Analysis of the Defects Generated in Aluminum Casting

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SUMARY

The following proyect study the factors and defects during the founding process of the aluminum , this process took to end through simulation of software SolidCast and Click2Cast to examine the temperature variation in the different points of the inter-face of the mold metal and the porosities distribution in the hot points respectively.
This way predicting behaviors varying the factors like temperature and examining the occlusion of gases, porosity, shrinkage cavities and blowings in metal.

Key words: Founding defects, porosity, intermittence.

INTRODUCTION

Founding is a manufacture process that basically consists of pouring in a so-called cavity metal in liquid status mold, finally you take the metal from the way this. This manufacturing technique dates from six thousand years back but you prove to be totally in use in our epoch and with a lot of option to keep on renewing oneself for years on end more.

They can get to another processes of manufacture pieces from various dimensions and geometry of a cost-reducing way comparatively with founding. For it, the control in the chemical composition and the mechanical properties that are obtained by means of this process is of utmost importance for the task that you must take out of pawn the manufactured piece in his service life. Besides, it is vital to prevent faults in the manufactured pieces that be to short or long term noxious for the productive process they were for assigned to avoid the defects that can be caused due to a bad founding.

This research work has for purpose to examine the mentioned before characteristics with a process of founding accomplished with aluminum and sand with the ones that you count Fundición's Laboratory of the Faculty of Mechanical Engineering.

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.

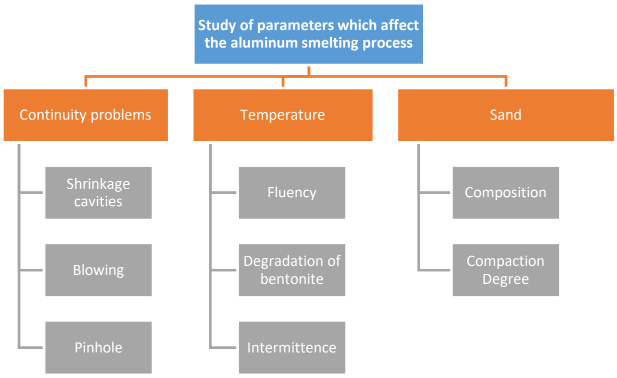

Figure 1. Classification of factors and defects in founding

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.

Figure 2. Shrinkage cavities on the surface of aluminum

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.

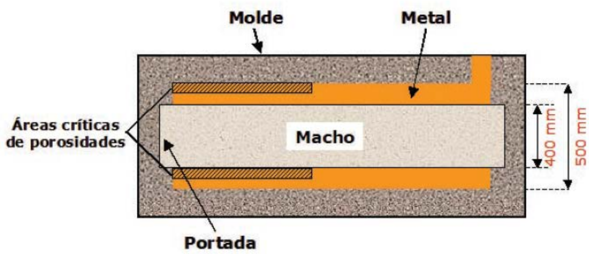

Figure 3. Critical areas of porosities during a wash.

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.

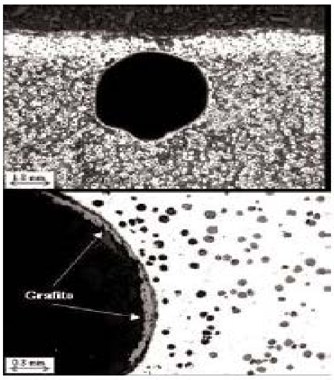

Figure 4. Decarburación and coating of graphite in the internal surface of a hydrogen pore.

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

Figure 5. Porosity on the surface of aluminum.

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.

Figure 6. Blowing on the surface of aluminum.

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

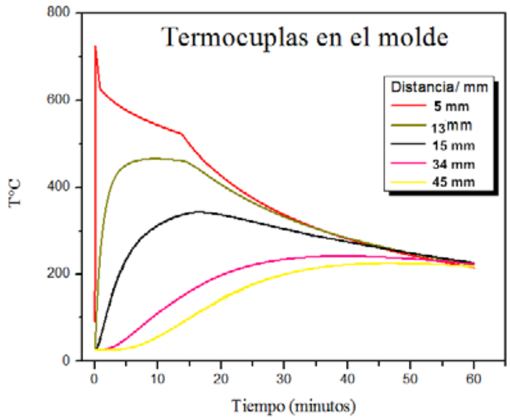

Figure 7. Distribution of temperature regarding the time to different distances of the inter-face mold metal.

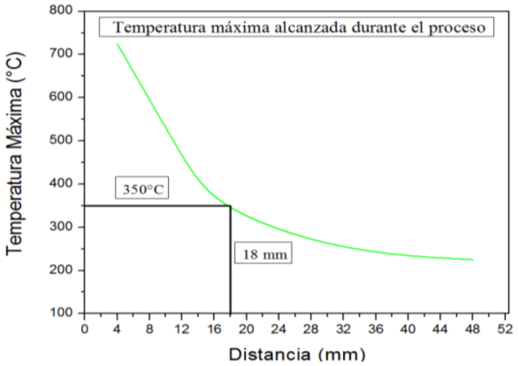

Figure 8. Maximum attained temperatures vs metal distances from the inter-face mold

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.

Properties such as permeability, compressive strength and shear strength, as well as the compaction degree are properties that define the sand properties and they are determinant on the piece, the reason is that the properly evacuation of the gases depends on these properties. The combustion of the different compounds involved in this process, both of them, soul sand and the steam reaction, react in order to create hydrogen which will be the primary source to form internal or external discontinuities. These defects are the reason of a subsequently fail provoke by fatigue because these cracks tend to travel faster following the discontinuities, making that, if they are workpieces subjected to cyclic loads, they fail in the least estimated time.

However, the bentonite loses these properties due to the destruction of its crystalline structure by the effect of the thermal shock that the binder can weaken causing that some of the surface of the mold collapse causing the surface enclosed some material of grains of sand inside. Also, this bentonite degradation produce that properties such as permeability changes and the collapse increases obliging that the degree of compaction is increased what in many cases is finished by decreasing with the permeability degree. A big amount of problems are added causing faults in the casting. Therefore, it is necessary to take into account the degradation degree of the bentonite and then replacing the lost in the next foundries with a suitable permeability new sand in order to avoid formations of porosities.

RESULTS

The experimental and software analysis came true for a set of connecting rods and pistons of a motor, the results were gotten from an analysis.

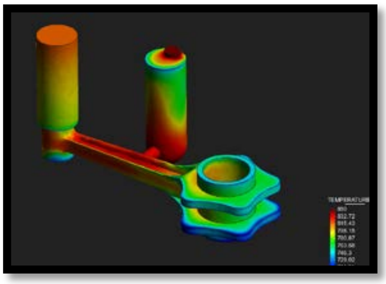

Figure 9. Thermic analysis

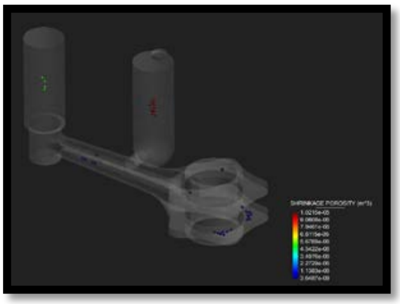

Figure 10. Porosity in the piece

It can be noticed that in the results they place the hot points in the feeder-head with a set of porosities (reds). Also, according to software, the porosities they meet within the material (blue), and adding this a low permeability a piece with more porosities will have itself so much interns like superficial.

Figure 11. Connecting rod (radial engine) fused with respective faults, porosity, rechupes falling apart.

CONCLUSIONS

- It was verified that the grade of compression yielded as a result give as a result of the formation of porosities
- The thermic crash's product the degradation of the affected bentonite to the compression of sand, defects for falling apart.
- The cooling in stages produces the intermittence than product of the internal tensions producing splits in the material.
- The composition of sand has influence in terms of the size of the piece to manufacture, which brings defects like cooling anisotérmic, bigger porosity (more gases within the mold generate more big pieces)

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