Hot distortion of sand cores

MAGMASOFT® 5
autonomous engineering

HIGHLIGHTS

Prediction of core deformation as a function of

- **Mechanical behavior** of different **sand** and **binder systems**
- Thermal loading including **buoyancy** during **filling** and early stage **solidification**
- Consideration of **core print layout** and **positioning**
- **Pressure** dependent description of the **bonded porous sand material**
- **Time** and **temperature** dependent **mechanical data**

MAIN BENEFITS

MAGMAstress quantitatively predicts core stresses and distortion offering:

- Increased **safety** by avoiding core failure during casting through quantitative prediction of core stresses
- **Effectivity** by optimizing shrinkage factors for core pattern layout through calculation of local thermal expansion coefficients
- **Robustness** due to stabilized core production through pre-shaping of core print layouts
- **Availability** by supporting major binder and sand systems
- **Cost savings** by minimizing design loops, tool rework and lead times through systematic core print development

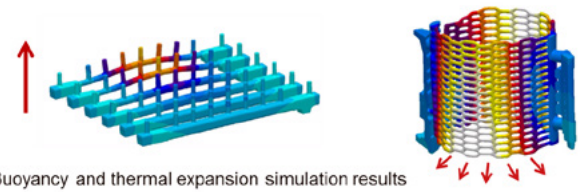
CHALLENGES

Knowing local core shrinkage factors and possible core distortion during the casting process are of prime concern for tool makers as well as the core shop to secure an optimized core box layout and robust manufacturing conditions. Both the designer and the end user of cast parts are concerned about the following challenges:

- Casting wall thickness tolerances become tighter due to light weight and thin walled casting design
- Core geometries become more complex, thin walled and fragile and hence more sensitive to distortion
- Environment-friendly inorganic binder systems increase the danger for core distortion due to higher thermal expansion and stiffness
- Higher cost and production efficiency in casting increase the mechanical and thermal loads on cores with the consequence of resulting distortion and failure

New developments in MAGMAstress allow the prediction of hot distortion of bonded sand cores. This enables tool makers and foundrymen to analyze how the core material performs during casting and how the cores influence the final shape of the cast part.

High temperature testing – 3 point bending, creep and buoyancy



Buoyancy and thermal expansion simulation results

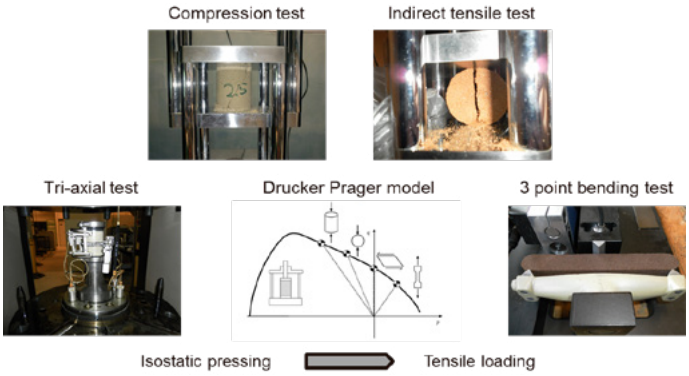
Detailed knowledge of bonded sand, from measurements to new mechanical model, validated on benchmark examples and used on complex cores

WHAT MAKES SAND SPECIAL

Bonded sand cores consist of a complex multi-state material which is fundamentally different from the mechanical behavior of metals and therefore needs special considerations in the stress simulation. The tensile strength of the core is governed by the binder system, which is sensitive to temperature, curing, degradation and for inorganic systems also drying and moisture. In compression, the strength of the core is governed by the contact between the grains, where the sand type plays an important role.

With special focus on the highly transient and irreversible properties of the core material it is now possible to predict core deformation during the entire casting process quantitatively.

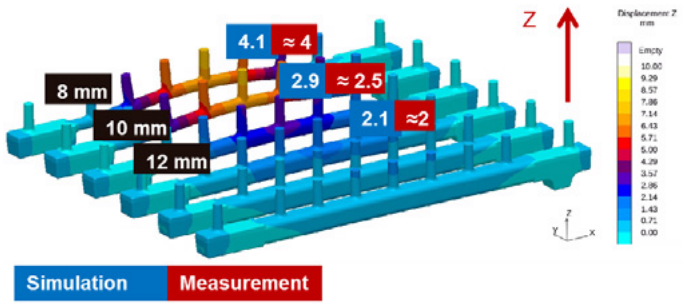
For new sand systems MAGMA provides measurement plans and recommended test conditions and offers support for extracting consistent material data used for the simulations.



Multi-state material from a loose granular material to a bonded porous material, where strength is governed by binder bridges and contact between grains

CONSIDERATION OF BUOYANCY

Thin walled cold box bonded cores and cores with limited support due to the casting layout and the possible location of core prints can deform severely due to buoyancy. MAGMAstress is able to simulate buoyancy forces during filling and solidification. This allows the prediction of the deformation resulting from the density differences between the cast material and the core.



Bending of long cores due to buoyancy can now be simulated and analyzed

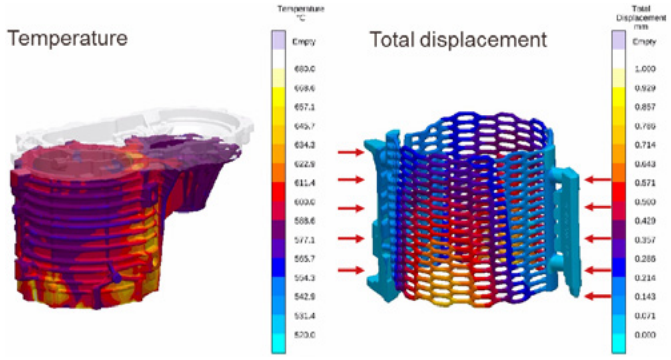
INTEGRATION IN MAGMAstress

The new material model is fully embedded in the MAGMAstress module. Selected material datasets for organic and inorganic bonded core material are available in the MAGMASOFT® database.

- **Fully integrated optimization** in MAGMASOFT® autonomous engineering
- Considers all **major influencing parameters** on core distortion
- **Comprehensive database** of selected core materials is available
- Developed and validated with **leading industrial partners**

ASSESSING CORE SHRINKAGE AND DISTORTION

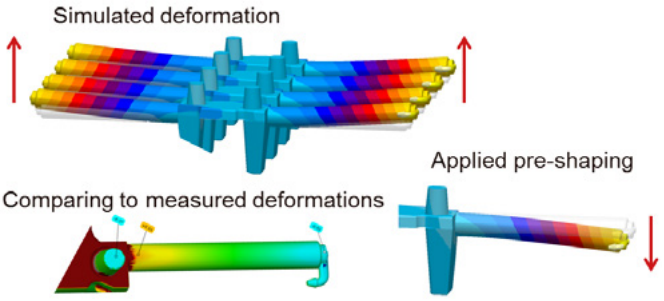
Core expansion and distortion can be quantitatively monitored during the entire casting process. During filling the core can deform in the liquid metal whereas during solidification the shell of the solidifying metal will constrain the core. Further deformation is governed by the interaction with the cooling cast part.



Core distortion modeling is fully coupled to the filling and solidication simulation allowing the user to optimize the entire process to minimize core distortion and related issue of dimensional tolerances in the casting.

PRE-SHAPING THE CORE BOX

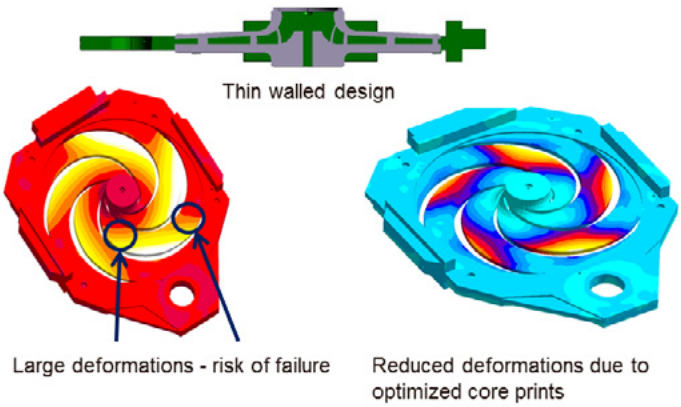
The predicted core distortion can be used to apply pre-shaping of the core box cavity into the accepted dimensional tolerances.



Simulation results are used to pre-shape the core to meet tolerance requirements of the final part.

AVOIDING CORE FAILURE

Location of core prints and other constraints on the core are easily analyzed. Different setups can be tested to optimize the quality of the casting.



Location of core prints are optimized to avoid problems in thin walled designs