Production of Aluminum Castings in Green Sand

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Abstract: Many Chinese and US foundries have already adopted the green sand process for producing aluminum castings but there are still plenty of other foundries around the world that could benefit. With growing global demand for aluminum castings and the mounting pressure to reduce costs, the green sand alternative fits well with the requirements of key markets like automotive.

This paper will discuss the opportunities and challenges involved in casting aluminum in green sand. The opportunities include significant cost savings driven by factors such as increased: productivity, flexibility, reduced 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 superior choice for producing aluminum components that are, today, produced using die casting. It will consider which types of aluminum components are most suitable and why.

The paper will consider the molding and pouring options available to suit different casting applications and annual casting volumes. It will include the low pressure pouring option that optimises castings' mechanical properties and, at the same time, fully automating the pouring process which further reduces the need for manpower. It will also include a detailed case study of a foundry that pours aluminum using green sand and its success in transferring aluminum components to green sand that were previously produced using die casting.

Keywords: green sand, aluminum, die casting, automotive

1 Introduction

Many automotive parts are already cast in aluminum, and many other components previously made from iron are now being transitioned to aluminum. Aluminum castings also play a key role in the transition to electric vehicles (EVs). As the automotive industry makes this change, new high-volume aluminum parts for EV drivetrains are introduced like e-motor housings and covers.

The green sand process is well known for producing high quality iron parts efficiently and inexpensively. Growing global demand for aluminum castings combined with rising pressure to reduce 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 to the production of aluminum parts.

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

Historically, green-sand-cast aluminum parts have been perceived as having lower dimensional accuracy and less desirable mechanical properties caused by slow cooling. Neither of these is no longer justified, as will be shown below.

Moulding

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

The best-known vertical molding lines can achieve very high speeds of up to 555 molds per hour without cores and up to 485 moulds per hour with cores. However, at least one manufacturer now supplies vertical molding lines with lower speeds.

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

Moulding material composition

Quartz sand mixed with clay and water remain as the moulding material. These are similar to the parameters used for cast iron but will have to suit the specific aluminum application. The use of coal dust is unnecessary for aluminum.

Advantages of green sand process

The green sand process offers several advantages, including very high productivity, a simple and proven core-setting process and rapid tooling changes: production only halts for one or two minutes.

Initial pattern costs are low and pattern plate lifetime is high. 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.

Pouring the mould

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 undesirable oxides. To achieve the best possible mechanical properties, another way of pouring method is needed.

A better alternative is low-pressure pouring through a sprue positioned low down on the bottom of the mold. Filling from the bottom up gives laminar flow and full control over the liquid aluminum's inflow, minimising oxide formation. Mould filling speed is no longer dependent on gravity and the casting profile can be easily optimised for each individual component.

This variant of low-pressure sand casting not only helps to improve the mechanical propertiesbut also fully automates the casting process. The runner bars can be very small which improves yield compared to conventional gravity casting from above. Smaller runner bars allow for more parts to be accommodated per mold on the pattern plate.

For aluminum parts with less stringent demands on their mechanical properties, manual gravity pouring of green sand molds is a good alternative. Hand pouring requires minimal investment and offers high flexibility, making it well suited to shorter series.

Metallurgy

Apart from mold 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 suitable for parts with thinner wall thicknesses from 3 mm up to approximately 10 mm where cooling power is less critical. However, thicker-walled parts can still be suitable for the green sand process.

The modification of the silicon phase is achieved with strontium, making it possible to have a continuous production flow.

Casting accuracy

Traditionally, sand casting was known for its lower casting accuracy. But the accuracy of castings produced in green sand has improved over the years, today achieving as little as 0.1 mm machine-related mismatch. Modern systems for in-line checking of mismatchs or mould gaps just before the moulds are poured give extra protection against possible dimensional problems and probable differences in weight.

Design for the green sand process

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

2 Conclusion

The green sand process's historic reputation for inconsistent quality and challenges around the mechanical properties of aluminum castings is unjustified.

Both safety-critical aluminum castings and castings with less stringent demands on their mechanical properties can be feasibly produced in green sand. Systems available today allow the highest 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 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 component and application should be judged individually.

The well-known benefits of the green sand process, along with 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.