

MAGMA

Real-World Application of Core Simulation for Process Optimization

Suraj Kumar

Manager – Ferrous

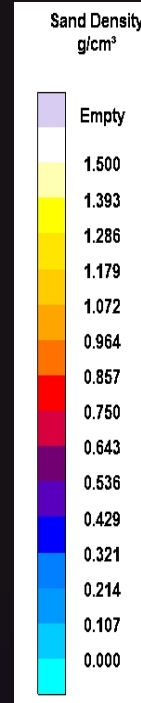
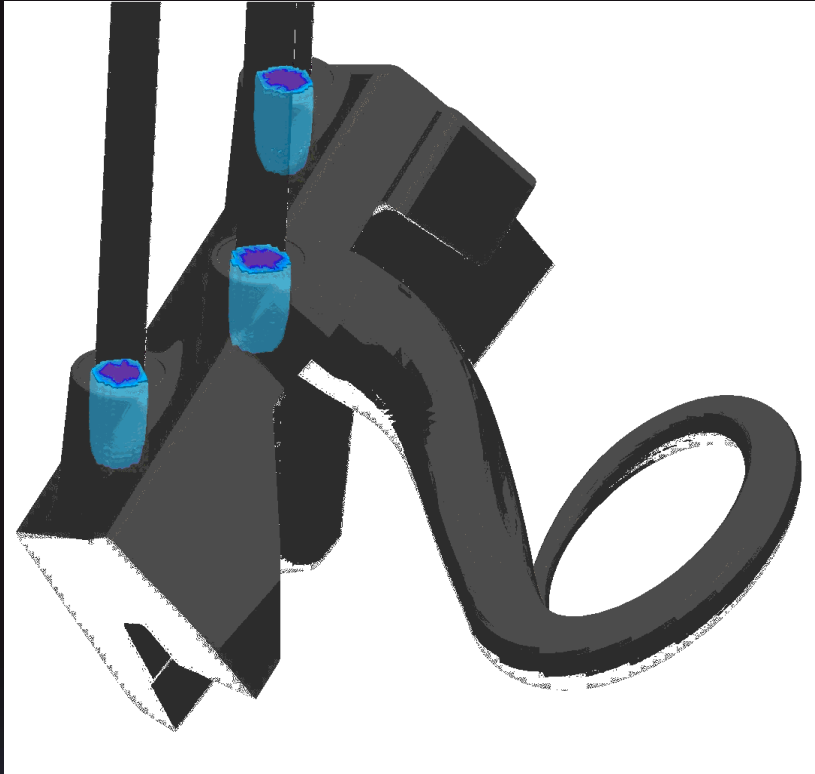
MAGMA Engineering India Private Limited



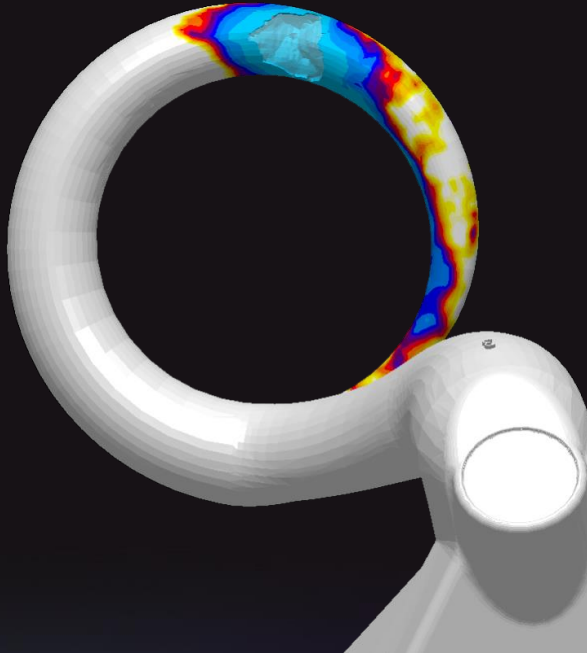
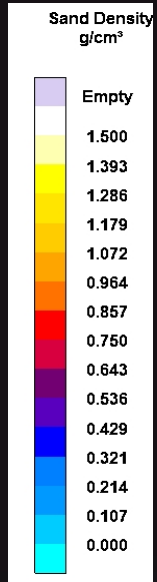
Core for a Turbocharger Housing Production Optimization



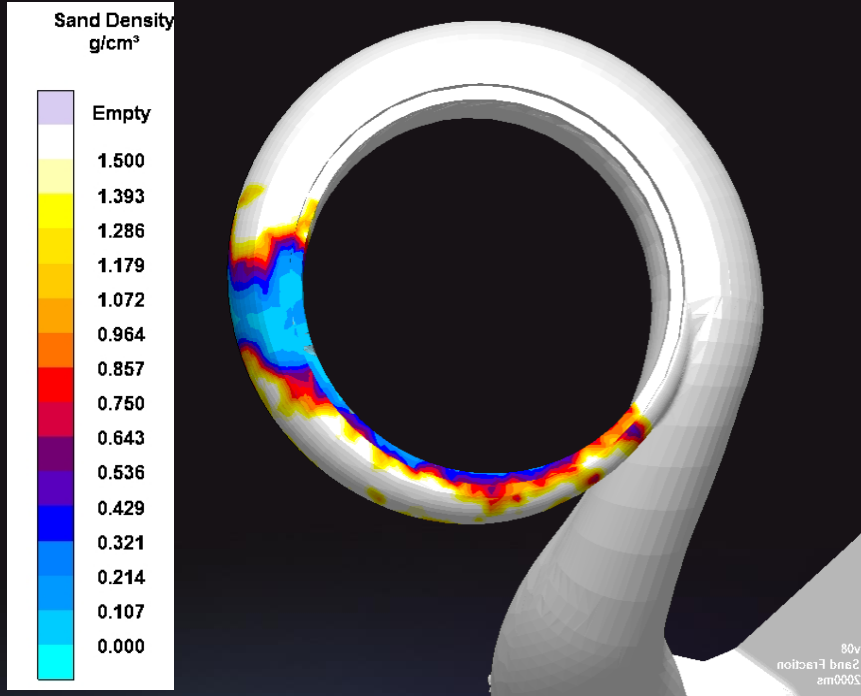
Sand Density during Shooting



Problems at the end of the curl after shooting

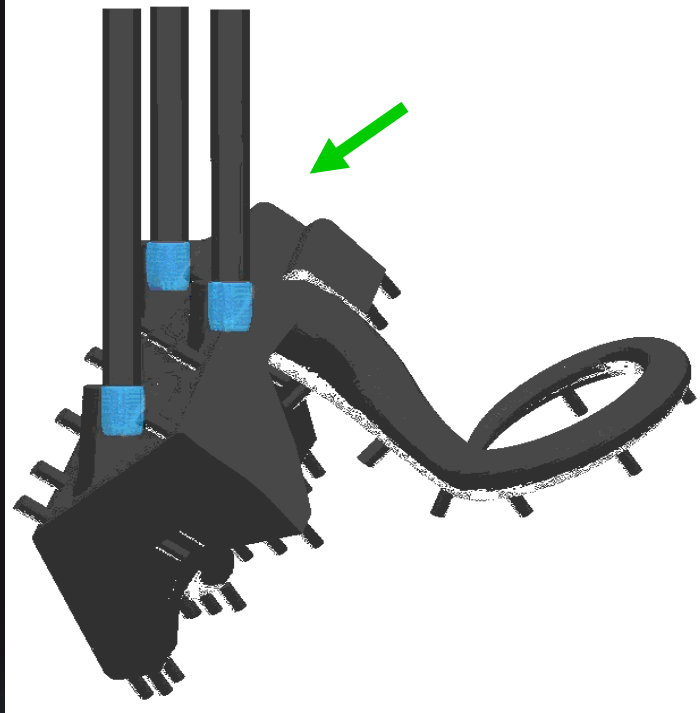


Problems at the end of the curl after shooting

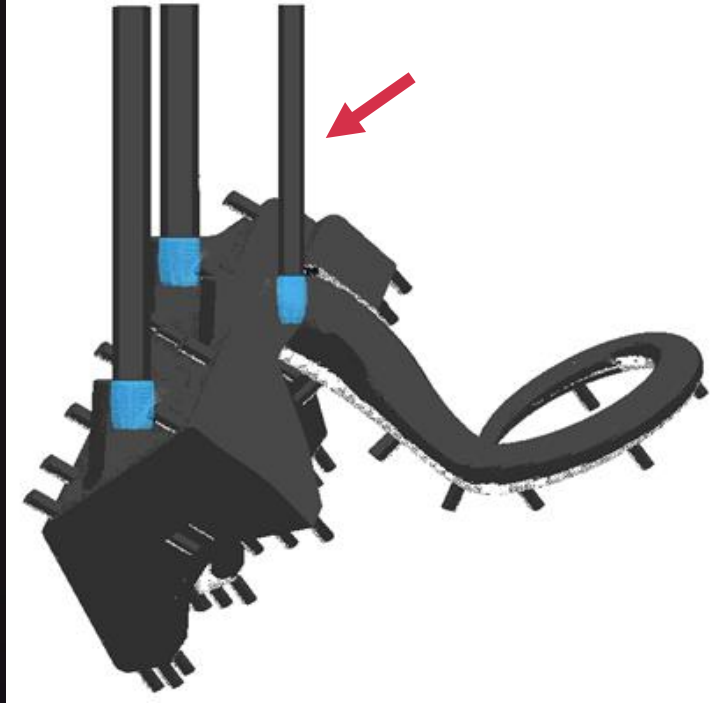


Optimization means Change

Modification of the Nozzle Positions and Sizes



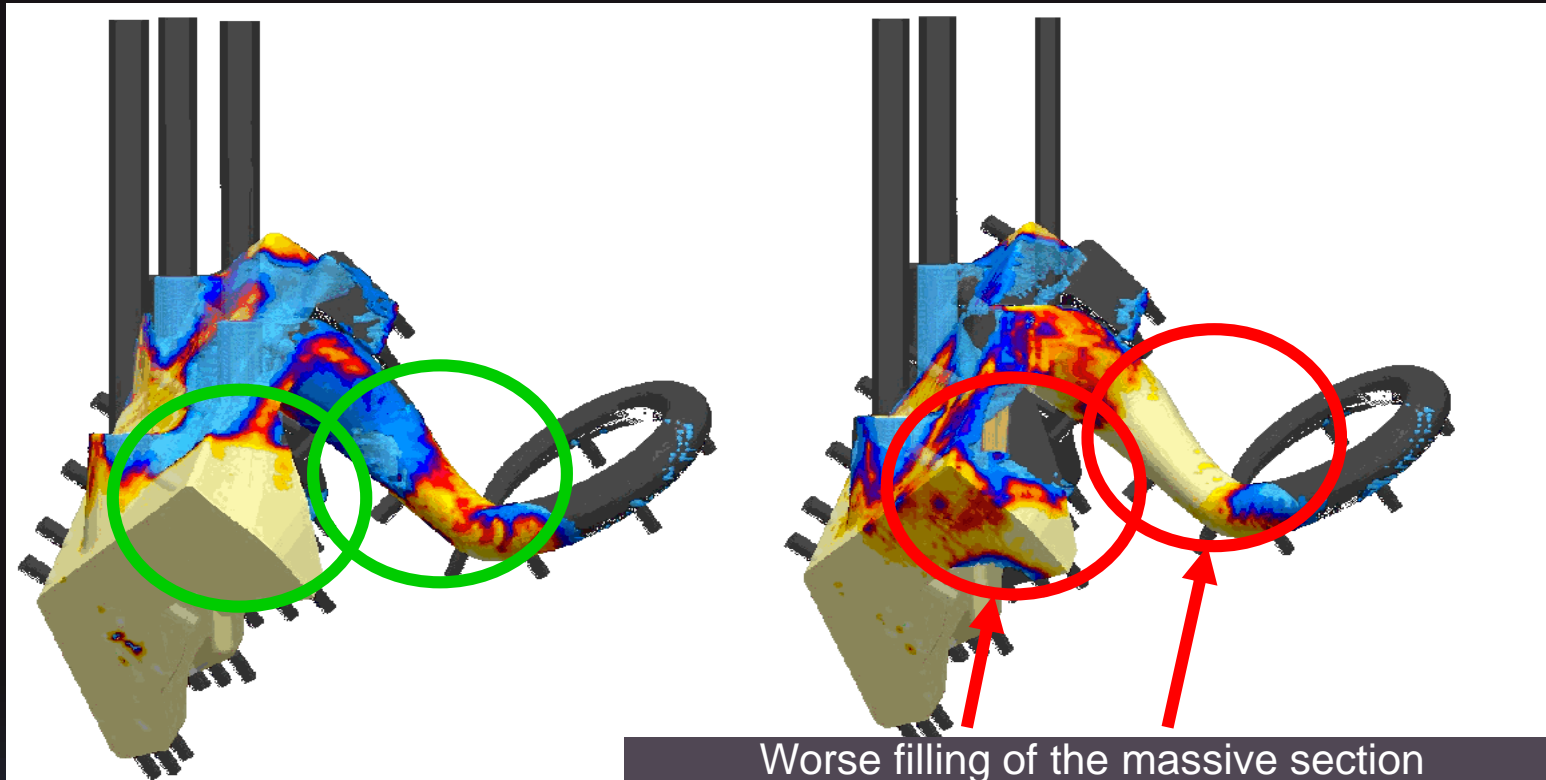
Original



Modified



Modification of the Nozzle Positions and Sizes

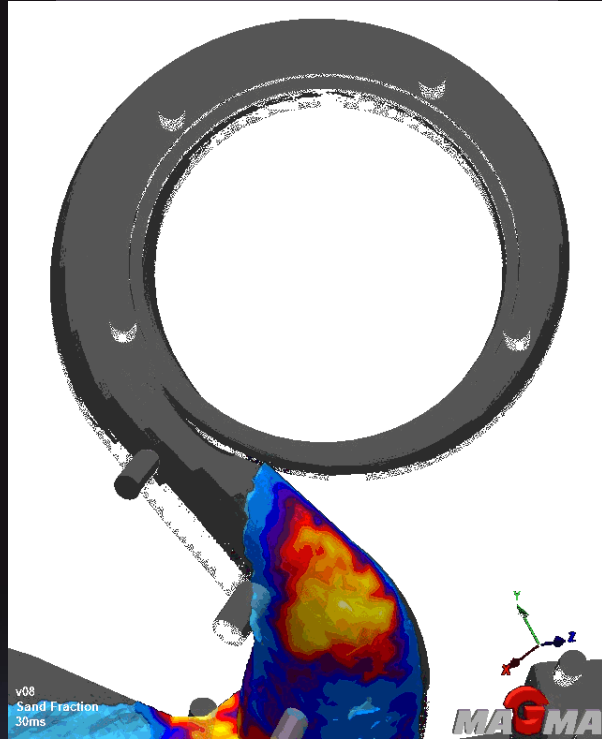


Worse filling of the massive section
Blocking of sand before the curl

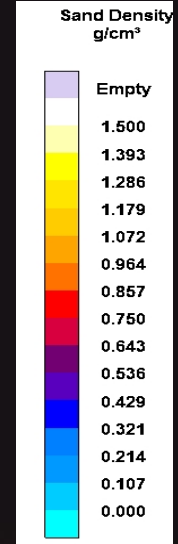
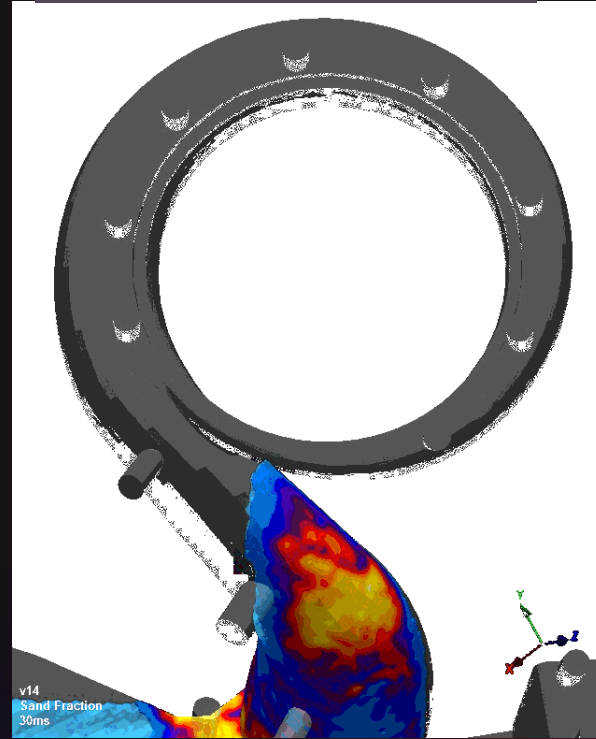
Optimization means Change

Modification of the Nozzle Positions and Sizes

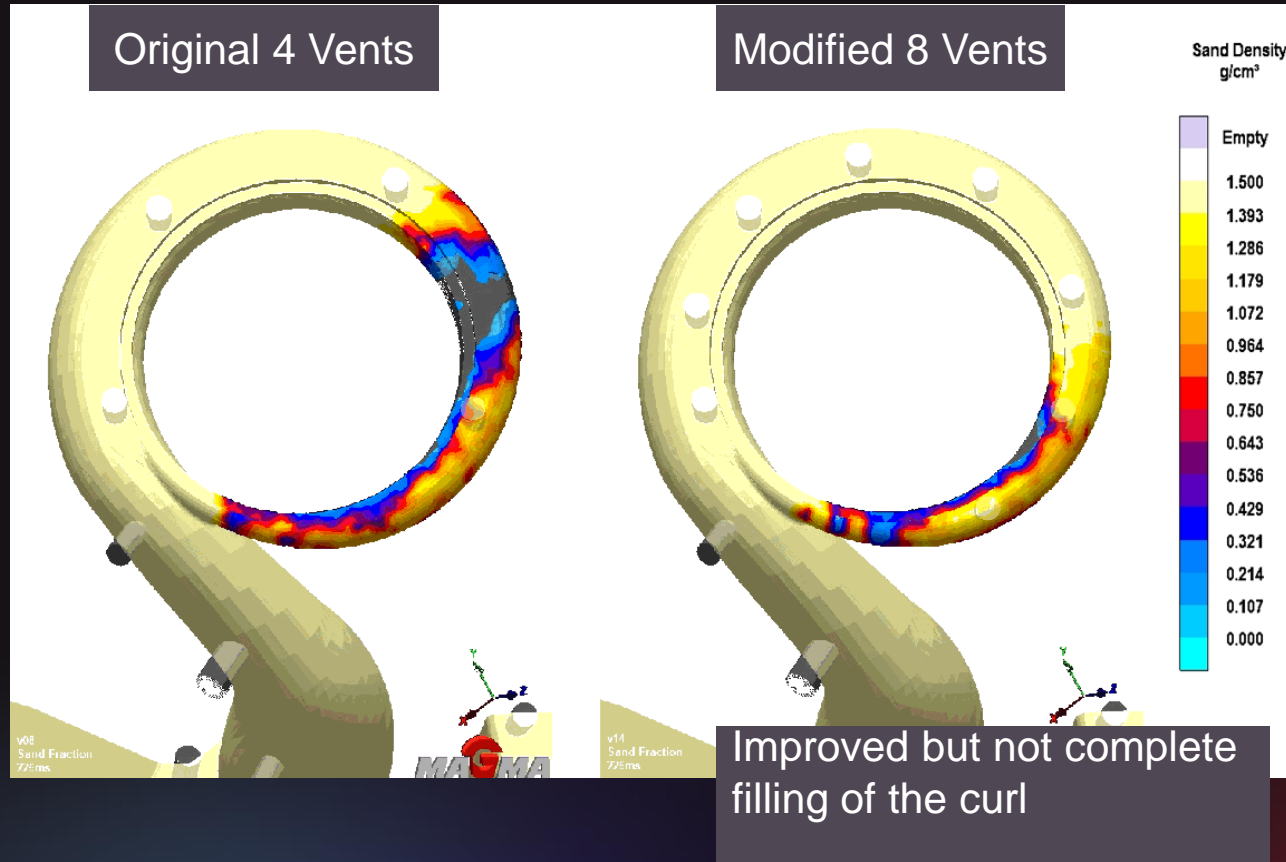
Original 4 Vents



Modified 8 Vents

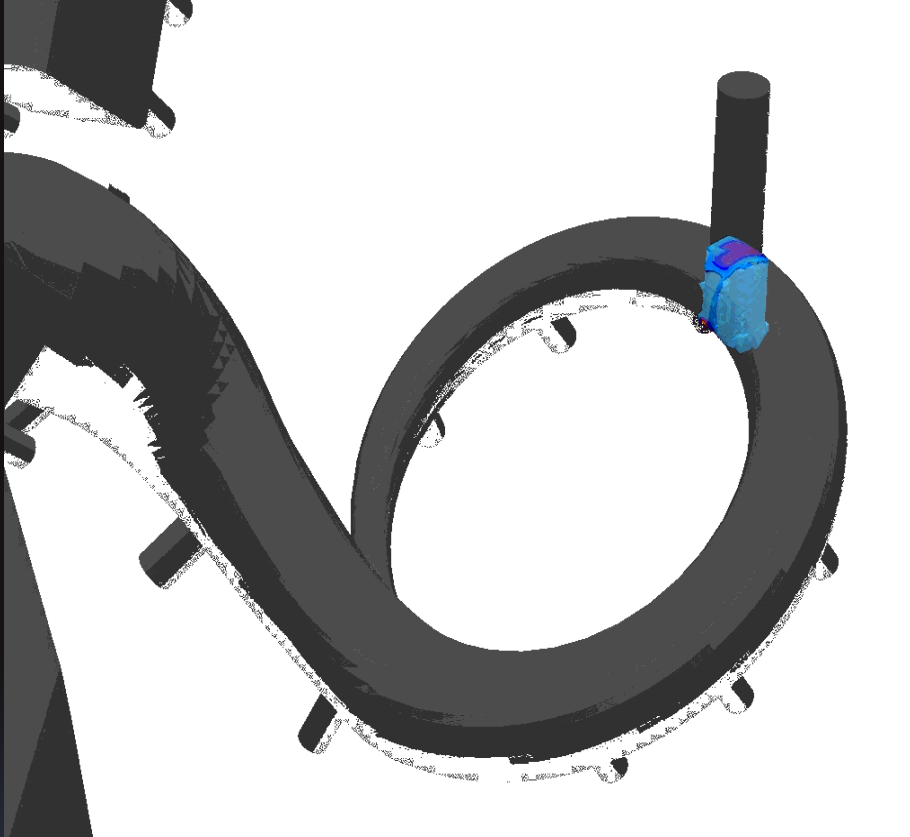


Additional Vents / Original Nozzle Configuration

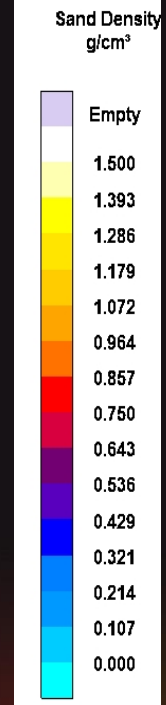


Optimization means Change

Modification of the Nozzle Positions and Sizes

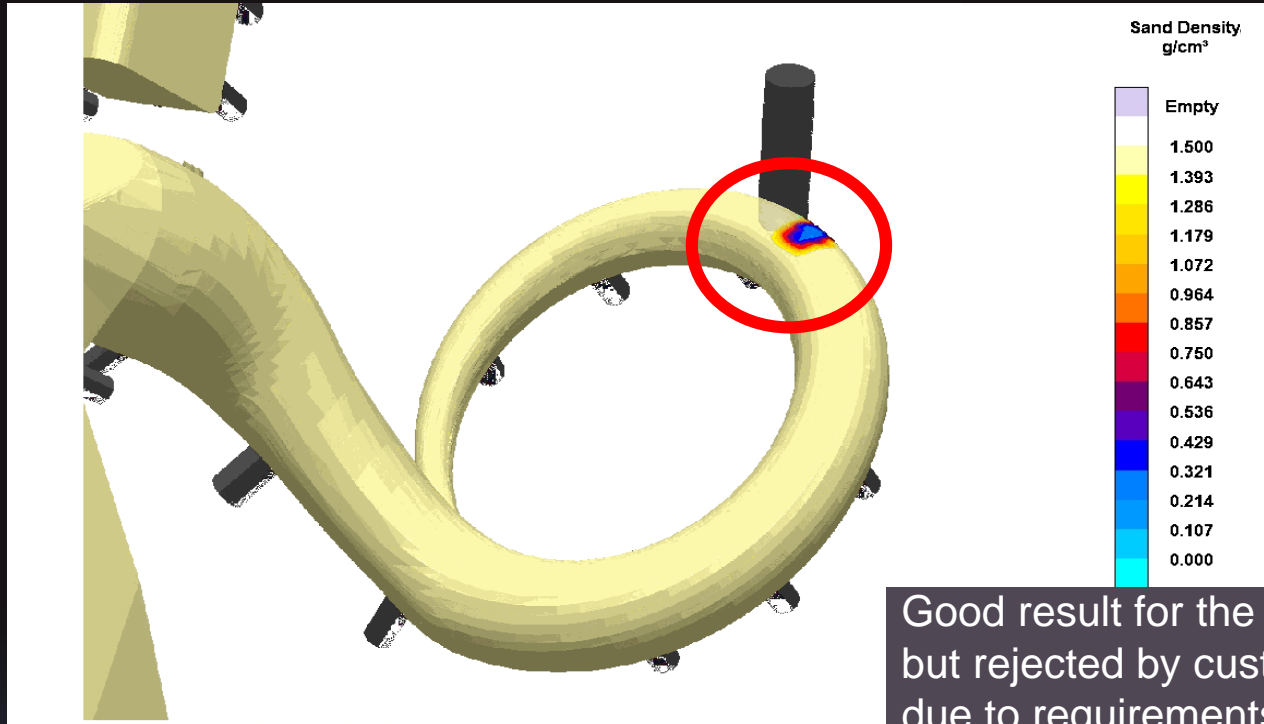


Added Extra Nozzle



Optimization means Change

Modification of the Nozzle Positions and Sizes



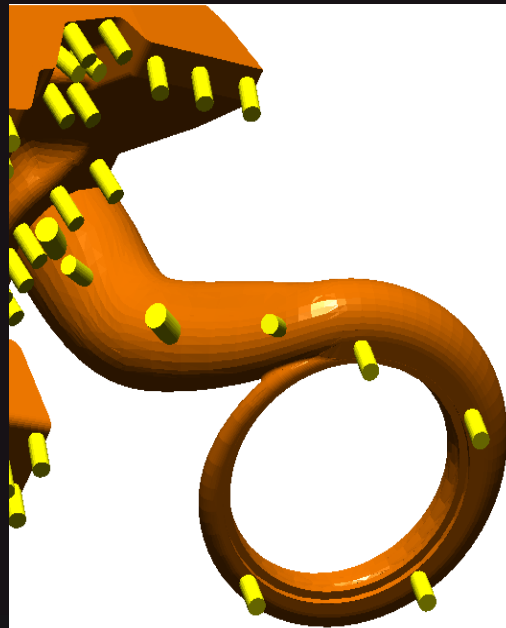
Good result for the shot,
but rejected by customer
due to requirements
on surface quality on the curl



Comparison

Initial Tooling

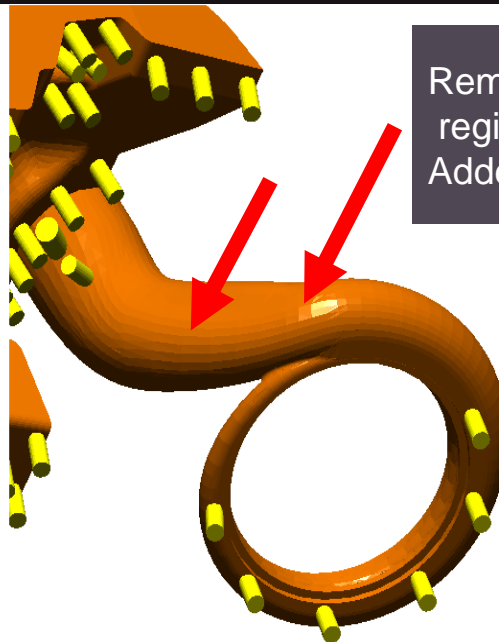
Improved Tooling



Sand Core
Core Box Vent
Core Box Vent
Core Box Vent
Core Box Vent



v08
Geometry

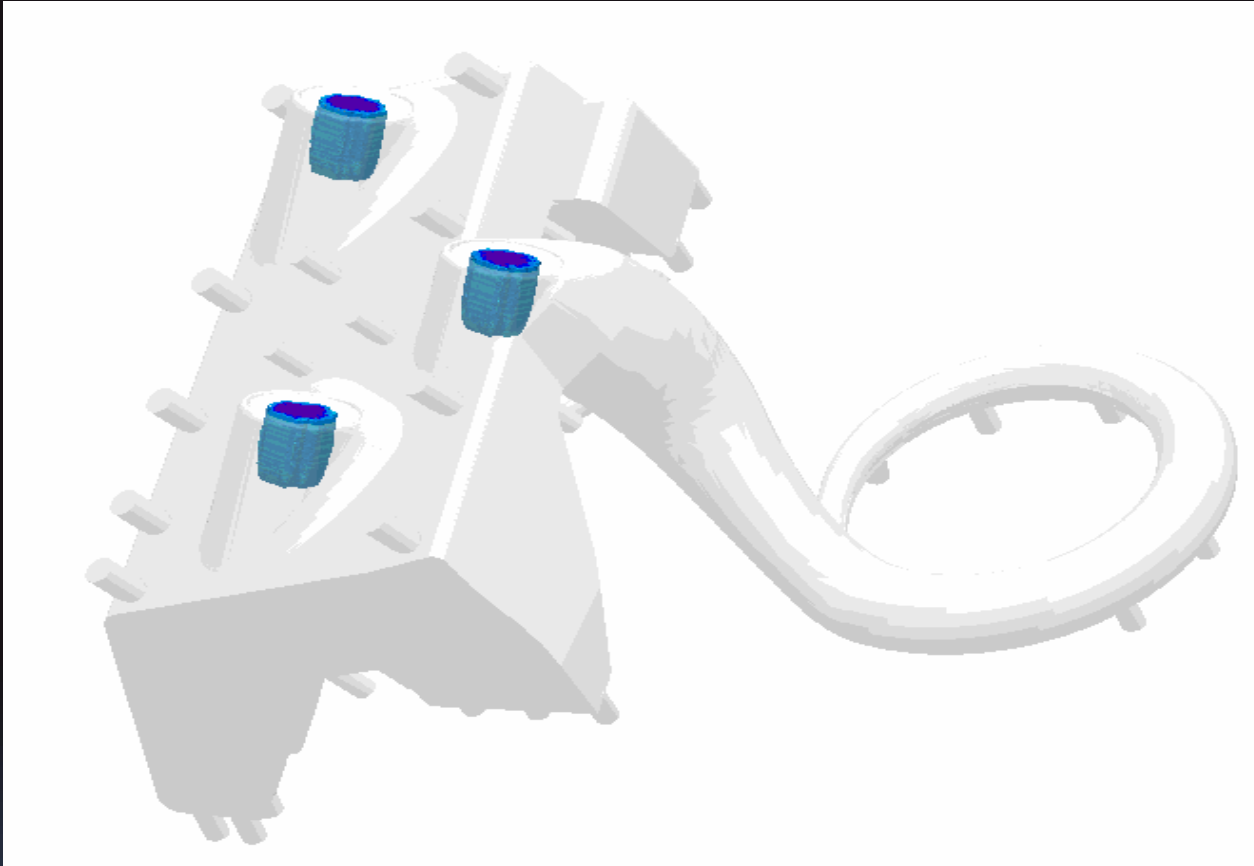


Remove vents in curl entrance region.
Added Additional vents on the curl

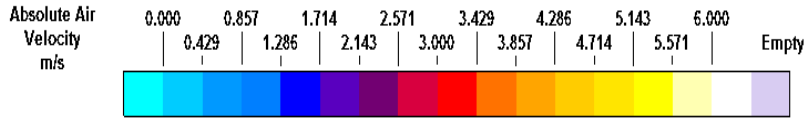
v21
Geometry



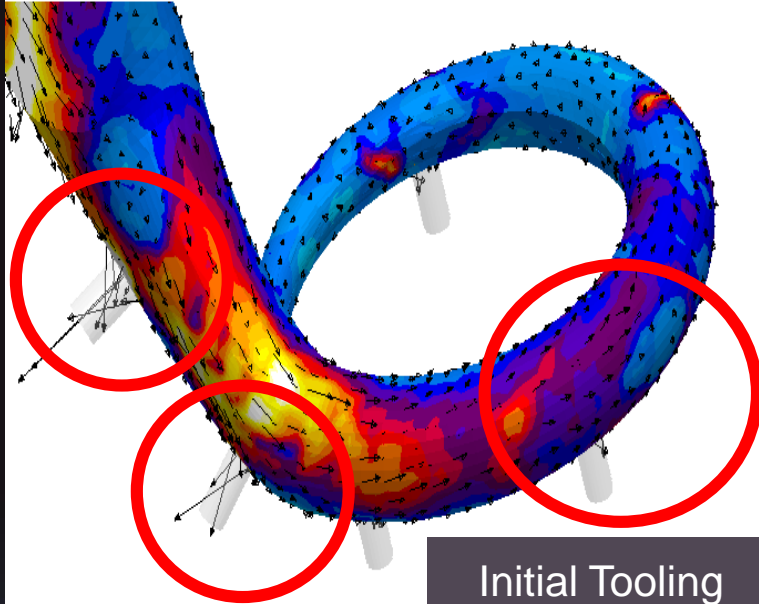
Shot Process for improved Tooling



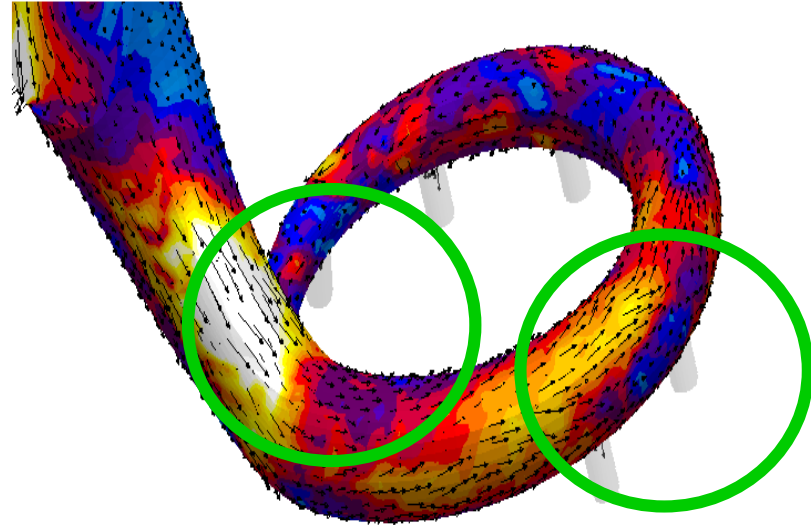
Shot Process for improved Tooling



Higher sand velocities make a better transport of sand in the curl possible



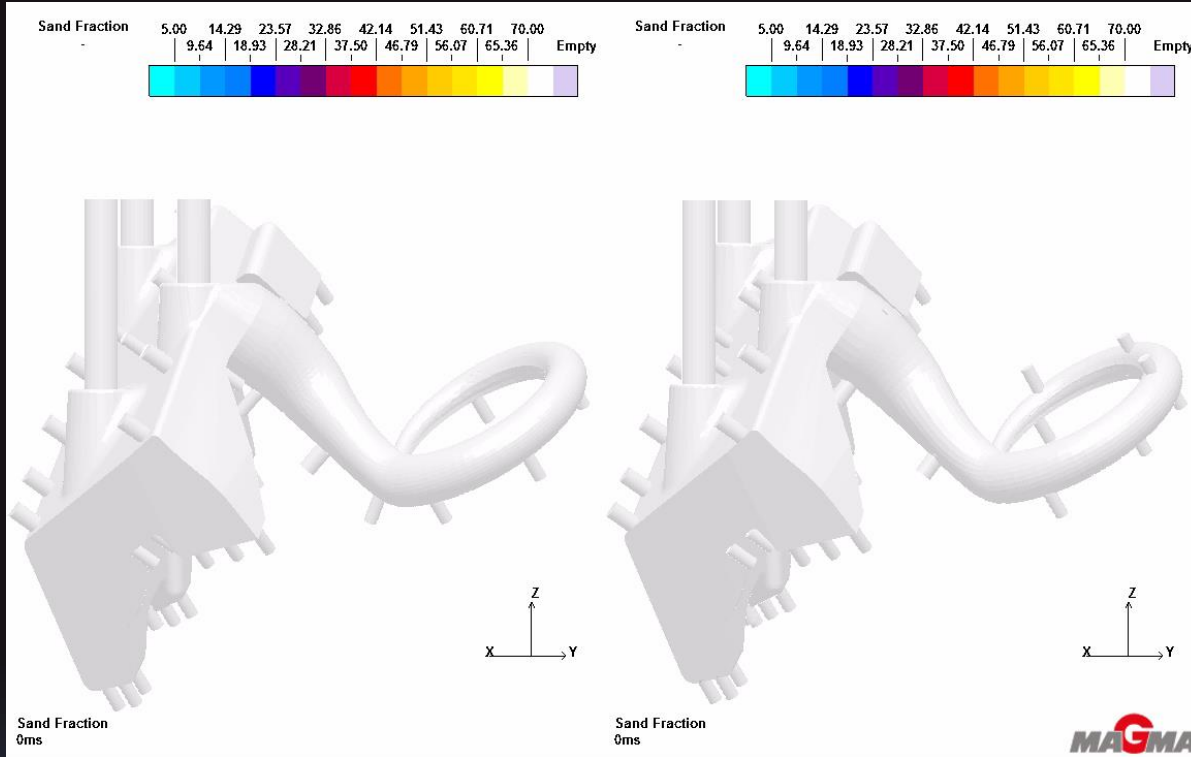
Initial Tooling



Improved Tooling



Sand fraction – Final Solution

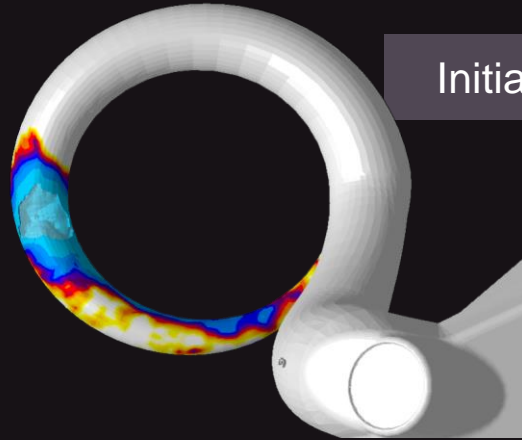


Initial Tooling

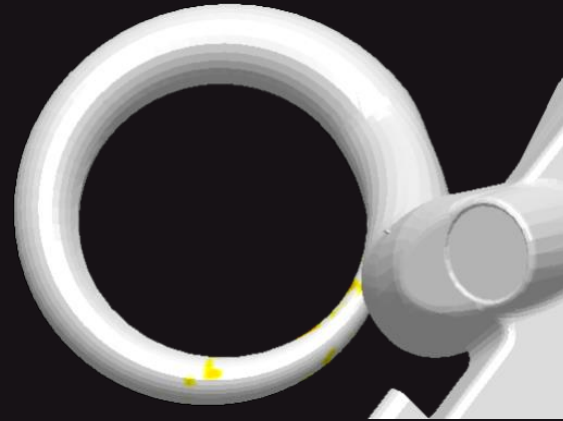
Improved Tooling



Defects Comparision



Initial Tooling



Improved Tooling

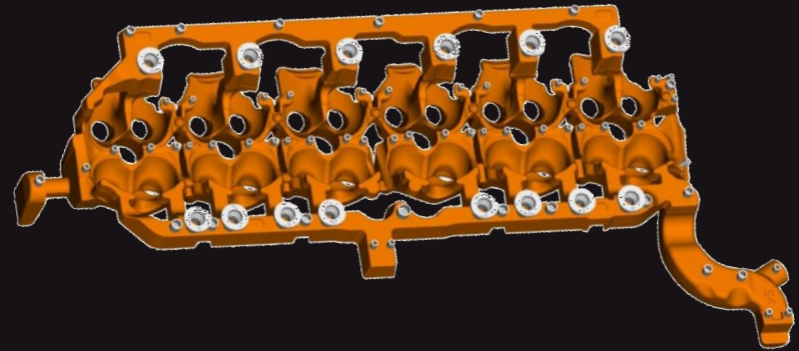


Core is free from Defects



AUTONOMOUS ENGINEERING

- Water Jacket Core:
Systematic Process Analysis
and Optimization

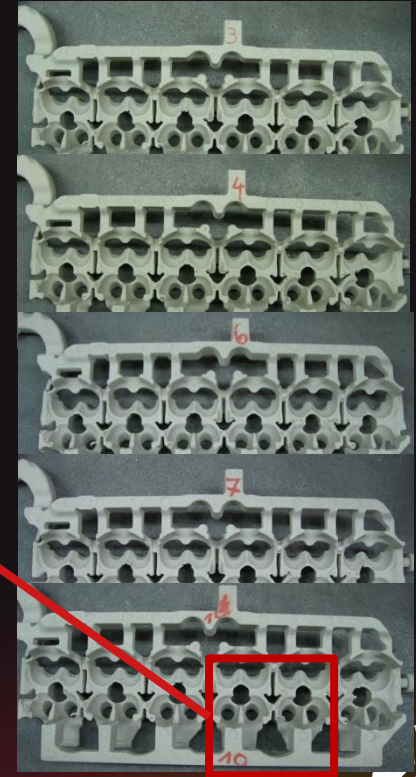
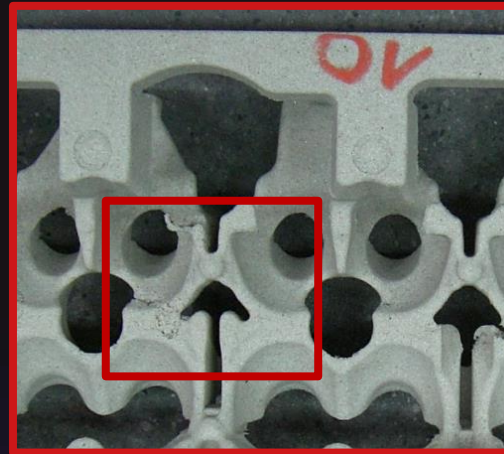
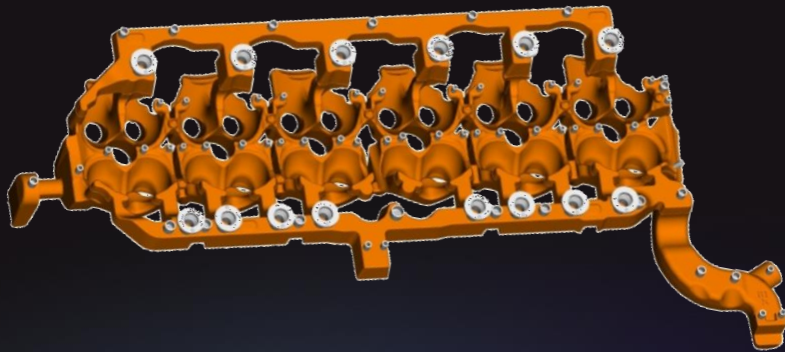


Analysis of the Initial State

- Collecting Data

Water Jacket Core

- Production tool causes occasionally certain defects
- Used shoot nozzles cause increased maintenance

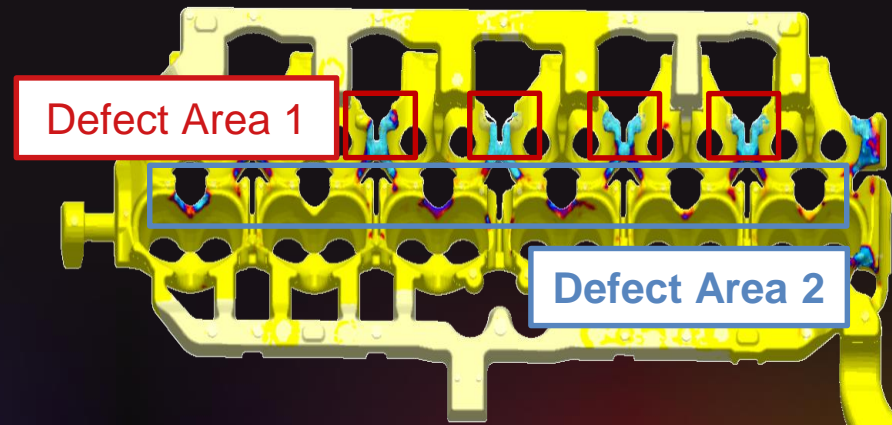


Analysis of the Initial State

- Which Issue Needs to Be Solved?

Single Simulation

- 2 typical defect areas can be observed
- Extension of defect is dependent on
 - shoot nozzle type
 - venting
 - shot pressure
 - sand properties?



SET UP YOUR OBJECTIVES

Think Ahead to Your Targets

- Reduce (minimize) scrap rate
- Reduce maintenance effort (= extra costs + time) by using shoot nozzle type with reduced need for cleaning
- Reduce shot pressure as far as possible
- Use standard sand without further modification in order to increase its flowability



DEFINE YOUR VARIABLES

— Which Options, Variables and Flexibility Do I Have?

Design Variables

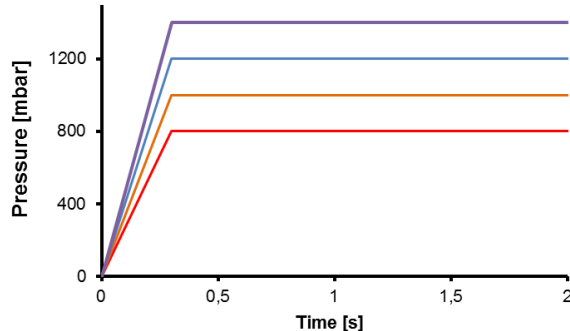
- Shoot Nozzle type
- Venting in particular at defect area
- Shot pressure
- Sand properties?
(How do sand properties affect results?)



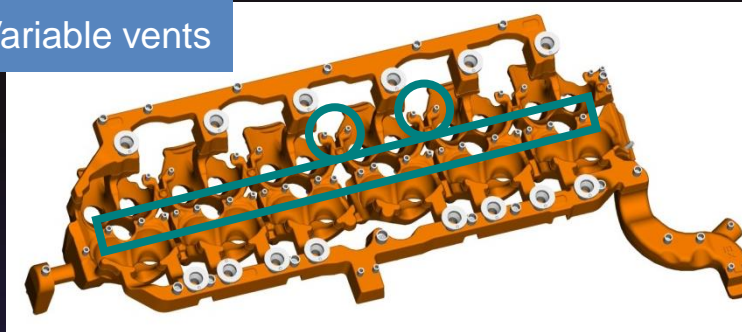
Cylinder: no maintenance
Core quality ok?



Stepped: maintenance
Core quality ok!

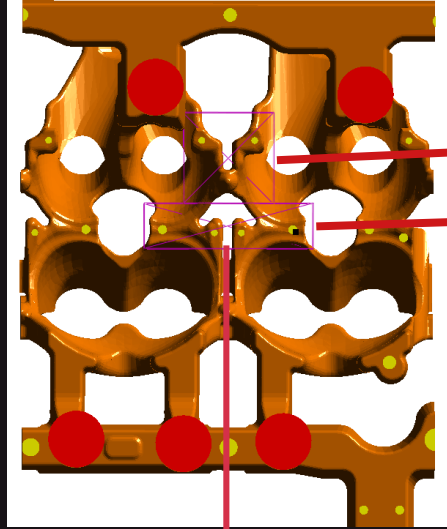


Variable vents



SPECIFY YOUR CRITERIA

— Which Quality Criteria Can Be Combined and Assessed?



Evaluation Areas:

- 1) Defect Area 1
- 2) Defect Area 2
- 3) Complete core



Objectives/Quality Criteria:

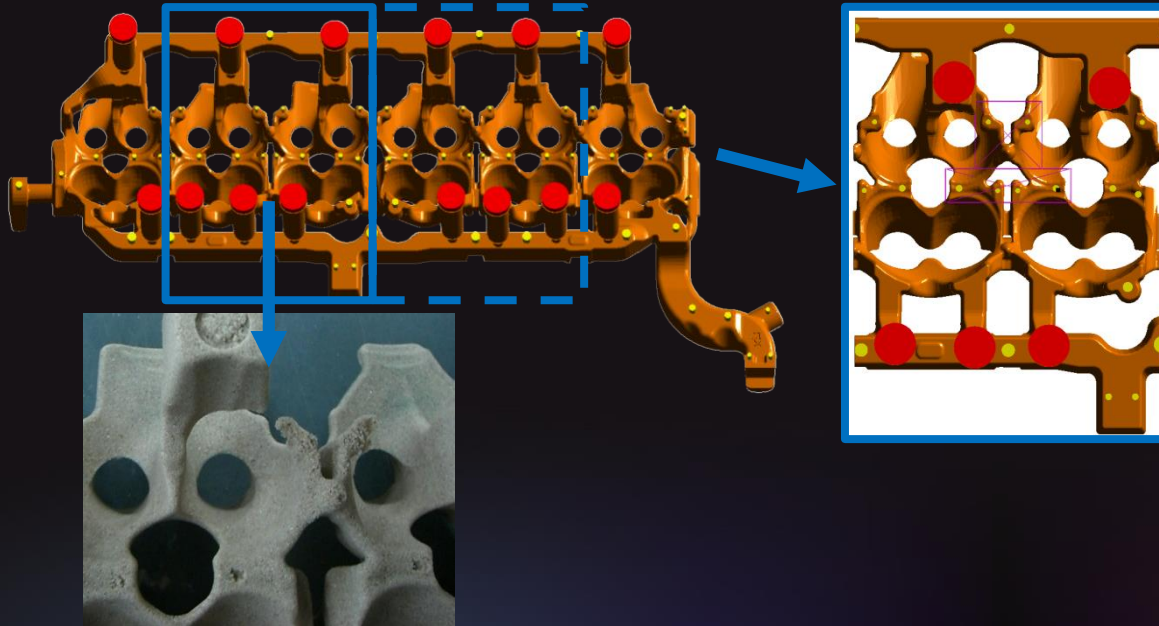
Sand density in defect areas



KEEP THE TASK EFFICIENT

— Structure and Simplify the Complexity of Your Task!

Simplification of the model, split into different tasks, reduction of influencing parameters, focus on a restricted number of degrees of freedom?



Similar defects in similar core areas

The expert knows:

Similar areas are filled independent of each other

The defect cause is the same in all similar areas

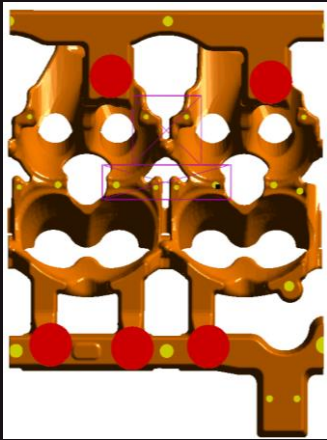
Consequence: Using a characteristic part of the core



KEEP THE TASK EFFICIENT

— Structure and Simplify the Complexity of Your Task!

Simplification of the model, split into different tasks, reduction of influencing parameters, focus on a restricted number of degrees of freedom?



First task:

- Analysis of shoot nozzle type together with
- How does sand flowability affect core quality?



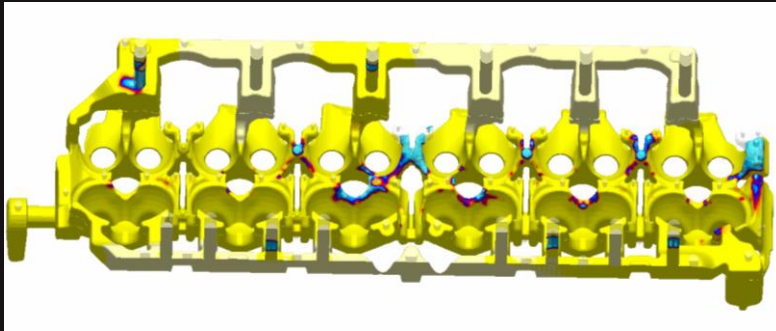
Second task:

- Analysis of venting together with
- How does shot pressure affect core quality?

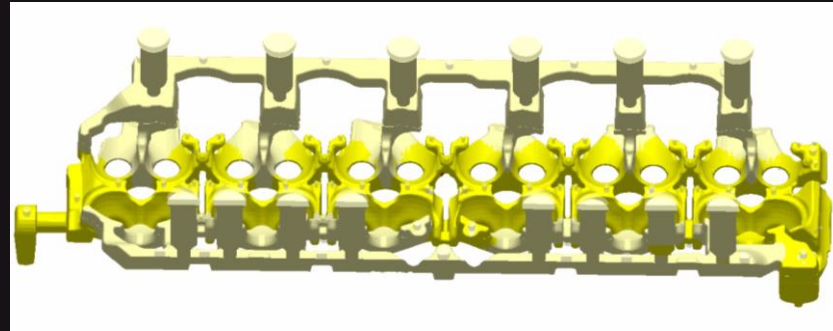


Assessment of DoE

— Filling Sequence for Different Nozzle Types



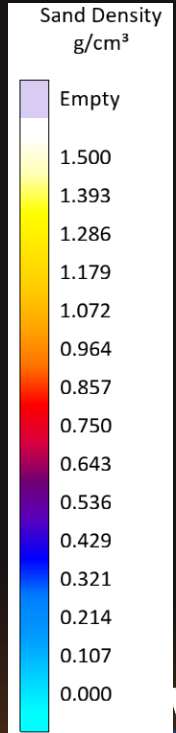
Cylinder: no maintenance
Core quality ok? ->NO!



Stepped: maintenance
Core quality ok!

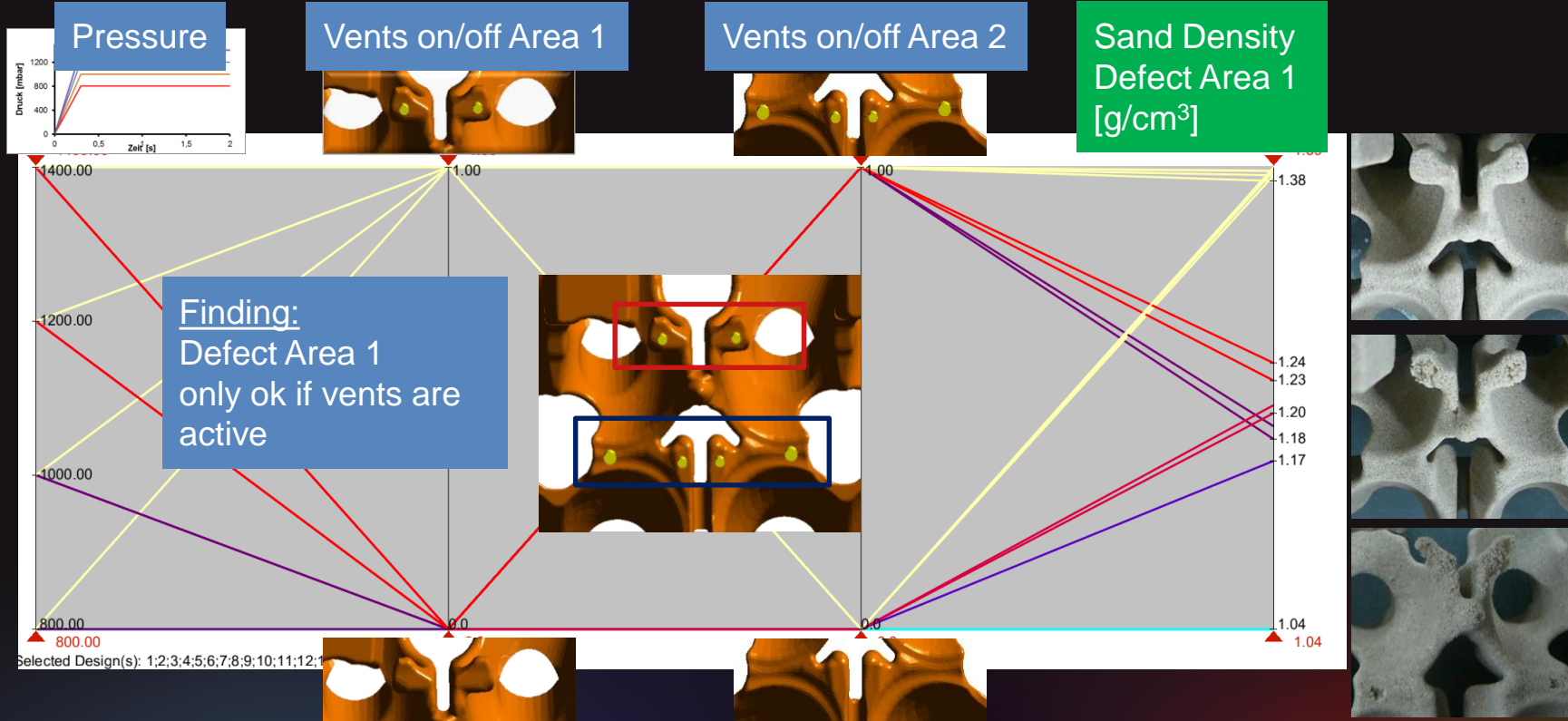
Conclusion:

- Core cannot be reliably filled using standard nozzle
- Established "special" stepped nozzle is required



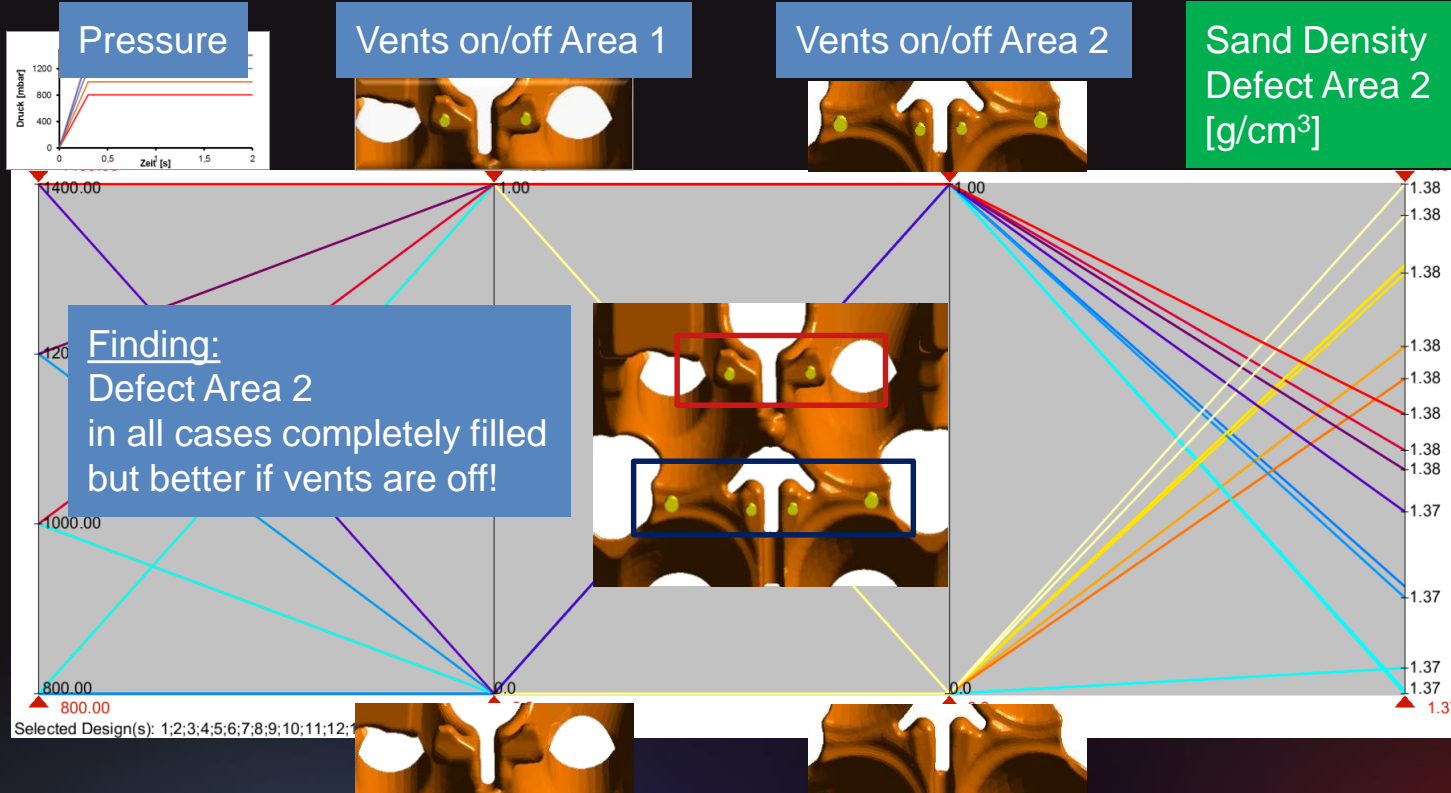
Assessment of DoE

DoE 3: Part of Defect Area 1 (Red) - Parallel Coordinates



Assessment of DoE

DoE 3: Part of Defect Area 2 (Blue) - Parallel Coordinates

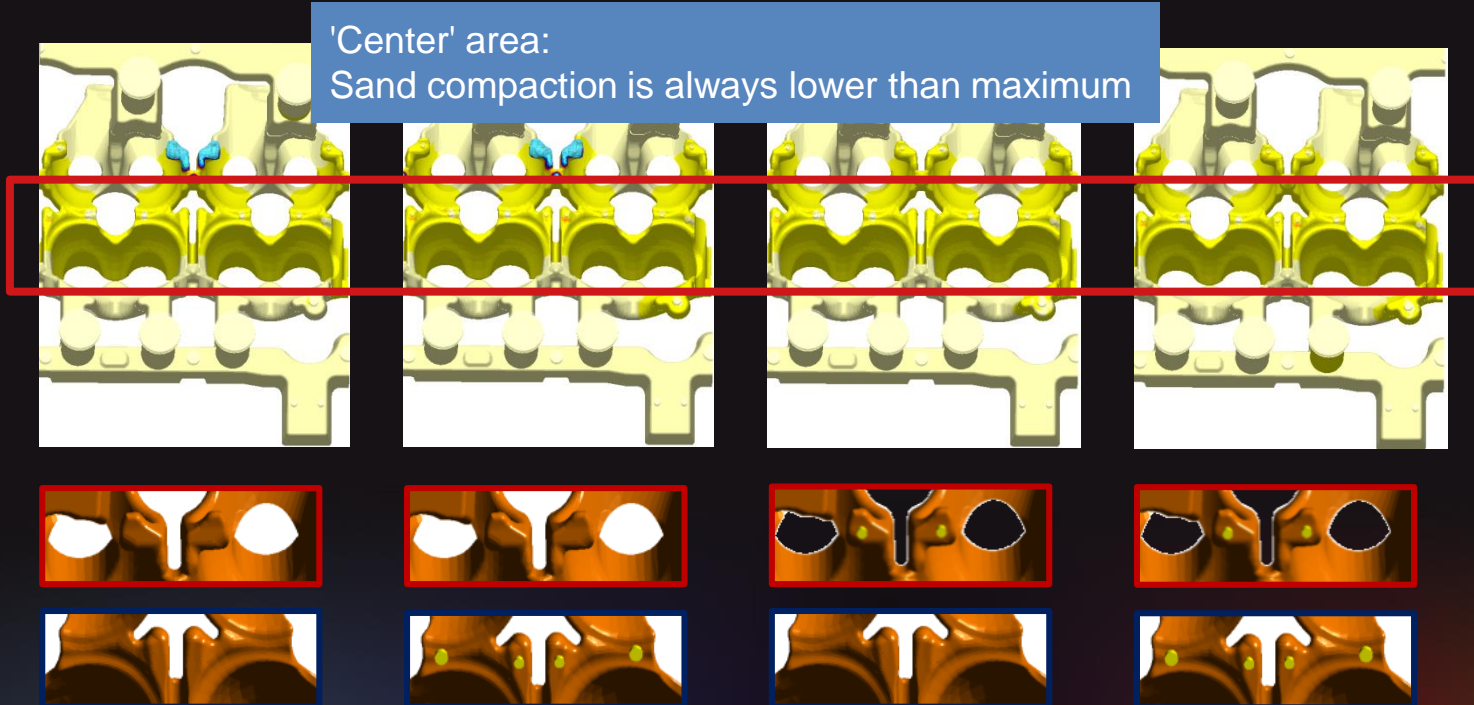


Validate your Assessment

- Filling of Area 1 and 2 for the Different Vents location

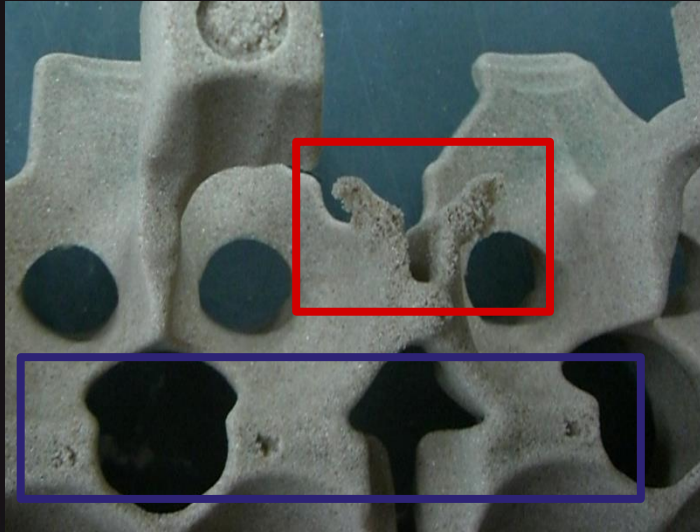
'Center' area:

Sand compaction is always lower than maximum



Validate your Assessment

- Filling of Area 1 and 2 for the Different Vents location



Defect Area 1

- Completely filled if vent is active
- Defect may occur if used for gas injection

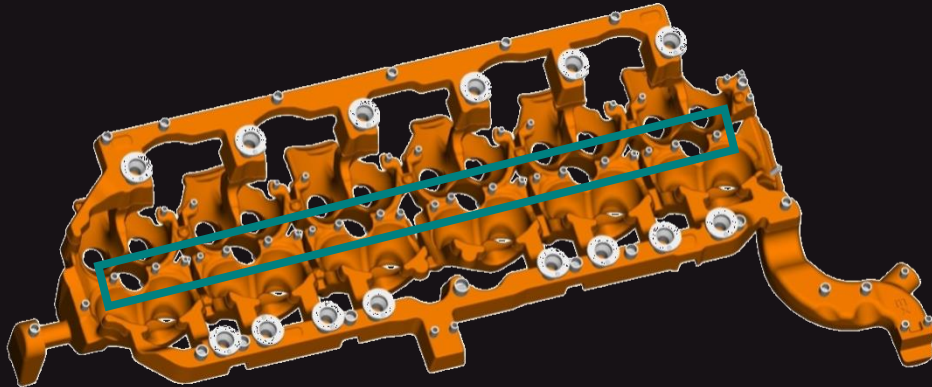
Defect Area 2

- In all cases completely filled
- Local density is higher if vents are closed
- Defect occurs if vent is active and used for gas injection

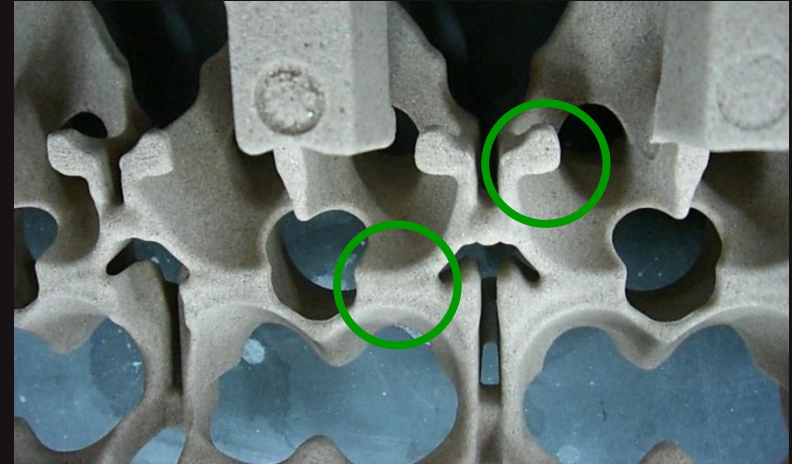


ACT & CHECK IMPROVEMENTS

- Track the efficiency of the measures and the success!



Defect Area 2
All vents closed



Improved core quality
in series production



ACT & CHECK IMPROVEMENTS

- Track the efficiency of the measures and the success!

Double-Check Your Improvement:

- EFFECTIVITY:
 - Series production is less sensitive against process specific variability in process conditions (shot pressure not exactly constant, sand properties vary more or less)
- QUALITY:
 - Scrap rate sustainably reduced
- EFFICIENCY:
 - Overall reduction in core production costs, increased production capacity – cost effectiveness improved
- KNOWLEDGE:
 - More venting does not always help
 - Obvious filling defects may be caused by gassing
 - Increased process understanding
 - Effects of nozzles and vents on core quality



Thank you



Suraj Kumar
Manager – Ferrous
MAGMA Engineering India Private Limited

