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Effects of Adding Glass Fibers As Additive for Sand-Casting

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ABSTRACT:- Foundry industries in a developing countries are suffering from poor quality and productivity even in completely controlled process. Defects in casting process have been seen which challenges explanation about the cause of casting defects. The objective of this research is to minimize casting defects by adding different fibers in different proportions, to check the productivity of the components with respect to the normal production and to check the temperature resistance by keeping the sand ratio same and using different proportions of additives. Different glass and steel fibers have been taken along with two different quality of sand having one proportion and sodium silicate as a binder. Results should show good amount of strength and less defect.

Keywords:- Foundry,productivity,casting defects,additives,binder

I. INTRODUCTION

A. Casting

Casting is a manufacturing process in which a liquid material is usually poured into a mold, which contains a hollow cavity of the desired shape, and then allowed to solidify. The solidified part is also known as a casting, which is ejected or broken out of the mould to complete the process. Casting materials are usually metals or various cold setting materials that cure after mixing two or more components together. For example epoxy, concrete, plaster and clay.

B. Types of casting

- **Sand casting :**

Sand casting, also known as sand molded casting, is a metal casting process characterized by using sand as the mould material. The term "sand casting" can also refer to an object produced via the sand casting process. Sand castings are produced in specialized factories called foundries. Over 70% of all metal castings are produced via sand casting process.

- Metal casting

In metal working, metal is heated until it becomes liquid and is then poured into a mold. The mold is a hollow cavity that includes the desired shape, but the mold also includes runners and risers that enable the metal to fill the mold. The mold and the metal are then cooled until the metal solidifies. The solidified part (the casting) is then recovered from the mold. Subsequent operations remove excess material caused by the casting process (such as the runners and risers).

- **Resin casting**

Plaster and other chemical curing materials such as concrete and plastic resin may be cast using single-use waste molds. When casting plaster or concrete, the material surface is flat and lacks transparency. Often topical treatments are applied to the surface. For example, painting and etching can be used in a way that give the appearance of metal or stone. Alternatively, the material is altered in its initial casting process and may contain colored sand so as to give an appearance of stone. By casting concrete, rather than plaster, it is possible to create sculptures, fountains, or seating for outdoor use.

- **Centrifugal casting:**

Centrifugal casting or rotor casting is a casting technique that is typically used to cast thin-walled cylinders. It is used to cast such materials as metal, glass, and concrete. It is noted for the high quality of the results attainable, particularly for precise control of their metallurgy and crystal structure.

- **Core plugs :**

Core plugs are used to fill the sand casting core holes found on water-cooled internal combustion engines. They are also incorrectly called frost plugs, freeze plugs, or engine block expansion plugs.

- **Die casting :**

Die casting is a metal casting process that is characterized by forcing molten metal under high pressure into a mould cavity. The mould cavity is created using two hardened tool steel dies which have been machined into shape and work similarly to an injection mould during the process. Depending on the type of metal being cast, a hot- or cold-chamber machine is used.

- **Glass casting :**

Glass casting is the process in which glass objects are cast by directing molten glass into a mould where it solidifies. Modern cast glass is formed by a variety of processes such as kiln casting, or casting into sand, graphite or metal mould.

- **Investment casting :**

Investment casting is an industrial process based on lost-wax casting, one of the oldest known metal-forming techniques. The term "lost-wax casting" can also refer to modern investment casting processes. Lost-wax casting is the process by which a duplicate metal sculpture (often silver, gold, brass or bronze) is cast from an original sculpture.

- **Permanent mold casting:**

Permanent mold casting is a metal casting process that employs reusable molds, usually made from metal. The most common process uses gravity to fill the mold, however gas pressure or a vacuum are also used.

C. Types of base sands

Base sand is the type used to make the mold or core without any binder. Because it does not have a binder it will not bond together and is not usable in this state.

- **Silica sand**

Silica (SiO_2) sand is the sand found on a beach and is also the most commonly used sand. It is made by either crushing sandstone or taken from natural occurring locations, such as beaches and river beds. Silica sand is the most commonly used sand because of its great abundance, and, thus, low cost. Its disadvantages are high thermal expansion, which can cause casting defects with high melting point metals, and low thermal conductivity, which can lead to unsound casting.

- **Olivine sand**

Olivine is a mixture of ortho silicates of iron and magnesium from the mineral dunite. Its main advantage is that it is free from silica, therefore it can be used with basic metals, such as manganese steels. Other advantages include a low thermal expansion, high thermal conductivity, and high fusion point. Finally, it is safer to use than silica, therefore it is popular in Europe.

- **Chromite sand**

Chromite sand is a solid solution of spinels. Its advantages are a low percentage of silica, a very high fusion point (1,850 °C (3,360 °F)), and a very high thermal conductivity. Its disadvantage is its costliness, therefore it's only used with expensive alloy steel casting and to make cores.

- **Zircon sand**

Zircon sand is a compound of approximately two-thirds zircon oxide (Zr_2O) and one-third silica. It has the highest fusion point of all the base sands at 2,600 °C (4,710 °F), a very low thermal expansion, and a high thermal conductivity. Because of these good properties it is commonly used when casting alloy steels and other expensive alloys. It is also used as a mold wash (a coating applied to the molding cavity) to improve surface finish. However, it is expensive and not readily available.

- **Chamotte sand**

Chamotte is made by calcining fire clay (Al_2O_3-SiO_2) above 1,100 °C (2,010 °F). Its fusion point is 1,750 °C (3,180 °F) and has low thermal expansion. It is the second cheapest sand, however it is still twice as expensive as silica.

D. Types of binders

Binders are added to a base sand to bond the sand particles together (i.e. it is the glue that holds the mold together).

- **Clay and water**

A mixture of clay and water is the most commonly used binder. There are two types of clay commonly used: bentonite and kaolinite, with the former being the most common.

- **Oil**

Oils, such as linseed oil, other vegetable oils and marine oils, used to be used as a binder, however due to their increasing cost, they have been mostly phased out. The oil also required careful baking at 100 to 200 °C (212 to 392 °F) to cure (if overheated the oil becomes brittle, wasting the mold).

- **Resin**

Resin binders are natural or synthetic high melting point gums. The two common types used are urea formaldehyde (UF) and phenol formaldehyde (PF) resins. PF resins have a higher heat resistance than UF resins and cost less. There are also cold-set resins, which use a catalyst instead of a heat to cure the binder. Resin binders are quite popular because different properties can be achieved by mixing with various additives. Other advantages include good collapsibility, low gassing, and they leave a good surface finish on the casting.
MDI (methylene diphenyl diisocyanate) is also a commonly used binder resin in the foundry core process.

- **Sodium silicate**

Sodium silicate [Na_2SiO_3 or $(Na_2O)(SiO_2)$] is a high strength binder used with silica molding sand. To cure the binder carbon dioxide gas is used, which creates the following reaction:

E. Types of glass fibers

There are three types of glass fibers namely

1) E-type (Polyethylene glass fibers)
2) P-type (Polypropylene glass fibers)
3) O-type (Woven rolling glass fibers*)*

F. Types of defects

The terms defect and discontinuity refer to two specific and separate things in castings. Defects are defined as conditions in a casting that must be corrected or removed, or the casting must be rejected. Discontinuities, also known as imperfections, are defined as interruptions in the physical continuity of the casting".

- **Blowhole**

Blowhole is a kind of cavities defect, which is also divided into pinhole and subsurface blowhole. Pinhole is very tiny hole. Subsurface blowhole only can be seen after machining. Gases entrapped by solidifying metal on the surface of the casting, which results in a rounded or oval blowhole as a cavity. Frequently associated with slags or oxides the defects are nearly always located in the cope part of the mould in poorly vented pockets and undercuts.

- **Sand burning**

Thin sand crusts firmly adhering to the casting. The defect occurs to a greater extent in the case of thick walled castings and at high temperatures. In addition, the always present iron oxides combine with the low melting-point silicates to form iron silicates, thereby further reducing the sinter point of the sand.

- **Sand inclusion**

Sand inclusion and slag inclusion are also called as scab or blacking scab. They are inclusion defects. Looks like there is slag inside of metal castings. Irregularly formed sand inclusions, close to the casting surface, combined with metallic protuberances at other points. Sand inclusion is one of the most frequent causes of casting rejection.

- **Cold lap/ cold shut**

Cold lap or also called as cold shut. It is a crack with round edges. Cold lap is because of low melting temperature or poor gating system. When the metal is unable to fill the mould cavity completely and thus leaving unfilled portion called misrun. A cold shunt is called when two metal streams do not fuse together properly.

- **Misrun**

Misrun defect is a kind of incomplete casting defect, which causes the casting uncompleted. The edge of defect is round and smooth. When the metal is unable to fill the mould cavity completely and thus leaving unfilled portion called misrun. A cold shunt is called when two metal streams do not fuse together properly.

- **Gas porosity**

The gas can be from trapped air, hydrogen dissolved in aluminium alloys, moisture from water based die lubricants or steam from cracked cooling lines. Air is present in the cavity before the shot. It can easily be trapped as the metal starts to fill the cavity. The air is then compressed as more and more metal streams into the cavity and the pressure rises. When the cavity is full it becomes dispersed as small spheres of high pressure air. The swirling flow can cause them to become elongated.

- **Mismatch defect**

Mismatch in mold defect is because of the shifting molding flashes. It will cause the dislocation at the parting line.

- **Flash set**

Flash can be described as any unwanted, excess metal which comes out of the die attached to the cavity or runner. Typically it forms a thin sheet of metal at the parting faces. There are a number of different causes of flash and the amount and severity can vary from a minor inconvenience to a major quality issue. At the very least, flash is waste material, which mainly turns into dross when re-melted, and therefore is a hidden cost to the business.

- **Cracks / hot tears**

Cracks can appear in die castings from a number of causes. Some cracks are very obvious and can easily be seen with the naked eye. Other cracks are very difficult to see without magnification.

- **Shrinkage**

Shrinkage defect occurring during the solidification of the casting. Open shrinkage defects are open to the atmosphere, therefore as the shrinkage cavity forms air compensates. There are two types of open air defects: pipes and caved surfaces. Pipes form at the surface of the casting and burrow into the casting, while caved surfaces are shallow cavities that form across the surface of the casting. Closed shrinkage defects, also known as shrinkage porosity, are defects that form within the casting.

- **Sink mark:**

Sink marks and voids both result from localized shrinkage of the material at thick sections without sufficient compensation. Sink marks appear as depressions on the surface of a molded part. These depressions are typically very small; however they are often quite visible, because they reflect light in different directions to the part. The visibility of sink marks is a function of the color of the part as well as its surface texture so depth is only one criterion. Although sink marks do not affect part strength or function, they are perceived to be severe quality defects. Voids are holes enclosed inside a part. These can be a single hole or a group of smaller holes. Voids are caused when the outer skin of the part is stiff enough to resist the shrinkage forces thus preventing a surface depression. Instead, the material core will shrink, creating voids inside the part. Voids may have severe impact on the structural performance of the part moldings sink mark and void.

II. METHODOLOGY

Experiment are tests or series of tests in which one can deliberately change one or more process variables (or factors) in order to observe the effect the changes have on one or more response variables. The (statistical) Design of Experiments (DOE) is an efficient procedure for planning experiments so that the data obtained can be analyzed to yield valid and objective conclusions. Design of Experiments refers to the process of planning, designing and analyzing the experiment so that valid and objective conclusions can be drawn effectively and efficiently. In order to draw statistically sound conclusions from the experiment, it is necessary to integrate simple and powerful statistical methods into the experimental design methodology. The success of any industrially designed experiment depends on sound planning, appropriate choice of design and statistical analysis of data and teamwork skills. In the context of DOE in manufacturing, two types of process variables or factors are considered: qualitative and quantitative factors. For quantitative factors, one must decide on the range of settings, how they are to be measured and controlled during the experiment. Qualitative factors are discrete in nature. A factor may take different levels, depending on the nature of the factor - quantitative or qualitative. A qualitative factor generally requires more levels when compared to a quantitative factor. Here the term 'level' refers to a specified value or setting of the factor being examined in the experiment.

The three principles of experimental design such as randomization, replication and blocking can be utilized in industrial experiments to improve the efficiency of experimentation. These principles of experimental design are applied to reduce or even remove experimental bias. It is important to note that large experimental bias could result in wrong optimal settings or in some cases it could mask the effect of the really significant factors. Thus, an opportunity for gaining process understanding is lost, and a primary element for process improvement is overlooked.

A. Methodology for DOE

The methodology of DOE is fundamentally divided into four phases.

1. Planning phase
2. Designing phase
3. Conducting phase and
4. Analyzing phase.

B. Testing

- Visual Inspection

Common defects such as surface roughness, obvious shifts, omission of cores and surface cracks can be detected by a visual inspection of the casting. Cracks may also be detected by hitting the casting with a mallet and listening to the quality of the tone produced.

- Radiographic Examination

The radiographic method is expensive and is used only for subsurface exploration. In this, both X-rays and γ-rays are used. With γ-rays, more than one film can be exposed simultaneously; however, x-ray pictures are more distinct. Various defects, like voids, nonmetallic inclusions, porosity, cracks and tears, can be detected by this method. The defects being less dense, film appears darker in contrast to the surrounding.

- **Ultrasonic Inspection**

In the Ultrasonic method, an oscillator is used to send an ultrasonic signal through the casting such as signal is readily transmitted through a homogeneous medium. However, on encountering a discontinuity, the signal is reflected back. This reflected signal is then detected by an ultrasonic detector. The time interval between sending the signal and receiving its reflection determines the location of the discontinuity. This method is not very suitable for a material with a high damping capacity (e.g. cast iron) because in such a case the signal gets considerably weakened over some distance.

- **Dye Penetrant Inspection (DPI)**

The dye penetrant inspection method is used to detect invisible surface defects in a nonmagnetic casting. The casting is brushed with, sprayed with, or dipped into a dye containing a fluorescent material. The surface to be inspected is the wiped, dried and viewed in darkness. The discontinuous in the surface will then be readily discernible.

III. CONCLUSIONS

It is hereby concluded that by adding glass fibres to sand, the sand properties like strength characteristics can be improved and the defects like sand inclusion, blowhole, cold lap can be reduced considerably.

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REFERENCES

[1]. Achamyeleh A. Kassie, Samuel B. Assfaw; “Minimization of Casting Defects”; Journal of Engineering; ISSN: 2250-3021; 2278-8719 Vol. 3, Issue 5 (May. 2013).

[2]. Bernhard J. Stauder, Hubert Kerber, Peter Schumacher “ Foundry sand core property assessment by 3-point bending test evalution”; Journal of Materials Processing Technology, Volume 237, November 2016, Pages 188-196

[3]. Eun-Hee Kim, Guen-Ho Cho, Yoon-Suk Oh, Yeon-Gil Junga “Development of a high temperature mold process for sand casting with a thin wall and complex shape” Thin solid films 20 September 2016.

[4]. Frank Peters et al; “Effect of mould expansion on pattern allowances in sand casting of steel”; International journal of cast materials; 2007.

[5]. Himanshu Khandelwal, B. Ravi “Effect of molding parameters on chemically bonded sand mold properties” Journal of Manufacturing Processes, Volume 22, April 2016, Pages 127-133

[6]. Hiren Khalasi, Milan Patel, Deep Parekh; “Classification of casting defects: A review”; International Journal of Advance Research in Engineering, Science & Technology; issue: 2393-9877, ISSN: 2394-2444; Volume 3, Issue 3, March-2016.

[7]. John Campbell “ Chap 10 – The 10 rules of good castings” Complete casting handbook, volume 2, 2011, pages 605-737

[8]. K M Maneesh1, Dr. Boby K George; “Job Safety Analysis and Elimination of Casting Defects by Application of Design of Experiments”; International Journal of Science and Research; ISSN: 2319-7064 Index Copernicus Value (2013): 6.14.

[9]. K.G. Swift, J.D. Booker”; chap 3–Casting Process” Manufacturing process Selection Handbook, 2013, Pages 61-91.

[10]. M. Viquar Mohiuddin, A. Krishnaiah, S. Ferhathullah Hussainy; “ Effect of Composition of Sand Mold on Mechanical Properties and Density of Al-Alloy Casting Using Taguchi Design Approach”; International Journal of Engineering Research and Applications; Vol. 5, Issue 3, March 2015, pp.37-41.

[11]. Prasan kinagi, dr. R.g mench; “A development of quality in casting by minimizing defects”; International Journal of Recent Research in Civil and Mechanical Engineering; Vol. 1, Issue 1, pages: (31-36),April 2014 - September 2014.

[12]. Pribulova Alena et al;“Quality control in foundry – analysis of casting defects”; Technical University.

[13]. Rajesh Rajkolhe, J. G. Khan; "Defects, Causes and Their Remedies in Casting Process: A Review"; International Journal of Research in Advent Technology; Vol.2, No.3, March 2014.
[14]. Rohan Muni Bajracharya, Allan C. Manalo, Warna Karunasena, Kin-tak Lau "Experimental and theoretical studies on the properties of injection moulded glass fibre reinforced mixed plastics composites" Composites Part A: Applied Science and Manufacturing, Volume 84, May 2016, Pages 393-405
[15]. Shraban Kumar Singha, Simran Jeet Singh "Analysis and optimization of sand casting defects with the help of artificial neural network"; International Journal of Research in Engineering and Technology; issue: 2319-1163.
[16]. Sunil Chaudhari et al; "Review on Analysis of Foundry Defects for Quality Improvement of Sand Casting"; International Journal of Engineering Research and Applications; Vol. 4, Issue 3; March 2014, pages 615-618.
[17]. Yaw A. Owusu "Physical-Chemistry study of sodium silicate as a foundry sand binder" Advances in Colloid and Interface Science, Volume 18, Issues 1–2, September 1982, Pages 57-91.
[18]. Sssss

*Bhavin Mistry. "Effects of Adding Glass Fibers As Additive for Sand-Casting." International Journal of Engineering Research and Development, vol. 13, no. 09, 2017, pp. 26–31.