Production of aluminum castings in green sand

Per Larsen

DISA Industries A/S, Højager 8, 2630 Taastrup, Denmark.

per.larsen@noricangroup.com

Abstract： Many foundries worldwide have already adopted the green sand process for producing aluminum castings but there are still plenty of aluminum foundries around the world that could benefit from the green sand process. With growing global demand for aluminum castings and mounting pressure to reduce costs, the green sand alternative fits well with the requirements of key markets like automotive. Also, market segments less demanding than automotive, both with regards to volume of castings and casting properties, can benefit from the green sand process. This paper will discuss the opportunities and challenges involved in casting aluminum in green sand. Opportunities include significant cost savings driven by: productivity, flexibility, low manpower requirements due to increased automation and high outputs, simple core handling, rapid prototyping and low tooling costs. Specifically, it will argue that green sand is often a better choice to produce aluminum components that are today produced using die casting. It will consider which types of aluminum components are the most suitable and why. The paper will consider the moulding and pouring options available to suit different casting applications and yearly casting volumes. It will, among other things, include the low-pressure pouring option that optimizes castings' mechanical properties and, at the same time, fully automates the pouring process which further reduces the need for manpower.

Keywords： green sand, aluminum, die casting, low costs, automotive

1 Introduction

Many automotive parts are already cast in aluminum and other components previously made from iron are now being transferred to aluminum. Aluminum castings especially play a key role in the transition to electric vehicles (EVs). As the automotive industry makes this shift, new high-volume aluminum parts for EV drivetrains are introduced like e-motor housings and covers while few or no new iron casting are introduced for EVs.

Apart from aluminum castings for the automotive industry, there are a huge number of aluminum castings produced for other industries, however often in smaller yearly volumes. In the following, it will be shown that the green sand process is also feasible to use also for short and medium size series.

The green sand process is historically well known for producing high quality iron parts efficiently and inexpensively. Growing global demand for aluminum castings combined with mounting pressure to cut costs is leading more foundries and manufacturers to explore the green sand process for aluminum applications as well.

Lower costs along with other benefits like rapid prototyping and flexibility are the rewards for successfully transferring the benefits of the green sand process enjoyed by iron foundries for many decades to the production of aluminum parts.

This paper investigates the opportunities and challenges of efficiently producing aluminum castings in green sand. It considers both automotive aluminum components and those with less stringent demands, as well as high and low production volumes.

Historically, green-sand-cast aluminum parts have had a reputation for lower quality. However, the many recent years of development in fully automated green sand moulding and the process around pouring aluminum in green sand have made this reputation untrue, as will be shown below.

2 Moulding

Green sand moulds can be produced both vertically and horizontally parted, with vertical parted moulding delivering the highest production speeds.

The best-known vertical parted moulding lines achieve very high speeds of up to 555 moulds per hour without cores and up to 485 moulds per hour with cores.

When used for aluminum applications, typically lower speeds are seen, however these are still higher outputs than from die-based processes.

Horizontally-parted moulding using matchplate technology is an attractive alternative to vertically-parted, especially with lower production volumes and when high flexibility is required. It demands relatively low investment and employs the well-known horizontal principle.

The most well-known supplier of vertically-parted green sand moulding lines now also offers vertically-parted green sand moulding lines with lower maximum outputs at reduced costs, but still based on over 60 years of experience in designing and producing vertically-parted moulding lines, highly benefiting foundries wanting all the advantagse of the efficient vertical green sand moulding process for aluminum but not having the annual production volumes to fully load a traditional vertical moulding line.

3 Moulding material composition

Quartz sand mixed with clay and water remain the base of the moulding material. The properties of the moulding sand are similar to the parameters used for cast iron but will have to be adapted to the aluminum application. The use of coal dust is not necessary for aluminum. If wanted other base materials than quartz sand can be used.

4 Advantages of green sand process

The green sand process offers several advantages, including very high productivity, a simple and proven core setting process and fast tooling changes: production only halts for one or two minutes when changing from producing one casting to another casting.

As the pattern plates are in contact with the moulding sand and not in contact with the liquid aluminum, many different materials can be used for the pattern plates. Everything from plastic patterns mounted on wooden plates to patterns in high grade tool steel can be used, depending on the geometry of the casting, the requirements for casting accuracy and the length of the series of castings to be produced. This gives feasible solutions from production of 20 prototypes through to producing several hundred thousands of castings annually.

Pattern plates produced in tool steel can produce up to 500,000 moulds or even more in some cases. Pattern plate maintenance costs are low. Lead times from the first 3D CAD drawing to the first casting prototypes and the start of series production are short.

5 Pouring the mould

For aluminum parts with less stringent demands on their properties and if typically produced in lower volumes, manual gravity pouring of the green sand moulds is a good choice. Hand pouring requires little investment and offers high flexibility, making it well suited to shorter series.

Aluminum forms oxides very quickly; these harm its mechanical properties. Because it lets the melt flow relatively freely, gravity pouring from the top of the mould generates these unwanted oxides. To achieve the best possible mechanical properties, another way of pouring is available.

A better alternative is low-pressure pouring through a sprue or an inlet positioned low down on the side of the mould. Filling from the bottom up gives laminar flow, and the low-pressure pouring device gives full control over the liquid aluminum's mould filling, minimizing oxide formation. Mould filling speed is no longer dependent on gravity so the pouring profile can easily be optimized for each individual casting to be produced.

This variant of low-pressure sand casting not only helps to improve the mechanical properties, it also fully automates the pouring process. The runner bars can be very short and there is no need for a traditional pouring cup; together, these improve yield compared to conventional gravity casting from the top of the mould. Bottom filling also means that more parts per mould can be accommodated on the pattern plate.

6 Metallurgy

Apart from mould filling, handling the metallurgy correctly is also important when aiming to achieve the best possible mechanical properties for aluminum castings produced in green sand.

Compared to the different die-based processes, casting in green sand moulds gives a lower cooling rate. This makes it more suited for castings with thinner wall thicknesses from around 3mm up to approximately 10mm where cooling power is less critical when high mechanical properties are needed. However, thicker walled parts can still be suitable for the green sand process.

The modification of the silicon phase is typically achieved with strontium, making it possible to have a

continuous production flow.

7 Casting accuracy

Traditionally, aluminum sand casting had a reputation for lower casting accuracy. But the accuracy of castings produced in green sand has improved over the years, with continuous development of green sand moulding lines. Today it is possible to achieve as little as 0.1mm machine-related mismatch.

8 Design for the green sand process

Most parts are designed with a production process in mind. The potential of green sand for aluminum castings can be further explored by adjusting the design of castings for the green sand process. This way, further weight reduction, productivity gains and, of course, cost savings can be achieved.

9 Conclusion

The green sand process's historic reputation for inconsistent quality wheh producing aluminum castings is unjustified.

Both automotive aluminum castings and castings with less stringent demands on their properties can be feasibly produced in green sand. Systems available today allow high production speeds of several hundred moulds per hour, but lower throughputs of less than 100 moulds per hour are also efficiently served by green sand moulding lines.

It does not make sense to produce every aluminum casting in green sand and this paper does not claim this. Instead, the suitability of each casting and application should be judged individually.

The well-known benefits of the green sand process, the fact that certain castings are inherently well suited for it and the increased efforts, especially by automotive manufacturers, to further reduce costs suggest that aluminum and the green sand process are an increasingly attractive combination.