Core Sand Additives

Lithium-free alternatives for iron, steel and aluminum foundries

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ABSTRACT

Constantly growing demands for productivity and efficiency are always present in the foundry industry. At the same time, social and political changes are taking place. The awareness and sensitivity to ecological problems and the consistent striving to protect the environment and conserve resources are becoming ever more present. Society and politics want to move away from tried-and tested classic combustion engines towards the electrification of the powertrain very soon. In this change, one raw material is gaining enormous importance: lithium.
Lithium is a key component for rechargeable batteries, but it is also an essential component of sand additives. The supply situation and especially the price development are hard to predict. In addition, mining conditions and the effort required for processing in South America have disastrous consequences for the environment and local people. Against this background, ASK Chemicals has set itself the goal to develop novel lithium-free sand additives which match the demands of the foundries for sustainable and cost effective production. In close cooparation with many foundries, considerable success have been achived over the last 4 years. With these innovative sand additives from ASK Chemicals, foundries can continiue to meet the current and future requirements.

The increasing importance of electromobility is leading to an extremely high demand for lithium for battery production. The associated shortage of this raw material is forcing the foundry industry and its suppliers to fundamentally reorient themselves. Running parallel with this is the issue of sustainability and social responsibility, which has a very high priority at ASK Chemicals. Thanks to the development of a new generation of innovative lithium-free sand additives, which are in no way inferior to conventional lithium-containing ones, the total amount of lithium required for the production of additives at ASK Chemicals has been reduced by 100%

Necessity of sand additives

Sand additives are essentially divided into 3 groups on the basis of their composition and mode of action (**Fig. 1**). The task of the supplier is to recommend to the foundry as an individual user the correct additive with the ideal addition rate (sand formulation) for the specific production process. Basically, it can be said that the use of sand additives is, not only decisive for maintaining or increasing competitiveness but essential for meeting the qualitative requirements of the casting. Particularly noteworthy are the good anti-veining properties and the excellent performance even at low additive addition rates. With this in mind, it is not surprising that the importance of sand additives is steadily increasing.

Fig. 1: Classification of additives groups (ASK Chemicals)

New types of lithium-free engineered sand additives

As an inorganic component, lithium has proven to be effective against veining and has therefore been depending on the technological requirements, different organic and inorganic components are combined. Established as an all-rounder for more than 30 years not only in inorganic, but also in newer hybrid additives. Given the circumstances, it was necessary to find a technically comparable but lithium-free alternative that offers both security of supply and price stability, both factors that are no longer present when lithium-containing products are used .

After extensive screening of alternative raw materials, ASK Chemicals' Research & Development team has succeeded in finding a solution, which was first tested in the foundry pilot plant for its properties (i.e. surface quality, bending strength or hot distortion, etc.). First trials done in our foundry pilot plant (**Fig. 2**) were successful, as a result the new product could be further tested in field trials at the customer's site.

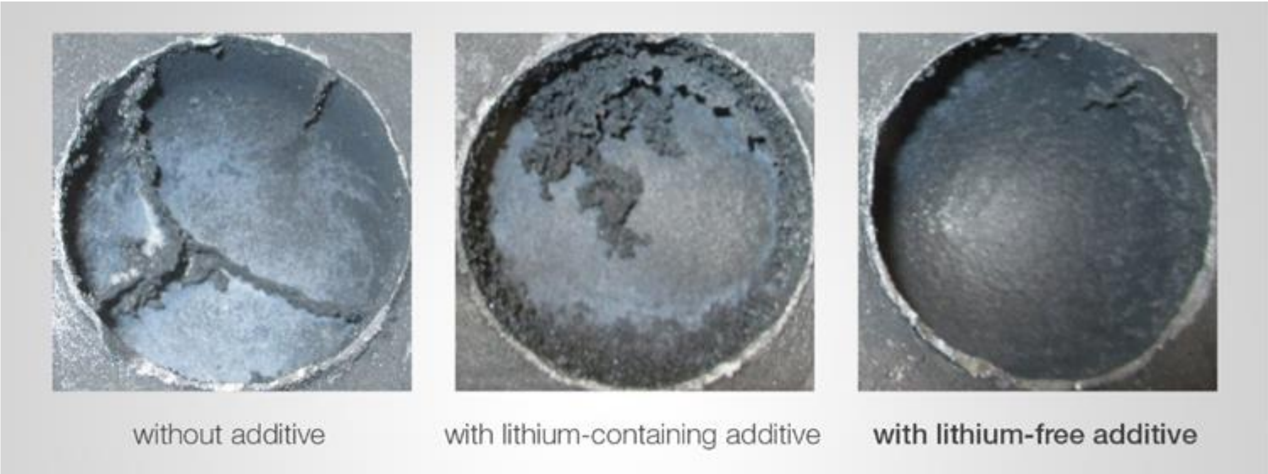

Fig. 2: Coated dome cores; additive addition 2% in the sand mixture, casting in GJL, casting temperature approx. 1420 °C (ASK Chemicals)

The newly developed sand additives have proven their worth in many respects:

- Significantly reduced casting defects that lead to rework or rejects
- reduction or even elimination of specialty sand additions
- under certain conditions, coating-free casting becomes possible,
- long lasting tool availability due to excellent release properties.
- the release agent application can be reduced,
- very good flowability of the core molding material with good contour reproduction,
- additives for aluminium foundries applying the PUCB (Phenolic Urethane Cold Box) process, with the goal to

improve the shake out of the sand,
- bending strength increasing additives (for cores/molds) for CB-, Resol-CO_2-, Resol-Methylformate (MF)-processes allow an economical binder application

More productivity through cleaner tools (Phenolic Urethane Cold Box)

Despite the application of a proven release agent, a mixture of sand and resin can build up within a very short time, especially underneath the blow tubes **(Fig. 3+4)**. Up to a certain degree, this contamination in the mold is accepted or tolerated.

Fig. 3: Core box; comparison of sand additive and binder buildup (cold box) underneath of two inserts. Result after 20 cycles and without release agent application, lab test (ASK Chemicals)

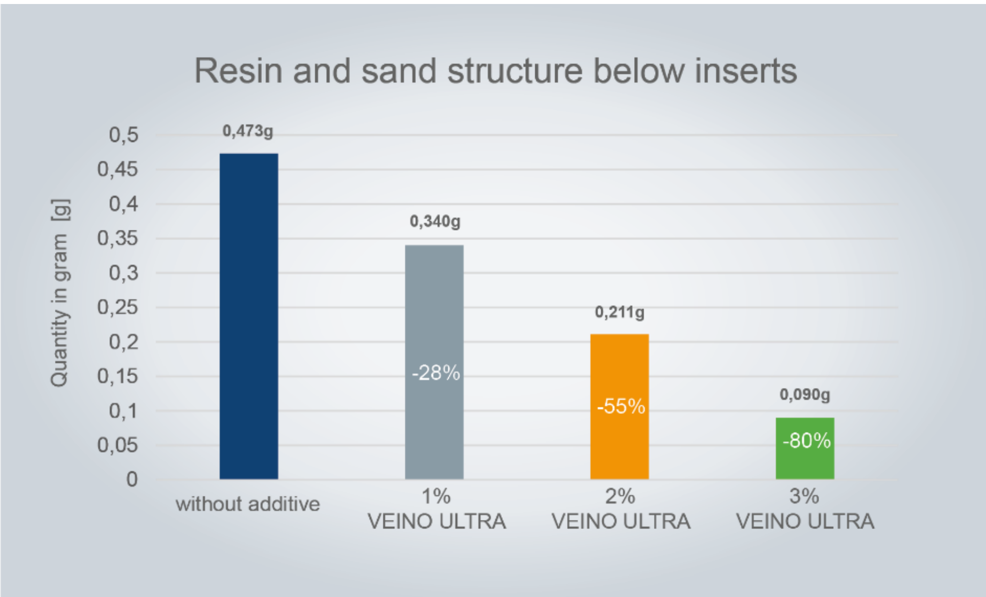

Fig. 4: Reduction of the sand buildup below the inserts depending on the additive quantity, after 20 cycles and without release agent application, lab test (ASK Chemicals)

An interruption of production for cleaning is nevertheless required after some time. The addition of the additive significantly reduces down time compared to the standard production, core box contamination (**Table 1**). After 117 cycles without cleaning the core box and without interruption in operation, the following picture was obtained. The release agent application was drastically reduced, resin build-up was absent and vents did not have to be cleaned.

Table 1: Productivity increase on the core shooter, field application (ASK Chemicals)

	Standard production	Additive New development
Release agent application	After 10 cycles	Once after 50 cycles
Removal of sand/resin buildup	After 30 cycles	Was not necessary
Cleaning of vents	After 50 cycles	Was not necessary

Reduction of overall process costs

In the field of cold box production, coating-free casting offers probably the greatest opportunity to increase the productivity and ensure high-quality castings. Over the past years, work has been carried out - in collaboration with leading foundries - to avoid the coating process wherever possible. For many castings (mainly in GJS, increasingly also in GJL), this goal has been successfully achieved with new additives.

The assessment of the conventional process takes into account the overall total cost of the core molding compound inclusive of additive, special sands, handling costs of the coating process and electricity costs for drying ovens. As a result, the coating-free process proves to be significantly more economical.In future, the CO2 tax will also need to be included in the calculations for the savings potential. Depending on the furnace design and the surfaces of the cores/molds, this can mean additional costs in a five figure EUR amount for the use of approx. 100 t of water-based coating per year from 2025.

Cost savings by replacing special sands

Special sands are natural mineral sands, sintered and melted products that are produced in granular form. They differ from silica sand in particular in their significantly lower thermal expansion behavior in the temperature range from 20 to 800 °C. In the casting process, special sands such as chromite sand, ceramic hollow spheres, andalusites and feldspar sands are used . The quantities added (usually 30 - 100 %) vary greatly depending on the specific requirements.
Special sands are an effective tool against casting defects with little or no gas or odor emissions. Alternatively, with a few exceptions, they are not reclaimable/separable and they generate high disposal costs. Above a certain level of accumulation, the use of special sands can also have a negative impact on the green sand system. Plus the cost of special sands can fluctuate widely.

The performance of special sands remains undisputed. However, from time to time, one should ask whether the choice of moulding material, as well as the amount used, is still up to date. Unfortunately, the costs are too often accepted in many cases (**Fig. 5**), because no alternative is seen to achieve the desired quality. The following example shows that it is possible to replace chromite sand without sacrificing casting quality (**Fig. 6**).

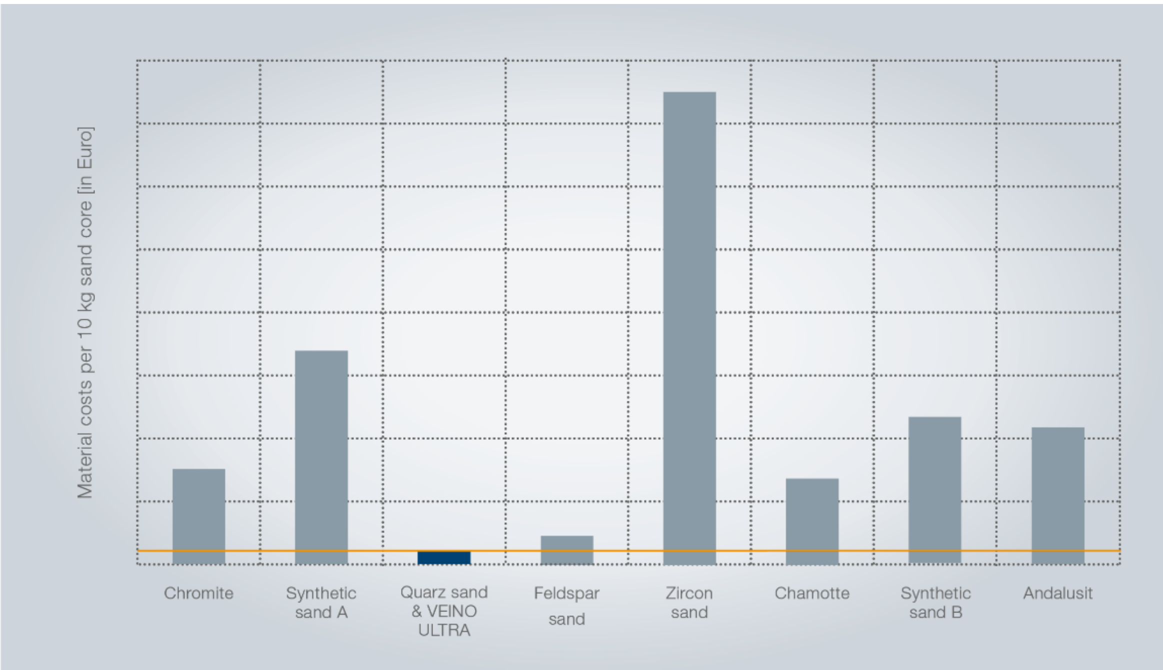

Fig. 5: Cost savings by eliminating the need for special sands (ASK Chemicals)

Fig. 6: Large step cone, GJL. Casting temperature 1410-1420 °C. Water-based coating, approx. 300 µm layer thickness (ASK Chemicals)

Strength increases in RESOL - CO2 / RESOL - methyl formate processes

Usually the addition of conventional additives requires a binder increase. A novel and patented additive development enables targeted strength increases in the core molding compound. This is of particular interest for binder systems such as RESOL-CO2 / RESOL-MF, which require high addition rates to achieve desired bending strengths but are at the same time limited by the high viscosity of the binder systems. The newly developed additive technology makes it possible to increase the strengths and at the same time improve the flowability. The system-related lower moisture stability and water-based coating resistance can also be improved with such additives (**Fig. 7**).

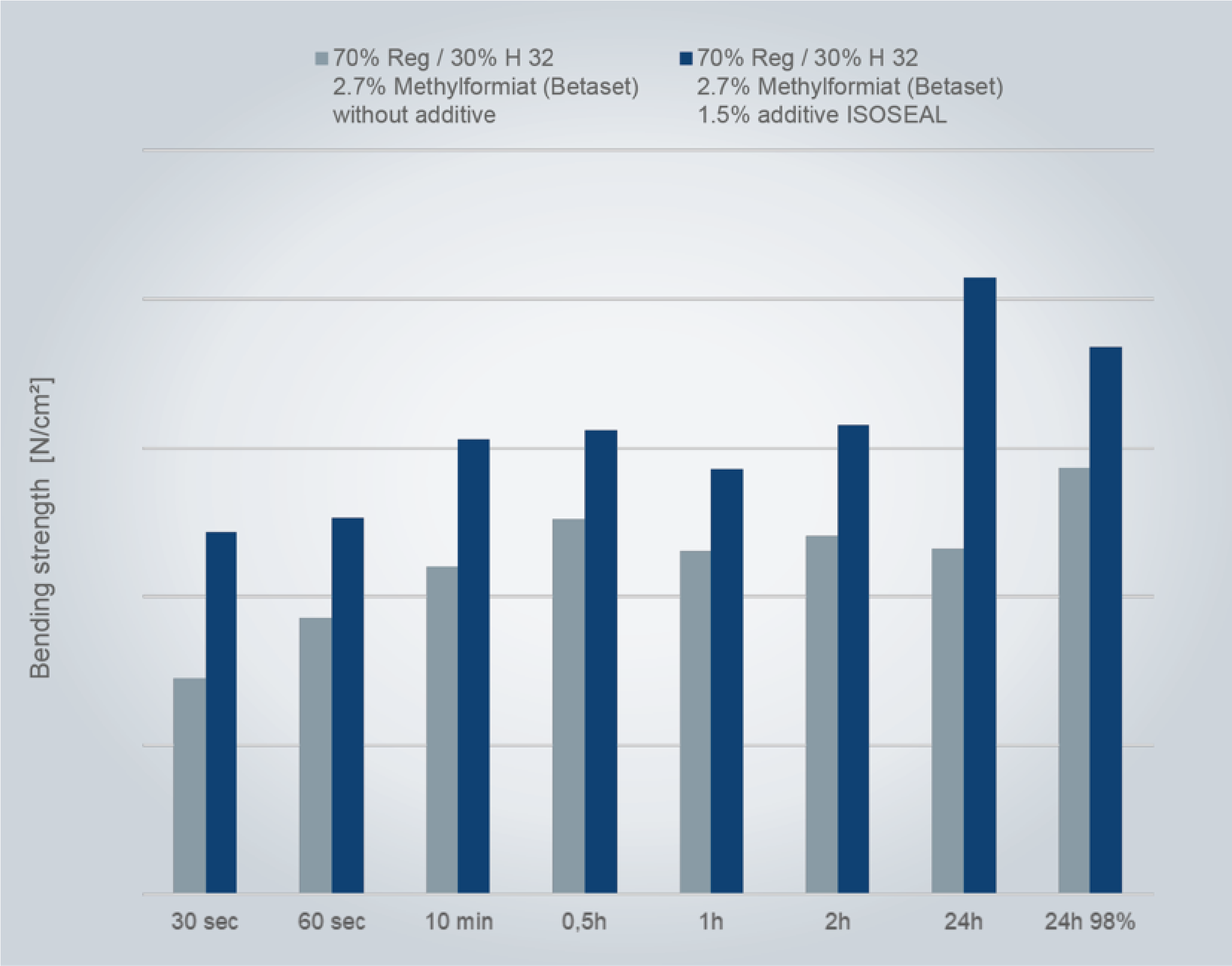

Fig. 7: Strengthening effect of additives (ASK Chemicals)

The strength-increasing effect is the result of the higher flowability of the core molding compound (physical) and the network-forming property (chemical) of the additive. This results in the following advantages for the overall process:

- avoid casting defects by reducing the binder quantity
- enabling or facilitating the use of water-based coatings,
- improvement of flowability and contour reproduction (while core shooting),
- improvement of shake-out after casting and unpacking,
- abandonment of reinforcements in cores (e.g. iron bars) may be possible,
- Increase in the shelf life of the cores,
- More robust production process i.e. a less sensitive system in case of process fluctuations.

Depending on the overall objective, this can be controlled via the binder and / or additive quantity. Thus, unprecedented possibilities are available to the user to realize specific requirements by using lithium-free additives. In the following example (**Fig. 8),** the strength-increasing effect was used to significantly reduce the penetration tendency of the core moulding material in combination with another additive, thus giving the posibility to dispense with special sands.

Fig. 8: small step cones, GJL, casting temperature approx. 1420 °C, water-based coating (ASK Chemicals)

Additives improving shake-out aluminum PUR cold box processes

To improve decomposition and shake-out, users are forced to keep binder quantities as low as possible and/or to produce with coarser molding sand. At first glance, low binder quantities are economically and ecologically good approaches. The low binder addition certainly improves the disintegration, but the handling strengths are very often in the critical range. More often than not, despite all efforts, the complete core or a large part of it remains in the casting after pouring and solidification. Consequently, the core residues have to be removed after knock out, sometimes taking great efforts. The poor breakdown properties of CB-bonded core moulding materials is therefore decreasing considerably productivity of aluminum casting processess.

The new decomposition-promoting additive offer significant benefit here (**Fig. 9).** Practical tests have shown that the decoring time can be reduced by more than 30 to 50 %.

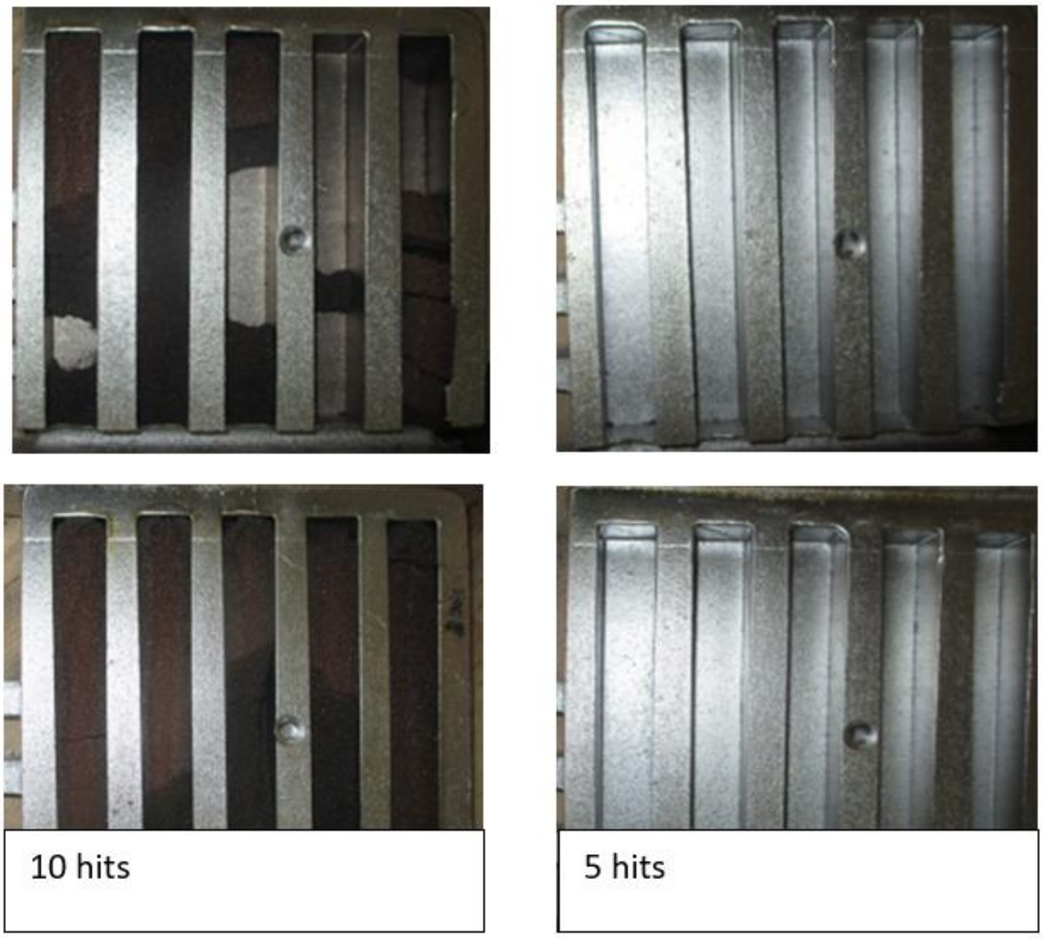

Fig 9: Test specimen for evaluation of decomposition. Material: aluminum, casting temperature: 650 °C, 1 hit = jackhammer at 2 bar; t = 3 seconds (ASK Chemicals)

In addition to this significant improvement in productivity, the new generation of additives offers the following advantages (**Table 2**, figure 9):

- relatively low additive addition (approx. 0,5-1,5 %),
- significantly improved shake-out,
- in some cases binder reduction possible,
- inorganic additive.

Table 2: Core sand mixtures without and with additive to Fig. 9 (ASK Chemicals)

Core molding material	H 32	H 32
Cold Box part 1	1,3 %	1,3 %
Cold Box part 2	1,3 %	1,3 %
Additive	without	1 % ISOSEAL

Summary

The development of powertrain technology in the automotive sector towards e-mobility makes it very clear how important battery production is, but also how dependent it is on lithium as a raw material. Supply bottlenecks and enormous price increases have been seen. In addition, it is also important to bear in mind the disasterous effects on the people, animals and the environment living in the mining areas. Since lithium has also been an essential component in many sand additives for more than 30 years, a technical alternative has been developed.

The newly developed lithium-free additive technology offers foundries important benefits:

- Productivity increases thanks to improved shake-out in in aluminum castings.
- Raw material cost savings by replacing expensive special sands
- Process costs saving and productivity increases by shorter cleaning cycles.
- Process cost savings, energy savings thanks to a coating-free process design.