INNOVATIVE SAND CORES WITH WATER-SOLUBLE BINDER SYSTEMS FOR THE NON-FERROUS SECTOR

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A key limit on the high pressure die casting process (HPDC) is the inability to produce complex, hollow castings at high volume and in a cost-effective and sustainable way, due to the difficulty in producing suitable cores. Standard sand cores made with common organic or inorganic binders cannot be used for HPDC, as they are difficult to remove after casting and do not provide adequate surface finish. Salt cores are more suitable, but can be expensive to produce, whilst presenting other operational limitations. In response to this challenge, the Foseco Foundry R&D Centre in Enschede, the Netherlands, has developed a new type of sand core, using an innovative Water-Soluble Binder (WASCO*) and coating, which offers competitive strength and manufacturability, whilst enabling easy removal after casting.

INTRODUCTION

HPDC offers a range of advantages, such as higher production rates and good surface finish; as a result, is the process of choice for many of the new, lightweight parts needed by the growing e-mobility and 5G markets. However, it is also not without its challenges. One significant limitation is the ability to produce complex internal cavity shapes. In order to overcome that obstacle, it is necessary to develop disposable cores that must be able to tolerate the high pressures, temperatures and speeds involved in the HPDC process.

A new type of sand core, developed by the Foseco Foundry R&D Centre, provides a solution to these challenges. These cores are made with the innovative WASCO binder and coating using standard sand core production equipment. They therefore offer a more cost-effective and sustainable option for HPDC of complex, hollow shapes at high volume and are equally suitable for use in liquid HPDC or also in semi-solid (Rheocasting) process.

MANUFACTURING SAND CORES

All sand cores are produced using a standard core shooter equipped with a hot box system. For the new HPDC-suitable cores, the sand mixture is prepared using the liquid binder and the additive (powder). It is then automatically injected at high speed into a specially designed core box using compressed air, and cured using hot air. Several types of cores were produced (see examples in Figure 1).

For high-pressure casting processes, a coating may also be necessary to avoid penetration of the liquid metal into the pores of the sand, which results in unacceptable roughness (encapsulation of the sand grains) of the casting surface. Different techniques can be used to apply a sealant, such as dipping or spraying.

MECHANICAL STRENGTH

Figure 2 shows the mechanical strength and sample weight of sand cores made from H33-type quartz sand, as a function of the amount of the additive. The liquid binder was set at 6.0wt% of the sand. Depending on the casting process and the related requirements, the exact strength values can be selected.

As can be concluded from Figure 2, the strength values of samples without the additive were relatively low (low compaction (low sample weight)); the average value was about 100N/cm². However, the addition of only a small amount of the additive, in this case 2.0wt%, resulted in a significant improvement in the mechanical properties: strength values were around 700N/cm². A further increase of the concentration resulted in strength values higher than 1200N/cm² (high compaction (high sample weight)).

Figure 1: Sand cores manufactured with WASCO* systems and treated with a coating.

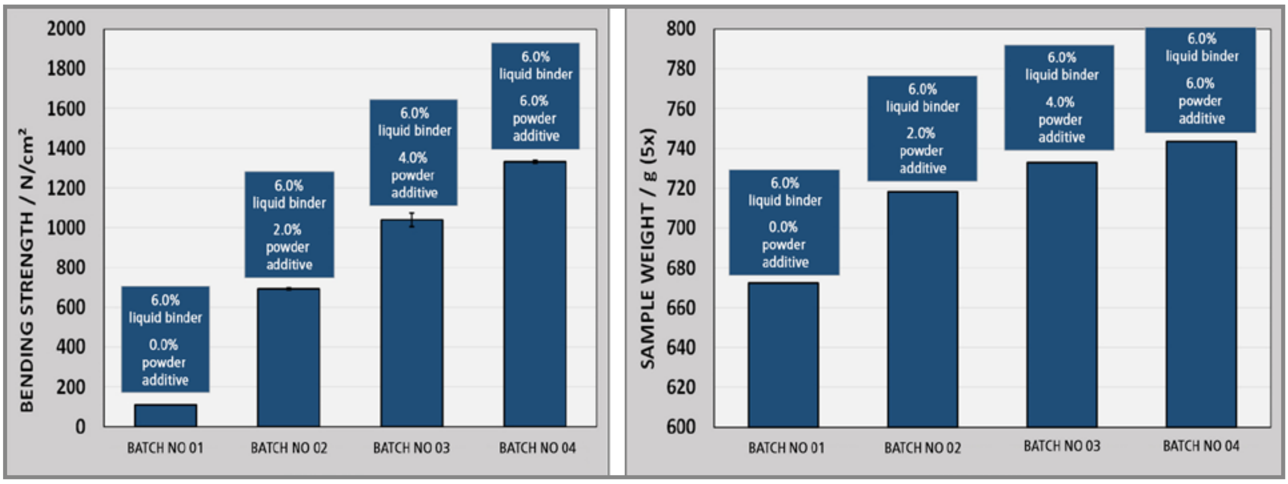

Figure 2: Bending (flexural) strength (left) and sample weight (right) as a function of the concentration of the additive.
The concentration of the liquid binder was set at 6.0 wt% of the sand.

Figure 3: The core solubility shows the clear benefits against conventional core.

WATCH VIDEO

WATER-SOLUBILITY OF THE BINDER

Irrespective of the mechanical strength of the sand cores, the water solubility of the binder was excellent with full dissolution feasible in less than 5 seconds (Figure 3). It is interesting to note that the new WASCO binders showed excellent solubility after the casting trials in multiple processes from liquid HPDC, Rheocasting, Gravity and LPDC processes, indicating that the application temperature of such a type of binder is at least 750°C. This makes these cores very promising candidates for slow and fast solidifying casting processes. An example of a Rheocast part is shown in Figure 4.

SURFACE ROUGHNESS

Surface roughness is one of the most important characteristics of the casting pieces after removal of core residue from the hollow part. In HPDC, use of a coating is indispensable, as an uncoated core will result in a casting with unacceptable surface roughness. This is caused by the penetration of liquid metal into the pores of the cores and consequent encapsulation of the sand grains into the surface of the casting. Figure 5 (left) shows the inner surface of a HPDC casting from an unsealed sand core; the use of an incorrect coating type can also result in similar surface appearance (Figure 5 – centre). Casting with an optimised coating, however, achieves a smooth and sand-free inner surface (Figure 5 – right).

Figure 4: Water tap manufactured in Rheocasting by Comptech AB

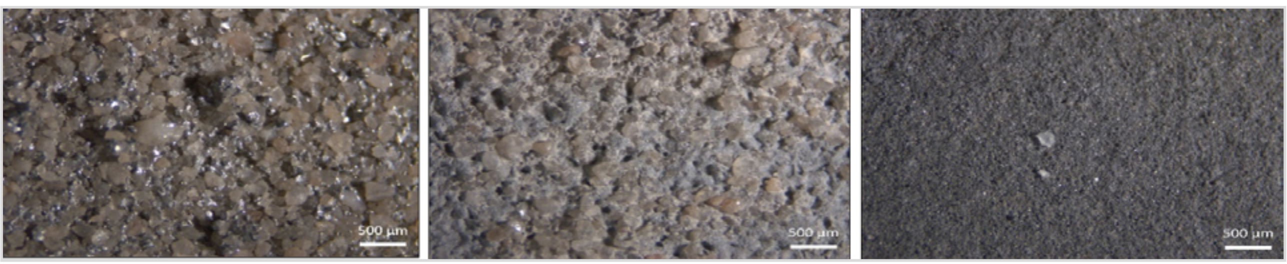

Figure 5: The inner surface of three casting pieces: left – a casting made with an uncoated core; centre – a casting made with the incorrect coating type; right – a casting made with an optimised coating.

Surface roughness of these castings was also measured by using a Keyence non-contact profilometer: In this case, the surface of a casting made with an uncoated sand core and one made with the optimised coating were measured. The value, Sa, is the extension of Ra (the arithmetical mean height of a line) to a surface, and expresses, as an absolute value, the difference in height of each point compared to the arithmetical mean of the surface. The uncoated core showed a relatively high roughness of Sa = 123µm (Figure 6); this confirmed the visual observation shown in Figure 5 (left). The application of a well-developed coating resulted in a significant improvement; the surface was much smoother with an average Sa of just 14 µm (Figure 7).

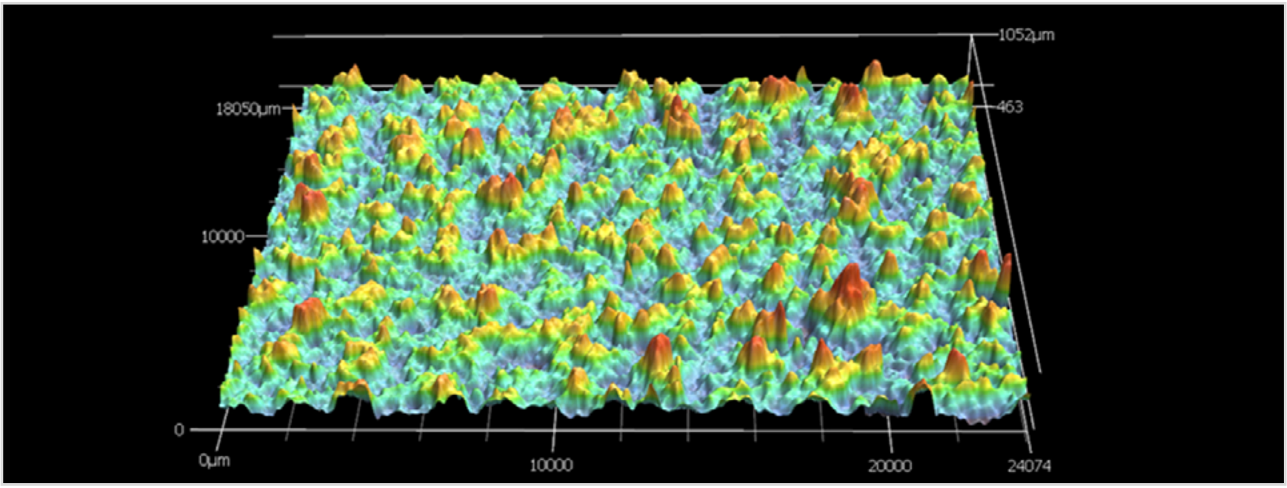

Figure 6: Keyence non-contact profilometer 3D image of a casting using an uncoated sand core (Sa – 123µm).

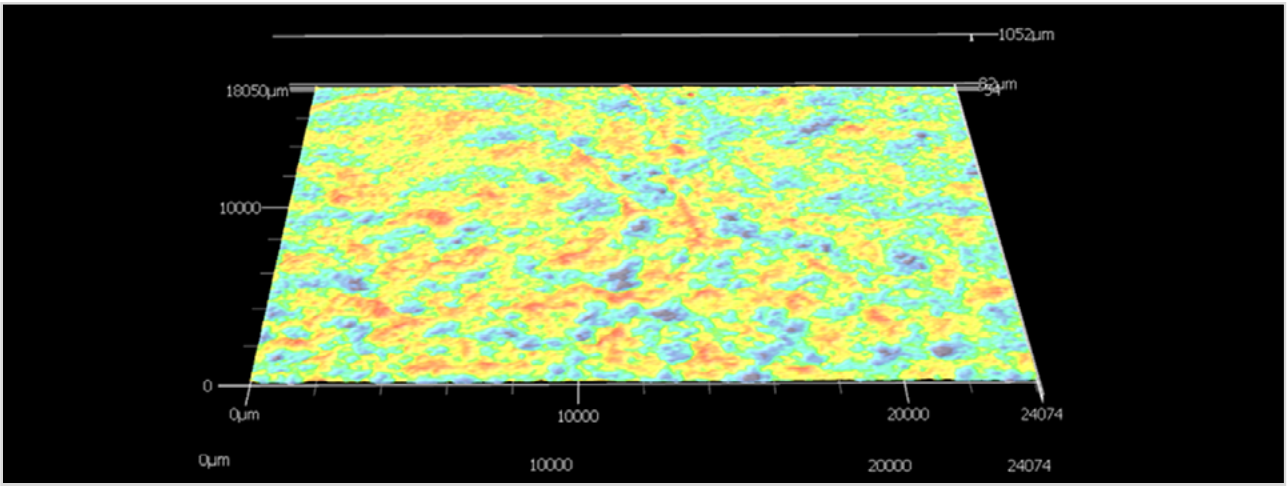

Figure 7: Keyence non-contact profilometer 3D image of a casting using a coated core (Sa – 14µm).

MAIN ADVANTAGES

Laboratory tests, as well as testing trials in the field, have demonstrated the strong potential of the new WASCO* system to meet a wide range of customer requirements, showing very promising results not only for liquid HPDC, but also gravity die casting and Rheocasting for aluminium.

CONCLUSIONS

The new WASCO* systems developed by the Foseco Foundry R&D Centre in Enschede, The Netherlands, have demonstrated their high strength in various applications. Even in severe processing conditions, such as HPDC, with the use of an appropriate coating, these innovative sand cores can withstand high pressures and high temperatures, whilst facilitating easy core removal from internal cavities by flushing water, leaving a smooth and sand-free surface.

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The main advantages of the new systems are:

- Core residue is easy to remove, even after longer times at 700°C
- Uses cost-effective materials
- High flexibility in the use of additives
- Manufacturing uses standard hot box core shooters
- Strength values exceeding 1000 N/cm^2 are achievable
- Thermal resistance up to 750°C is possible

ABOUT THE AUTHOR

Mark has worked for Foseco since 2020 and is currently Global Product Director for the non-ferrous foundry market. In this role, he is responsible for developing and implementing our growth strategy for current and future non-ferrous products. It's a job that regularly takes him around the world to learn about regional market dynamics and needs from our network of experts. In his free time, Mark enjoys spending time with his wife and children, walking, reading, and playing cricket, golf, and football.

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Vincent joined Foseco in 2011. He is currently R&D Manager for Binders at our Global R&D Centre, where he leads development of our innovative and environmentally-friendly inorganic binders. He is also responsible for communicating the benefits of our new binders to the foundry industry, and he regularly presents at conferences and workshops, and publishes in scientific journals. Outside work, Vincent enjoys spending time with his family, cycling, playing the organ and piano, cooking, and learning languages.

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