Selecting DC Casting Rings

It is more than price

Craig S. Johnson, P.E.
CJI Systems Inc.
May 7, 2008

Introduction

The selection of consumable materials for industrial process equipment goes far beyond a simple price comparison. Many issues must be considered before choosing the best solution. In DC Casting of aluminum billet there are two critical consumable components that come into play: the transition plate and the casting ring. This paper addresses the choice of casting ring supplier and the aspects that influence the overall casting costs. A higher-priced part with a longer life often results in lower overall costs.

A number of key operational variables must be considered. These include billet size, quantity and length of billets cast, equipment utilization, production and maintenance labor rates, scrap remelt cost, and consumable component cost. A close review of all of these allows a comparison of costs for various operating scenarios.

Purpose of Casting Ring

History

Graphite has been used for DC casting applications for over 60 years. The application has varied from manufactured inserts to molds made completely from graphite. The key advantages of graphite are high temperature capabilities, resistance to molten metal attack, ability to convey casting fluids, and precision dimensional and surface control.

There are unlimited uses for graphite, yet like many materials, there are different grades and types of graphite that are better suited for specific applications.

In the early use of graphite for DC casting there were attempts to use "graphite" with little understanding of the different grades and their influence on performance.

Figure 1 Graphite comes in many specifications and shapes

All modern DC Billet casting systems utilize graphite at the solidification plane in the mold.

Function

The casting ring is one of the most critical parts of a billet casting operation. This is the point in the process where metal solidification begins and influences many of the properties of the finished billet.

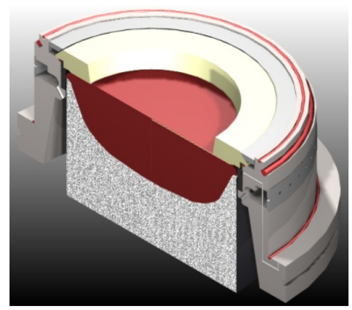

Figure 2 Cross Section of popular air casting mold

As molten metal enters a DC hot top mold, it contacts the chilled surface of the graphite. Heat is extracted from the molten metal causing the solidification of the shell of the billet.

For air casting, molten metal contacts an air envelope created inside the mold. The air envelope serves as a frictionless surface and a thermal insulator. Heat is extracted downward toward the direct chill sprays. The surface of the billet is formed without contact on the graphite.

Casting lubricant is fed through the graphite by high-pressure injection. The distribution of oil across a given cross section of the ring depends on the permeability of the graphite.

In the case of air casting, a casting gas, usually air, is forced through the graphite under pressure. Variation in permeability results in different flow characteristics.

For these reasons it is critical to achieve uniform permeability across an entire casting ring. Variation around the ring or between casting rings is undesirable.

Form

Casting rings are typically manufactured in the shape of a hoop with an internal diameter serving to control the final billet diameter. The outside diameter of the ring is precisely machined to fit within specific tolerances to accommodate placement into the mold. Grooves are typically machined on the outside surface to allow distribution of casting lubricant and casting gas. Depending on the casting process, close tolerance machining is used to achieve other features pertinent to the specific design.

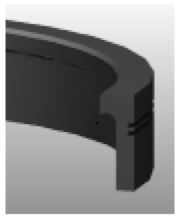

Figure 4 Pocketed type Casting Ring

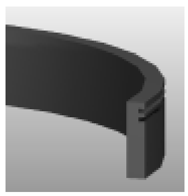

Figure 3 Straight Type Casting Ring

Manufacturing

Graphite Material Selection

Like alloy selection for aluminum applications, choosing the right graphite is crucial to the success of DC casting. Understanding the environment and performance requirements dictates the choice of graphite material. Interaction with specific casting lubricants, casting gas, and aluminum alloy factor into the selection process.

There are many types and grades of graphite available for industry. For DC casting, a few grades are recognized for superior performance.

Production of graphite is a time-consuming, energy intensive process that results in an end product with a range of properties. For most DC billet casting processes, the consistent permeability of the graphite is of utmost importance.

Dimensional Control

The fit of a casting ring is critical to the process. This is due to the sealing interfaces for molten metal, casting lubricant and casting gas. Close attention to geometric shape and surface finish is critical. The technique of machining can influence the performance of a ring by altering the fluid flow through the ring.

Fluid Flow Properties

Casting oil and gas pass through the graphite at elevated temperature conditions. The flow rate is influenced by the permeability of the graphite. The uniform flow rate around the ring depends on the consistency of the graphite. Additionally, the physical properties of the fluids affect the flow rate. Consideration must be given to the interaction of fluid flow properties, temperature, and resistance to flow (permeability).

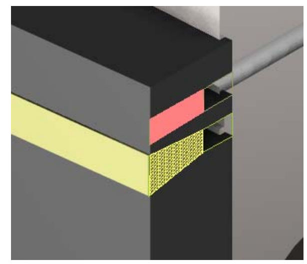

Figure 5 Oil and Gas flow in separate conduits

Quality Control

Dimensions are easy to measure. However, uniform permeability and flow properties are challenging and require special equipment to automatically test each ring for conformance to standards.

Figure 6 Casting Ring test apparatus

Operational Aspects

Useful Life

No casting ring lasts forever. The challenge is to get the longest possible life out of casting rings, while replacing the rings before casting quality deteriorates.

The service lives of casting rings vary considerably from plant to plant depending on factors such as mold maintenance, alloy and casting practices. Ultimately, the deterioration of mold components results in unacceptable billet quality. Before a mold is replaced, efforts are made to restore good mold performance. Corrections are made to lubrication settings, gas flow settings, transition plate coatings, component joint fillers, etc. When these corrective efforts do not improve mold performance, the mold is replaced.

When a mold needs to be replaced, the mold assembly is removed from the casting table. The mold is then disassembled; cleaned, and new or certified-used components are installed. The mechanical design of typical hot top billet molds requires the transition plate be removed in order to replace the graphite ring. The interdependency of the transition plate and casting ring requires a close

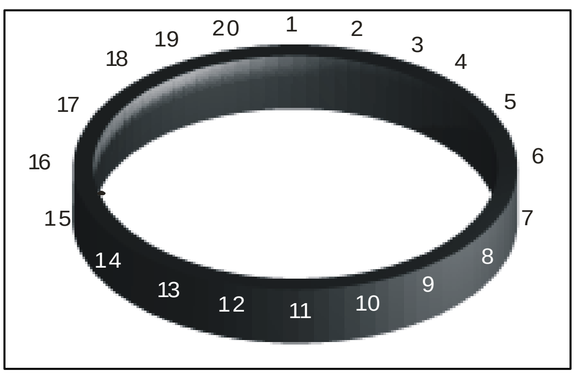

Figure 7 Defining Sectors around casting ring

look at planned replacement schedules to optimize the lives and minimize the overall casting cost.

In most cases, scrap billet is produced before the decision is made to change the mold. The cost of this scrap can be significant. Every casthouse has a threshold amount of scrap that triggers the decision to change a mold. This is typically one to three billets. However, it is practical to change the mold before scrap is produced by monitoring casting ring condition and predicting the remaining useful life, allowing a preventative change-out of the mold.

Casting Recovery

A well run casthouse maximizes recovery rates by eliminating causes of scrap. A casting ring that is used beyond its useful life will generate scrap. Therefore the key is to replace the casting ring before it reaches that point. To know when to replace the ring is a challenge.

Monitoring Condition

Top quality casting rings should be measured for flow capabilities at the time of manufacture and checked against quality standards. The data should be retained as the baseline performance data for a particular ring.

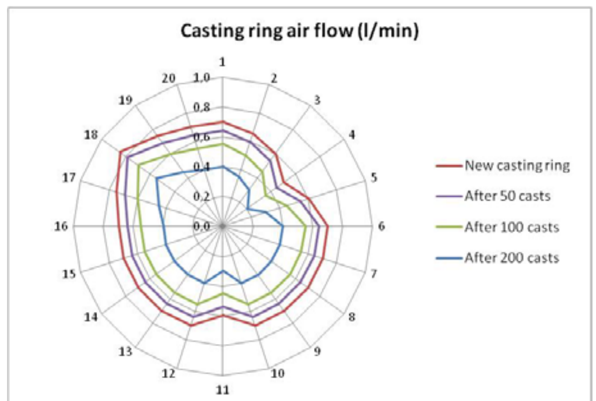

Figure 8 Graph inferring permeability at various stages of ring life

When the ring is installed in a mold, the ring serial number should be recorded to match with the mold number.

After a number of casts (recommended by the casting ring manufacturer) the mold should be removed from the casting table and the casting ring tested for flow capability. Comparing current measurements to previous measurements provides an indication of the ring condition and a prediction for the remaining life.

When the casting ring reaches the predicted replacement point, the casting ring should be changed before scrap is created.

Financial Considerations

Value of Quality

Price is an important criterion in selecting a product or service, however, the ultimate criteria is the value the product or service delivers. Value is a function of many things including purchase price, useful life, cost of failure, product quality and service support. In the case of casting rings, the purchase price of the casting ring is small compared to the impact the casting ring can have on the casthouse operating costs.

Use Cost

Use Cost expresses the overall costs directly associated with a particular component over the life of the component. For casting rings, the calculation is the sum of all related costs divided by the tonnage of billet produced and is expressed as:

$$\text{Use Cost} = (QC+C_{ps}+C_{pr}+C_{pd}+C_{pm}+C_{pc}+C_{pd}) / L$$

Where:

$Q=$ Casting Ring Consumption (per year)
$C=$ Casting Ring Purchase Price ($/casting ring)
$C_{ps}=$ Before Mold Change Scrap ($/yr)
$C_{pr}=$ Casting Scrap ($/yr)
$C_{pd}=$ Casting Ring Disposal Cost ($/yr)
$C_{pm}=$ Mold Maintenance Cost ($/yr)
$C_{pd}=$ Caster Downtime cost ($/yr)
L =Useful life of Casting Ring (Weight of billet produced)

Higher Quality = Lower Overall Cost

The most significant influence on the Use Cost is whether the mold is operated past the useful life of the casting ring. Scrap is then generated resulting in remelt costs, lowered productivity, and possibly casting system downtime. The optimum operating approach is to use high quality casting rings, measure and track the condition of the ring, and then replace the mold before scrap is generated. In most cases, higher quality casting rings, even if at a higher price, significantly reduce overall casting costs.

Summary

The quality of casting rings has significant influence on casting recovery in the casthouse. Accurately manufactured casting rings produced from the highest quality materials and tested to conform to specifications, contribute significantly to casthouse performance. Using modern testing methods and following a predictive failure approach to replacing casting rings dramatically improves recovery and lowers casting costs.

About CJI Systems - CJI Systems was founded in 2007 by aluminum industry veteran Craig Johnson. Johnson has over 30 years of experience in all facets of the industry, including engineering, production and sales. He is former vice president of sales and international operations for Wagstaff, Inc., and gained additional industry experience through positions at Alcoa, Kaiser Aluminum and Permatech. Johnson holds BS Mechanical Engineering and MBA–Global Management degrees. He is a registered professional engineer.

CJI Systems Inc.
5321 S. Pinebrook Ct.
Spokane, Washington 99206 USA
T 1-509-926-4800
F 1-509-984-6999
www.cjisystems.com