



International MAGMA User Meeting 2024

October 9-11, 2024

RADISSON BLU – Frankfurt

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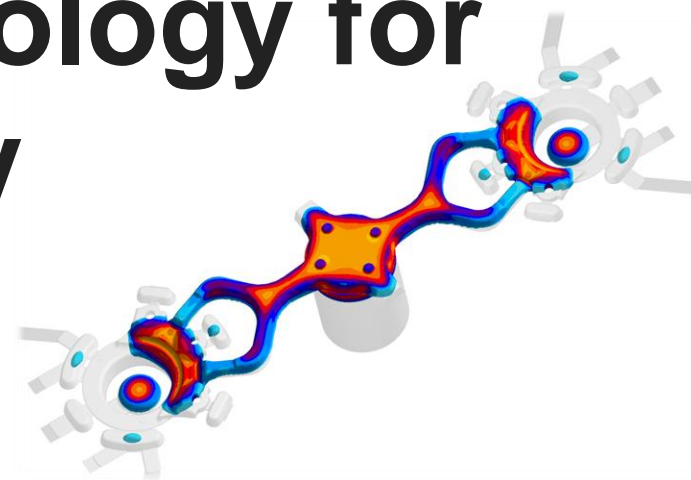


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Indirect Squeeze Casting Technology for the Automotive Industry



**ARE
YOU
READY
BEV
NO**



Dr. Milan Luňák – R@D manager – TOP Alulit s.r.o.



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Generally about our company...



Technologies:

- Gravity casting
- LPDC casting
- Squeeze casting
- CNC machining



Plan for 2024 – 15,5 mil. EUR
(in 2023 was 16,4 mil. EUR)



Employees – approx. 130



Purely Czech capital - 100% has
Thein industry



Automotive business is about 50% of all turnover !

We are „only“ Tier 2 supplier !

Milestones:

- Since 2005
- IATF certification 2013
- First experience with Squeeze casting technology 2018
- Start with MAGMA SW 2019
- Acquisition 2024





Some our parts go to automotive giants...

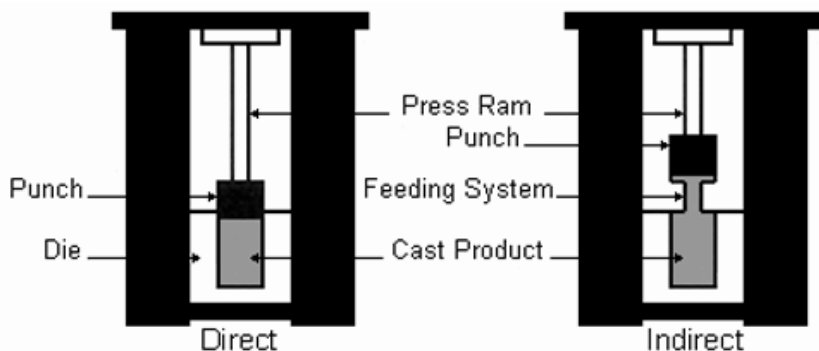




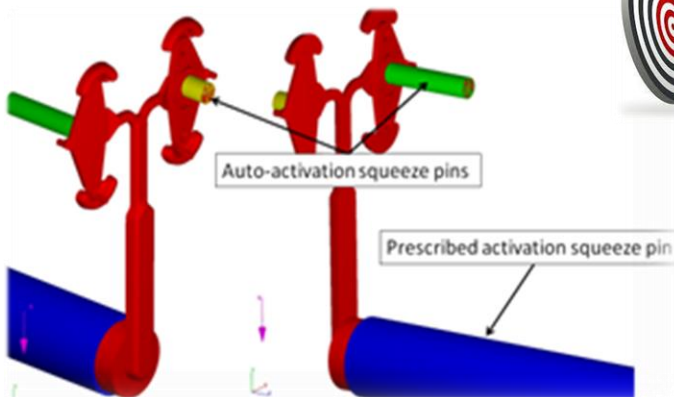
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Basic information about Squeeze casting technology...



Compare Direct and Indirect perform



Local squeeze casting pins – that is different !

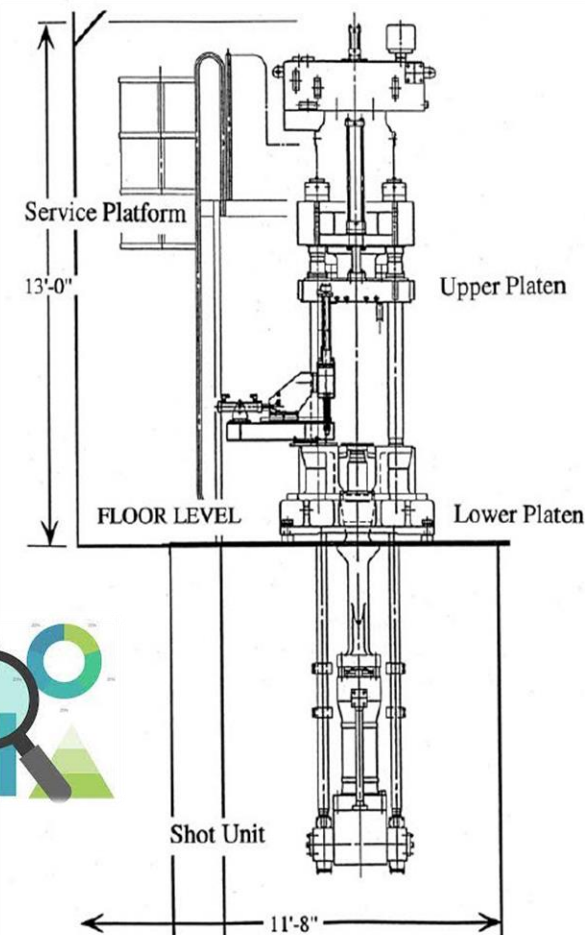
The comparison of Squeeze casting & Die casting

Casting Method	Mold intake	Castings solidified	Casting pressure (kg/cm ²)	Intake speed (m/s)	Max shot Speed (m/s)	Air contents (c.c./100g)	Property (c.c./100g)
Squeeze Casting	Thick	on liquid state	600 - 2000	0.5 - 2.0	4	1 - 2	High strain and less air holes
Die casting	Thin	on gaseous state	150 - 600	30 - 70	10	10 - 30	Normal

The most important parameters from technical and quality point of view !

Due to the filling parameters and specific pressure, we call this technology hybrid...

Schema of Indirect Squeeze casting machine

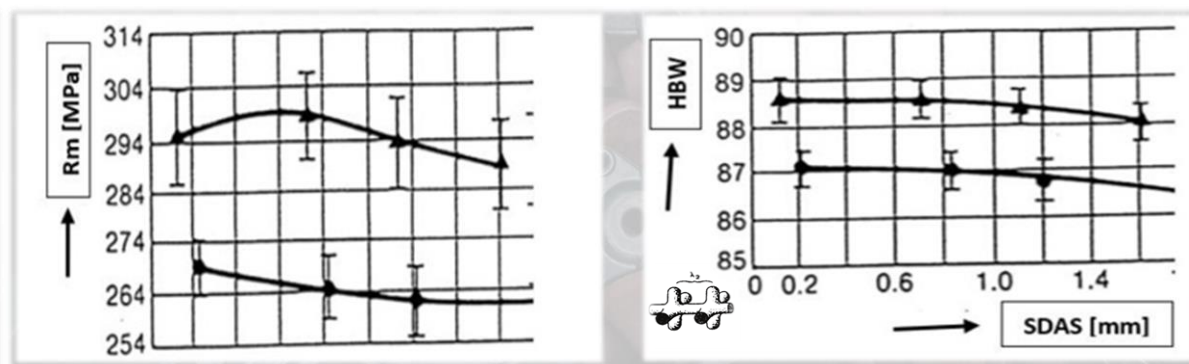
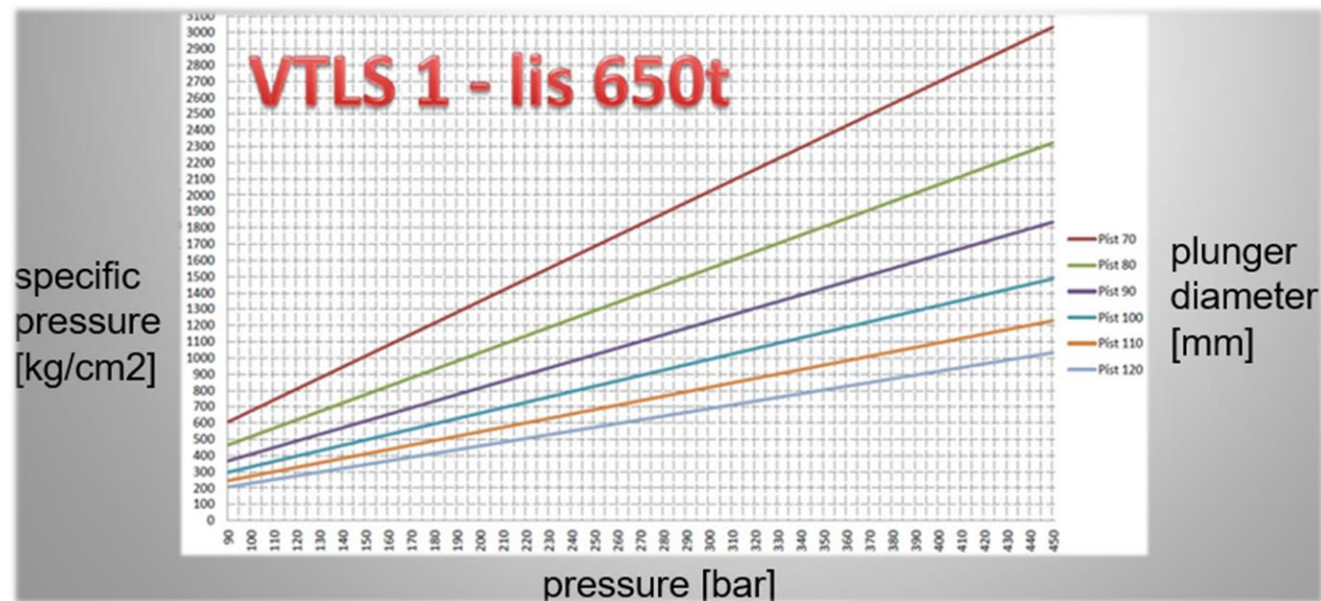




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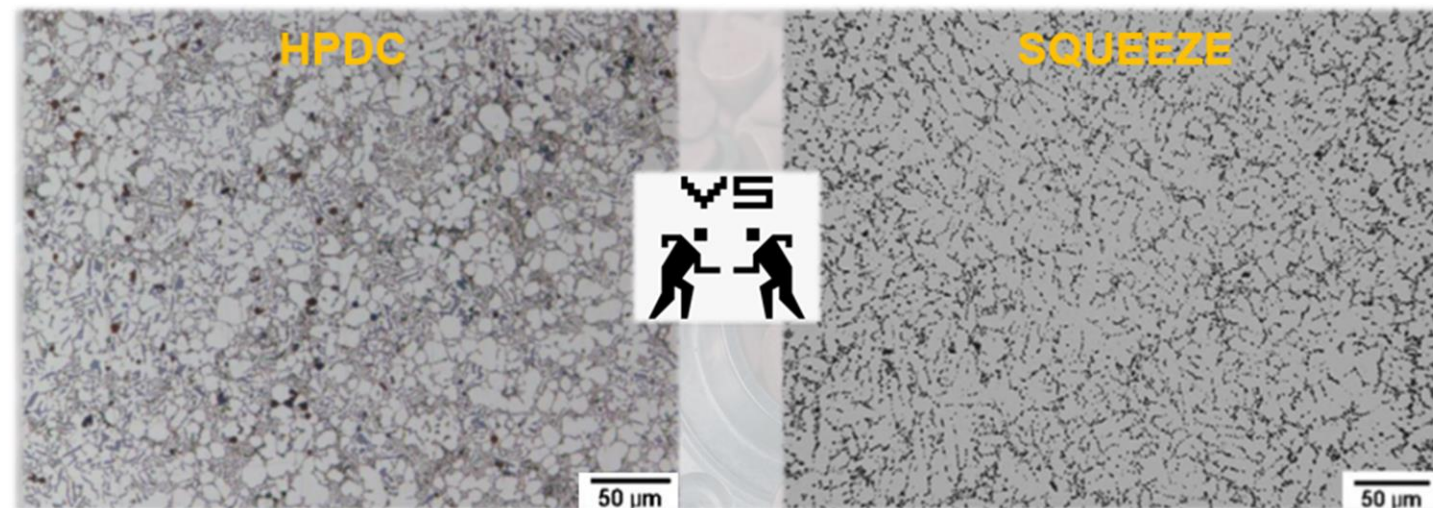
Parameters and results of Squeeze casting technology...

Mechanical properties



Technical advantages:

- Less pores than HPDC castings
- Better microstructure than HPDC castings
- Higher mechanical properties than HPDC castings
- Tightness comparable to LPDC
- Parts can be heat treated
- Dimensional accuracy comparable to HPDC
- Surface roughness comparable to HPDC
- Corrosion resistance better than HPDC
- Abrasion resistance better than HPDC

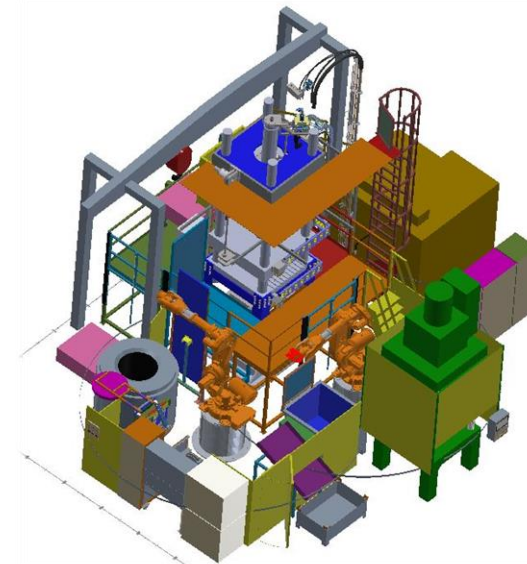


Real photos of machines and devices in our company...

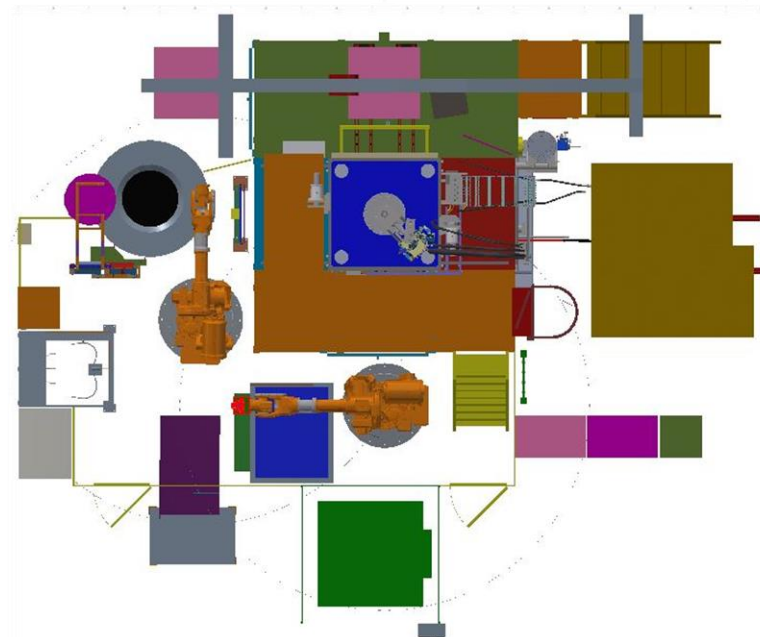


TECHNICAL EXPERTISE

*Clamping force
650 tones*



*Clamping force
1000 tones*





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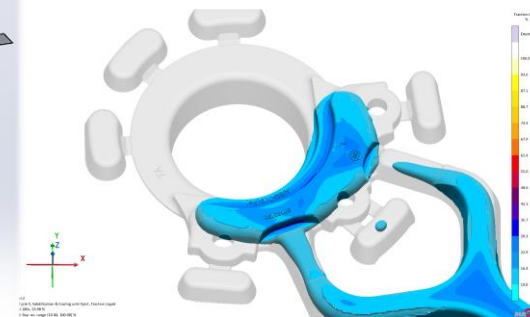
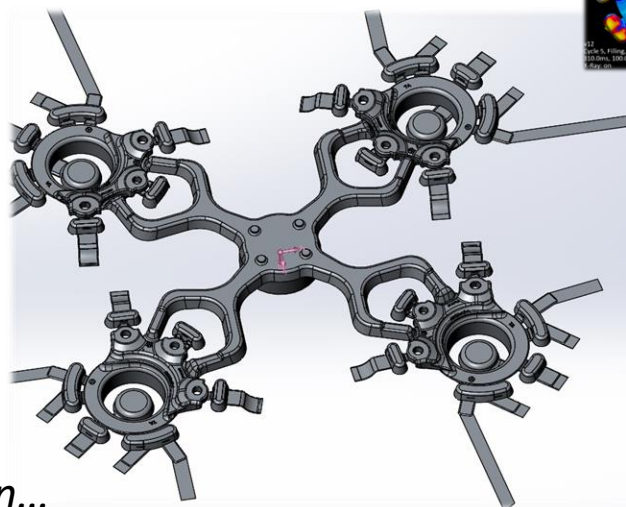
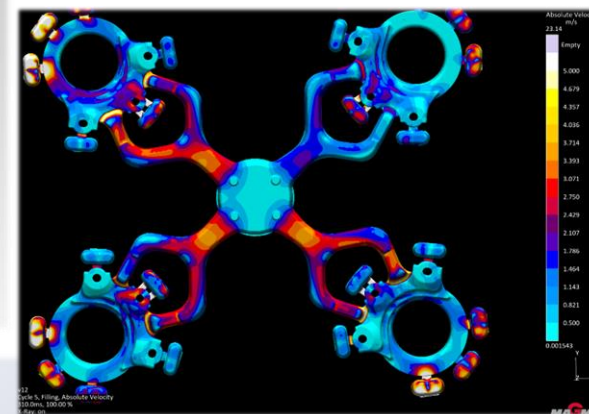
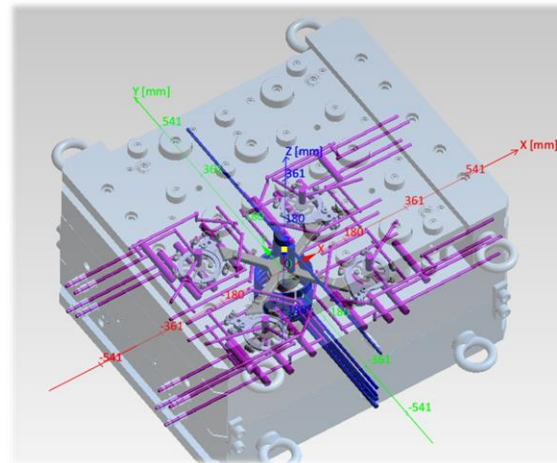
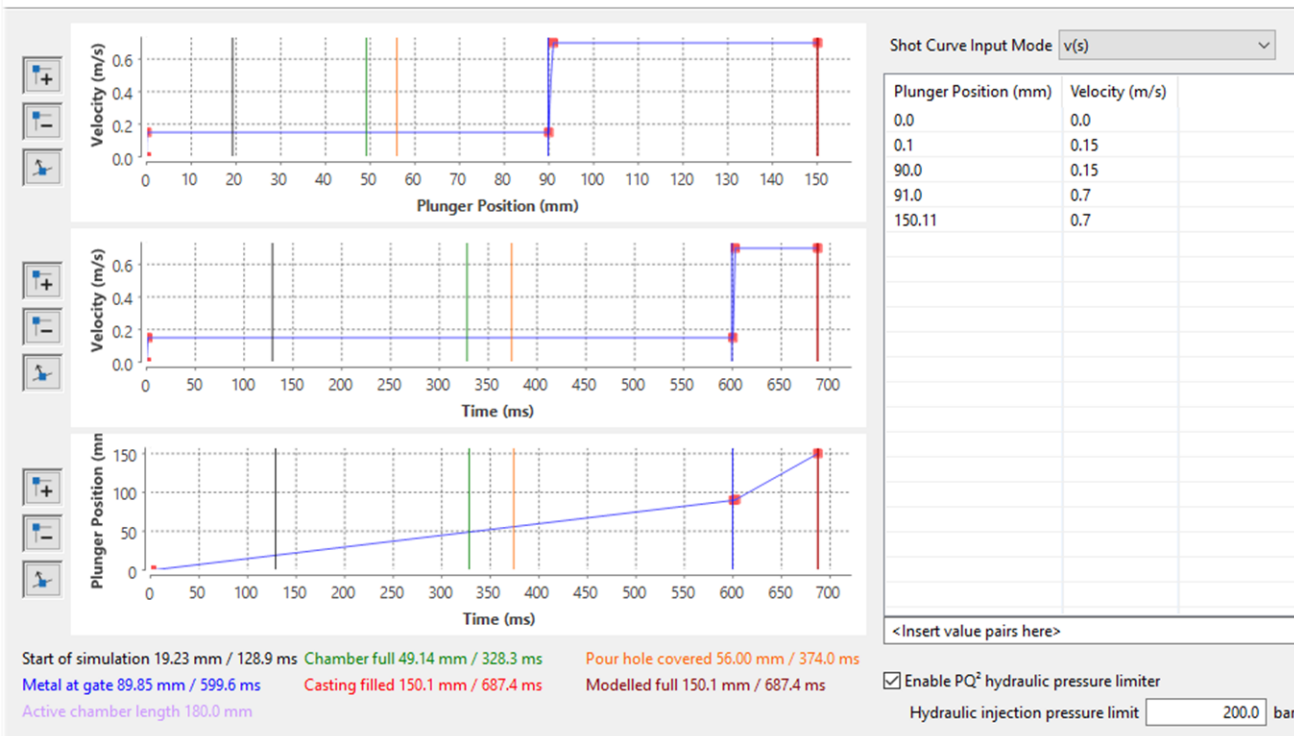


Squeeze casting and simulation in MAGMASOFT[®]...

For calculations we use **HPDC Cold Chamber module** and regularly perform verifications with results from real production . We also use supervision through colleagues from the official Czech MAGMA office.

Shot Curve Definition - Shot Curve Coordinates

Modify or enter coordinates of the shot curve.



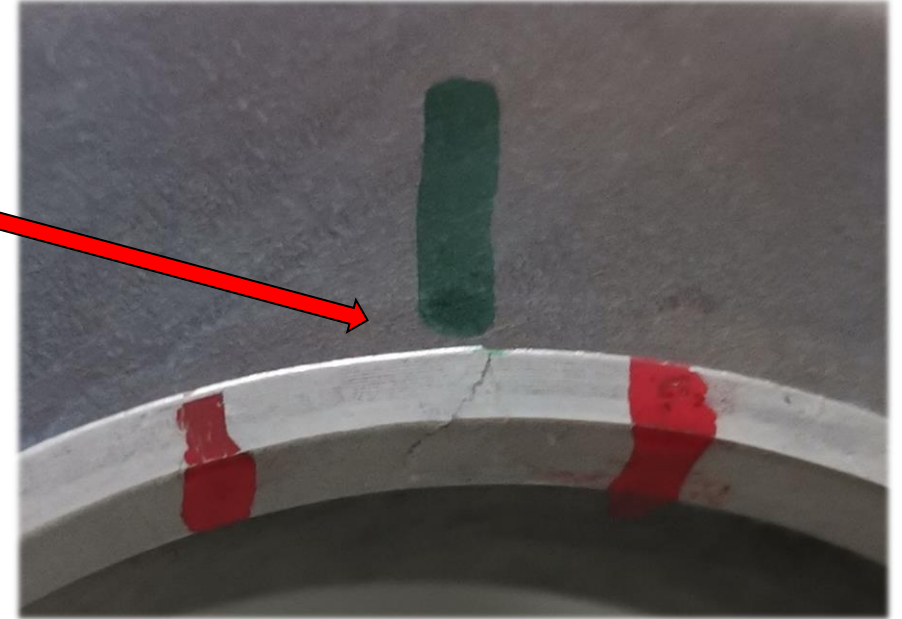
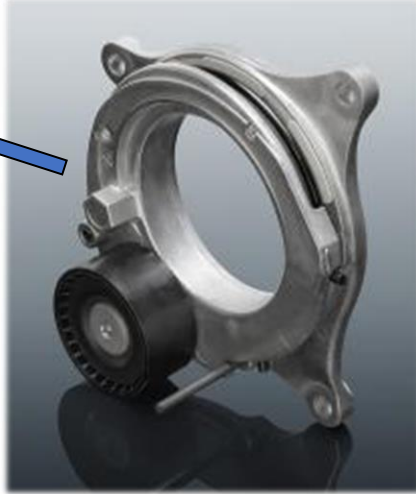
In this case, more than 19 versions were created and analyzed before SOP and many others during serial production for optimization...



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Specific solved example – case study: Belt tensioner for the combustion engine of a passenger car



The main reason for the change of manufacturing technology from the original HPDC to Squeeze casting was the **cracking** of the part **during pressing connection** and subsequent assembly.

It is necessary to achieve a **better material microstructure** and thus **higher ductility**, which ensures a significantly **lower percentage of parts damaged** in this way.

Simulation in MAGMASOFT[®] was **very important** to solve this specific casting technology, in fact, it played an irreplaceable role. We were **very pressed in terms of time!** Deliveries were just in time !



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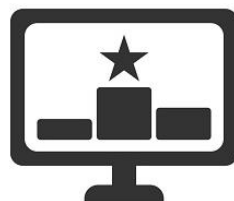


Case study solved by simulation in MAGMASOFT[®]...

Used criteria calculated in MAGMASOFT[®] to evaluate the suitability of the technology:

Filling

- Temperature
- Air
- Entrapped Air Mass
- Absolute Velocity



Ranking



Solidification

- Fraction Liquid
- Hot Spots
- Porosity

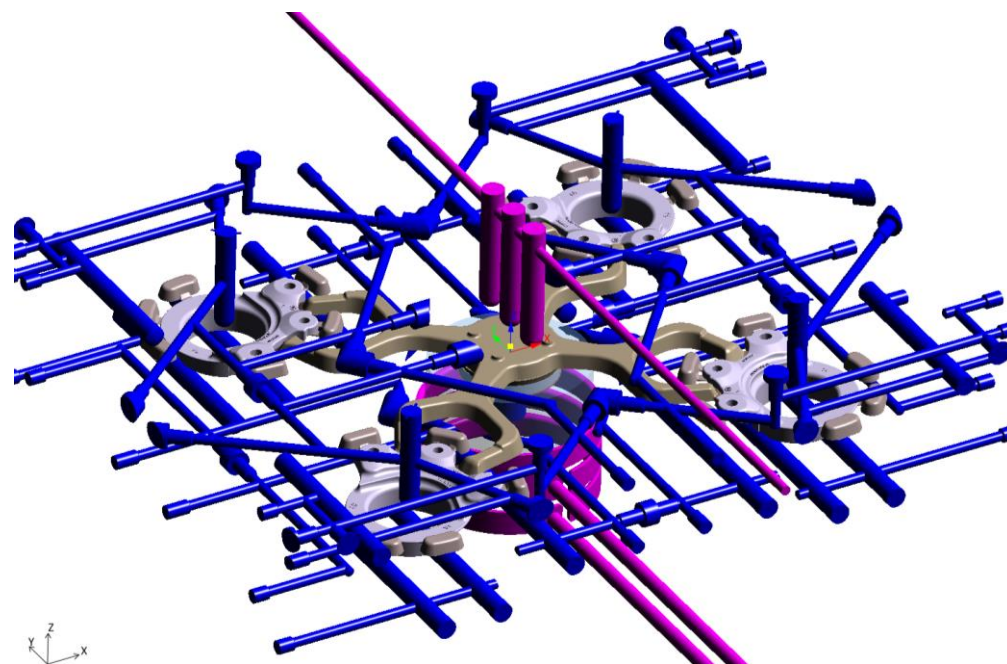


RESULT

Initial Casting Geometry



Initial Cooling/Tempering System





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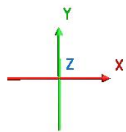
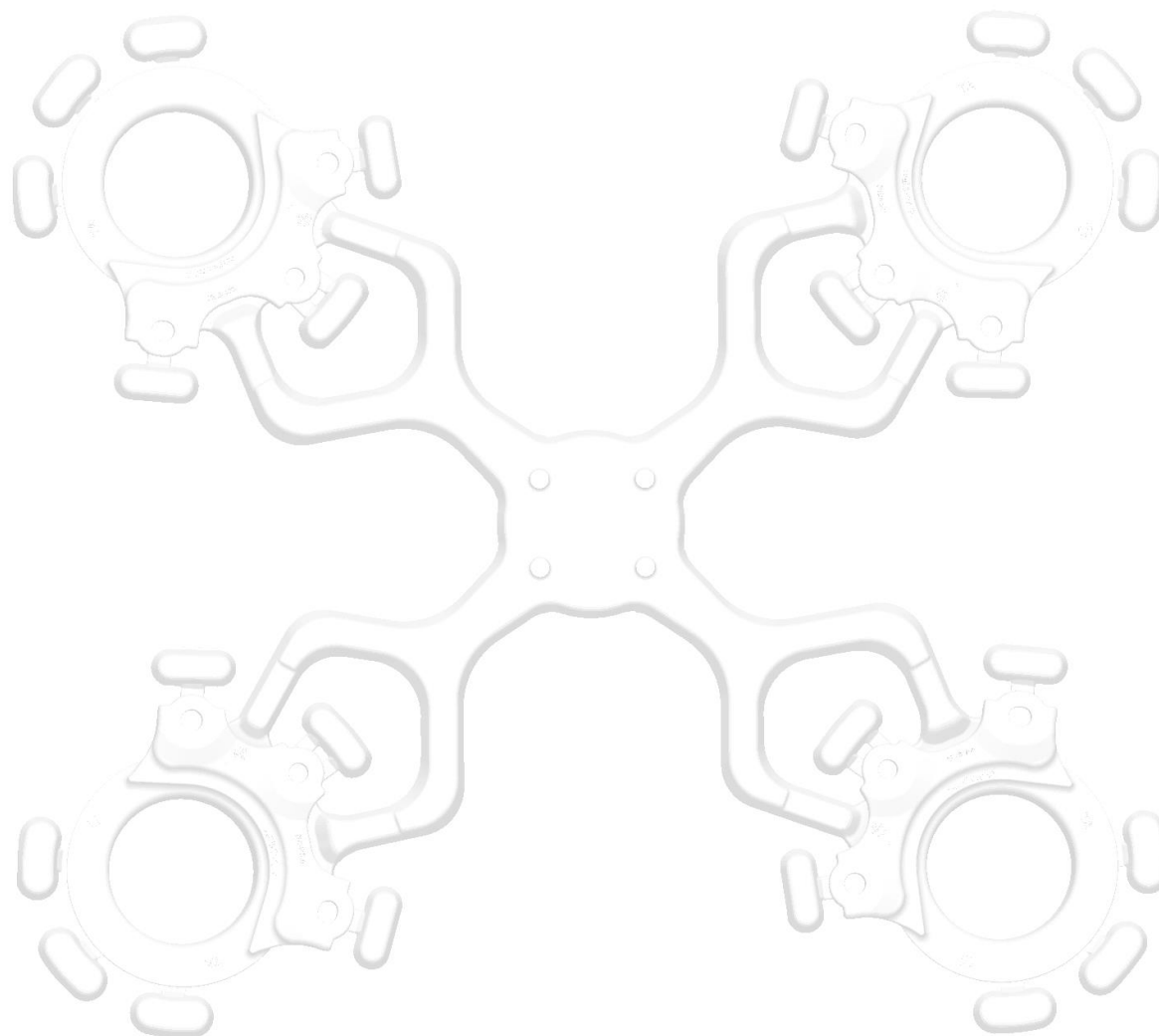
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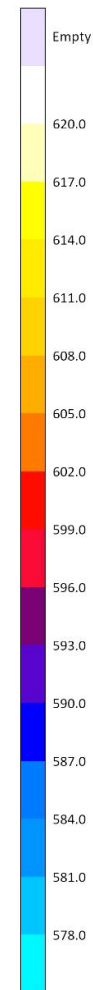
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v12
Cycle 5, Filling, Temperature
53.7ms, 0.00 %
X-Ray: on

Temperature
°C



Filling temperature

*No problematic areas are visible
- all 4 cavities will be fully filled*

*In this design, the mold
was realized and sampled.*

*This means that 12
simulation iterations were
performed before
production began.*





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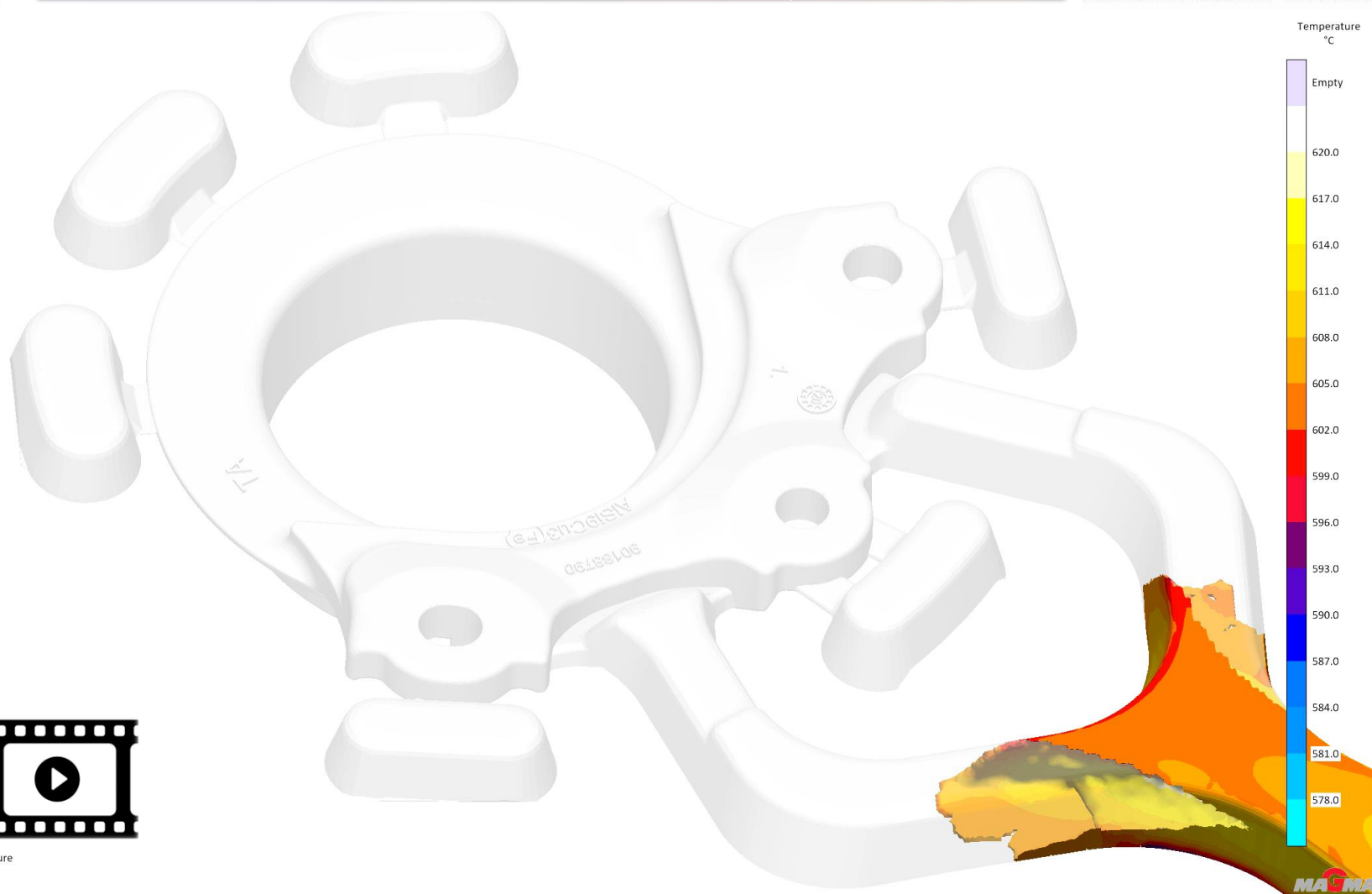
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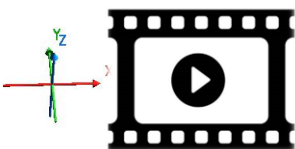


Filling temperature

The detail of the selected cavity confirms that there will be no problem in filling the cavity and therefore running-in.

Casting temperature is 720°C.

Problematic areas would have to be significantly below liquidus, but we don't see those.



v12
Cycle 5, Filling, Temperature
132.5ms, 30.01 %
X-Ray: on



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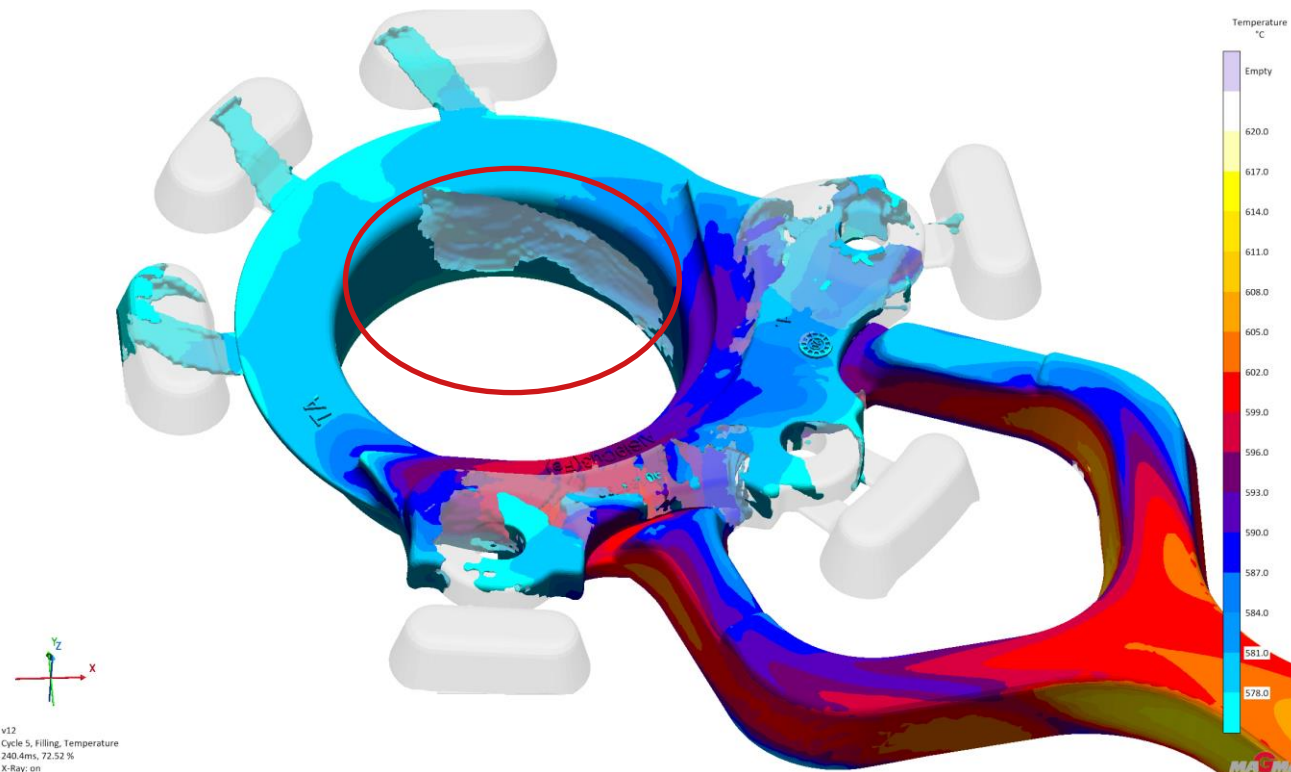
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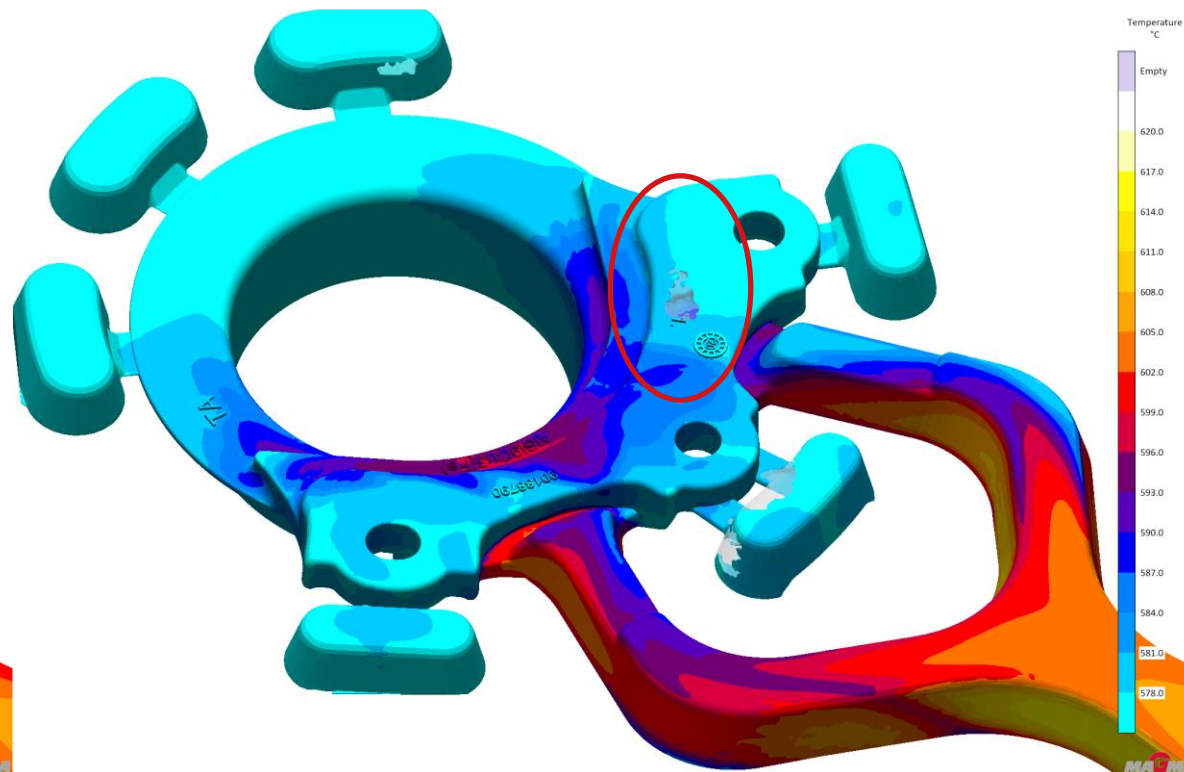
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Filling temperature

At 72.5% filled, there are indications implying the possibility of closed air in the highlighter area.



Filling temperature

At 96% filled, there are also indications implying the possibility of closed air in the marked area – different location.



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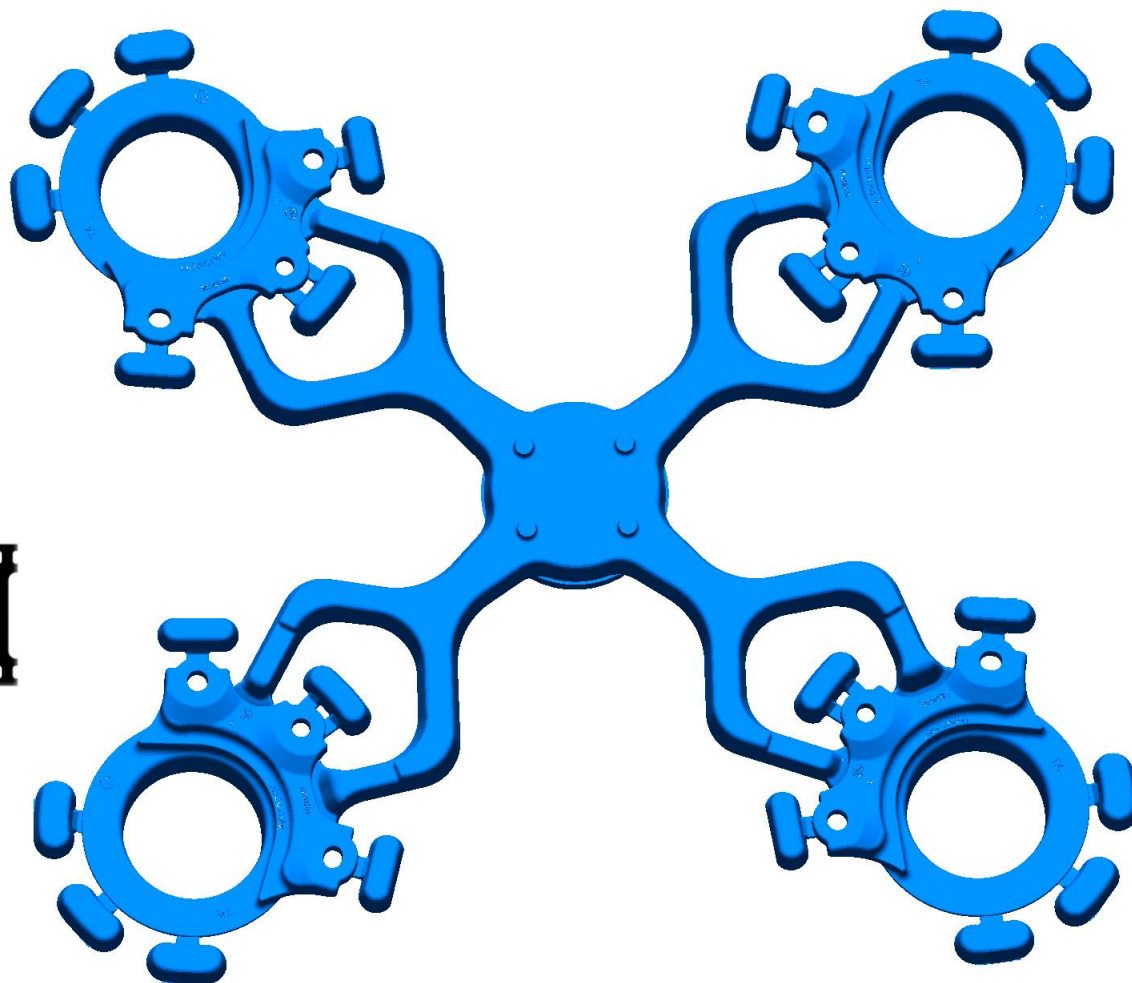
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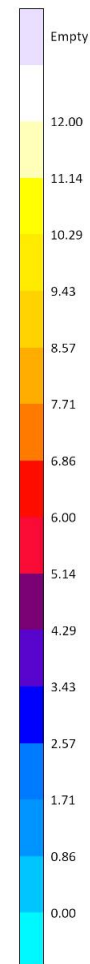
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Air
kg/m³



Filling Air

Course of residual air in the casting during filling.

As expected, the most massive part of the casting has the most air.

The largest air pockets are formed correctly in the overflows (kidneys) - orange to red in color.

Details are shown in the following pictures on next slide.

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v12
Cycle 5, Filling, Air
53.7ms, 0.00 %
X-Ray: on, range [0.50, 1.20] kg/m³



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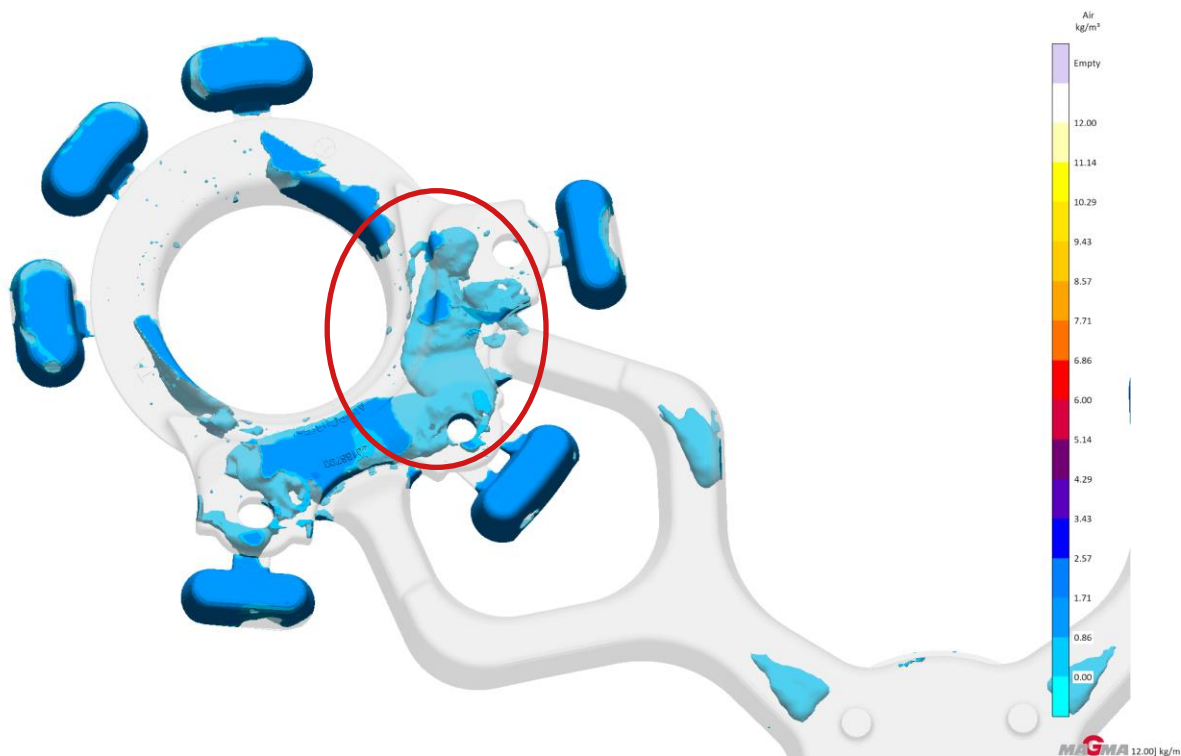
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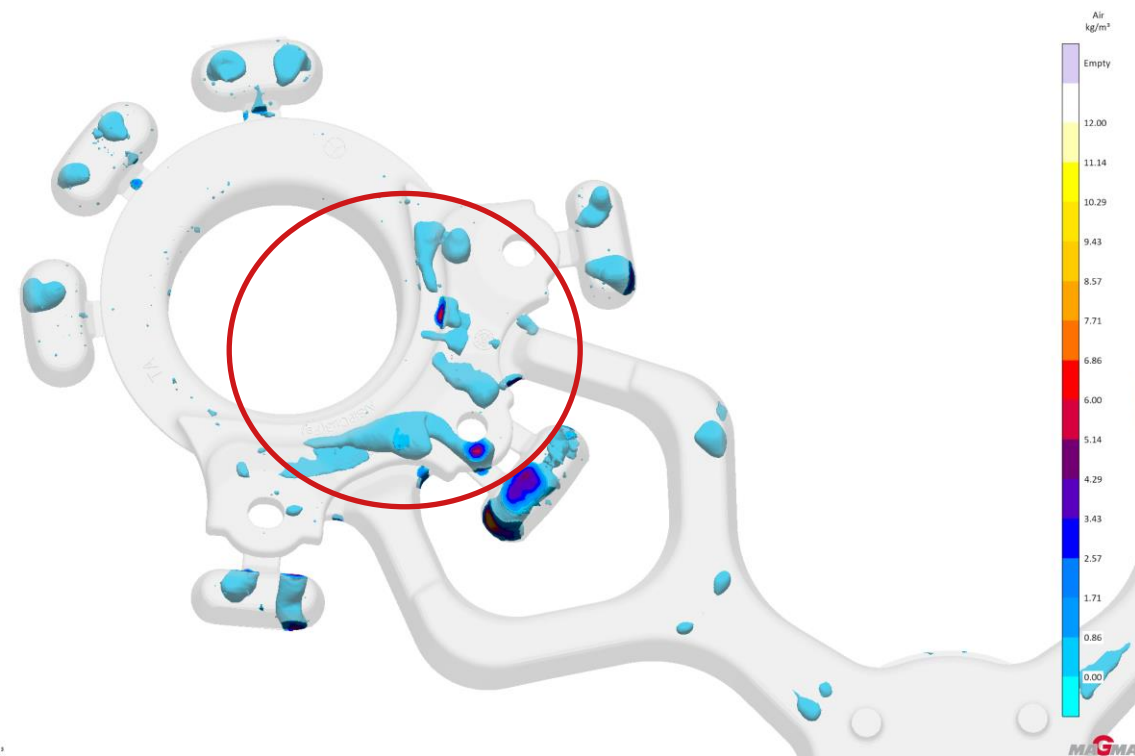
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Filling Air

At 80% filled, there are indications implying the possibility of closed air in the marked area.



Filling Air

At 100% filled, there are indications implying the possibility of closed air in the marked area. It's just a suspicious area doesn't necessarily mean a defect in the casting.



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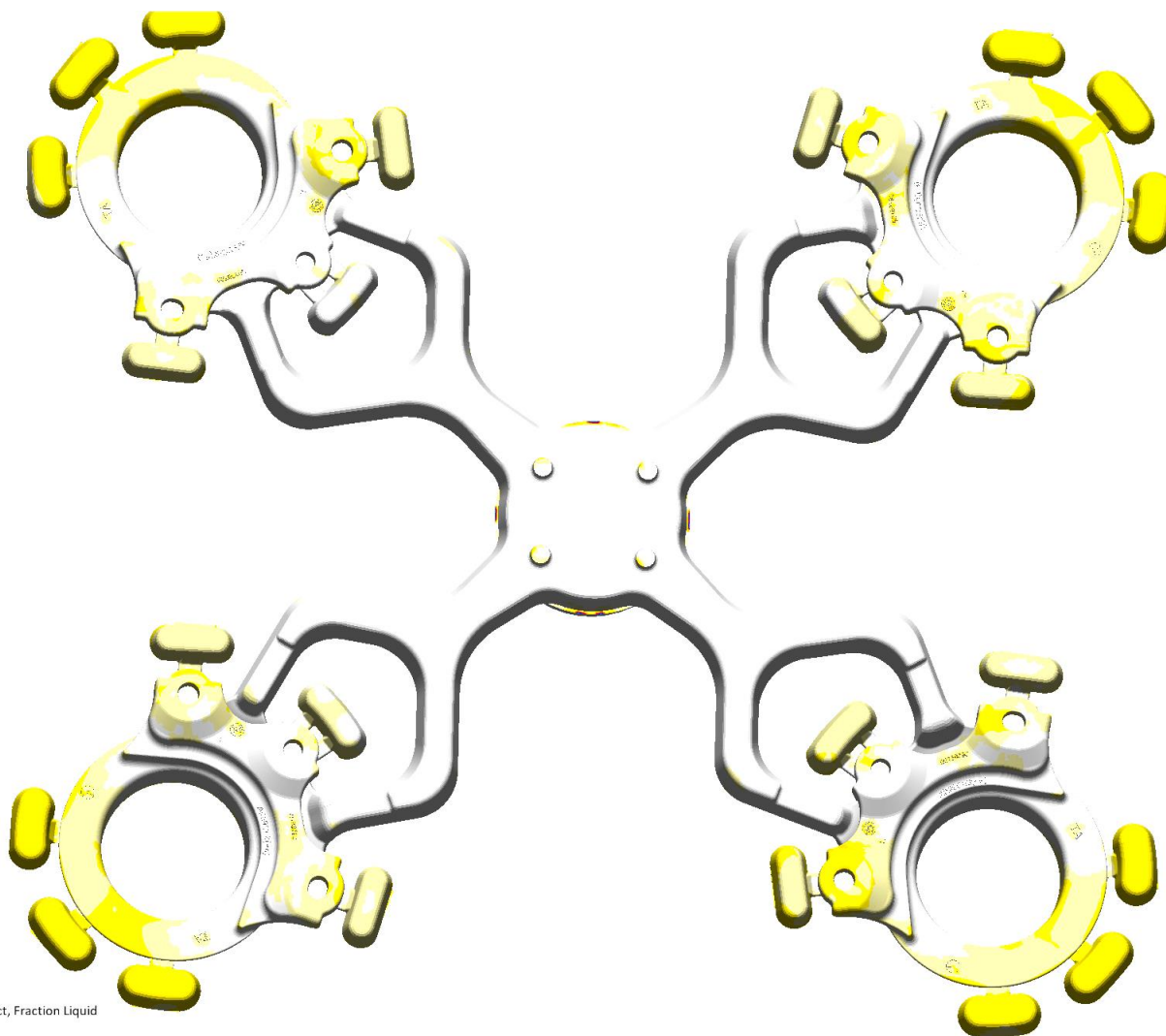
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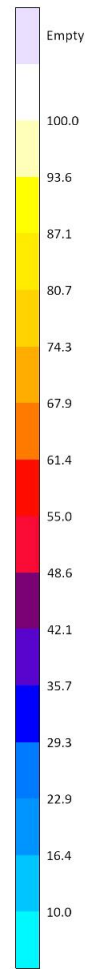
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Fraction Liquid
%

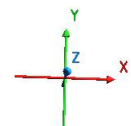


Solidification Fraction Liquid

During solidification, some locations are recorded where directed solidification towards the biscuit is interrupted. This indicates insufficient cross-sections of the gating system. Mainly in ingates areas.

The presentation also shows the solution to these possible difficulties on next slides.

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v12
Cycle 5, Solidification & Cooling until Eject, Fraction Liquid
310.2ms, 98.83 %
X-Ray: on, range [10.00, 100.00] %



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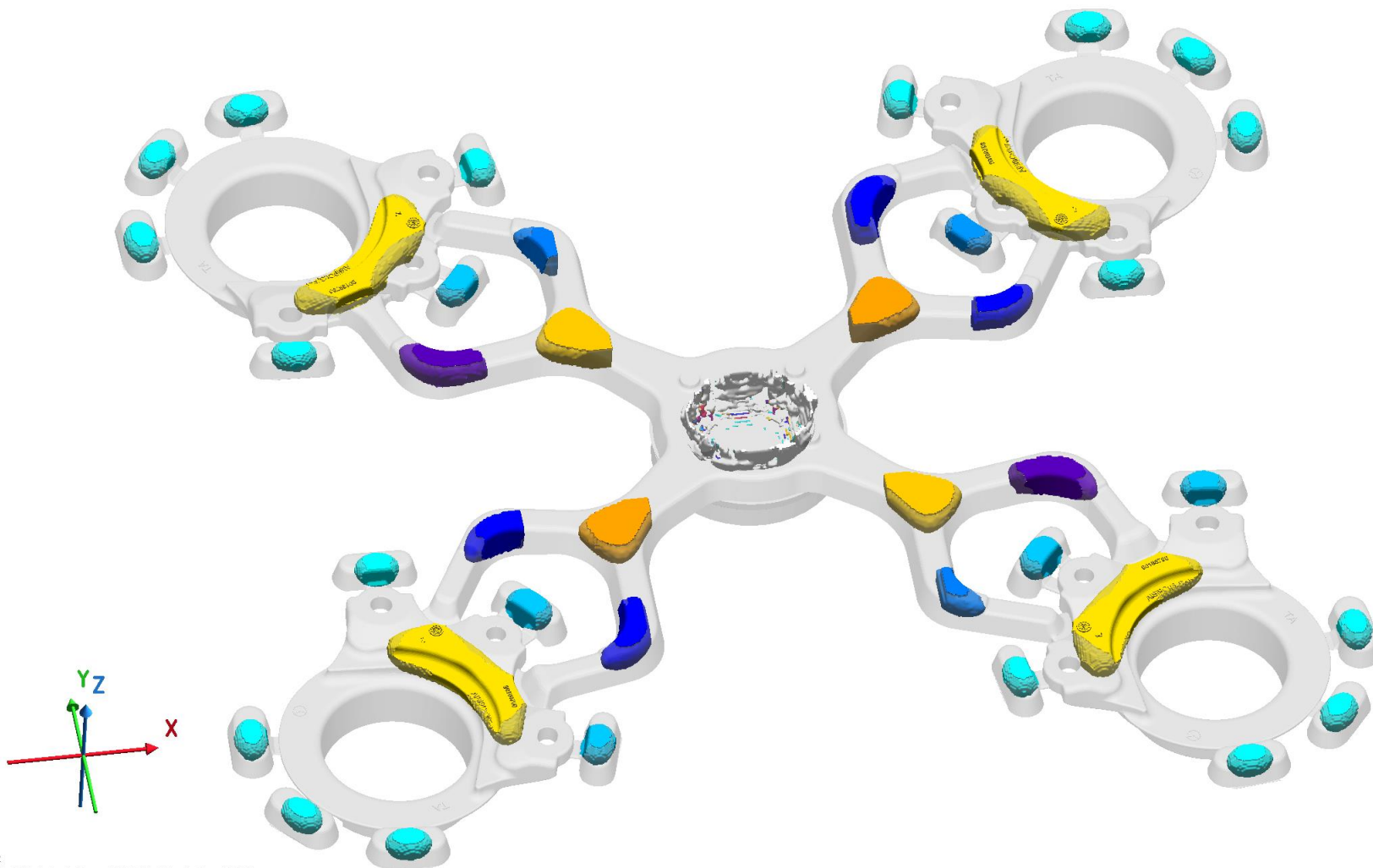
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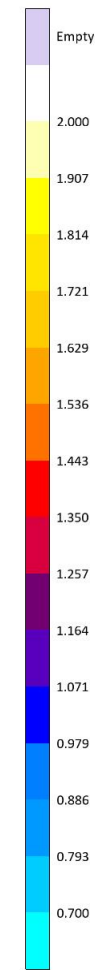
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Hot_Spot_Time_F
s



Solidification Hot Spot Time

During solidification some locations are recorded where directional solidification towards the biscuit is interrupted. This indicates insufficient cross-sections of the gating system. Mainly in ingates areas.

The presentation also shows the solution to these possible difficulties on next slides.

v12
Cycle 5, Hot_Spot_Time_HPDC, Hot_Spot_Time_HPDC
20.310s, 93.80 %
X-Ray: on

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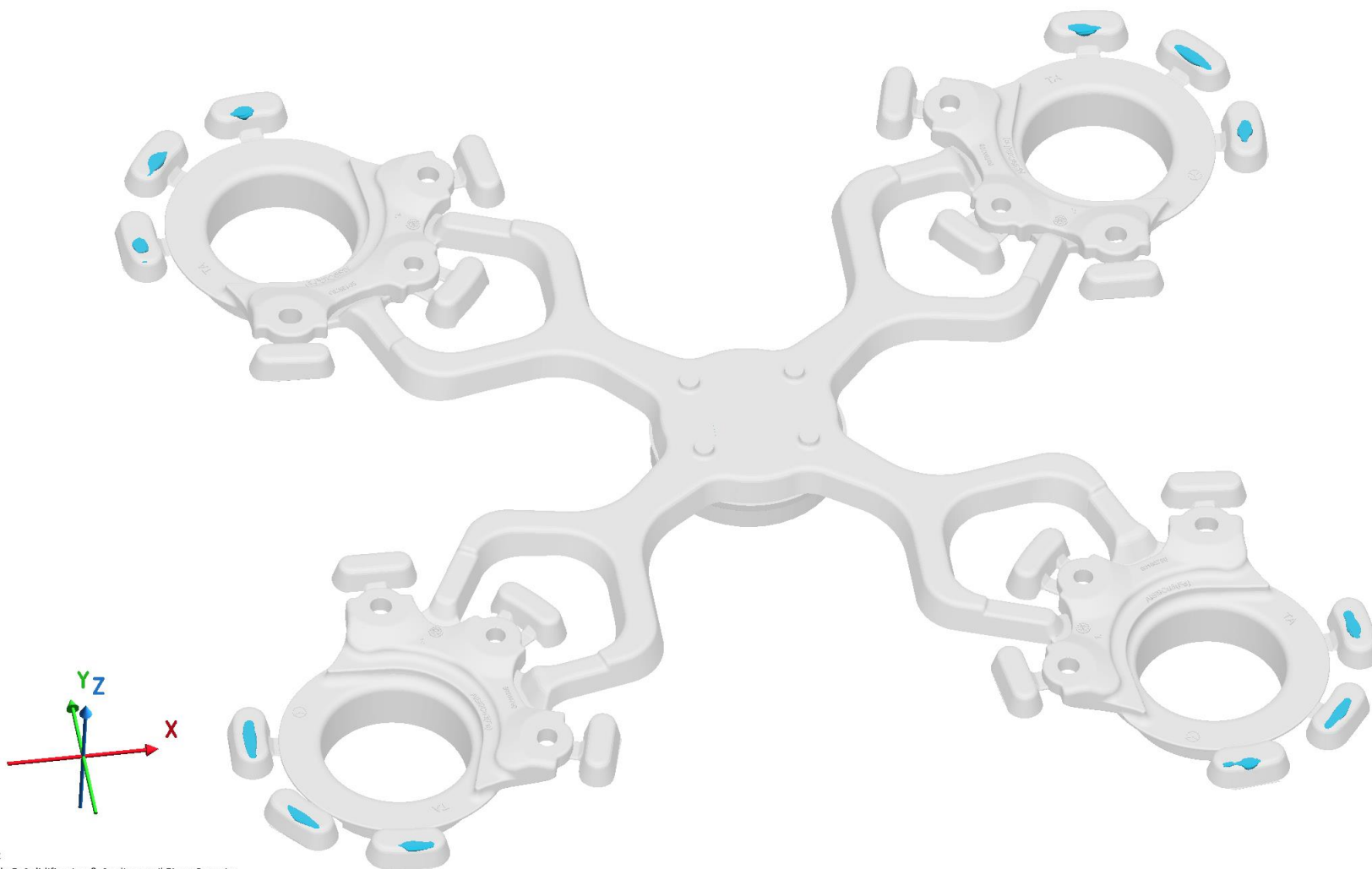
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Porosity
%

Empty

69.38

64.42

59.47

54.51

49.55

44.60

39.64

34.69

29.73

24.78

19.82

14.87

9.91

4.96

0.00

Solidification Porosity

This criterion does not show any significant porosity in the casting, which confirms the suitability of the proposed technology.

There will be no shrinkage in the casting, but microporosity is expected. This is evaluated by a different criterion.

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v12
Cycle 5, Solidification & Cooling until Eject, Porosity
20.310s, 99.42 %
X-Ray: on, range [1.00, 69.38] %



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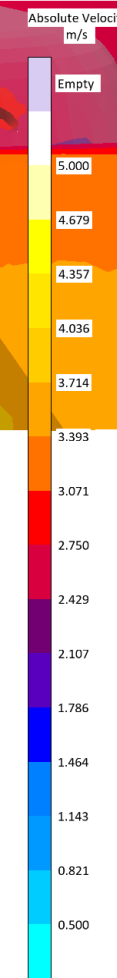
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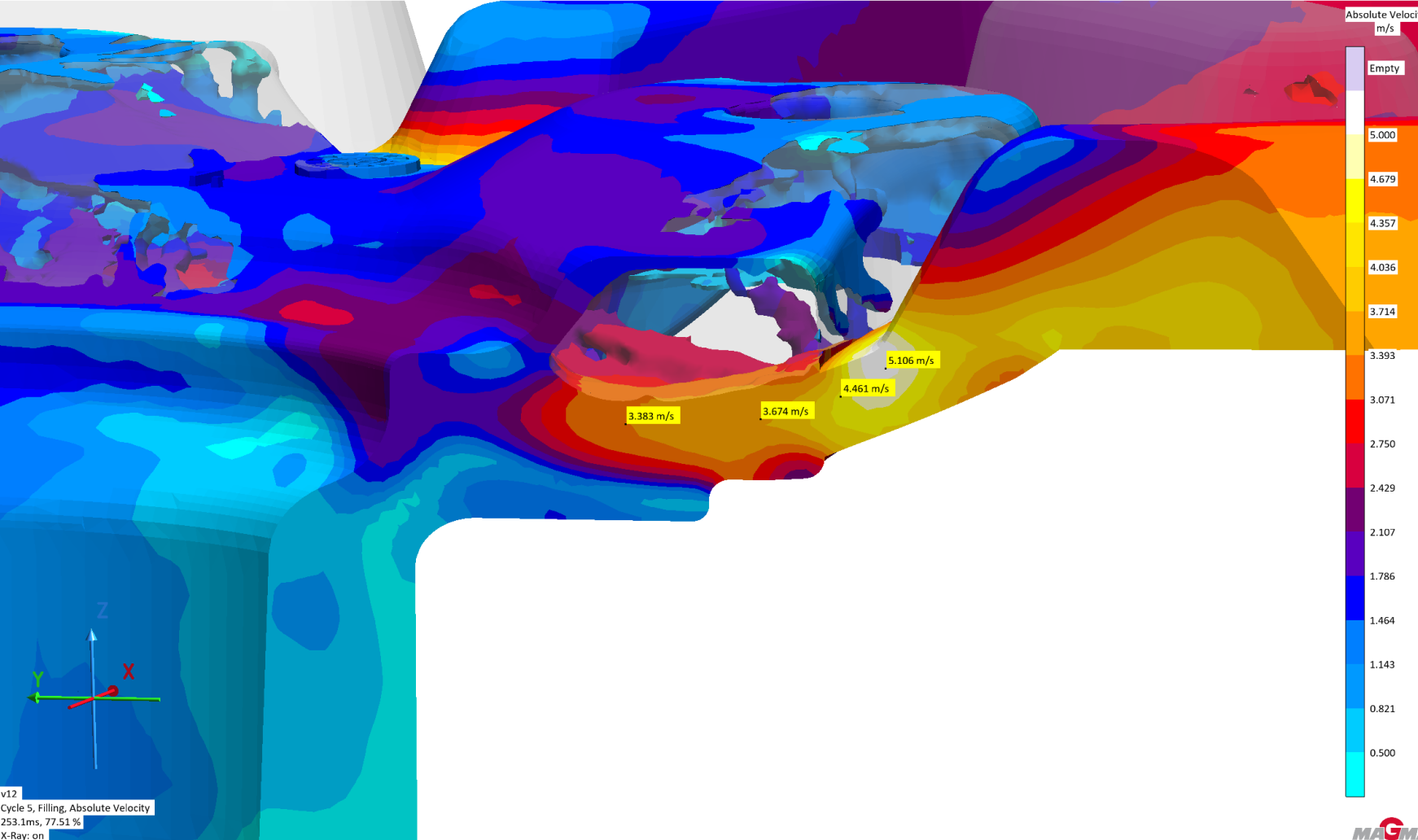
Filling Absolute Velocity

This detail is more to complete the information. This is the melt speed at filling at the stage of approx. 77% filling of the casting.

This is a speed in ingate system that is significantly lower than is usual at HPDC casting technology, but the goal of Squeeze casting is to be at even lower speeds...around 1 m/s.



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v12
Cycle 5, Filling, Absolute Velocity
253.1ms, 77.51 %
X-Ray: on



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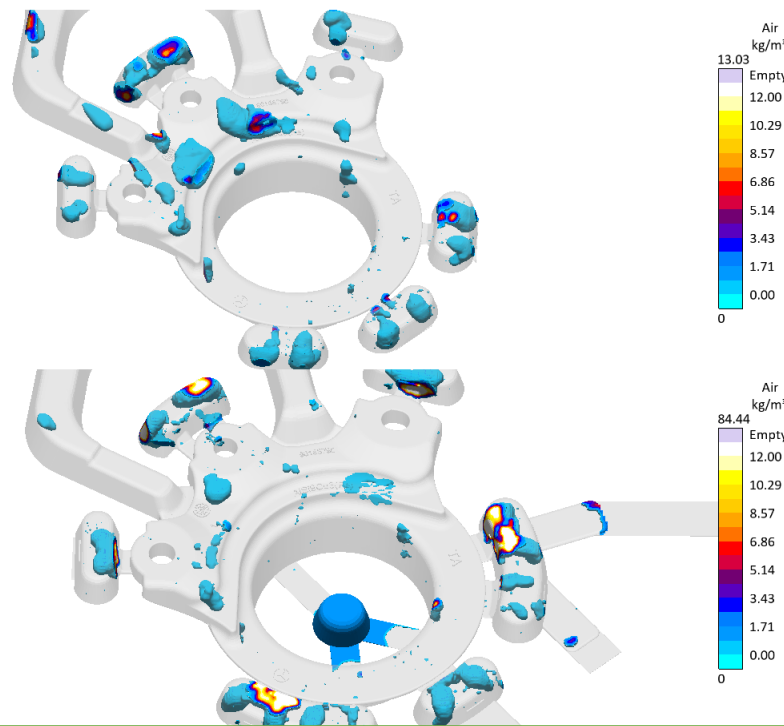
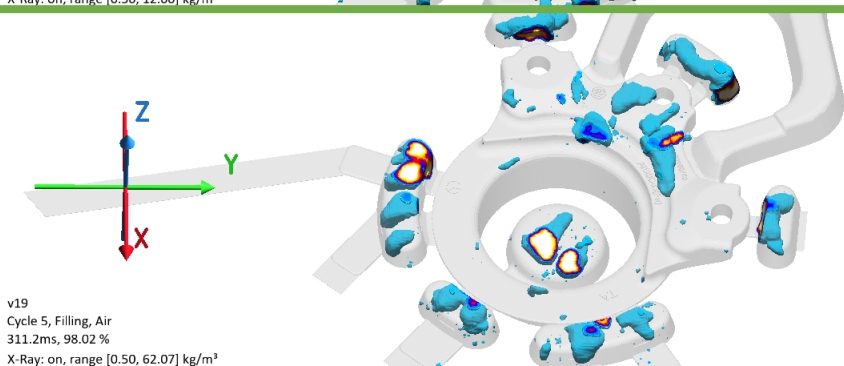
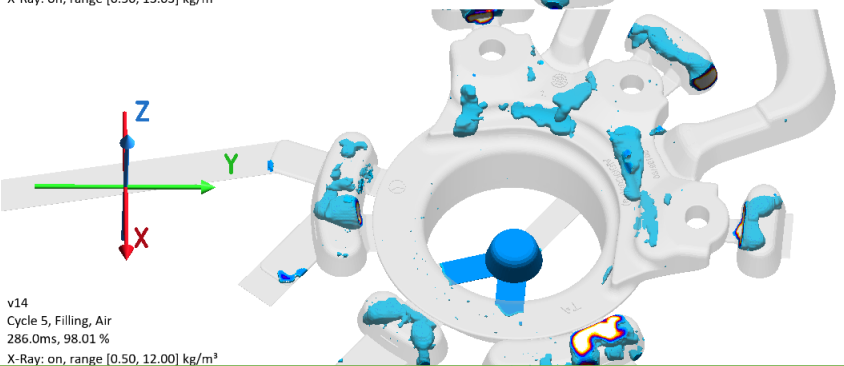
Impact of technical changes

Filling Air – comparison

Direct comparison of several variants of venting solutions.

The addition of overflows (kidneys) brought an improvement in terms of the enclosed air in the casting.

The most advantageous result came from the solution with central venting - highlighted in the picture.

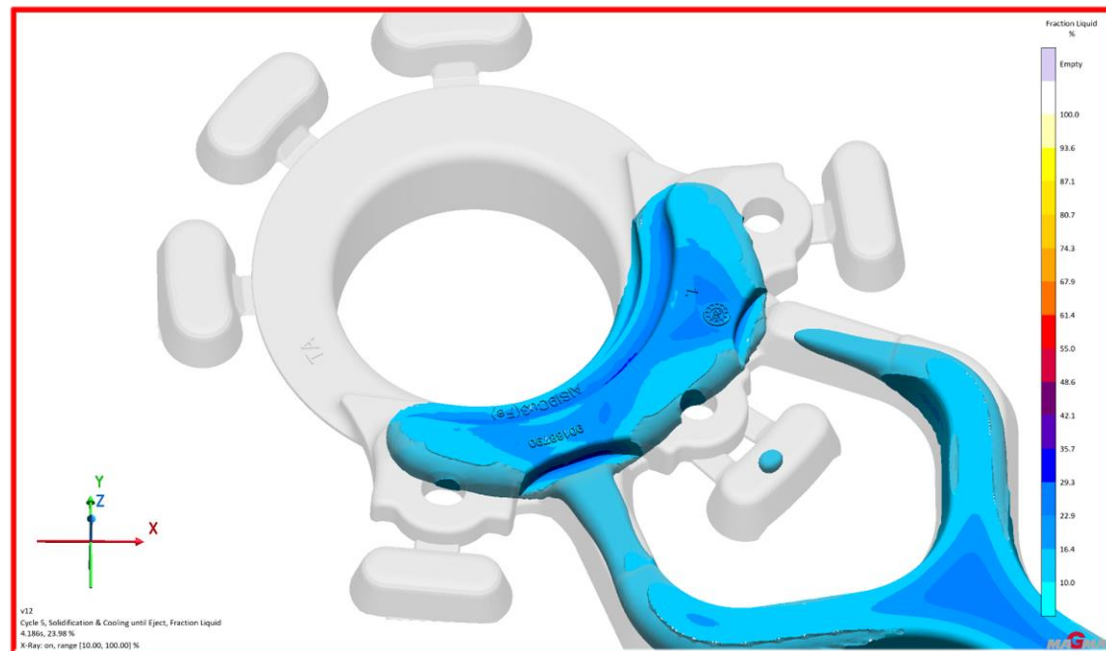




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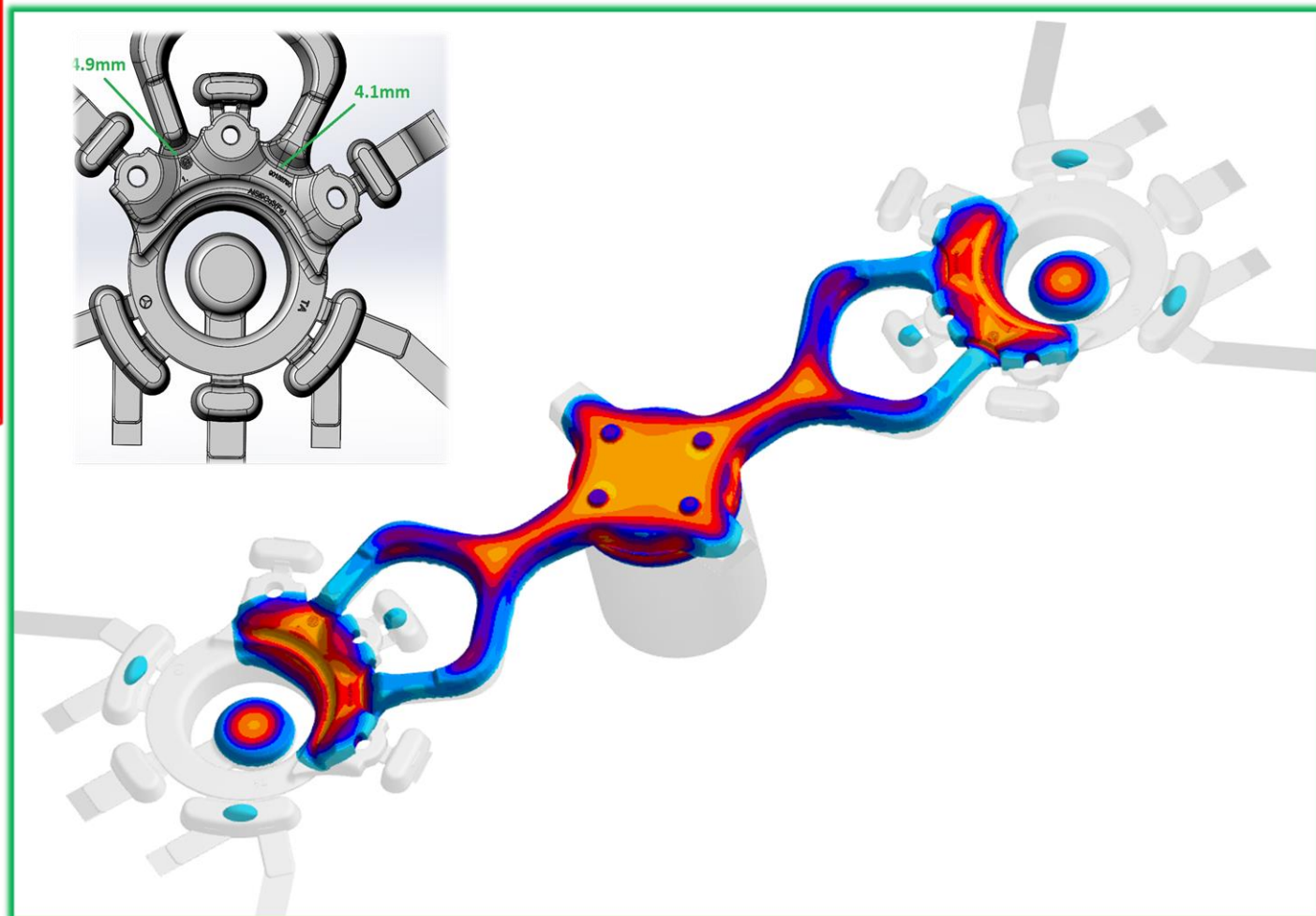


The result after adjusting wall thickness at the ingate and also blinding of 2 cavities shows a significant improvement for feeding effect and ensuring directed solidification while using the full squeeze function/effect.



Impact of technical changes

This detail shows the interruption between the gating system and the casting. The feeding effect does not work completely correctly due to the small wall thickness at ingate.





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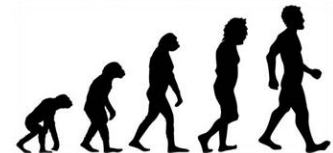
Case study conclusions and next direction including visions...

- ✓ *Due to fundamental technological changes the scrap rate was significantly reduced at the customer from the original many tens of % using the HPDC technology*
- ✓ *Internal scrap rate was reduced to an economically acceptable level*
- ✓ *Managing to fulfill the customer's orders repeatedly with no risk of stopping the production line in the car factory at final customer BMW or Daimler !*
- ✓ *The main reason why this technology was chosen worked and functionally, the supplied parts are OK (ductility is satisfactory)*
- ✓ *Although we no longer run this project, we have been able to supply tens of thousands of serial parts and we have verified that we can handle this technology – SQUEEZE CASTING !*

Our vision for MAGMASOFT®...to develop further...to increase the usage of numerical optimization and calculations as much as possible...

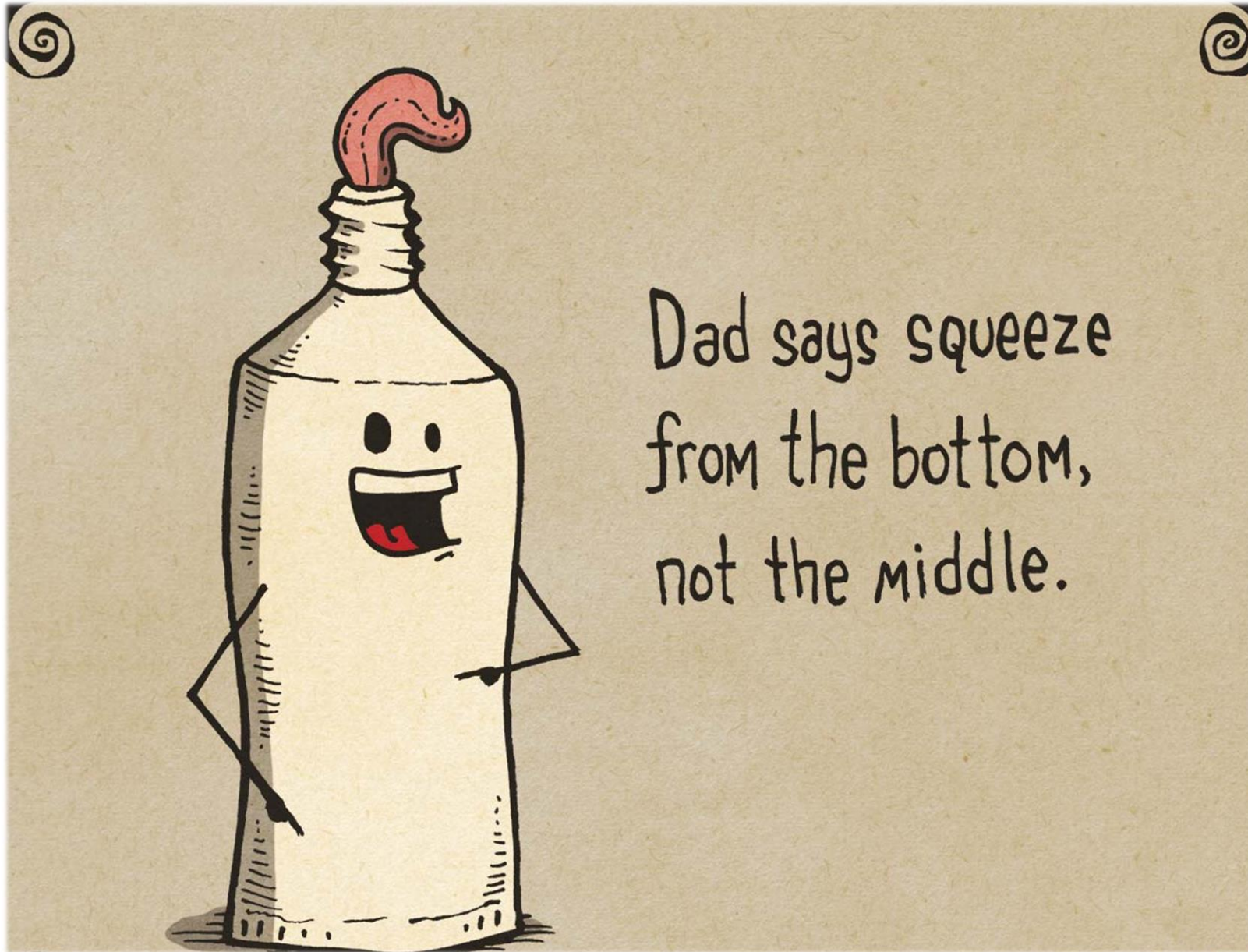
To get new projects for Squeeze casting technology, but also for other our technologies...

An article on this topic will also be published in MAGMA TIMES, most likely in the next edition.



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MANY THANKS FOR YOUR ATTENTION...