CGC International Journal of Contemporary Technology & Research
ISSN: 2582-0486 (online), Vol.-2, Issue -1 DOI: 10.46860/cgcijctr.2019.12.20.77

Methodology to Reduce Casting Defects of Alluminium alloy using Post Heat Treatment

[1]Varinder Mandley*, [2]Mamta Janagal,
[1]Green Hills Engineering College, Solan
[2]Chandigarh Enginerring Colleges,Landran, Mohali
*vmcalling@gmail.com

Abstract— In early years with the expansion of industries and growth of technology, the usage of aluminum and its alloys is also expanding. Therefore It is additionally utilized in aviation and vehicle industries because of their low thickness, good hardness property, great mechanical properties, better consumption opposition and low coefficient of extension when compared with other metals and alloy. The initial step of assembling in the aluminum combinations begins with the throwing strategy in light of the fact that the underlying throwing structure importantly affects the achievement of thermo-mechanical properties. The initial step of manufacturing in the aluminium alloys is the casting method . The casting structure has an important effect on the success of thermo-mechanical properties. The quality of aluminum amalgams can be dictated by its size and microstructure highlights of circulation all through the throwing procedure. In this way, it is essential to characterize throwing parameters of the aluminum compounds examples for controlling the microstructure properties and throwing abandons. This paper depends on the strategy to evacuate throwing abandons and improve the hardness of the aluminum composites.

Keywords— ***Casting; defects in casting, Effects of casting parameters, Microstructure of casting alloys.***

I. Introduction

Since the 1930s, aluminium alloys have been the basic material which are used for the structural components of aircraft and it also widely used in commercial airliners, military cargo and transport aircraft for manufacturing. Foundry enterprises in creating nations suffer from low quality casting alloys. It is due to involvement of number of procedure parameters in casting process. Even in a totally controlled procedure the casting defects occurs in the samples[1]. The defect free casting is the only result of proper combination of various casting parametres. The parameters "i.e rapidly change its state to solid, new ingot alloys, new tempers, aluminium–lithium alloys" which enhanced the property of aluminium alloy. This material is widely used in manufacturing beacuase of its advantages in terms of fabrication cost, sound, corrosive resistance, light weight, adaptability and reuseable practices in design which make its life long [2]. The Green sand throwing process comprise of emptying liquid metal into a sand form, enabling the metal to harden, and afterward splitting ceaselessly the sand shape to evacuate a casting items. In every one of these procedures we see there are a few imperfections happen in the throwing item and it influences the hardness of the product. Selecting the correct method for a given application involve its rigidity, thickness, flexibility, formability, functionality, weld capacity, and consumption opposition. Aluminum composites are those in which aluminum is the overwhelming metal. The regular alloying components are copper, magnesium, manganese, silicon, and zinc [3] Various examination has been done on throwing procedure and its imperfections which is:

Naro [4] discussed the defects in casting due mould and metal reaction take place in between casting process and he also discuss about the effect of binders in casting. The unfavorable binders also a reason for defects occur in final casting. Abdul rahman [5] study the effects of moisture content of the green sand from river and its moulding properties by using Tudun-Wada clay as a Binder. Singaram [6] analyzed the significant process of green sand casting and implemented the Taguchi method by using L9 orthogonal and taking variable parameter like moisture content, green compression, mold hardness. Turbalioglu [7] manufactured the billets at different metal temperatures and different casting speeds, using the vertical continuous casting method. Olufemi et al. [8] investigated the mechanical properties of aluminium 6063 alloy and observed the effects of ageing temperature and soaking time. Isadare et al. [9] investigated the influence of diffusion annealing on some mechanical properties of 6063 aluminum alloy. They used the tensile and hardness test samples to diffuse the annealing. Sharma A. et al. [10] discussed the composit of Al6063/Al2O3/SiC through Stir casting technique and the grain size of alloy is increased with increased with reinforcement ,microhardness 49H is attained for Al6063/6%Al2O3/6%SiC alloy. In above literature review it is observe that the pouring temperature affect the hardness of the alloys because it helps in making the finer grain size. The other two parameters i.e. binder ratio and moisture content also have their importance more than other parameters to obtain defect free casting which improves hardness and some of the author reported that post heat treatment where applicable may be useful tool for improvement in mechanical properties.

II. SELECTION OF PARAMETERS FOR CASTING AND CASTING DEFECTS

The casting technique is combination of different parametres at various levels and this combinations is influences the casting quality. The Taguchi technique is use to reduced the percentage of dismissal because of sand and embellishment related imperfections by setting the ideal combinations of the parameters of the green sand casting [3].This strategy includes decreasing the trial in a casting procedure through structure of experiments. By choice of ideal procedure parameters the defects such as porosity, inadequate spread of liquid material, shrinking and shape defects are limited. The trials will take place according to the taguchi orthogonal array with selected casting parametres, for general investigation let us take some factor like "Sand molecule size, moisture content in sand, green pressure quality, mould hardness, permeability, pouring temperature of liquid metal, pouring time of liquid metal in shape and casting defects". These above mentioned defects are important consideration factor to make a casting.

Casting defects can be divided as deformities occur due filling of molten metal, due to shape, thermal deformities and defect by gating system.

1. **Deformities due to pouring of molten metal are:**
   i. **Blow holes:-** Blowholes are casting flaws which are created by intruption of air into the mould. The air which does not escape from the mould during the pouring of molten metal into the cavity is main reason of blow holes.
   ii. **Sand Burning:-** Sand burning is a flaw which arises due to improper temperature of molten metal which burn the mould cavity.
   iii. **Misrun:-** Misrun is the imperfection which occur due to improper temperature of molten metal.
   iv. **Cold shut:-**cold is the defects rises due to improper gating system. When the molten metal poured from more the one gating system the molten metal enable to meet properly from all sides of gating system.
   v. **Gas Porosity:-** Gas porosity is flaw which arises due to the intruption of gases like hydrogen, air.

2. **Shape Defects related deformities which are:**
   i. **Shape Defects**:- This defects occurs when partine line dislocates form its original position. It cause improper fitment of the moulding box.
   ii. **Distortion or Warp**:- Distortion or wrap is the defects occur due to shifting of the mould.
   iii. **Flash Defect**:- The excess material which attached with casting after the solidification of mould is called flash defects. It is unwanted material which must be removed before use.

3. **Thermal defects related deformities which are**:
   i. **Cracks or tears**: - Cracks or tears are the flaws which arises due to the improper cooling of molten metal in cavity.
   ii. **Shrinkage: -** Shrinkage defects is a defect which occurs due to shrinkage of casting after solidification of molten metal. In the molten metal when it cools the neucleation strats as first crystal formation and after neucleations all crystals are formed one by one till all molten metal become solid.
   iii. **Sink mark and void:-** Sink marks and voids are the defects occurs due to localized shrinkage of thick section of casting.
   iv. **Defect by Gating system related deformities:**
   Gating system in casting is a path of flow of molten metal from runner to riser. The gating frame work must be proper for defect free casting.

TABLE 1: Cast Aluminium Alloy Designations [5]

Alloy Designation	Details	Heat treatable/ Non Heat treatable
1XX.X	99% pure aluminium	Non Heat treatable
4XX.X	Si containing alloy	
5XX.X	Mg containing alloy	
2 XX.X	Cu containing alloy	Heat treatable
3 XX.X	Si, Cu/Mg containing alloy	
7 XX.X	Zn	
8 XX.X	Sn	
9 XX.X	Miscellaneous	

III. METHODOLOGY TO IMPROVE CASTING QUALITY AND REDUCE CASTING DEFECTS

A). Design of Experiment

For conducting the experiment, the utilization of Taguchi strategy for exploratory structure is mostly use because it gives effects of the all parametres with minimum experimental trials. The step by step of taguchi method is written below [1]:

i. Aim should be justified and mentioned.
ii. Selection of number of factors.
iii. Selection of variables or potentially communications to be assessed.
iv. Test condition and uncontrollable factors will be measured.
v. Mention the number of levels for the controllable factors.
vi. Mention the levels of controllable and uncontrollable factors.
vii. Choose the suitable level Orthogonal Array (OA).
viii. Caclculate the total degree of freedom .
ix. Assignment of factors and interaction of the columns.
x. Execution of experiments as indicated by preliminary conditions in the cluster.

TABLE 2: Selection of ranges for different parameters

S.no	Factors	Values
1	Sand particle size	Constant
2	Moisture percentage in sand	C-D%
3	Binder ratio	A-B %
4	Mould hardness	Constant
5	Permeability	Constant
6	Pressure test	M-N

(B). Selection of Orthogonal Array

When OA is choose for the system then some parameters are needed to be take care i.e number of adjustable factors and interface of interest [3]. For example we take general experiment with three parameters like moisture content, binder ratio and pouring temperature.

The total 6 DOF is calculated for this experiement for tgree level parameters. The DOF of the orthogonal array selected should be higher than that of total DOF of the experiment.

CGC International Journal of Contemporary Technology & Research
ISSN: 2582-0486 (online), Vol.-2, Issue -1 DOI: 10.46860/cgcijctr.2019.12.20.77

TABLE 3: Standard Design of orthogonal ayyar by using Taguchi

Trial	Moisture Content	Binder Ratio	Pouring Temperature
1	A	A	A
2	A	B	A
3	A	C	A
4	B	B	B
5	B	C	B
6	B	A	B
7	C	C	C
8	C	A	C
9	C	B	C

The design with minimum experimental trial is only be achieved by using taguchi technique and it also give the best control range of input parameters and their effects on the output parameters. In above table adjustable factors are divided into three parts which are presence of moisture level, binder ratio in green sand and variation in temperature. The there main types of parametres now sub devided into their different ranges, range from A to C. The internal or controllable factor which gives its effects on final experimentation are called signal factors and the effect of the external factors (uncontrollable factors) on the final experimentation is known as noise.

(C). Casting

The sand casting process used to prepare the samples compromises of six main steps, which are explained as follow:-

i. **Mould –** The first step is to make the shape of the casting. A mould is the hollow or empty shape box in which liquid metal or pliant material such as plastic, glass, metal or ceramic is poured to gain desired shape of the casting. when the casting shape are complex then the segmented moulds should be use which have two or more pieces, come together to form the complete mold, and then disassemble to release the finished casting.

ii. **Clamping –** After the mould production the next step is to pouring liquid metal into a mold, to which have a hollow cavity of the final shape, and then remain unchanged upto its cooling and solidification. The solidified part is also known as a casting, which come out of the mould to complete the process. The outside of the shape cavity was first greased up to encourage the evacuation of the casting. It was basic that the shape parts remain safely shut to forestall the loss of any material.

iii. **Pouring:** The liquid metal was kept up at a set temperature in a heater. After the form has been cinched, the liquid metal can be spooned from its holding compartment in the heater and filled the shape. The pouring was performed physically. Enough liquid was poured to fill the whole cavity and all directs in the form. The occupying time was exceptionally short so as to forestall early cementing of any one piece of the metal.

iv. **Cooling -** After the whole depression was filled and the liquid metal set, the last state of the throwing was shaped.

v. **Removal –** After passing of time the predetermined solidification take place, the sand mould simply broken, and then remove the casting. This step, sometimes called shakeout, is typically performed by a vibrating machine that shakes the sand and casting out of the flask but some time mould will remove manually too.

vi. **Trimming –** After the completion of casting the unwanted material come from channels may attached to the final casting then it is remove by cutting and extra material will be reused again in casting. The trimming is the finshing step of the casting. It gives final shape to casting after removing extra material.

(D). Signal-To-Noise Ratio For Response Characteristics:

The parameters that impact the final structure can be devided into two classes, specifically controllable (or configuration) factors and uncontrollable (or commotion) factors. Controllable variables are those elements whose range can be set and effectively balanced by the originator. Wild factors are the wellsprings of variety frequently connected with operational environment. The best settings of control factors as they impact the yield parameters are resolved through investigations. Controllable variables are isolated into three fundamental sorts. Those which influence the normal degrees of the reaction of intrigue, alluded to as Target Control Factors (TCF), some of the time called signal components. Those components influence the fluctuation in the reaction, the Variability Control Factors (VCF). At the core of Taguchi theory is the quality misfortune work. The misfortune work elevates endeavors to ceaselessly diminish the variety in product's useful attributes. The adjustment in quality trait of an item under scrutiny in light of a factor presented in the test configuration is the "signal" of the ideal impact. The impact of the outside elements (wild factors) on the result of value trademark is named as "noise". The target of any examination is to accomplish the most ideal S/N proportion [6]. Finding a right target capacity to expand in a building structure issue is significant.

(E). Analysis Of Results Using Anova

Taguchi method can't pass judgment and decide the impact of individual parameters on whole procedure while rate commitment of individual parameters can be resolved utilizing ANOVA method.

(F). Heat Treatment

To make a desired change in the physical properties of a metal heat treatment is a best method to be used. In this method number of controlled heating and cooling operations is used. Its purpose is to improve the structural and physical properties for some particular use or for future work of the metal. There are five basic heat treating processes: hardening, case hardening, annealing, normalizing, and tempering. Although each of these processes give different results in metal, all of them have some basic steps: heating, soaking, and cooling. The heat treatment will give effect of grain size on strength and to find out the best result or better strenghtfull casting we have to compare the hardness of the cast specimen before and after heat treatment.

(G). Microstructure Analysis Using SEM

The SEM technique performed twice to analyse the microstructure changes in the Al-Si-Mg alloy before and after heat treatment of casted samples produced by sand casting technique.

The key microstructural features obtained by SEM which control the properties of aluminium alloys are:-

i. Coarse inter-metallic compounds which form during ingot cooling or during subsequent processing. These particles are often aligned as stringers in fabricated products [9].
ii. The submicron size particle referred to as dispersions, the transition metals like chromium, manganese, and zirconium or other high melting point elements contains intermetallic compound.
iii. which are the inter-metallic compounds containing transition metals like chromium, manganese, and zirconium or other high melting point elements.

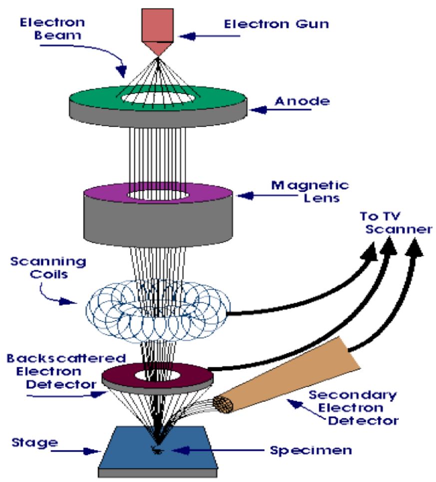

Fig.1 SEM working [8]

iv. The size and shape of grains.
v. The intruption in substructure resulting from cold working.
vi. Fine Precipitates, which form during precipitation hardening or age hardening, heat treatments and which results or enhance strengthening.

IV. CONCLUSION

From this study, the mechanical properties of aluminium alloy can be change by changing different casting parameters during the production with the sand casting method. The following general conclusions were drawn:-

1. The change in microstructure and hardness of the casted aluminium alloy produced after and before heat treatment can be compare.
2. The change in casting parametres with their diefferent levels may also give defect free castings.

As after heat treatment, the alloy may attains tempered state and hardness is achieved through the precipitation of inter metallic phases during ageing which leads to increase in hardness and refinement of grain structure.

REFERENCES

[1]. Dabade U.A. and Bhedas gaonkar R.C., “Casting Defect Analysis using Design of Experiments (DoE) and Computer Aided Casting Simulation Technique”, Sciverse science Direct, 2013.
[2]. Vasudevan S. and Srivatsan T.S., “Advance structural material”, Taylor & Francis Group, pp. 225-233, 2006.
[3]. Upadhye R.A., “Optimization of Sand Casting Process Parameter Using Taguchi Method in Foundry”, International Journal of Engineering Research & Technology, Vol. 1 (7), pp. 1-9, 2012.
[4]. Naro R.L, “Porosity Defects in Iron Castings From Mold- Metal Interface Reactions”, AFS Transactions, 99-206, 2010.
[5]. Abdulraham, “Effect of Moisture Content on the Moulding Properties of River Niger Sand Using Tudun-Wada Clay as a Binder”, 170-174, 2010.
[6]. Singram L., “Improving quality of sand casting using taguchi method and ANN analysis”, International journal on design and manufacturing technologies, Vol. 4 (1), pp. 1-5, 2010.
[7]. Turbalioglu, “Fractographic study of two damage tolerant aluminium alloys”, Structural Integrity. Fundación INASMET. C. Portuetxe, San Sebastian, 2009.
[8]. Olufemi, “Reducing Shrinkage in Plastic Injection Moulding using Taguchi Method in Tata Magic Head light”, International Journal of Science and Research, Vol.2 (4), pp. 107-110, 2013.
[9]. Isadare, Jouneau P., TholletG., Basset D. and Gauthier C., “A history of scanning electron microscopy developments: Towards ‘‘wet-STEM’’ imaging”, science direct Elsevier, pp. 390–401, 2007
[10]. Sharma A., Mohal S.,Panwar N. and Singh R., “Fabrication And Characterization Of Al6063-Al2o3- Sic Composites By Stir Casting”, CGC International Journal of Contemporary Technology and Research,Vol. 1 (2) ,2018