Study of the Parameters Affecting Aluminum Smelting Process

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SUMARY

INTRODUCTION

La fundición es un proceso de manufactura que consta básicamente de verter metal en estado líquido en una cavidad llamada molde, el metal finalmente toma la forma de este. Esta técnica de manufactura data de seis mil años atrás pero demuestra estar totalmente vigente en nuestra época y con mucha opción de seguir renovándose por muchos años más.

Con la fundición se pueden obtener piezas de diversas dimensiones y geometría de una manera relativamente económica en comparación a otros procesos de manufactura. Por ello, el control en la composición química y las propiedades mecánicas que se obtienen mediante este proceso es de suma importancia para la tarea que la pieza fabricada debe desempeñar en su vida útil. Además, evitar los defectos que pueden ocasionarse debido a una mala fundición es vital para prevenir fallas en las piezas fabricadas que a corto o largo plazo sean nocivas para el proceso productivo para el que fueron asignadas.

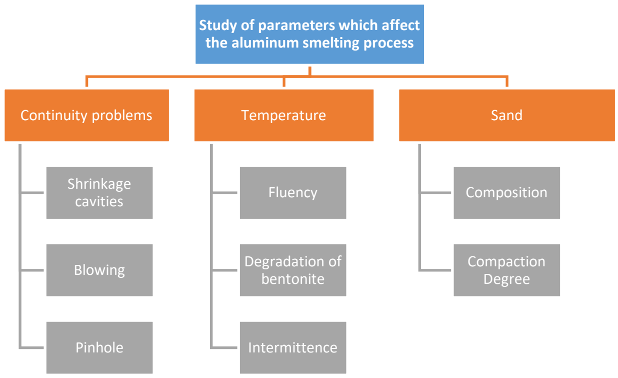
Este trabajo de investigación tiene por propósito analizar las características anteriormente mencionadas con un proceso de fundición realizado con el aluminio y arena con los que cuenta el Laboratorio de Fundición de la Facultad de Ingeniería Mecánica.

PRESENTATION OF THE PROBLEM

The manufacturing processes of castings with special technological applications subjected to critical situations must eliminate all kinds of defects in the material.
These defects have a negative influence on physical and mechanical properties, and under critical conditions are prone to fail of fatigue, those are the causes of these porosities and cracks in the material that give rise to a big amount of failures.

The following project is looking for the perspective of doing a study about the factors that influence the smelting process, it will consider defects and factors such as: porosity, degradation of bentonite, blowouts, sand analysis, and temperature effects.

Studies and experimental results allow us to establish a classification of the factors and defects of the foundry in a scheme showing in the following diagram



The factors and defects in the material poses a huge risk, because the trust of these parts impairs the profitability throughout the manufacturing process, this is the reason which make necessary to do different non-destructive tests such as X-rays, Ultrasound and Penetrating dyes in order to detect the position of the pores and tears produced by the erroneous execution of the procedures during the casting.
In this case the continuity defects can be generated in different positions of the material, within the material or at the surface.

The shrinkage cavities are produced by the solid contraction of the material during its transition from liquid to solid due to a lack of material feed (by means of feeder-heads close to them) during this process.

The blowing is a conglomeration of gases of different origins that are placed on the surface of the material causing pores and a deformation in the region where they are situated, if this piece is part of an assembly it will provoke problems of precision.

Pinhole may be caused by gases produced during the casting or product of the endogenous precipitation of the previously dissolved gases, which is originates as a result of the change in solubility as it cools down.

In contrast, factors such as temperature in a process of the metallic material give rise to properties that favor improvement of the piece and in others provoke defects mentioned herein.

The temperature not only lies in the fluidity of the liquid metal during the casting, however it also the cost of overheating it to ensure the necessary fluidity and reach regions of the mold with geometry difficult to access. On the other hand, the temperature in a superheated metal-liquid over the bentonite is detrimental, because it subjected it to melting cycles inducing the degradation of the bentonite and provoking a deficiency in the properties of the sand at the time of the casting.

The intermittency is the defect produced by the solidification of the same material at different moments which causes that while it cools down internal forces take place and internal cracks propagate in the piece.

Not only the sand is indispensable because it is the material which provides the condition enough for the gases to escape from the mold in order to avoid formations of pores or blowholes in the material, but also it is indispensable because it gives the consistency of the mold and prevent failure by mold collapse.

OBJECTIVES

General objectives:

Study and compare the parameters that are determinant in a correct casting of components made of aluminum from the Foundry Laboratory of the Mechanical Engineering Faculty.

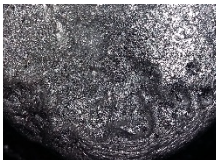
Specific objectives:

- ✓ Determine the consequences of gases released from the materials involved in the process.
- ✓ Determine the degradation degree of bentonite in a cyclic casting process.
- ✓ Compare the mechanical properties of the components fabricated after the casting.
- ✓ Analyze the composition in order to obtain the properties of the material according to its use.

DESCRIPTION OF THE SOLUTION

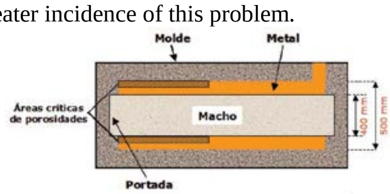
Continuity defects

Shrinkage cavities
It is a cavity with walls cutted by the presence of dendrites formed during the solidification. Sometimes the dendrites occupy the entire cavity, and the dendritic porosity is present.
In addition, the shrinkage cavities may depend on an improper design of the piece, when it has crossed ribbons, different thicknesses or badly arranged with each other; also insufficient metalostatic pressure could be a reason, when the upper half case weight is too low; Or a misconception of the casting device when the troughs and loaders are poorly arranged, are too small or are badly attached to the piece, etc. Also the composition of the metal is one of the most frequent causes of shrinkage cavities. In smelting, this defect can be favored by two opposing causes: excess of graphitizing elements such as silicon and phosphorus, or excess of carbide stabilizing elements, such as excess of manganese or silicon shortage. In the most difficult and important cases, the spindles destined to form a reserve of liquid metal are applied at the highest points to feed until the solidification of the solid parts of the piece is complete; Other external chillers (shells) or internal (nails) are placed on the affected walls of the mold.



Pores: Present Gases in the smelter

The occlusion of the gases in the process of cooling and solidification. These discontinuities in the structure of the molten materials are given just before the liquid-solid transformation occurs, leaving the gases occluded in the solid material.
Often the discontinuities originating in the material are the result of the pre-dissolved endogenous gas precipitation, which is originated as a result of changes in the liquid metal solubility as it cools down after being cast into the molds. Trapped gases are also the result of the combustion of the components used in the souls and males during the process.
The use of expanded polystyrene and similar in the casting are also the cause of porosities within the material. The polystyrenes once reached 400 ° C tend to volatilize, then in the case of aluminum casting the temperature of the liquid metal is 630 ° C more if it is a superheated liquid metal, which in the laundry evaporate and some of them occlusion product will be part of the formation of the porosity.
These gases are produced if recycled sand which pass by a smelting cycles to which bentonite was not added to buffer the bentonite losses due to the high temperatures is used, the properties of either compression or, the most important for this case, its permeability will be greatly affected, which will let out an small amount of gases from the mold because most of the gases will be trapped inside the liquid metal.
The gases that are part of this violent chemical reaction are the carbon monoxide which tends to form micropores (CO especially for this defect). It will generate regions within the mold of greater incidence of this problem.



The pores or pinholes are small rounded holes (2-3mm in diameter), made as a consequence of the formation of gas bubbles located along the surface (preferably), these are superficial pores. In general they show a smooth and spherical inner surface in most cases with a smooth texture without any oxides or residues trapped in it.
The pores are classified according to the material from which they originated, that is to say, the gas contained in it: nitrogen, oxygen, carbon dioxide, hydrogen nitrogen.
The pores also depend on the humidity of the mold because if they are in a very high range this can be used to generate more hydrogen which makes it the main source of this element for this effect.

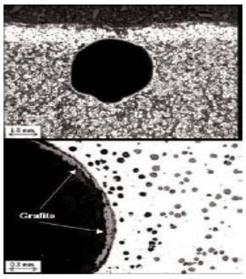
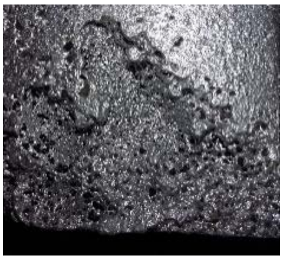


Figure xxx. Decarburation and coating of graphite on the inner surface of a hydrogen pore.

These pores can also be lot more critical problem when hydrogen, and sometimes nitrogen, can diffuse from the liquid metal to the micropores of monoxide of carbon , increasing their size which puts at risk the material produced, which subjected to loads cyclically can fail due to fatigue if it is not taken into account at the time of the casting of the piece

Blowouts

This defect is a gas cavity in the form of a ball caused by an escape of gases from the mold during emptying. It occurs on the top of the foundry surface or near toit. The low permeability, unsuitable ventilation and the high moisture content in the mold sand are the general causes. The main problem of this effect on the piece is the lack of permeability in the mold which makes it impossible to escape the gases formed during the casting. If the green sand has a high percentage of moisture, the vapors that are formed help the formation of the blowings on the surface. High percentage of bentonite or high compaction which reduces the permeability required to prevent blowing.



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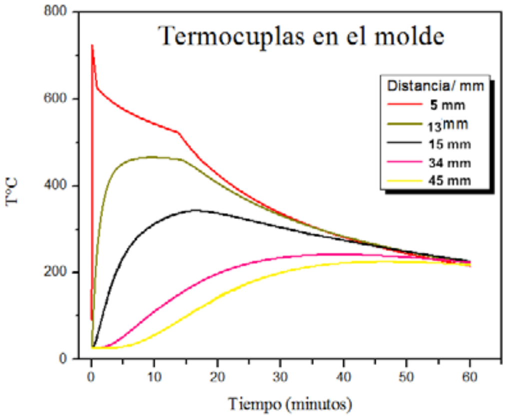
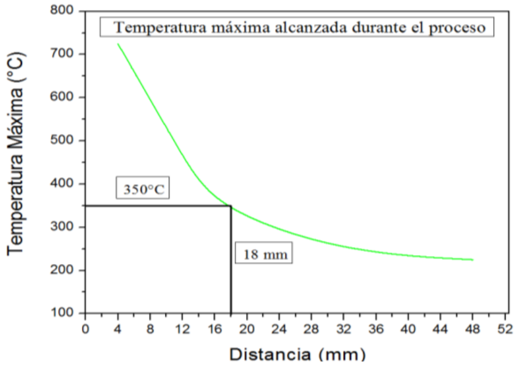
Temperature effects in foundry

Fluency

The factors which affect the fluidity are the casting temperature, the metal composition, the viscosity of the liquid metal and the heat transferred from the surroundings. A higher temperature, relative to the solidification point of the metal, increases the time that the metal remains in the liquid state allowing it to advance further, before solidifying. This tends to aggravate certain problems such as oxide formation, gaseous porosity and the penetration of liquid metal into the interstitial spaces between the grams of sand that compose the mold. This last problem causes the surface of the foundry to incorporate particles of sand that make it more rough and abrasive than normal.

Based on investigations, the respective simulation of a thermogravimetric analysis (TGA) was carried out in solidCast and to have a notion of the behavior of the temperature in the layers of sand between the interfaces mold-metal whereby it was possible to determine maximum temperatures at a certain distance from the interface. At 5 mm from the mold-metal interface, a fast increase in temperature is evidenced up to a maximum of 730 ° C equal to the emptying temperature, after this the temperature begins to fall due to the transfer of heat from the metal interface -mold towards the outer face of the mold. At 13 mm from the mold-metal interface the temperature increases over time to a maximum of 480 ° C in 7 minutes, in which point the temperature is maintained until 16 minutes, after that it descends. The parameters analyzed for different points have the same behavior between the mold-metal interfaces (figure--). In order to more accurately determine the thickness of the mold area reaching the degradation temperatures, a graph of maximum temperature vs distance (Figure--) was constructed, which allowed to estimate that the thickness of the molding mixture that reached temperatures equal or higher than the degradation on set temperature of the bentonite (350°C) was 18mm





The characteristics of the molding sands and many of the surface defects of the molded parts are highly dependent on the binder used.

The binding power of bentonites is related to their water retention capacity, which is assessed by the tests of Infinity and Liquid Limit and complemented by the Sedimentation Volume.

A more direct measurement is obtained with the test of Resistance to the compression in green.

However, the bentonite loses these properties due to the destruction of its crystalline structure due to the thermal shock that occurs during the casting process of those in the region of high temperatures, simulated with a maximum value of 18mm. If the bentonite presents a good thermal stability, due to its mineralogical composition and good crystallization, the less the quantity to be added to the sand in each cycle of casting in the casting process, therefore, the lower the manufacturing costs due to molding sand.

Sand analysis: composition and compaction degree

The main component in smelting is the sand that makes possible to manufacture countless pieces of different uses in daily life, but to obtain optimal results it depends largely on the composition of the sand with a close relation with the size of the manufactured piece,

RESULTS

CONCLUSIONS

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