All

Excluded Designs...
Export...

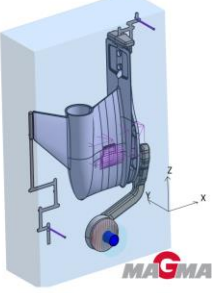
Compare

Compare selected designs

Rank Design CO₂

Rank 1	Design 25	57.04
Rank 2	Design 10	56.77
Rank 3	Design 18	57.24
Rank 4	Design 29	57.01
Rank 5	Design 22	57.27
Rank 6	Design 26	57.27
Rank 7	Design 14	56.8
Rank 8	Design 30	57.3

Generated: 32 Calculated: 32



Using the Compare dialog, all calculated values of the design variables and the objectives with their distribution to the individual designs can be listed and analyzed in detail. The screenshot shows the partial results from "Economics" with a list of the individual cost items and the CO₂-Estimations.

Compare Dialog

Compare your selection

Name	Design 3	Design 4	Design 7	Design 15	Design 11
> Design Variables					
> Objectives					
> Output Values					
> Constraints					
> Economics					
> Total cost of cast alloy $f(x)$	28.18 €/part	28.18 €/part	28.18 €/part	28.18 €/part	28.18 €/part
> Total cost of melting $f(x)$	11.48 €/part	12.07 €/part	11.56 €/part	11.64 €/part	11.56 €/part
> Total cost of preparation, filling, solidification $f(x)$	3.35 €/part	3.35 €/part	3.35 €/part	3.35 €/part	3.35 €/part
> Manufacturing costs per part $f(x)$	43.01 €/part	43.59 €/part	43.09 €/part	43.17 €/part	43.09 €/part
> CO ₂ Estimation of the Cast Material $f(x)$	50.705 kg CO ₂ /eq/part	50.705 kg CO ₂ /eq/part	50.705 kg CO ₂ /eq/part	50.705 kg CO ₂ /eq/part	50.705 kg CO ₂ /eq/part
> CO ₂ Estimation of Melting $f(x)$	4.316 kg CO ₂ /eq/part	4.54 kg CO ₂ /eq/part	4.346 kg CO ₂ /eq/part	4.378 kg CO ₂ /eq/part	4.348 kg CO ₂ /eq/part
> CO ₂ Estimation of Preparation, Filling, Solidification $f(x)$	1.494 kg CO ₂ /eq/part	1.494 kg CO ₂ /eq/part	1.494 kg CO ₂ /eq/part	1.494 kg CO ₂ /eq/part	1.494 kg CO ₂ /eq/part
> CO ₂ Estimation per Part $f(x)$	56.515 kg CO ₂ /eq/part	56.739 kg CO ₂ /eq/part	56.545 kg CO ₂ /eq/part	56.577 kg CO ₂ /eq/part	56.547 kg CO ₂ /eq/part

Thank you for your attention.

Tobias Wilden

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