Quality Management and Control of Low Pressure Cast Aluminum Alloy

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Abstract. This paper briefly reviews the history of low pressure casting and summarizes the major production processes of low pressure casting. It briefly introduces the quality management and control of low pressure cast aluminum alloy. The main processes include: preparation of raw materials, Melting, refining, physical and chemical analysis, K-mode inspection, sand core, mold, heat treatment and so on.

1. Introduction

Low-pressure casting method has been developed for more than one hundred years, the first few decades of development is relatively slow, until 1958 the United States in the small car engine parts using low-pressure casting method to produce a large number of aluminum alloy castings, this piece Events in the automotive industry around the world caused a great response, for the low-pressure casting method has epoch-making significance [1-3]. Low-pressure casting develops rapidly due to the casting utilization is very high, almost no riser, easy to form directional solidification, fewer internal defects, high degree of automation advantages, overcome many technical problems, especially in the automotive industry [4-10].

Casting in our country has a long history, but the low-pressure casting method was introduced into our country in 1957, about 1960 really attracted the attention of the industry, and began to carry out various studies, the introduction of equipment, rapid development in recent years.

Due to the advantages of light weight, good thermal conductivity and less rust, aluminum alloy products are widely used in aviation, automobile and other fields. Aluminum alloy casting due to advanced technology, low prices, and strong momentum of development. Especially in recent years, the varieties and quantities of auto parts have been expanding constantly, and their functions are very prominent in the light weight of automobiles [4].

As people become increasingly aware of environmental protection, energy-saving emission reduction efforts have been put on the agenda. Green casting concept has been deep casting workers in mind. To improve the passing rate of castings is also a contribution to energy saving. With the industrial production efficiency, quality requirements continue to increase, process technicians need to understand the process parameters unprecedented. In this paper, the author of the actual work, a brief introduction of low-pressure casting aluminum alloy quality management and control.

2. The Main Process Control

2.1. Raw Material Preparation

The control of raw materials is very important for getting qualified castings. If the raw aluminum ingots are not qualified, the quality of recycled aluminum cannot be guarantee. Before aluminum
ingots used in the factory it should have manufacturers’ certification and factory sampling. If the composition of material is in line with certification of material, it can be receive; otherwise, it can be refused. In addition, check the appearance and fracture of aluminum ingots. Aluminum ingot surface does not allow obvious mildew, slag, impurities and other foreign matter. Which allows a single aluminum ingot diameter less than or equal to 5mm foreign body no more than 8, and this kind of aluminum ingot should not exceed 5% of the total amount. Warm surface of aluminum ingot size should be less than 80mm * 3mm. First, we extract one batch of the batch of aluminum alloy, and then sprue opposite ingot 1/4, from the bottom of the saw to not more than 1/3 of the ingot interrupt, fracture inspection, fracture does not allow the diameter of more than 3mm slag.

2.2. Melting
We strictly control the material back to the charge <30%, the material must be clean and dry before feeding, with no oil. Some non-aluminum metal will make the composition of the material failed, the performance deteriorated. Non-metallic inclusions of various non-metallic minerals caused by non-metallic inclusions, but also make the material performance and quality degradation. Recycled aluminum must be the same brand, do not mix. Back to the charge which should be the same brand parts failed part of the gate or filter sawing parts, discarded, there are specialized manufacturers to deal with; there are inserts back to the charge of the insert, and remove the insert, if it not removed can not be used as Recycled aluminum use. Melting process with increasing temperature will accelerate the reaction between molten aluminum and H₂O, O₂, the solubility of hydrogen in the molten aluminum also increases sharply with the increase of melting temperature, when the temperature is higher than 900 °C, the aluminum oxide film on the surface is not Dense, so the melting temperature of most aluminum alloys are generally not more than 760°C, if more than should be ingot treatment. From smelting furnace to low pressure pouring machine generally need to turn the water bag, water bag preheating temperature 750°C ~ 770°C, in order to safely produce alloy liquid does not allow more than 80% of the total volume of water bag. Strontium (Sr) is a long-term metamorphic agent, metamorphism and Na equivalent, and not exist the shortcomings of Na metamorphism, is a promising modifier. Generally press the charge ratio of 0.05 to 0.1% can be added AlSr10 intermediate modifier into the transfer package.

2.3. Refined
Due to the characteristics of aluminum, aluminum alloy has a strong tendency to produce pores, but also prone to oxidation inclusions. The next step is the refining process of molten aluminum. The purpose of aluminum refining is to obtain a high cleanliness, low gas content alloy solution after degassing and cleaning. As the environmental protection requirements are getting higher and higher, the mass production of aluminum alloy castings by chlorination method is gradually replaced by the ventilation method, if the access is nitrogen, the pressure is generally 0.3MPa ~ 0.5MPa; nitrogen flow 10L / min ~ 20 L / min. Before rotating the degassing graphite rotors, rods, baffles should be preheated with the water diversion package. Degassing time is generally 5min ~ 10min, the treatment temperature is 720°C ~ 740°C; standing time is 10min ~ 15min, when after treatingment, the time increase 0.2 ~ 0.5% covering agent. Alloy liquid if the entire insulation process, the temperature cannot exceed 760 °C, if more than only ingot casting products are not allowed. If the refined alloy liquid holding time more than 8 hours, does not allow casting products, only ingot treatment. Test each pack of liquid gold refining effect to be measured liquid alloy density equivalent. Which the density equivalent is describe as DI = (atmospheric pressure - negative pressure) / atmospheric pressure at a density of * 100, only DI is less than 2 Regarded as refined qualified.

2.4. Physical and Chemical Analysis
After the completion of the water from the scoop to get the alloy liquid poured into the sample mold, to be completely solidified, chilling, cross-section cutting, using a direct-reading spectrometer to measure the composition of the sample alloy and record. Material composition in line with product requirements identified that the furnace liquid alloy qualified, do not meet the requirements of re-test, re-test pass after qualified; still unqualified, the furnace aluminum ingot treatment.
2.5. **K-Mode Check**

K-mode calculation: the amount of slag with M, said the number of small pieces N, K value algorithm is: \( K = \frac{M}{N} \). K value between the grade of the relationship as show the Table 1. When \( K = 0 \), it is a very pure aluminum liquid, the result is A + grade; when \( K < 0.1 \), it is pure aluminum liquid, the result is Grade A; when K value is between 0.1 and 0.5, The result is Grade B; When the K value of 0.5 to 1, the more pure liquid aluminum, the result is C, the need for further refining before use; when the K value is greater than 1, for the contaminated aluminum liquid, the result is D-level, is not Qualified aluminum, can not be put into use, only ingot treatment, the frequency of sampling once every half month.

| K value | Grade |
|---------|-------|
| 0       | AA    |
| <0.1    | A     |
| 0.1-0.5 | B     |
| 0.5-1   | C     |
| >1      | D     |

2.6. **Sand Core**

Sand core should be strictly controlled the amount of gas, because the entire mold cavity is a closed space, coated sand will be produce gas when the high temperature aluminum liquid will affect the quality of the castings, the gas volume is generally controlled within 15ml / g. If the air volume is greater than 15ml/g, the chance of air holes in the casting will greatly increase, which will seriously affect the casting quality. The bending strength of the sand core is generally greater than 2.5Mpa. If the core is too low, it is not suitable to store. Thermal bending strength is greater than 1.5Mpa, but not too large, too large sand core to return poor quality, the casting is prone to crack. The amount of coating sand burning is generally less than 2%, which means that the dust in the sand core is more than 2% and the air permeability is poor. Application of the core head position steel jack, the sand core of the gas can be quickly discharged to prevent castings such as porosity foundry defects. Sand core surface appearance smooth, flat, without wearing sew, no cracks, no impact on the quality of the casting bending deformation, no floating sand. Sand core storage period should be less than 48 hours, more than 48 hours of the sand core is not allowed to put into use. Sand core inspection items as shown in Table 2.

| Gas production <15(ml / g) | Thermal temperature resistance >1.5(Mpa) | Room temperature strength >2.5(Mpa) |
|---------------------------|------------------------------------------|----------------------------------|

2.7. **Mold**

Mold design should fully discuss with the manufacturer, continue to optimize the program. After the program is confirmed, CAE simulation analysis is carried out to verify the casting system, shorten the research and development cycle and continue to optimize the program. For most of the thick castings should be fully from the design and workmanship, to make up for consideration. Most of the thick as much as possible in the downward direction, in order to get shrinkage, the other thick majority can also do a bit cold (including water and air) or chilled iron or insert adjustment cooling rate in order to ensure the solidification rate. Mold exhaust design, as much as possible to place the exhaust plug and pull the exhaust groove. Mold preheat temperature is generally 250°C~ 350°C, need to spray insulation coating and release agent. Inlays castings, inlays need preheating, experience temperature 180°C~ 220°C.
2.8. Heat Treatment
In strict accordance with the provisions of the rules of the time process to prevent over-burning. Quenching water temperature control at 65°C~85°C, the temperature is too low will appear quench cracking, high hardness appears not enough.

3. In Conclusion
How to effectively use advanced low pressure casting process equipment and manage production factors, to obtain uniform composition, compact structure, small grains is a period of time in the future the main problem of the low pressure casting needs to solve. LPC process factors are many, and sometimes small factors have a great impact on the quality, small factors can not be ignored. This article only summarizes the control factors encountered in the process of engaging in relevant work and personal opinion, and the specific problems of specific products should be treated specifically. The process includes: preparation of raw materials, melting, refining, sample preparation, physical and chemical analysis, K-mode inspection, sand core, mold, heat treatment and so on.

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