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GISS Technology

Rheozama project: slurry casting application to hot chamber zinc die casting

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Zinc Die Casting Conference 2025

Introduction to Slurry Casting

Materials Science and Engineering, 25 (1976) 103 - 117

Rheocasting

It has been discovered recently, however, that when metal alloys are vigorously agitated during solidification, the solid which forms has a special "non-dendritic" structure [3 - 5]. Partially-solidified metals with this special structure behave as highly fluid slurries at fractions solid as high as 0.60. They can be

Liquid

Superheated Slurry

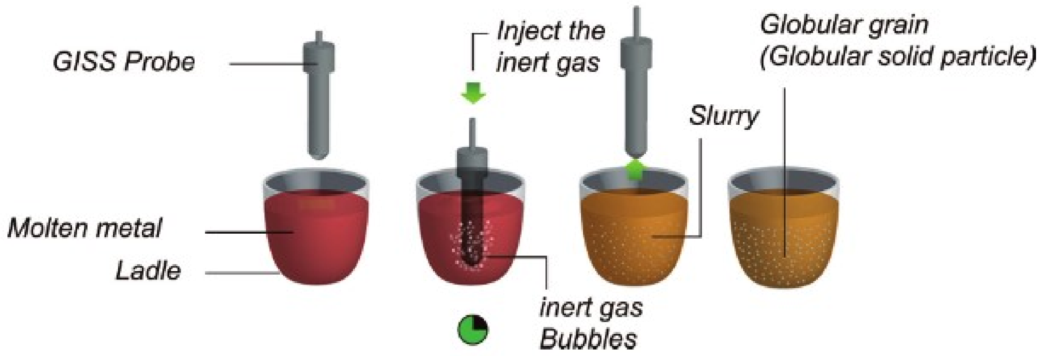
Warm Milk

Slurry

Semi-solid

Gas Induced Superheated Slurry

The process can be divided into four steps:
Step 1: **Placing a probe into the melt** to remove a controlled amount of heat.
Step 2: **Vigorous convection** by injection of inert gas bubbles is applied to the melt to assure nearly uniform cooling of the melt to the temperature slightly above the liquidus temperature and also to create solid nuclei.
Step 3. The probe is then rapidly removed from the melt when the desired **solid fraction** is reached.
Step 4: The melt is quickly transferred to a mold for casting into parts.



Gas Induced Superheated Slurry

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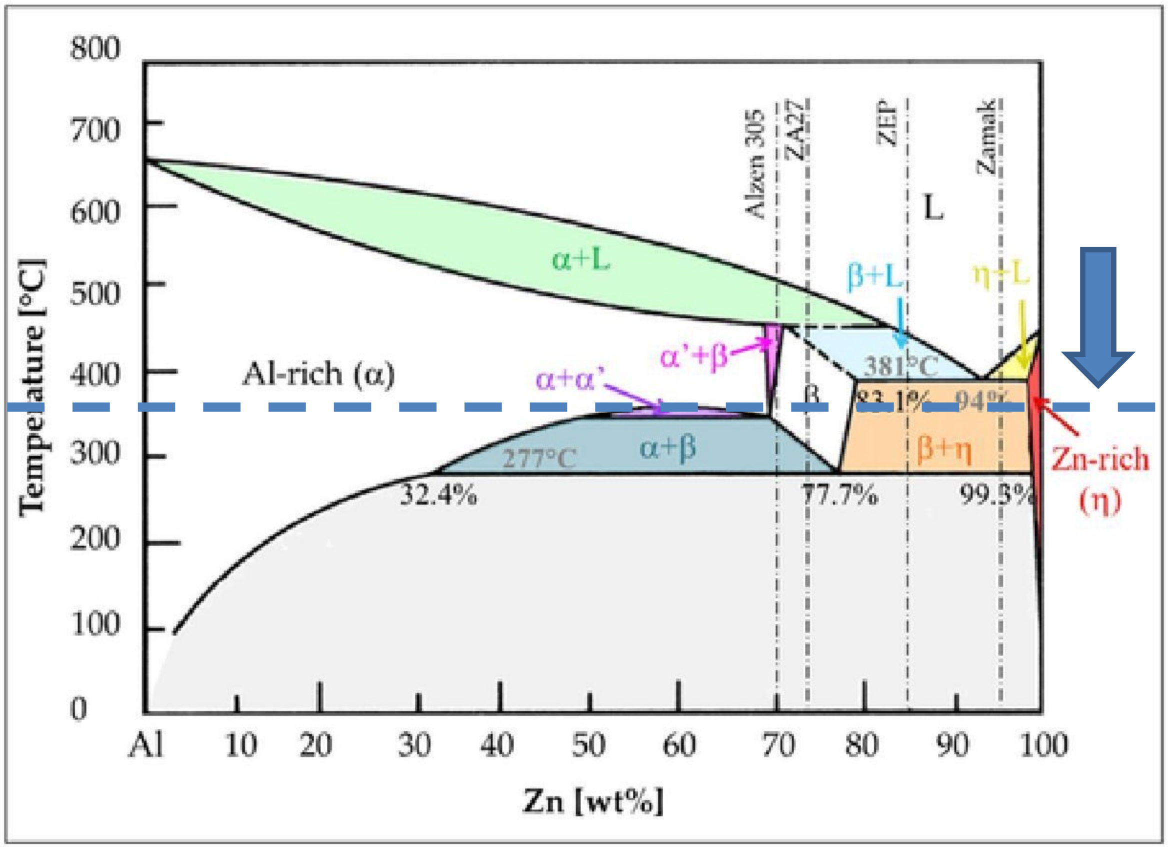


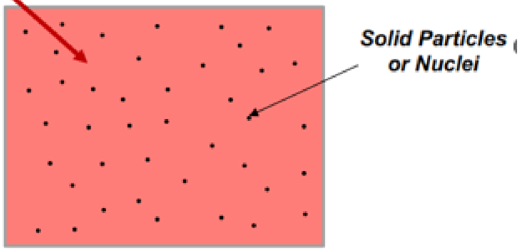
$T_{semi\text{-}solid}$ is in T_L and T_S range

T_L > Al > T_S ≈ 60°-70°

T_L > ZA5 > T_S ≈ 6-8°

$T_{slurry} > T_L$

T_{GISS} is above T_L



Gas Induced Superheated Slurry

Through GISS technology, a small fraction of fine solid nuclei is created in the melt even though the bulk liquid melt is at the temperature **slightly above the liquidus temperature**.

Applicability:

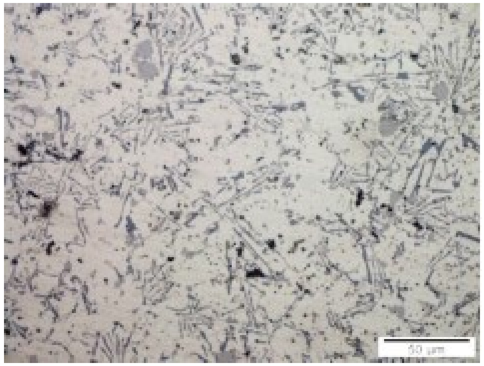
- No need to change gate size
- No need to modify runners
- Any alloy
- Rapid installation time
- Movable to any convenient DCM

The **fraction of solid** changes the flow pattern into the die cavity. As a result, gas porosity can be effectively controlled. Furthermore, the presence of **pre-existing solid particles** in the slurry changes the solidification mode of the metal in the die cavity such that shrinkage porosity is greatly reduced.

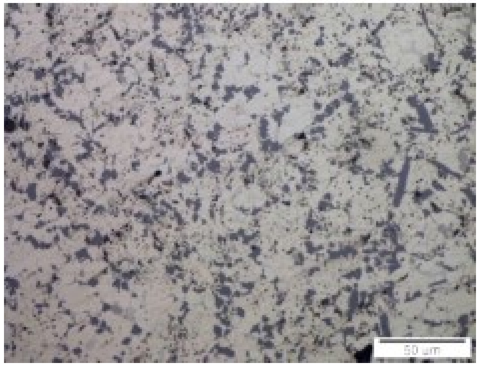
Key features – cold chamber

- Gas porosity is reduced in the GISS casting process because the controlled solid fraction in the slurry implies **less turbulent flow** compared with conventional high-pressure die casting.
- Shrinkage porosity is reduced in the GISS casting process because the initial solid particles present in the slurry act as nucleation sites in liquid metal. Additionally, the temperature range from metal temperature in the cavity and the solidification temperature is lower, consequently the solidification time is shorter, and the shrinkage porosities decrease.
- Slurries enter the die with significantly **reduced heat content**, resulting in shorter cycle time and longer die life.
- Solid particles in the slurries are ultra-fine, yielding easy flow into the ultra-thin sections and uniform microstructure.

Comparison of microstructure of alloy A383 (AlSi11Cu3)



Conventional HPDC



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Key benefits (cold chamber)

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Energy Savings (Furnace) ❋
Water treatment reduction ❋
Ev. DCM Size reduction ❋

Gas Porosity ❋
Shrinkage Porosity ❋
Planarity ❋

Min Die Temperature ❋
Less Time of cast Part into the mould ❋
Less Lubricant Quantity per Shot ❋

Min Solidification Time ❋
Min Lubrication-Blowing Time ❋
Faster Slow Phase ❋

R&D applications

Mini slurry casting project

- ZA3 alloy
- Cold chamber vertical machine
- Machine tonnage 5t
- Temperature ≈ 5° > T_{liq}
- → Vertical Slurry Casting

ZA-27 applications

Structure and properties of stir-cast zinc alloys

H LeHuy, J Blain, J Masounave, GL Bata

TMS (The Metallurgical Society) Paper Selection;(USA), 1984 · osti.gov

Stir casting (or rheocasting) of ZA-27 zinc alloys was investigated experimentally. By vigorously agitating the alloys during cooling, the dendrites that were forming were fragmented giving a unique structure composed of spherical and rosette shaped particles

Forming Gears from ZA-27 Zinc Alloy Using Semi-Solid Slurry Squeeze Casting Process

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Aluminum segregation in ZA27 rheocast alloy

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Slurry Test

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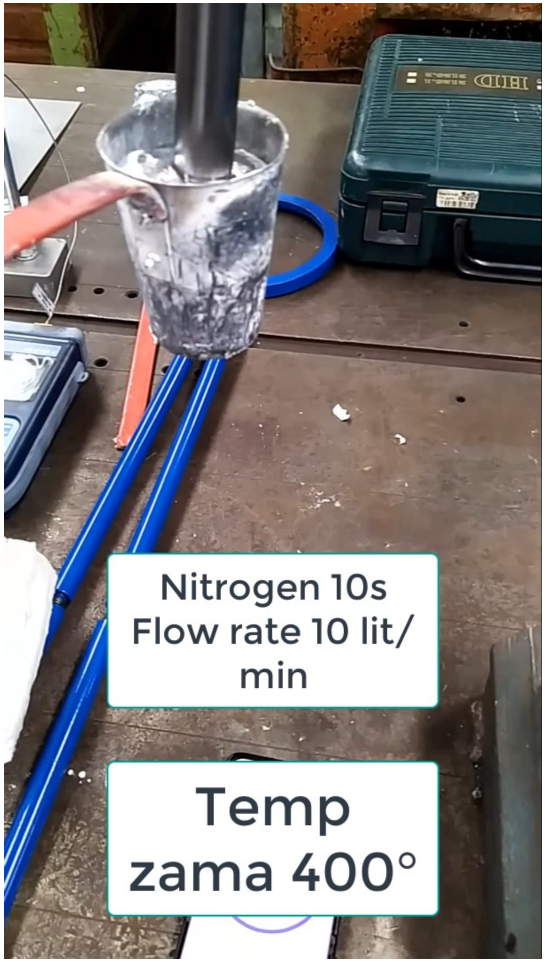

Castle Rheo Simulation Software

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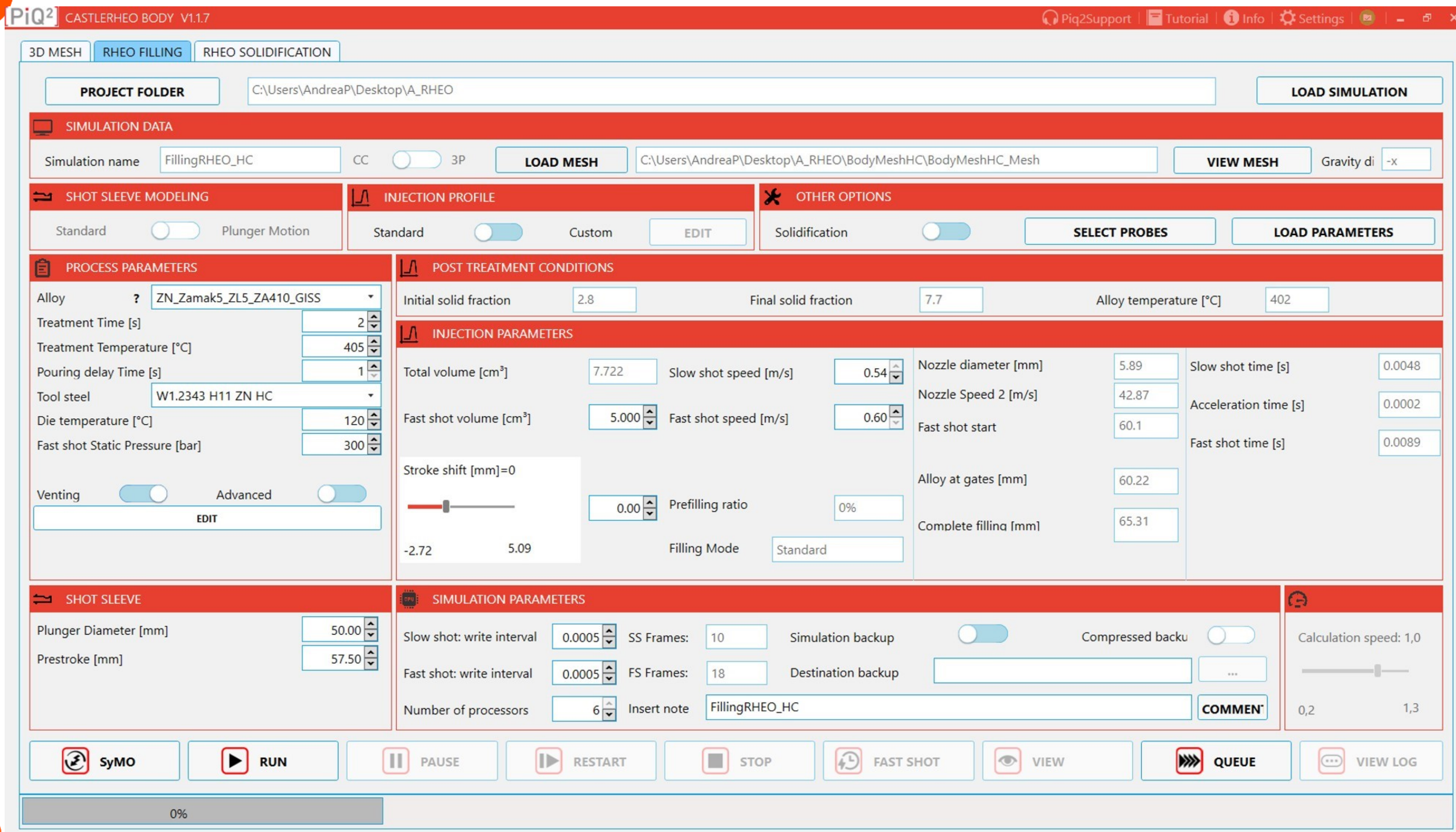
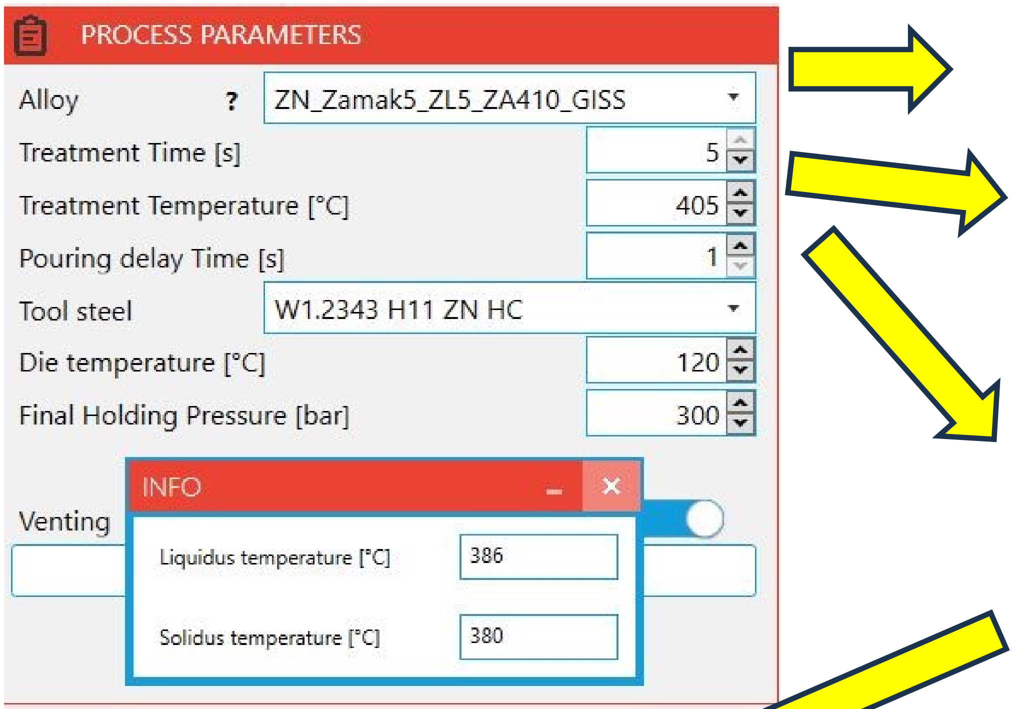
[castle] DIE CASTING SIMULATION SOFTWARE



www.mambretti.tech

Castle Rheo Simulation Software



Alloy Liquidus and Solidus Temperature

GISS Time: number of seconds the probe is in the melt

Metal temperature when the probe is in the melt

Calculated solid fraction immediately after application

to

Rheozama project

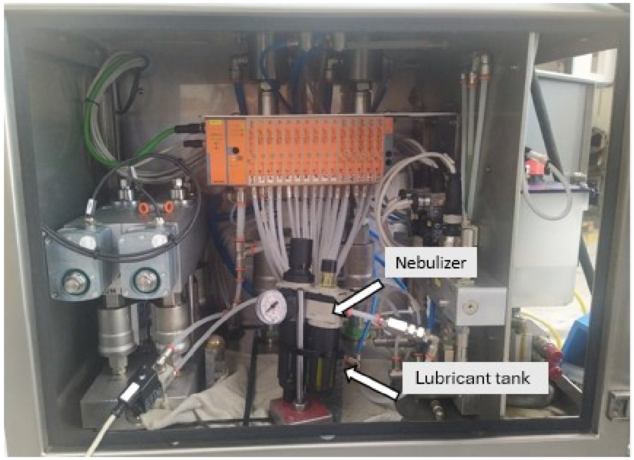
Crucible with movable bulkheads to limit the amount of metal being treated

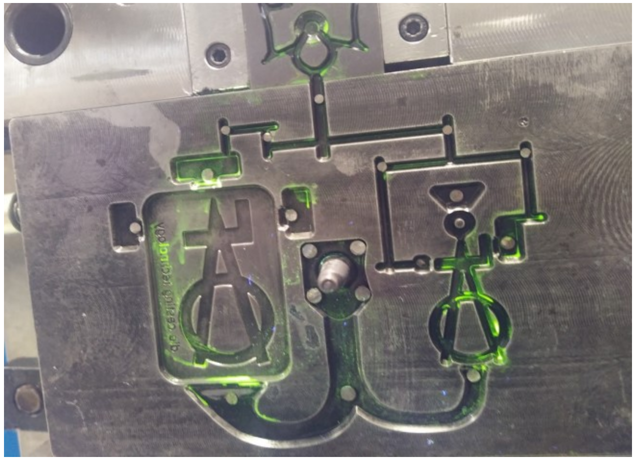
Rheozama project

ZL5 - ZnAl4Cu1

Rheo Time 5s
Subdivided crucible

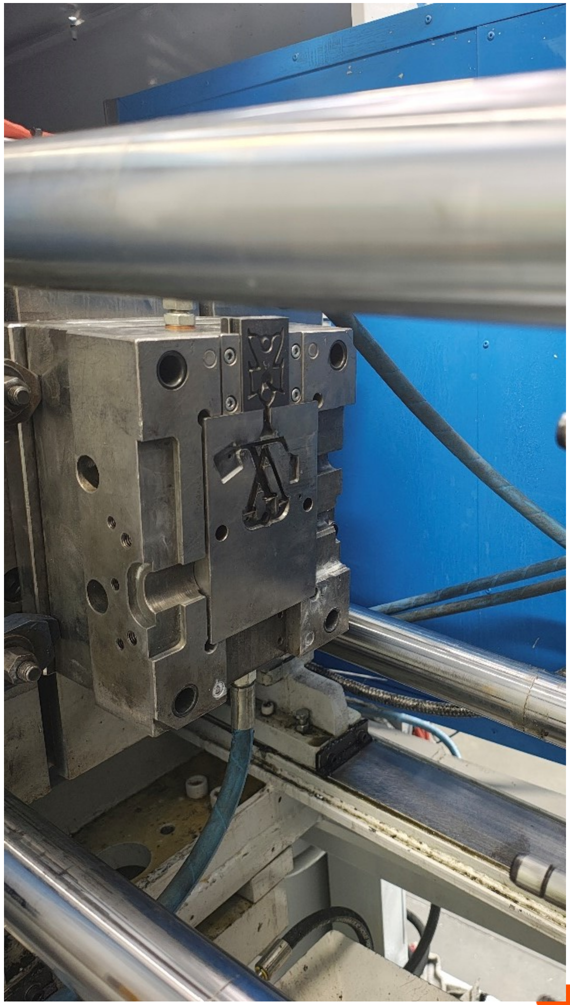
Integration of vacuum technology to convey a lubricant modified in its state from liquid to aerosol (or oily mist) and then conveyed inside the die through the vacuum suction valve.





Rheozama project

Application to a production mold. Cycle time about 20s, dip time 15s not related to cycle



Rheozama project

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Furnace Temp ≈ 405°

! < 400°

Probe Temp ≈ 45C

! > 90°

6 bar @ 20 ml/min

! < 5 bar

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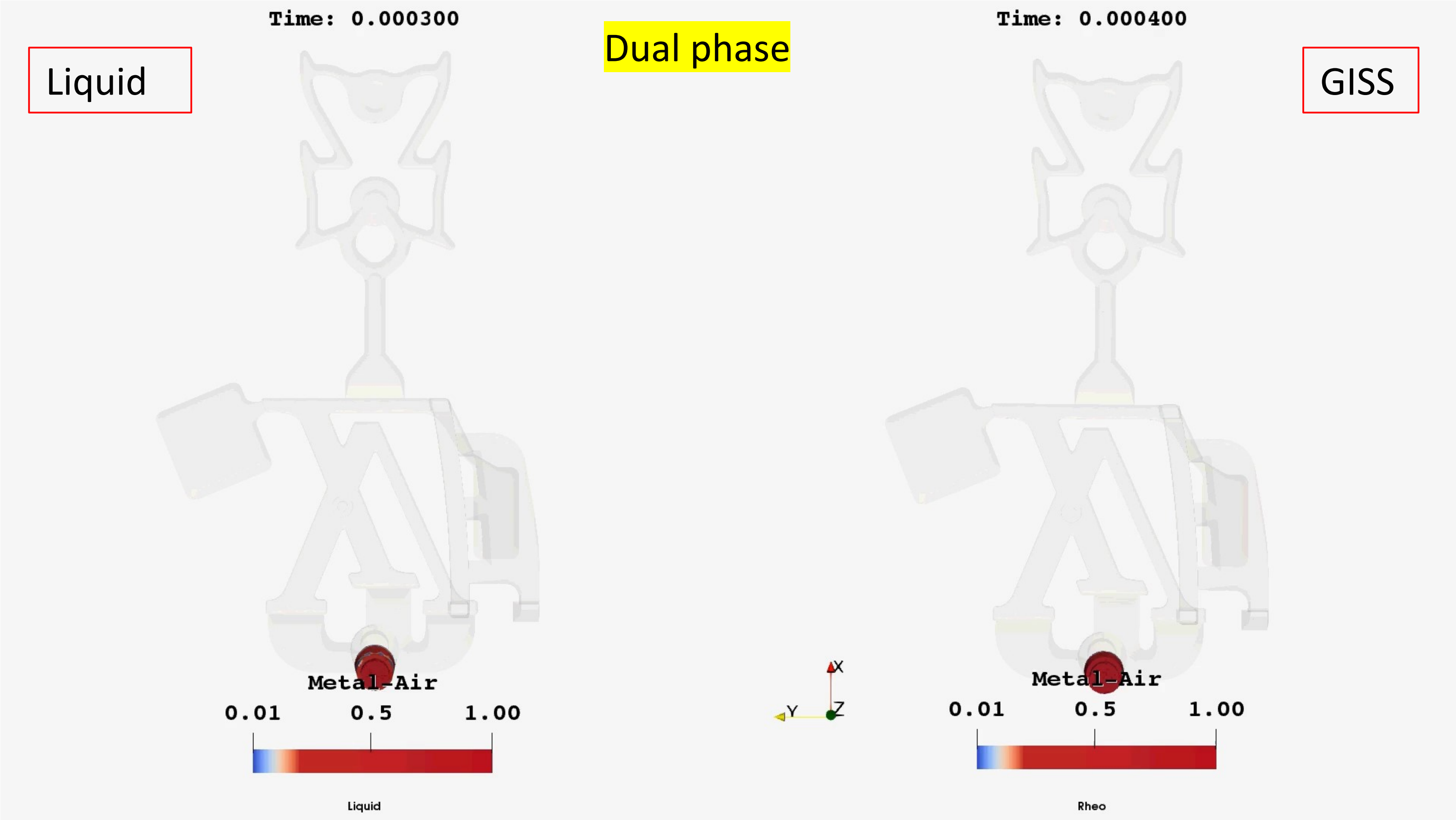

Castle Rheo Simulation Software

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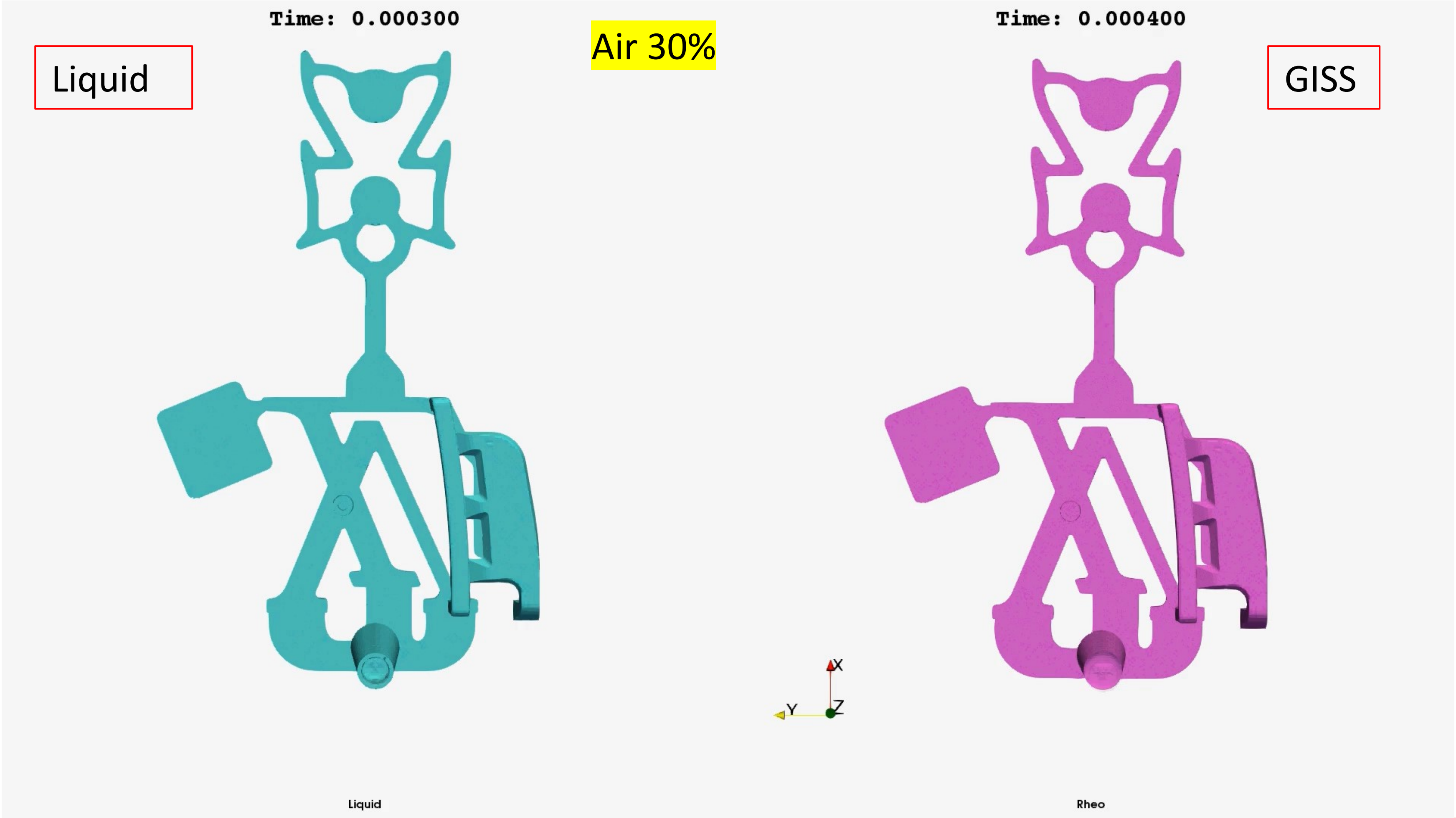

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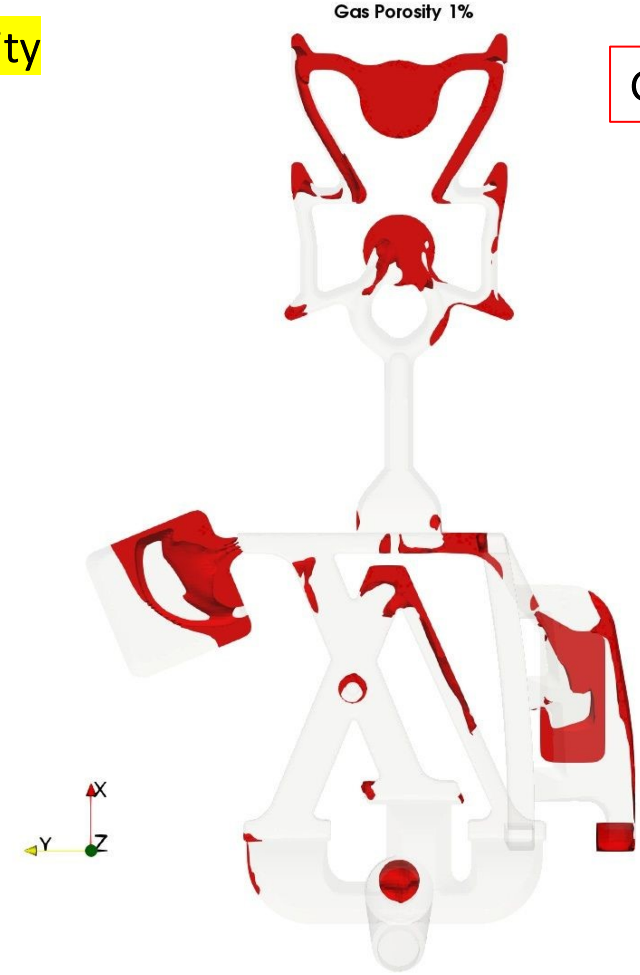
Gas Porosity

Liquid

GISS



Castle Rheo Simulation Software

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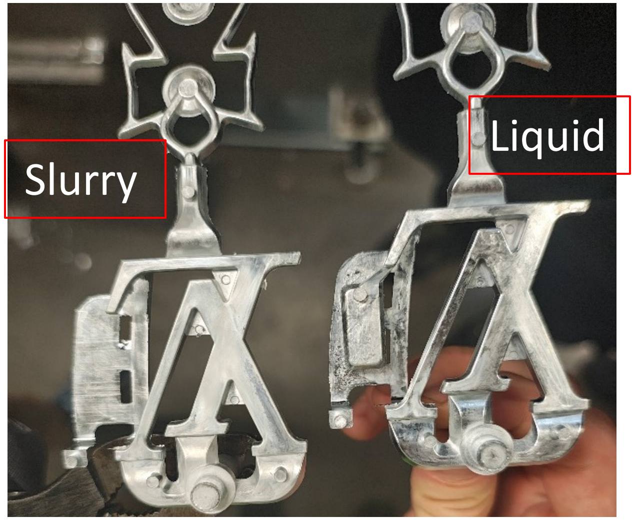
Gas Porosity

Liquid

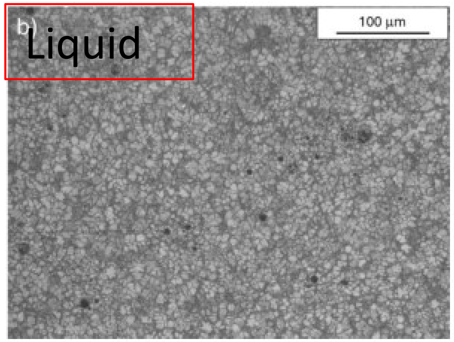
GISS

Rheozama project

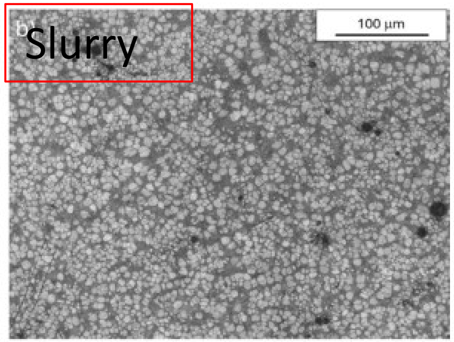


	No slurry U-B	Slurry U-G
Densità Media [gr/cm³]	6.630	6.640
dev. Std.	0.046	0.019
Porosità %	0.3	0.15

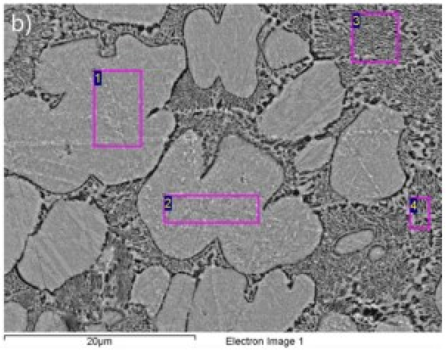
Tabella I Risultati misure di densità



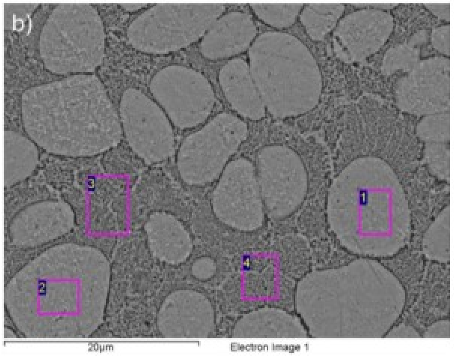
Liquid: primary phase pseudo dendritic



Slurry: more globular shape



Spectrum	O wt.%	Al wt.%	Cu wt.%	Zn wt.%
1	5.58	2.09	2.47	89.85
2	6.00	2.00	2.85	89.14
3	6.93	10.82	1.99	80.26
4	6.92	11.42	2.44	79.22



Spectrum	O wt.%	Al wt.%	Cu wt.%	Zn wt.%
1	2.51	2.46	2.66	92.37
2	3.15	2.42	2.51	91.91
3	3.53	11.27	2.02	83.18
4	3.19	11.30	2.97	82.55

Summary

The Rheozama Project aimed to investigate the possibility of applying slurry technology to traditional hot chamber die casting, using a standard zinc alloy and without modifying the mold. So far, the application of the technology had been limited by some peculiar aspects of HCDC:

- the very small liquidus-solidus temperature range
- the difficulty of limiting the amount of metal where the slurry is formed
- the reduced benefits of the hot chamber compared to the cold chamber

The project has tried to go beyond these limitations through:

- ✓ The adoption of GISS technology that works at $T_{slurry} > T_{liq}$
- ✓ DCM crucible modifications
- ✓ The introduction of a closed-mould lubrication system through the vacuum valve
- ✓ Development of an ad hoc software simulator to verify the potential benefits in advance

The results confirmed the possibility of generating slurry for zinc alloys but also the difficulty of applying it to the standard process without further modifications of DCM.

Experience has highlighted some critical issues, in particular the need to further limit the amount of metal to be treated and to cool the probe more. The changes will be prepared in the coming months and will be the subject of further studies.

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