
MAGMA


International MAGMA User Meeting 2024
October 9-11, 2024
RADISSON BLU – Frankfurt
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MAGMA
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Tips and Tricks

Workshop Core Making Processes

Ľuboš Pavľak

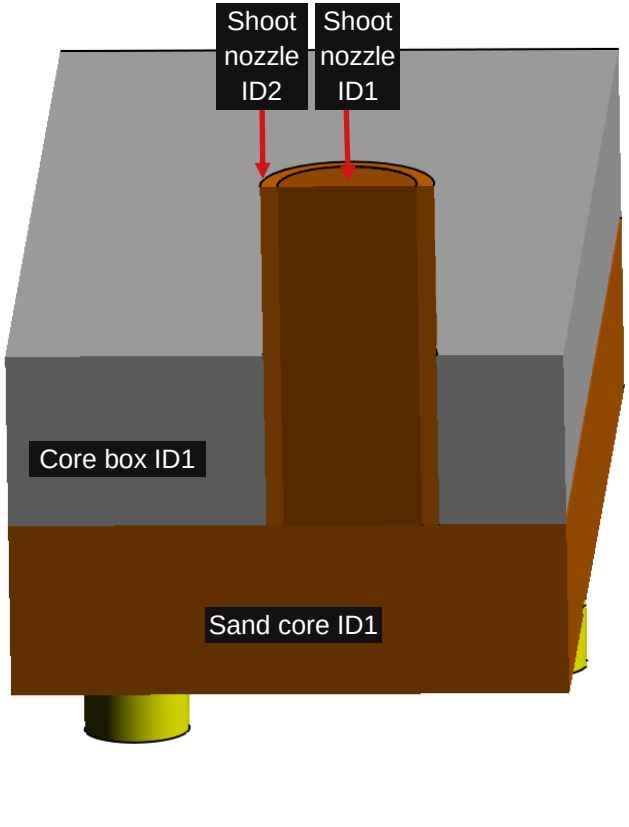
Frankfurt, October 10th 2024

Agenda

- Nozzles for shooting and curing
- Inorganic
  - Temperature of hot air
  - Speed up
- Coldbox processes
  - New curing gas dataset "Methyl Formate"
  - Resol CO_2
- User Results
- Optimization with economics „live demo“
- Future development?

Nozzles for Shooting and Curing Simulation

1. Option – Shoot nozzle go up after shooting and curing go through opening

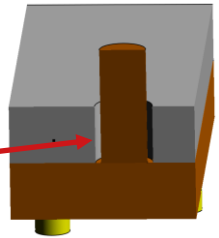


- Shooting:

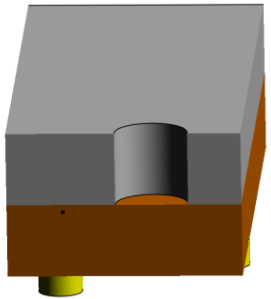
Core Shooting Definitions

Specify the boundary conditions for the sand/a

Shooting Parameters	Nozzle / Vent Settings	
Nozzle ID	Active	Database/Filename
ID 1	☑	MAGMA/Nozzle_D10
ID 2	☐	MAGMA/Nozzle_D12
Vent ID	Active	Database/Filename
ID 1	☑	MAGMA/Slot_D6



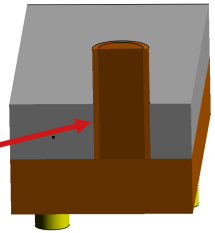
- Curing:



Gassing Definitions

Specify the boundary conditions for the gas flo

Gassing Parameters	Vent Settings	
Nozzle ID	Active	Database/Filename
ID 1	☑	MAGMA/Nozzle_D10
ID 2	☑	MAGMA/Nozzle_D12
Vent ID	Active	Use As Nozzle
ID 1	☑	☐



Nozzles for Shooting and Curing Simulation

2. Option – Shoot nozzle exchange for curing with different size

- Shooting v01:

- Curing v01:

D10 open area for curing ~15%=~12cm2

D4 open area ~12cm2

Core Shooting Definitions

Specify the boundary conditions for the sand/a

Shooting Parameters | Nozzle / Vent Settings

Nozzle ID	Active	Database/Filename
D10	☑	MAGMA/Nozzle_D10
D4	☑	Project/Nozzle_D4
Vent ID	**Active**	**Database/Filename**
ID 1	☑	MAGMA/Slot_D6
ID 2	☑	MAGMA/Slot_D6

Gassing Definitions

Specify the boundary conditions for the gas flow into the core box fc

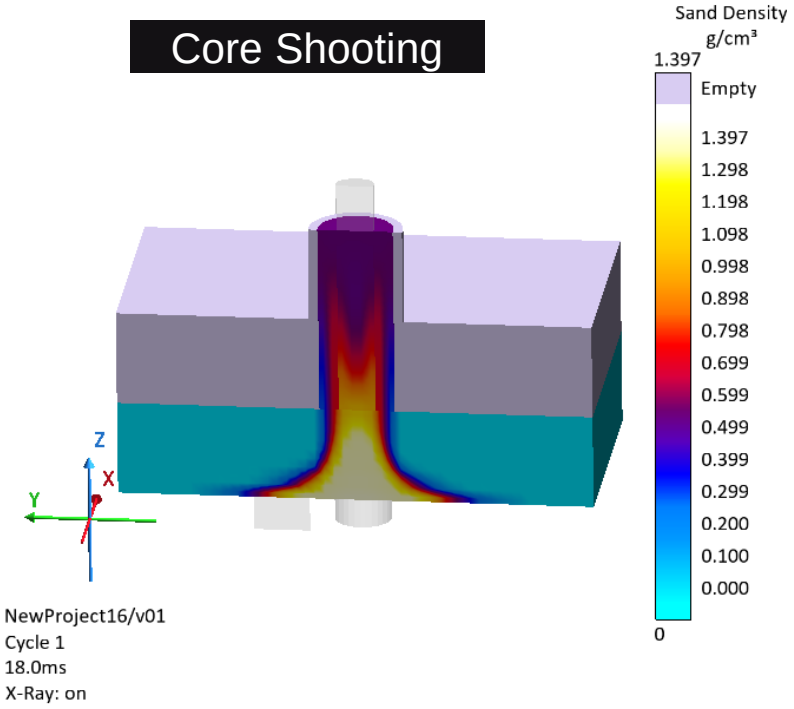
Gassing Parameters | Vent Settings

Nozzle ID	Active	Database/Filename	Pressure Loss 1 (-)
D10	☐	MAGMA/Nozzle_D12	0.5
D4	☑	Project/Nozzle_D4	0.5
Vent ID	**Active**	**Use As Nozzle**	**Database/Filename**
ID 1	☑	☐	MAGMA/Slot_D6
ID 2	☑	☐	MAGMA/Slot_D6

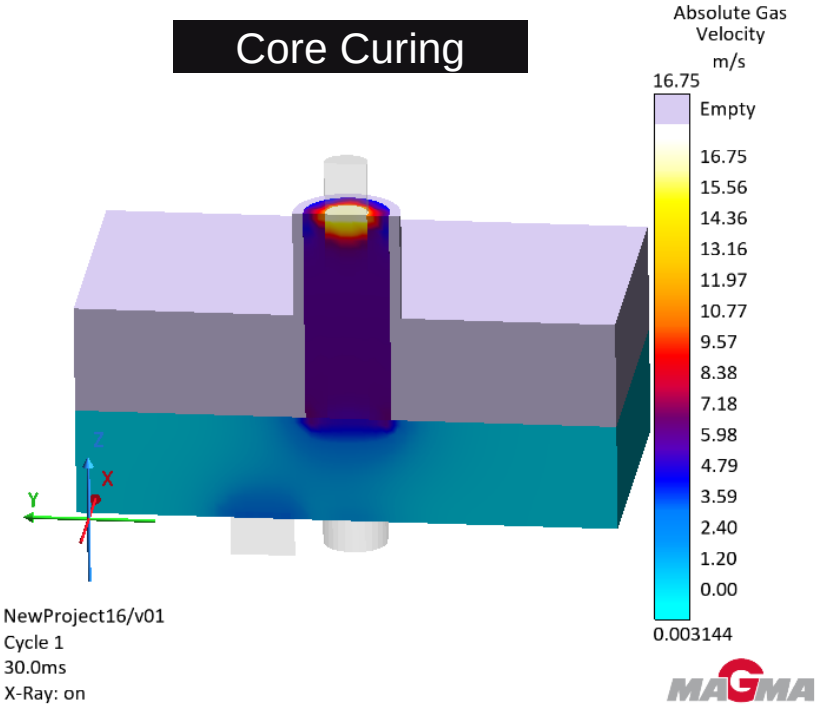
Nozzles for Shooting and Curing Simulation

2. Option

Core Shooting



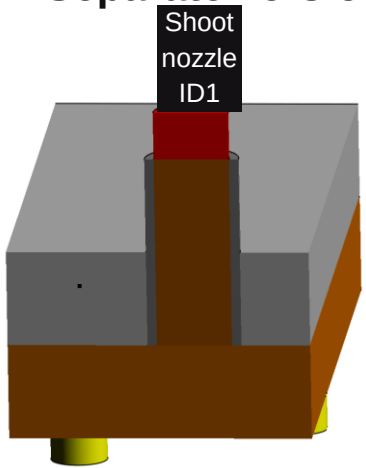
Core Curing



Nozzles for Shooting and Curing Simulation

3. Option – Separate version for shooting and curing

- Shooting v01:



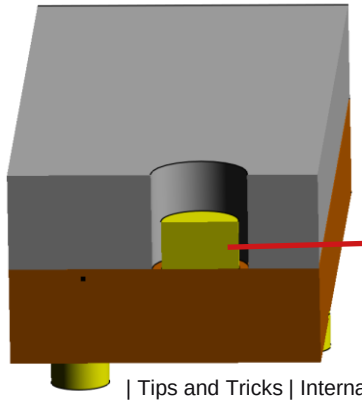
Core Shooting Definitions

Specify the boundary conditions for the sand/a

Shooting Parameters | Nozzle / Vent Settings

Nozzle ID	Active	Database/Filename
ID 1	☑	MAGMA/Nozzle_D10
ID 2	☐	MAGMA/Nozzle_D12
Vent ID	**Active**	**Database/Filename**
ID 1	☑	MAGMA/Slot_D6

- Curing v02:



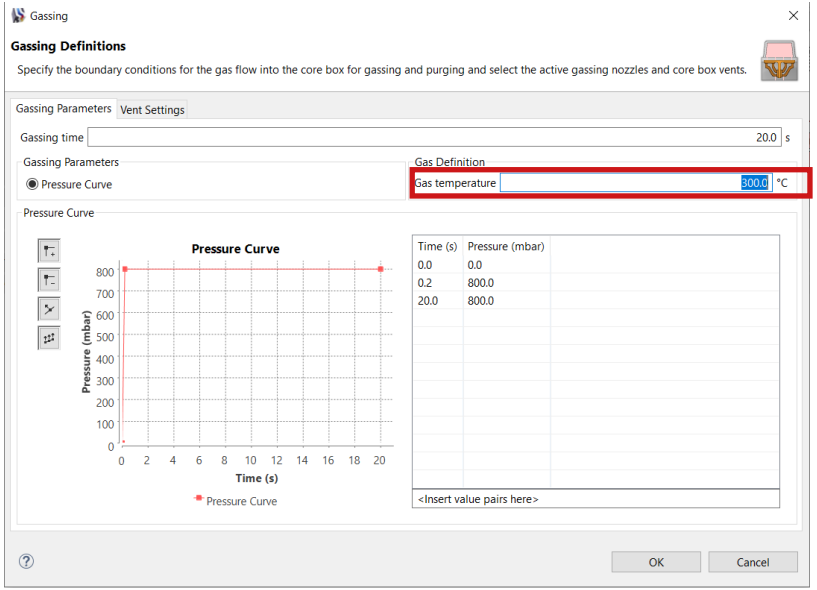
Gassing Parameters | Vent Settings

Nozzle ID	Active	Database/Filename
ID 1	☐	MAGMA/Nozzle_D10
ID 2	☐	MAGMA/Nozzle_D12
Vent ID	**Active**	**Use As Nozzle**
ID 1	☑	☑
ID 2	☑	☐

Inorganic process

Inorganic Curing Simulation

Gas temperature

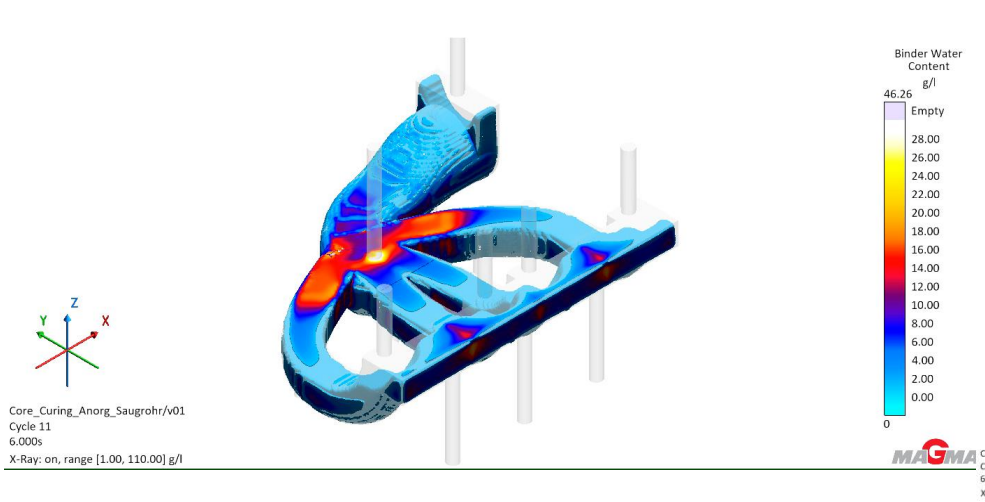


- Higher gas temperature is now in MS6.1 possible
- 300°C gas temperature is working
- In MS6.0 was max. ~273°C allowed

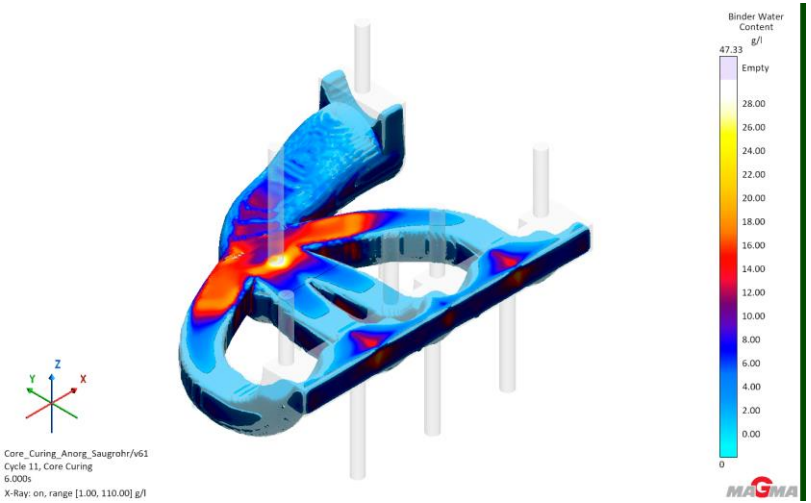
Inorganic Curing Simulation

Speed up of simulation time

Example - MS6.0 calculation time 24hrs (8CPU)



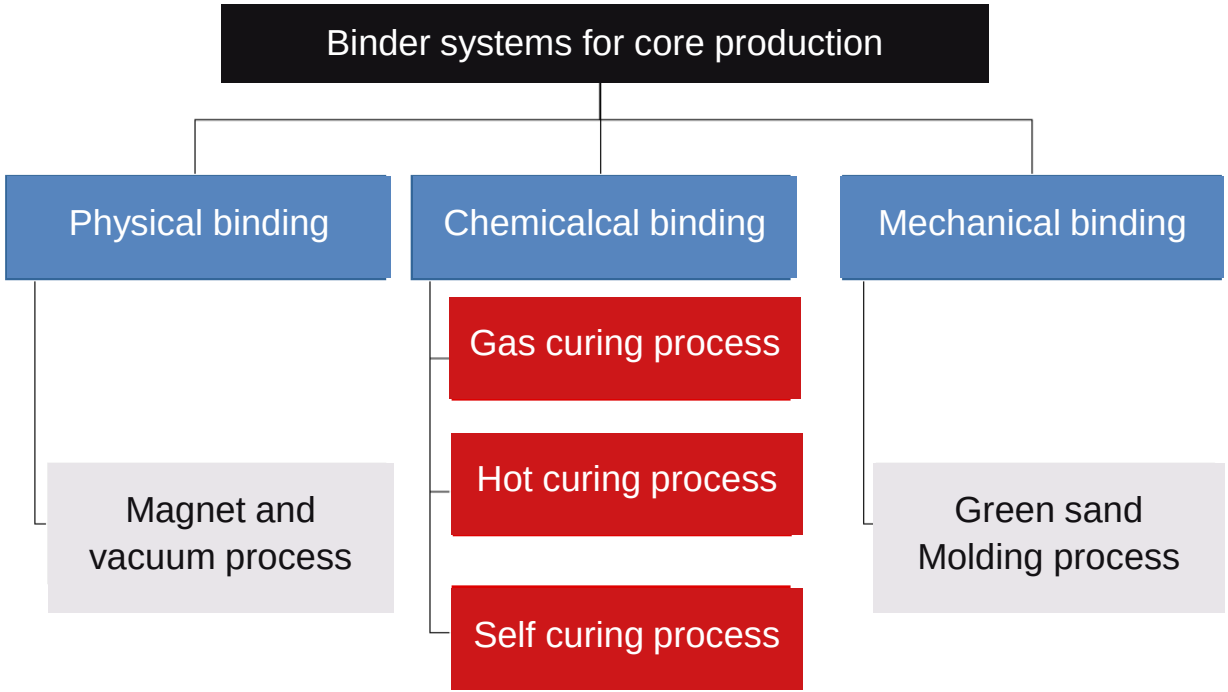
MS6.1 calculation time 11hrs (8CPU)



In MS6.1 speed up of inorganic curing simulation up to factor 4 in comparison to MS6.0

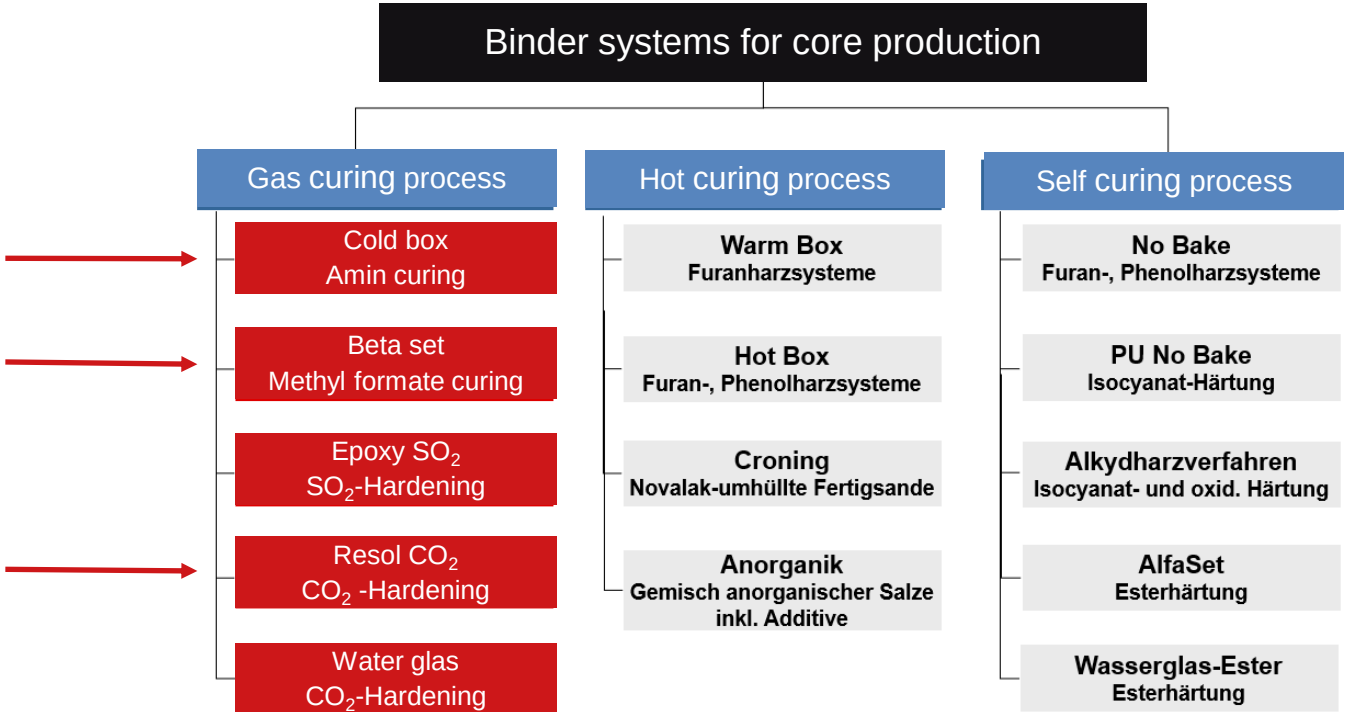
Binder Systems for Core Production

General Overview Binder Types



Source: André Gerhards, ASK Chemicals, Bindersysteme für die Kernherstellung, MAGMA User Meeting 2023, Aachen

General Overview Binder Types



Source: André Gerhards, ASK Chemicals, Bindersysteme für die Kernherstellung, MAGMA User Meeting 2023, Aachen

PU Coldbox

Variation „Curing gas adsorbtion/release factor“

PU Coldbox

Curing gases – recommended settings

- Gas temperature: at least boiling point of gas (see tables)
- Amount of gassing gas:
  - DMEA, DMIPA, TEA: standard 0,5-1g Amin/kg Sand, Trend goes to 0,25g/kg Sand
  - CO_2 4-5g/kg Sand
- Curing gas fraction in gas flow: 5-10% Amin, 50% CO_2

Gas Definition

Curing gas	MAGMA/DMEA	
Curing gas adsorption factor	1.0	
Curing gas release factor	0.1	
Gas temperature	37.0	°C
Amount of gassing gas	1.5	g
Curing gas fraction in gas flow	5.0	%

Gas Definition

Curing gas	MAGMA/DMIPA	
Curing gas adsorption factor	2.0	
Curing gas release factor	0.05	
Gas temperature	67.0	°C
Amount of gassing gas	1.5	g
Curing gas fraction in gas flow	5.0	%

Gas Definition

Curing gas	MAGMA/TEA	
Curing gas adsorption factor	3.0	
Curing gas release factor	0.03	
Gas temperature	89.0	°C
Amount of gassing gas	1.5	g
Curing gas fraction in gas flow	5.0	%

Gas Definition

Curing gas	MAGMA/Methyl_Formate	
Curing gas adsorption factor	1.0	
Curing gas release factor	0.1	
Gas temperature	32.0	°C
Amount of gassing gas	1.5	g
Curing gas fraction in gas flow	5.0	%

Gas Definition

Curing gas	MAGMA/CO2	
Curing gas adsorption factor	2.0	
Curing gas release factor	0.00001	
Gas temperature	45.0	°C
Amount of gassing gas	6.0	g
Curing gas fraction in gas flow	50.0	%

Basic Physical Models

Core gassing and purging simulation

Pressure Equation

$$\Rightarrow \phi c_g \frac{\partial P}{\partial t} + \phi \beta_g \frac{\partial T}{\partial t} + \sum_k \rho_k^{-1} \nabla . \left(\rho_k c v_k \frac{K}{\mu_g} \nabla P \right) = \sum_k \frac{Q_k}{\rho_k} + \sum_k \frac{R_k}{\rho_k}$$

Evaporation/Condensation
Adsorption

Porosity

Permeability

Gas Concentration

$$\frac{\partial C_k}{\partial t} + \nabla . (\rho_k C v_k \mathbf{U}) - \nabla . (\phi \rho_k D_k \nabla C v_k) = Q_k + R_k \quad k = 1, \ldots N$$

Convection

Diffusion

Evaporation/Condensation
Adsorption

Condensate

$$\frac{\partial C_{k'}}{\partial t} = R_{k'} \quad k' = 1, \ldots N'$$

Energy Equation

$$\frac{\partial}{\partial t} \left[(1-\phi) \rho_s b_s + \sum_{k=1}^{N} b_k C_k \right] T + \nabla \left(\sum_{k=1}^{N} \rho_k b_k C v_k T \mathbf{U} \right) = \nabla (\sigma \nabla T) + \sum_{k=1}^{N} b_k Q_k T_s$$

Heat Capacity

Convection

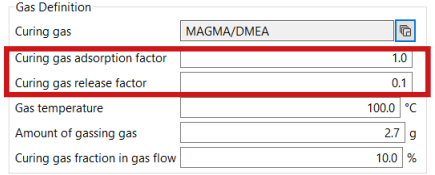
Conduction

Langmuir Adsorption Model:

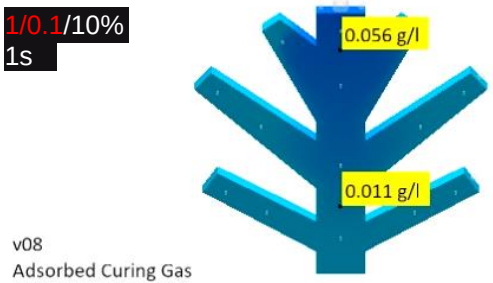
$$A_L = \frac{k1 * \cdots * A_G}{k2 * \cdots + (k1 - k2) * A_G}$$

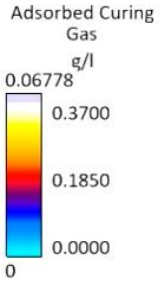
PU Coldbox

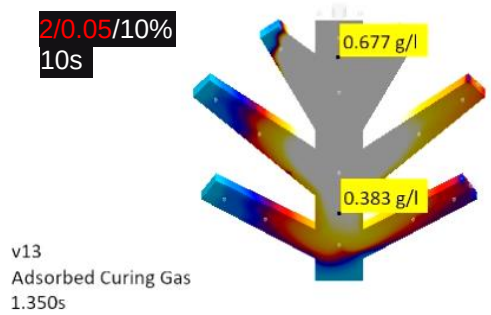
Variation „Curing gas adsorption/release factor“

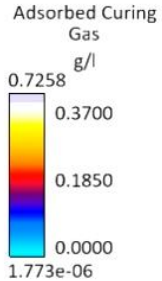


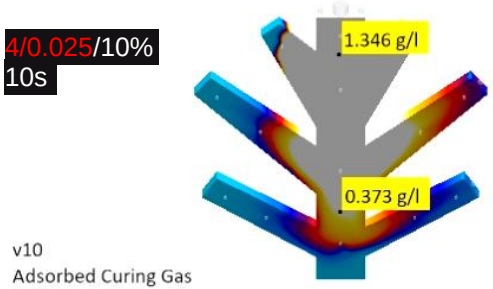
1/0.1
2/0.05
4/0.025
10/0.01

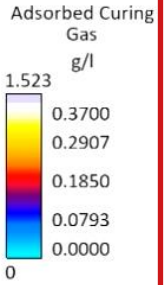


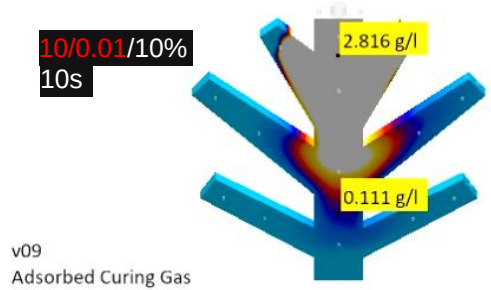


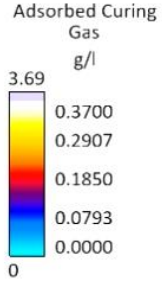












PU Coldbox

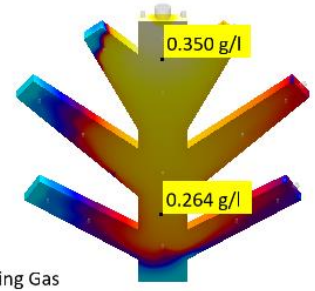
Variation „Curing gas adsorption/release factor“

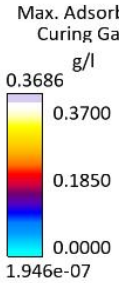
Gas Definition

Curing gas	MAGMA/DMEA
Curing gas adsorption factor	1.0
Curing gas release factor	0.1
Gas temperature	100.0 °C
Amount of gassing gas	2.7 g
Curing gas fraction in gas flow	10.0 %

1/0.1
2/0.05
4/0.025
10/0.01

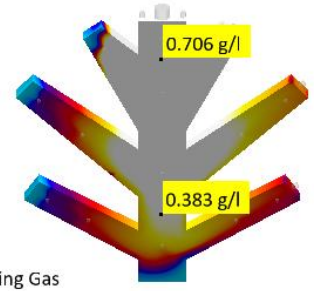
1/0.1/10%

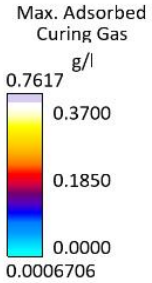




v08
Max. Adsorbed Curing Gas
1.000s

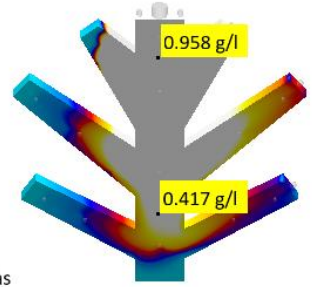
2/0.05/10%

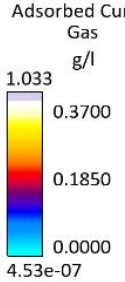




v13
Max. Adsorbed Curing Gas
10.000s

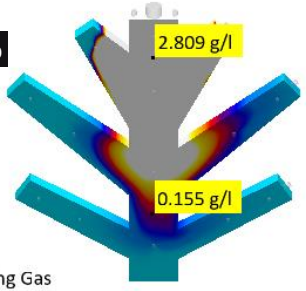
4/0.025/10%

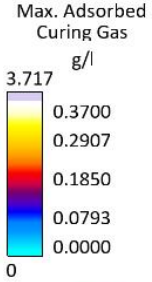




v10
Adsorbed Curing Gas
7.400s

10/0.01/10%

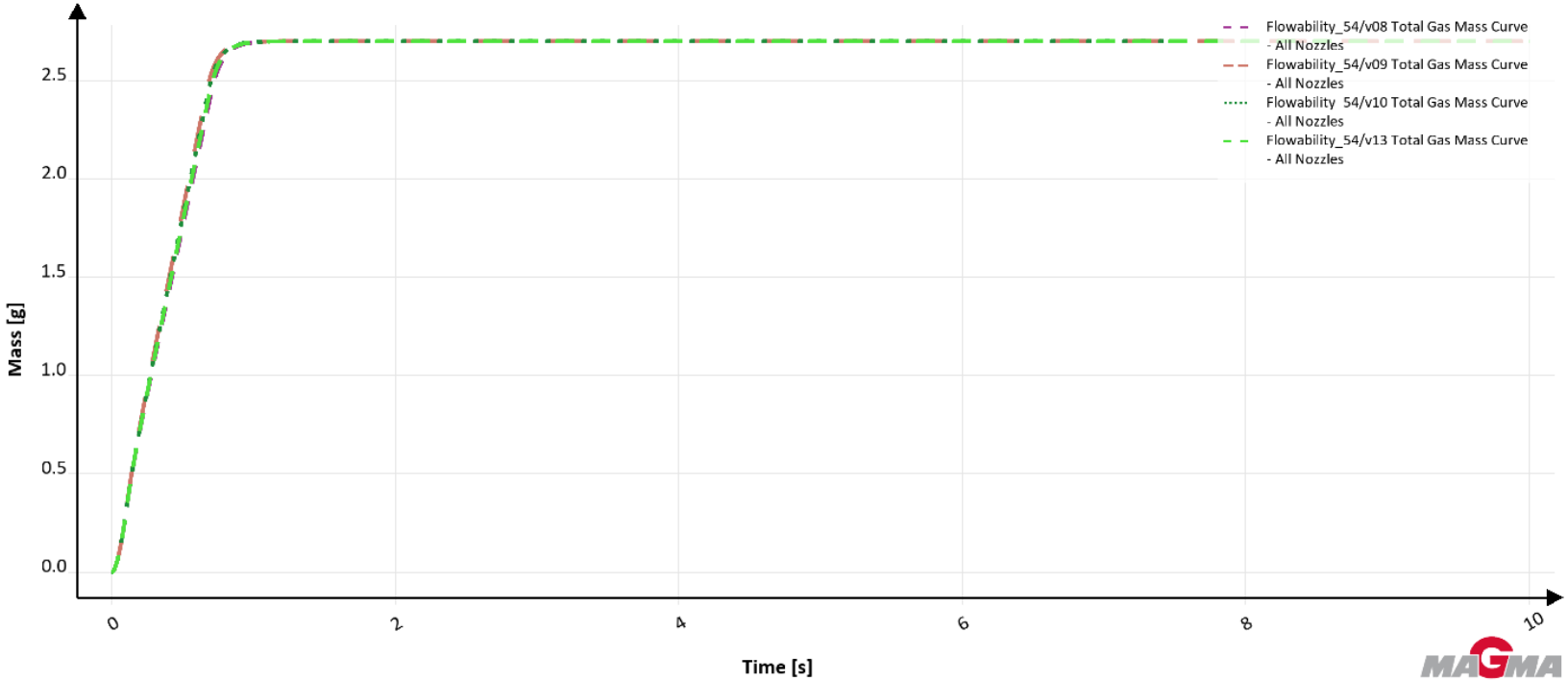




v09
Max. Adsorbed Curing Gas
10.000s

PU Coldbox

Total gas mass curve



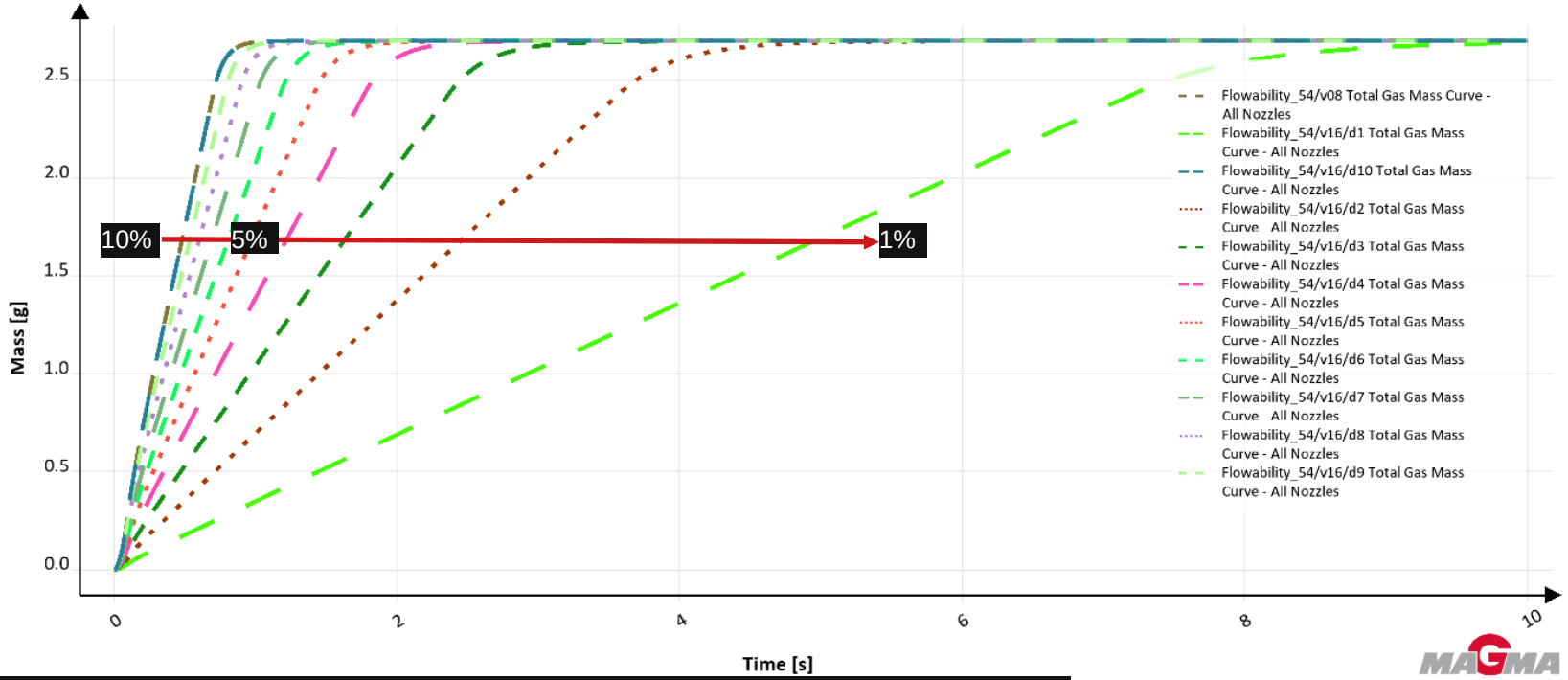
Modifying „Adsorbed/released curing gas“ values doesn't change gas mass inflow

PU Coldbox

Variation „Curing gas fraction in gas flow“

PU Coldbox

Total gas mass curve



Reducing „Curing gas fraction in gas flow“ slows down gassing/adsorption

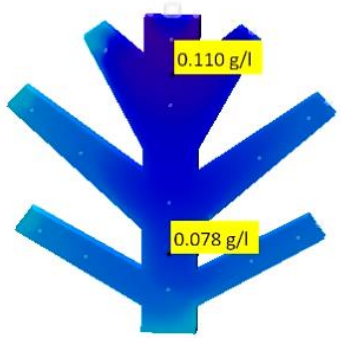
PU Coldbox

Adsorbed Curing Gas

Gas Definition

Curing gas	MAGMA/DMEA
Curing gas adsorption factor	1.0
Curing gas release factor	0.1
Gas temperature	100.0 °C
Amount of gassing gas	2.7 g
Curing gas fraction in gas flow	10.0 %

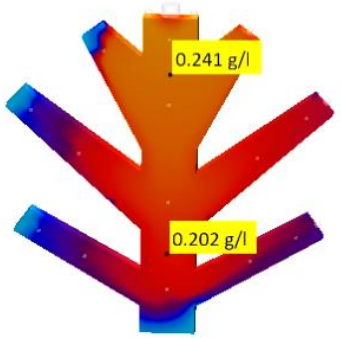
1/0.1/1%



Adsorbed Curing Gas g/l
0.1159
0.3700
0.1850
0.0000
0.0002708

v16_d1
Adsorbed Curing Gas
3.000s

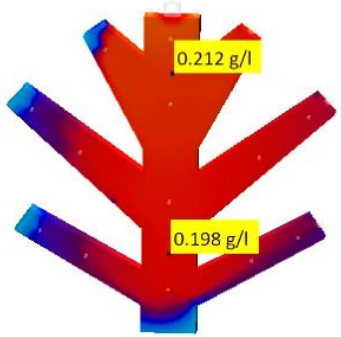
1/0.1/5%



Adsorbed Curing Gas g/l
0.251
0.3700
0.1850
0.0000
0.001337

v16_d5
Adsorbed Curing Gas
3.000s

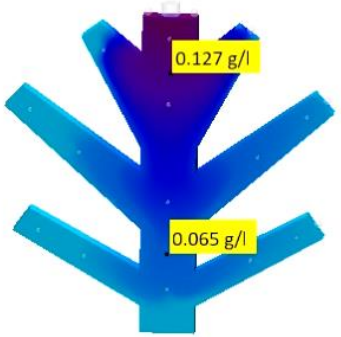
1/0.1/10%



Adsorbed Curing Gas g/l
0.2204
0.3700
0.1850
0.0000
0.002187

v16_d10
Adsorbed Curing Gas
3.000s

1/0.1/10%



Adsorbed Curing Gas g/l
0.1472
0.3700
0.2907
0.1850
0.0793
0.0000
0

v08
Adsorbed Curing Gas
300.1ms

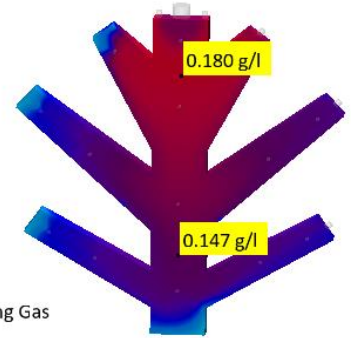
PU Coldbox

Max. Adsorb Curing Gas

Gas Definition

Curing gas	MAGMA/DMEA
Curing gas adsorption factor	1.0
Curing gas release factor	0.1
Gas temperature	100.0 °C
Amount of gassing gas	2.7 g
Curing gas fraction in gas flow	10.0 %

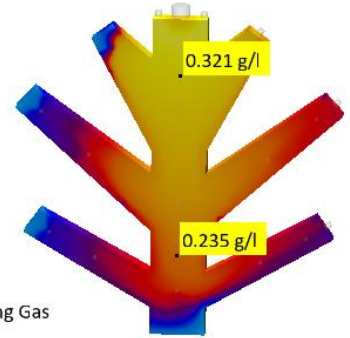
1/0.1/1%
10s



Max. Adsorbed Curing Gas g/l
0.1829
0.3700
0.1850
0.0000
0.008329

v16_d1
Max. Adsorbed Curing Gas
10.000s

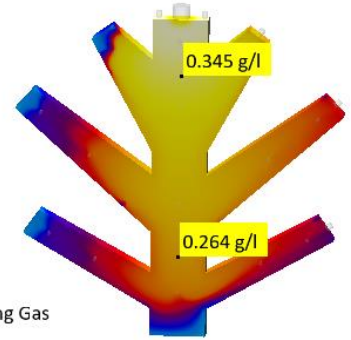
1/0.1/5%
10s



Max. Adsorbed Curing Gas g/l
0.3401
0.3700
0.1850
0.0000
0.01629

v16_d5
Max. Adsorbed Curing Gas
10.000s

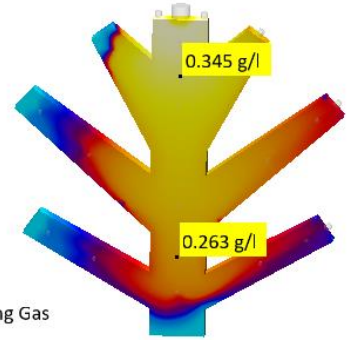
1/0.1/10%
10s



Max. Adsorbed Curing Gas g/l
0.3686
0.3700
0.1850
0.0000
0.01871

v16_d10
Max. Adsorbed Curing Gas
10.000s

1/0.1/10%
1s

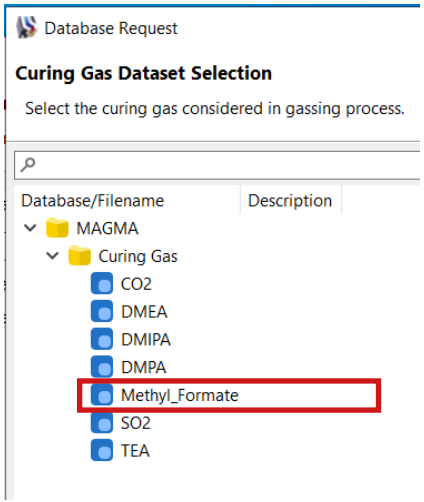


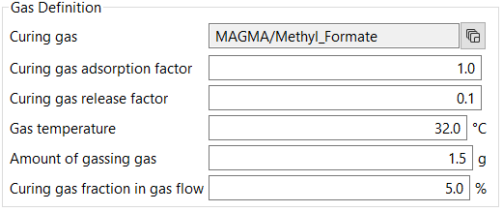
Max. Adsorbed Curing Gas g/l
0.3686
0.3700
0.1850
0.0000
1.946e-07

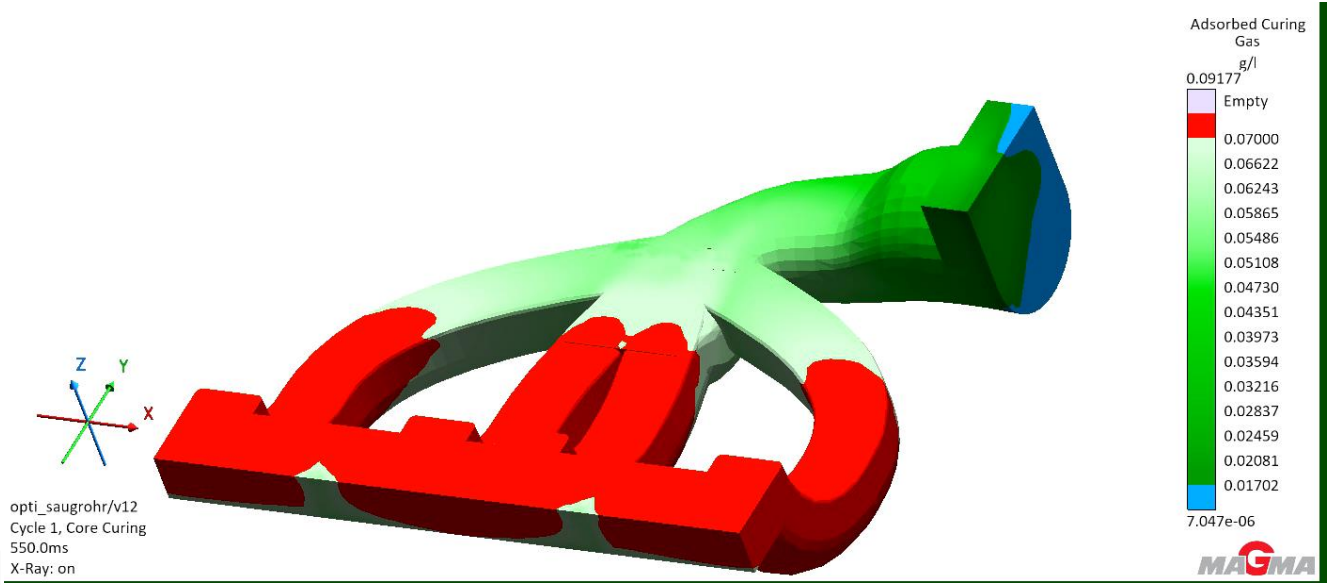
v08
Max. Adsorbed Curing Gas
1.000s

New Dataset in Coldbox Process

New curing gas type – 'Methyl_Formate'





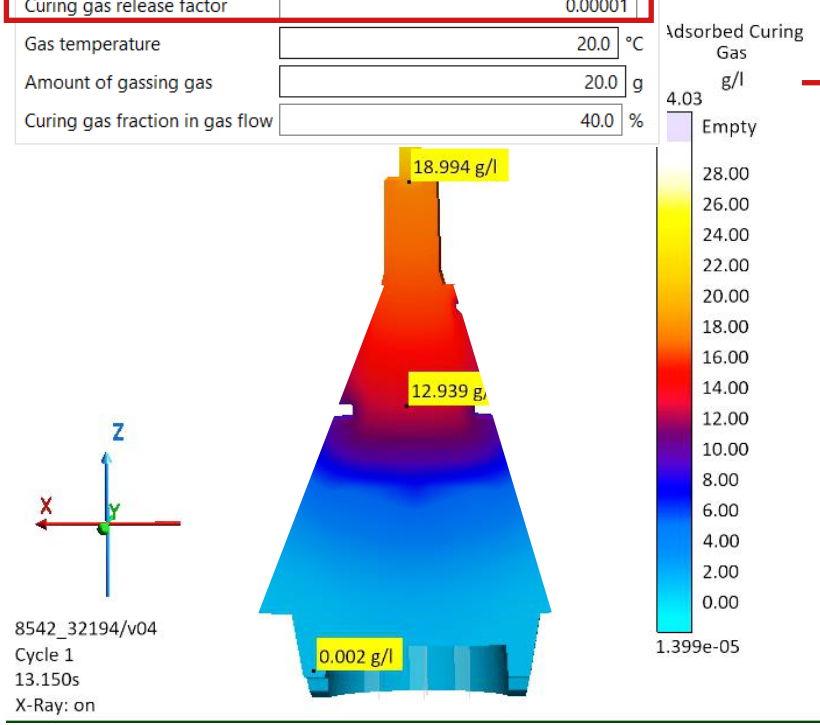


Resol CO_2

Default settings

Gas Definition

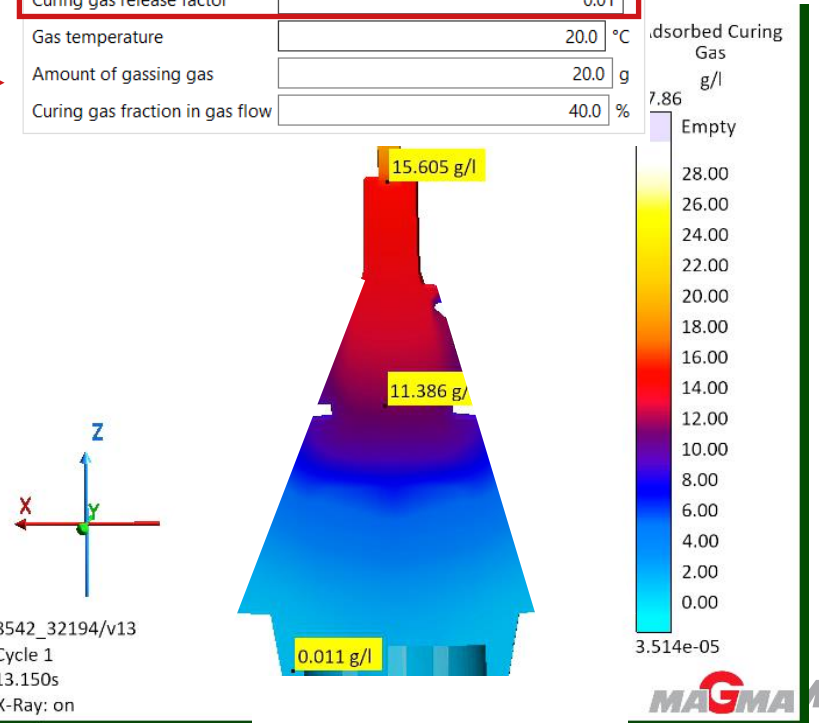
Curing gas	MAGMA/CO2	
Curing gas adsorption factor	2.0	
Curing gas release factor	0.00001	
Gas temperature	20.0	°C
Amount of gassing gas	20.0	g
Curing gas fraction in gas flow	40.0	%



Changed settings

Gas Definition

Curing gas	MAGMA/CO2	
Curing gas adsorption factor	2.0	
Curing gas release factor	0.01	
Gas temperature	20.0	°C
Amount of gassing gas	20.0	g
Curing gas fraction in gas flow	40.0	%



User Results

User Result

Sand velocity at higher sand fraction

User Result Editor

User Result Definition – 541_FAW_Tracer_KS/v03

Create or edit an expression for an user result.

Result name: Pack_v

Description: Sandgeschwindigkeit bei hoher Packungsdichte

Output Definition

Calculation domain: All Groups

Scale unit: m/s

Expression 1 : 1 — Result type: Scalar3D

```
{/Cycle 1/Core Shooting/Sand Fraction} -50 > 0 ? {/Cycle 1/Core Shooting/Sand Velocity/Absolute Sand Velocity} :0
```

If 'Sand Fraction' - 50 is higher than 0 → Then show sand velocity, in other case is the value 0

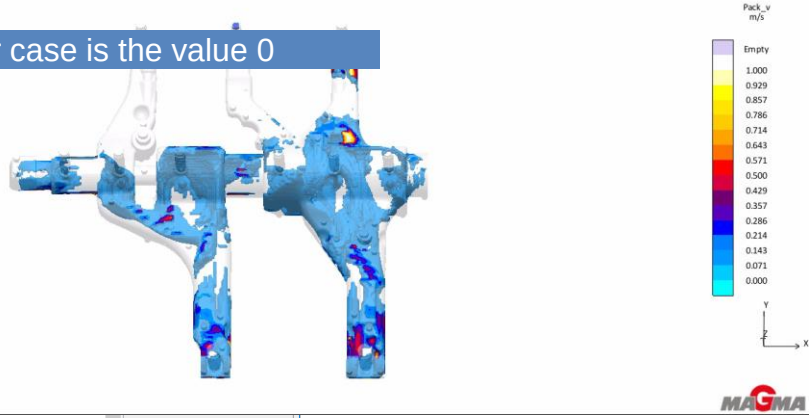
Arguments

Name	Type	Seq	Unit	Assigned Parameter
ARG1	Scalar3D	☑	-	/Cycle 1/Core Shooting/Sand Fract...
ARG2	Scalar3D	☑	m/s	/Cycle 1/Core Shooting/Sand Veloc...

Function Library | Results

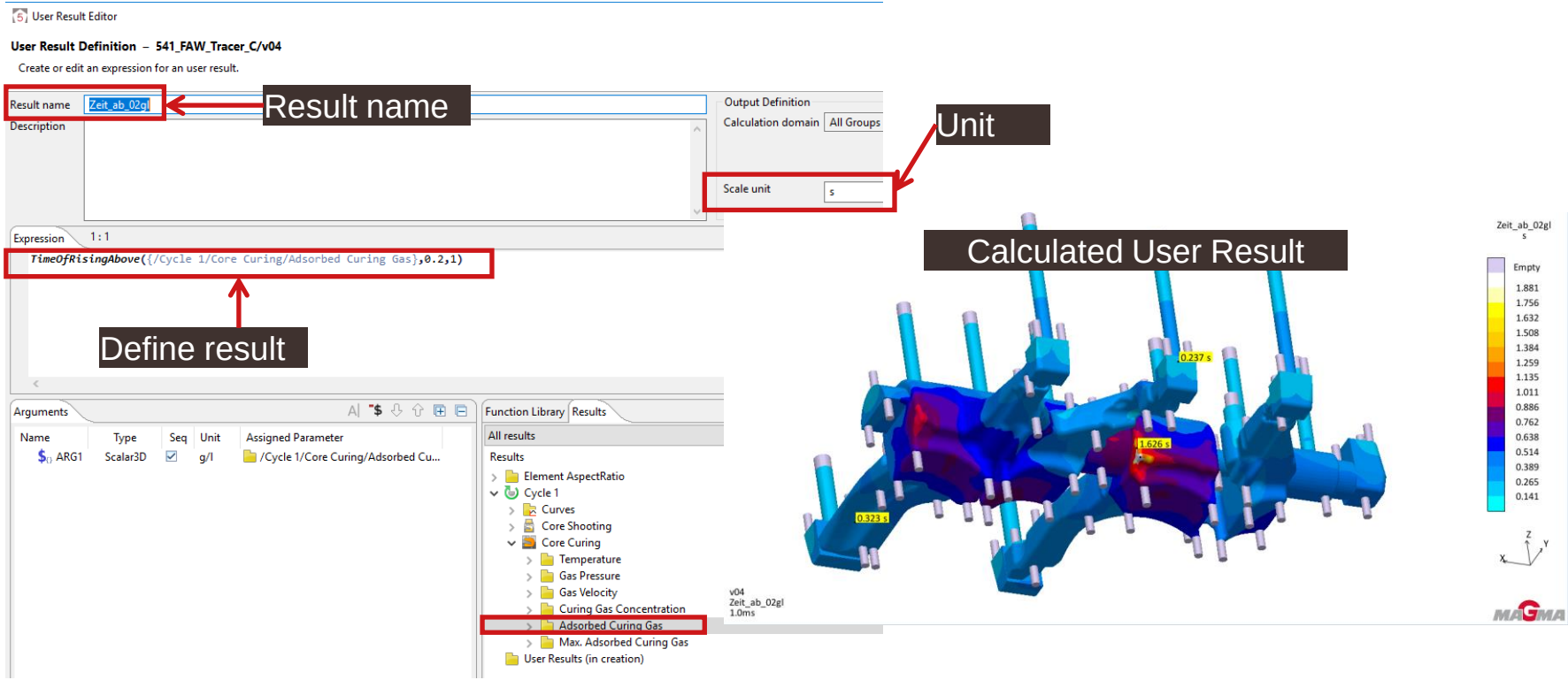
Filter

Functions	Description
Basic	
abs()	Absolute Value
acos()	Arc Cosine
asin()	Arc Sine
atan()	Arc Tangent
avg()	Average Value
ceil()	Ceiling
cos()	Cosine
exp()	Exponential Functi
floor()	Floor
ln()	Natural Logarithm
log()	Decimal Logarithm
max()	Maximum Value



User Result - Time of Rising Above

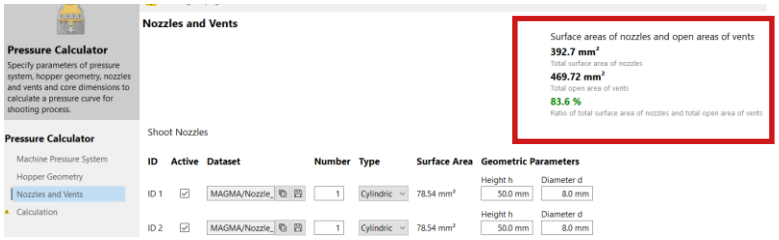
If critical concentration is reached …

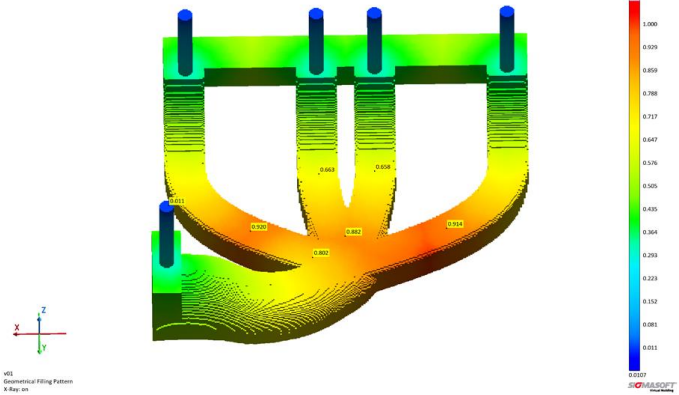


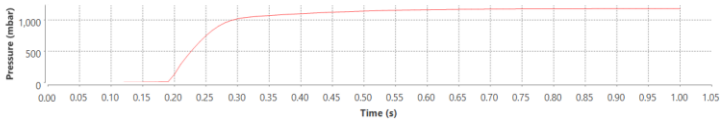
Nozzle / Vent Assisstant

Ideas for future development

- Core identification/describe shape-size-volume
- From pressure calculator:
  - Shooting pressure
  - Ration surface area nozzle/vents
  - Mass flow from nozzle
- Geometrical filling:







Thank you for your attention.

Ľuboš Pavľak

MAGMA Gießereitechnologie GmbH

l.pavlak@magmasoft.de