Revolutionizing Metal Casting: Integrating Inorganic Binders with Refractory Coatings for Structural Applications

Christian Lustig, Ekaterina Potaturina
Hüttenes-Albertus Chemische Werke GmbH, Germany
*Corresponding address: e-mail: christian.lustig@ha-group.com , ekaterina.potaturina@ha-group.com

Abstract: This paper explores advances in metal casting, focusing on inorganic sand cores with specialized developed water-based coatings in HPDC for automotive applications. This technology can be used to produce lightweight, hollow structures especially required for the manufacture of structural components.

Keywords: Inorganic Binder, HPDC, Sand Cores, Sustainability, Refractory Coating

1 Introduction

This paper presents a comprehensive overview of the recent advancements in metal casting, focusing on the integration of inorganic sand cores in aluminum high-pressure die casting (HPDC), with a special emphasis on the automotive industry. The innovation lies in the synergy of traditional sand cores coated with a (water based) core wash and the dynamic HPDC processes, addressing the need to produce large, lightweight, hollow structures for automotive applications.

Key Considerations for the use of Inorganic Sand Core Usage in High-Pressure Die Casting

As the automotive industry shifts from internal combustion engines (ICE) to battery electric vehicles (BEV), the requirements for the body-in-white (BIW) structure must evolve accordingly. This evolution entails a transition from designing simple, single-piece components to more complex structures, offering several benefits such as increased design flexibility, the ability to create undercuts, and the elimination of the need for draft angles in high-pressure die casting (HPDC) tools.

A significant innovation to realize these demands is the use of sand cores in the casting of large, volumetric components. Traditionally, various methods have been employed to create cavities within HPDC parts these include steel cores and salt, or ceramic cores mainly used for smaller cavities.

Inorganic sand cores in HPDC applications represent a new approach, not intended to replace existing technologies but rather to complement them–with focus on bigger and more complex cavities. They provide many advantages, such as greater design freedom and especially a well-established and economically efficient production processes. Sand cores have been a part of foundry technology for many years, with the first machine-made sand cores dating back several decades.

Especially inorganic bonded sand cores show high potential for the use in HPDC applications as they are environmentally friendly not only in their production but especially also in casting and suitable for wet decoring and reclamation process. Especially as inorganic cores are water disposable, these cores can be easily and gently removed from thin-walled castings. This is the basis for the application of this technology in the field of HPDC castings.

2 Experimental procedure and results

Combining Sand Cores and HPDC: The Best of Both Worlds

A demonstrator was designed to develop and evaluate the concept of lost cores in HPDC applications. An existing HPDC casting node was modified with integrated sand cores that have ribs and undercuts. The tests were run at piston speed between 5.5 and 7.0 m/s. The after pressure varing between 300 and 900 bar.

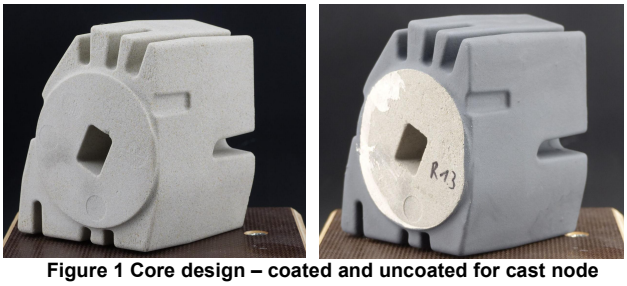

Figure 1 Core design – coated and uncoated for cast node

MAGMA simulations were also carried out to understand the flowability of the demonstrator cast node.

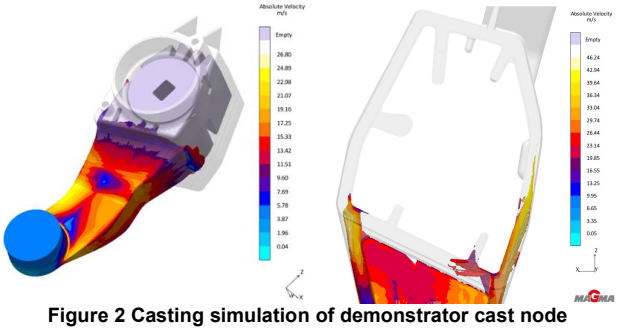

Figure 2 Casting simulation of demonstrator cast node

As a result, most of the metal penetrations and sand adhesion between the ribs were present until the optimum parameters were found.

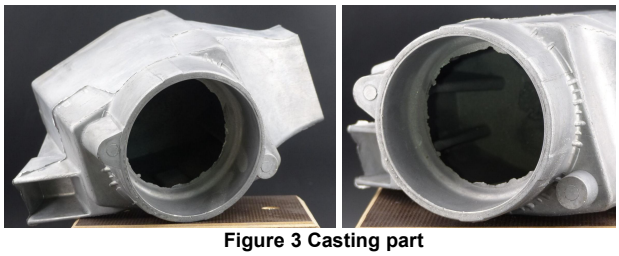

Figure 3 Casting part

Integrating sand cores with HPDC casting technology requires several process steps:

- machine production of sand cores
- surface sealing of the cores
- core removal
- recycling of core sand

While the core-making process for inorganic sand cores is well established, the surface sealing of these cores is a new and challenging topic. The coating process plays a crucial role in this integration. One of the biggest challenges is the development of a water-based coating that is suitable for inorganic and water-disposable sand cores and does not damage them. When developing such coatings, factors such as the composition and rheological properties of the coating must be considered, especially as these cores should have long, deep, narrow ribs to be coated. Among the various application methods, dipping is a viable option. It is crucial that the cores do not absorb too much water and that the coating does not penetrate too deeply. The coating should be applied well to avoid dripping and the formation of runs to ensure a smooth and even coating layer.

When transferring the parameters from the demonstrator casting to the real, various machine-side parameters, such as the flow rate and the casting pressure, were varied. The influence of the sand core type and, in particular, the applied coating was evaluated. It is easy to see that the casting results correlate to a high degree with the applied flow rates and the applied coating. As the sand core is porous by nature, the coating has a dominating influence on the casting result and especially on the surface finish.

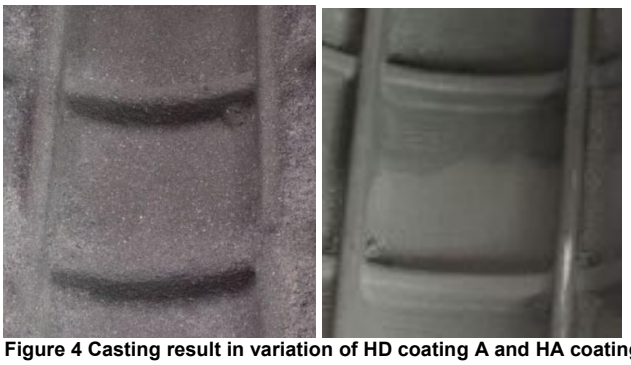

Figure 4 Casting result in variation of HD coating A and HA coating B

3 Conclusion

For HPDC applications, the sand cores used are important but not the only criterion for successful casting. The selection of a suitable coating and its application to the sand core is crucial for the successful use of sand cores in HPDC casting.

The suitability of this new technology was proven based on several demonstrator castings. All process steps were examined and evaluated:

- Core production
- Core finishing - Sealing of the core
- Casting
- Sand removal
- Recovery of the sand

With these findings, a start has been made on further evaluating this technology and bringing it into initial series applications.

References

[1] Kallien L Böhnlein C Dworag A Müller B. Ergebnisse aus dem Forschungsprojekt 3-D-Freiform– medienführende Kanäle im Druckguss Giesserei 2013 (100)12: 36-43.

[2] Zaretskiy, L. Modified Silicate Binders New Developments and Applications. Inter Metalcast 2016 (10): 88–99.