Journal Of Harmonized Research (JOHR)

Journal Of Harmonized Research in Engineering
2(4), 2014, 417-423

ISSN 2347 – 7393

Original Research Article

ANALYSIS OF DEFECTS IN CENTRIFUGAL CASTING BY HYBRID METHOD

Aakanksha Suryawanshi and Shiena Shekhar

Mechanical Department, B.I.T. Durg, India

Abstract: The defects of the centrifugally cast samples decrease the strength and quality of product, to reduce these problem randomly design the experiments has been used to analyses the influence of process parameters on centrifugal casting of aluminum alloy. Tests carried out on eight design of experiment characterized by different variation of Speed, Temperature and Type of cooling on aluminum alloy that solidify and analysis the defects of shrinkage and blow holes produce during cooling. The results of confirmation experiments reveal that grey–fuzzy hybrid method can effectively optimize an optimal combination of the process parameters.

Keywords:-Centrifugally casting, hybrid method, shrinkage and blow holes.

Introduction

The centrifugal casting method was developed after the turn of the 20th century to meet the need for higher standards. The process of centrifugal casting differs from static casting in that the mold itself is spinning during the time, casting is solidifying. Centrifugal castings are usually poured while the mold is spinning; however, for certain applications, particularly in the case of a vertical casting, it is sometimes preferable that the mold be stationary when pouring begins. The centrifugal casting process consists of pouring the molten metal at a suitable temperature into a rapidly rotating mould or die. It is essential that pouring temperature of molten metal should be high enough to enable it to reach the farthest point in the mould before solidification commence. The roll works in contact with molten Material at a temperature of 1100^{o} C and its outer surface should not exceed temperatures between 425 and 475^{o}C. During the glass rolling operation, the roll is cooled internally by water circulation. According to information, the inner walls of the cylinders are lined with hard chromium to avoid the formation of deposits, which may reduce the cooling efficiency of the roll [1]. Using of wetting agents could be another choice in this direction. The other factors which improve the

For Correspondence:
conveytoaakankshaATgmail.com
Received on: December 2014
Accepted after revision: December 2014

wettability are high surface area of the particles, decreasing the surface tension of the alloy by heating at higher temperature and reduction of interfacial energy at the surface of the particles. The other variables may include design of the mold, proper gating system and temperature of mold before pouring. Commercial grade aluminum is liquefied first and ceramic material is added in the desired manner and magnitude followed by agitation via mechanical means. The difficulty of doing so is that alloying elements that are beneficial for improving the former property are usually detrimental for the latter. In order to achieve reliable results a high number of specimens have to be produced and tested. In this research obtained compact tension and tensile specimens via direct centrifugal casting. During specimens manufacturing a large number of them fractured during cooling, while others showed a delayed fracture. Considering that a large number of fractured specimens were available, a study has been carried out with the aim of finding the factors that determine this phenomenon. In this work specimens' structure and composition were analyzedand crack paths were studied in order to identify causes determining high residual stresses that in many cases are able to produce explosive crack propagation throughout the castings.

The greater thickness of the melt prevents the ceramic phase to settle down in the bottom of the pan as described by Shabestari [6]. Settling of the fine reinforcement particles during formation of the composite results in the irregular distribution of reinforcement, irregular mechanical and chemical properties as expressed by Gao[8]. There are several stages where there are chances of irregular distribution of particles in the melt as shared is summarized at the time of mixing while the melt is being continuously heated and stirred. At the time of pouring into the mold there has been observed irregular flow of the melt. At the time of solidification stirring is impossible in the molds. For that reason, reference castings are frequently employed when the solidification rate has to be accurately controlled and different microstructures have to be achieved. Therefore, in these castings, the solidification conditions can be set up by varying the thickness and the material of the mold, as well as the sample size. [7] Aluminium Alloy compositions on an international basis, most countries have agreed to adopt the 4 digit classification for wrought alloy composition designation. The European reference for the alloys will be identified with the preface EN and AW which indicated European Normative and Aluminium Wrought alloys, respectively. [5]

Centrifugal Technique

Centrifugal casting uses the centrifugal forces generated by rotating the mold to propel the metal and to facilitate filling. Vacuum arc skull furnaces discharge titanium alloy at a temperature just above its melting point, and the centrifugal casting is usually needed to ensure good filling. Dental and jewelry casting use centrifugal casting to fill thin sections and fine detail. The centrifugal technique is used primarily for the production of hollow components, but centrifugal casting is used to create solid parts The centrifugal casting process is generally preferred for producing a superior-quality tubular or cylindrical casting, because the process is economical with regard to casting yield, cleaning room cost, and mold cost. The centrifugal force causes high pressures to develop in the metal, and it contributes to the feeding of the metal, with separation from nonmetallic inclusions and evolved gases. In centrifugal casting of hollow sections, nonmetallic inclusions and evolved gases tend toward the inner surface of the hollow casting. By using the outstanding advantage created by the centrifugal force of rotating molds, castings of high quality and integrity can be produced because of their high density and freedom from oxides, gases, and other nonmetallic inclusions. When casting solid parts, the pressure from rotation allows thinner details to be cast, making surface details of the metal-cast components more prominent. Another advantage of centrifugal casting is the elimination or minimization of gates and risers. Centrifugal casting machines are categorized into three basic types based on the direction of the spinning axis: horizontal, vertical, or inclined. Centrifugal casting processes also have three types.

- True centrifugal casting (horizontal, vertical, or inclined)
- Semi centrifugal (centrifugal mold) casting.
- Centrifuge mold (centrifugal die) casting.

Objective of Paper

The problems associated with these castings are unknown to the type of machine, the size of the tube and the type of alloy but the quality of tubular parts obtained during centrifugal casting is strongly influenced by various process parameters like pouring temperature, die-speed, pre-heat temperature of the mould. It is the ability of the iron to undergo the allotropic transformation from ferrite (alpha) to austenite (gamma) during heating, and back to ferrite again during cooling, which makes it possible for the tool steels to develop high hardness and wear resistance. . Researches about the centrifugal casting mainly focus on the as-cast defects. In the process of the centrifugal casting, the molten metal flow has a great influence on the quality and the performance of the roll. Preparation of a casting slip with suitable additives and fabrication of ceramic body use the centrifugal casting setup and drain casting. Since the centrifugal casting is under the complicated force situation and under the high speed, the high temperature and the opaque environment, it is difficult to know the defects develop in casting. Therefore, it is necessary to analyze the defects of the casting in the centrifugal casting process. Also found the condition and temperature which gives lesser defects by hybrid method.

Material and Method

Centrifugal casting is one of the advanced casting techniques widely used in metallurgical industries. However, it is rarely used in ceramic. Few literatures are available on fabrication of ceramic body using centrifugal casting technique. It has been reported that centrifugal technique is very useful for production of functionally graded porous membranes for gas permeable applications. A detailed study of the principle and operations of centrifugal casting machines available commercially suggests that there exist two types of centrifugal casting machine designs. The chemical composition of the Aluminum alloy and the heat treatment details are given in Table 4.1**.** The castings were produced in the form of circular pipe (approximately 2 cm thick by 10 cmoutside diameter by 8 cm inside diameter) using two different mold rotation speeds, 800 to 1000 rpm. As in that case taking eight combination of experiment input parameter and check out their defects in per centimetre of cylindrical casted parts. The cylindrical parts have been cuts along to its axis for seen the defects of inside of cylindrical parts by microscope. The eight input parameter are shown in table 1

Table 1 Design of Experiment

S No.	Temperature in ^{o}C	Speed of Motor in RPM (S)	Type of cooling (Co)
1	450	850	Water cool
2	500	900	Sand cool
3	550	1000	Water cool
4	600	950	Sand cool
5	450	1000	Water cool
6	500	850	Sand cool
7	550	950	Sand cool
8	600	900	Water cool

After performing the experiment the casted specimen are shown in fig 1. These tubes were taken from a pyrolysis furnace after prolonged service, variation of temperature; speed and type of cooling are following as per table 1.

Fig. 1 Specimen by Centrifugal Casting

The particles was responsible for the reduced impact strength of the composite visible a shown in fig 2The pouring temperature there is increase in the time of solidification which results in columnar structure that is; there is a grain-coarsening effect, which reduces the ultimate tensile strength. The appropriate boundary conditions and initial conditions are imposed on the model, and the transient effect of the model has been obtained.

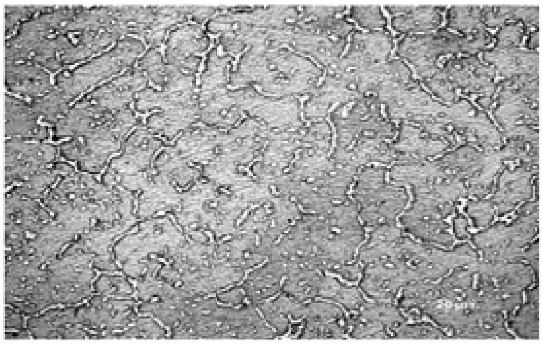

Fig 2 Microstructure of casting materials

From these microscopic procedures find number of shrinkage defects and pin holes defects in per centimeter of cylindrical parts of respected casting specimens shown in table 2. The shrinkage defects are obtained by veneer caliper to measure thickness of cylindrical piece in millimeter. Pin holes or blow holes defect was found by counting of holes through microscope.

Table 2 Defects Found in Specimen

S. No.	Temp. in ^oC	RPM	Type of cooling	Shrinkage defects in mm	No. of Blow holes
1	450	850	1	1.46	6
2	500	900	2	2.04	4
3	550	1000	1	1.58	8
4	600	950	2	1.4	5
5	450	1000	1	1.55	8
6	500	850	2	1.98	7
7	550	950	2	1.69	6
8	600	900	1	1.36	6

1 = Water cooling
2 = Sand cooling

Grey Relation

The grey means the primitive data with poor, incomplete, and uncertain information in the grey systematic theory; the incomplete relation of information among these data is called the grey relation. First, the grey relation analysis was carried out to normalize the responses; surface roughness was normalized by given equation (1) and material removal rate was normalized by given equation (2).

For higher-the-better criterion, the normalized data can be expressed as

$$X_i = \frac{(y)_i - \min(y)_i}{\max(y)_i - \min(y)_i} \quad \ldots\ldots(1)$$

For lower-the-better criterion, the normalized data can be
expressed as

$$X_i = \frac{\max(y)_i - (y)_i}{\max(y)_i - \min(y)_i} \quad \ldots\ldots(2)$$

$where\ i = 1,2 \ldots\ldots n$

The calculation of the grey relational coefficient and the weight of each quality characteristic are determined by equation (3):

$$G_i = \frac{L_{min} + \varepsilon L_{max}}{L_i(k) + \varepsilon L_{max}} \qquad \ldots\ldots(3)$$

Where, $L_{min}$is the global minimum, L_{max} is the global maximum and ε is distinguish coefficient which is taken in between 0 to 1 in this case 0.5 weight is taken. The normalized value of above response will take lower the better, grey relation coefficient and grey–fuzzy reasoning grade (GFRG) is shown in Table 3.

Fuzzy Interface System

The fuzzy structure was made by two inputs and one output on the basis of designed membership function and fuzzy rule. A fuzzy logic unit comprises of a fuzzifier, membership functions, a fuzzy rule base, an inference engine, and a defuzzifier. In the fuzzy logic analysis, the fuzzifier uses membership functions to fuzzify the grey relational coefficient, as it contains some degree of uncertainty and vagueness with respect to response characteristic. The hybrid fuzzy application applies on the obtained GRC as shown in Fig. 3.

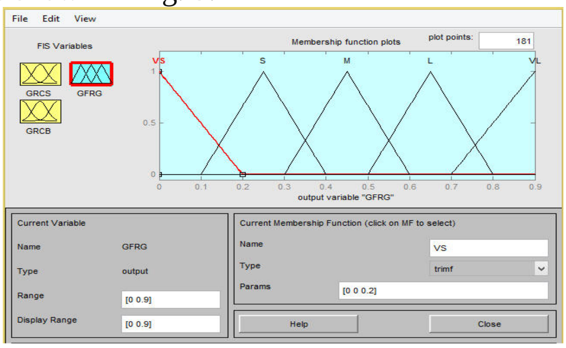

Fig 3 Fuzzy Membership Output Function

Grey–fuzzy logic

A membership function is used to determine how each value is mapped to a membership value between 0 and 1. The GFRG are estimated by FIS for the multi-response results, plot mean graph based on GFRG which gives optimal output. The GREY-FUZZY method is applied by following steps written below:

- Designing an appropriate plan of experimental design and determining the level of parameters.
- Conducting the experiments based on parameters.
- Normalized the responses of experimental results using Eqs. (1 and 2).
- Computing grey relational coefficients from the normalized values using Eq. (3).
- Fuzzify the grey relational coefficients of each response by membership function and fuzzy rules.
- Calculating the fuzzy multi-response output by defuzzification of the output linguistic variables into crisp values, i.e., grey–fuzzy reasoning grade.
- Performing the response table and response graph to select the optimal level setting of injection process parameters.

Table 3 Normalized, GRC and GFRG of Response

Normalized Shrinkage defects	Normalized No. of Blow	GRCS	GRCB	GRG	GFRG
0.852941	0.5	0.147059	0.5	0.32353	0.25
0	1	1	0	0.5	0.45
0.676471	0	0.323529	1	0.661765	0.65
0.941176	0.75	0.058824	0.25	0.154412	0.153
0.720588	0	0.279412	1	0.639706	0.65
0.088235	0.25	0.911765	0.75	0.830883	0.815
0.514706	0.5	0.485294	0.5	0.492647	0.45
1	0.5	0	0.5	0.25	0.25

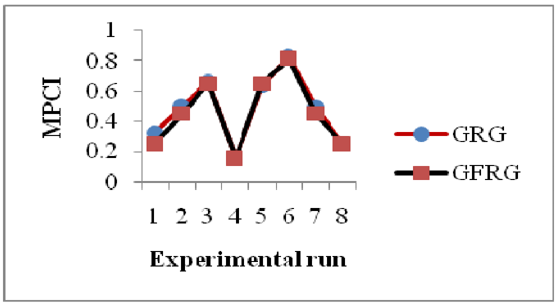

Fig. 4 Graph between GRG and GFRG

By arrange the GFRG value in increasing order in Table 4, highest value of GRG and GRG will give low defects as corresponding to their input parameter. In this table shows the highest GFRG Value gives high quality and low defects with high quality. In this case 500°C temperature, 850 rpm and sand cooling gives better response of output.

Table 4 Increasing order of GRG and GFRG

S No.	Temp. in °C	Speed of Motor in RPM (S)	Type of cooling (Co)	GRG	GFRG
1	600	950	Sand cool	0.154412	0.153
2	600	900	Water cool	0.25	0.25
3	450	850	Water cool	0.32353	0.25
4	550	950	Sand cool	0.492647	0.45
5	500	900	Sand cool	0.5	0.45
6	450	1000	Water cool	0.639706	0.65
7	550	1000	Water cool	0.661765	0.65
8	500	850	Sand cool	0.830883	0.815

Conclusions

Defects were finding in centrifugally casting with the objectives to minimize the thermal stress. The particle size of reinforcement should be finer so that the miss fitting problem can be accommodated accordingly. By using fine particle size, the problem arising from the centrifugal force can also be minimized that produces segregation in the melt due to which the non-uniform properties are attained. This suggests that in order to prevent this phenomenon the GRG and GFRG give higher value should be reduce the defects. Further improvement can be obtained by pouring the alloy in vacuum in a preheated mould, leaving the casting to cool down in a furnace. Centrifugally casting of alloy produced less porosityas per GRG and GFRG for mould speeds of 500 and 850 rpm with sand cooling. It is seen from the experiments done that if further experimentations, varying the speed of rotation are carried out then better results could be obtained by Taguchi design of experiment of the centrifugally casting input parameter and optimizes the outputs of cast materials.

References

[1]. J. Datta, Ed. AluminiumSchlussel: Key to Aluminum Alloy: 6th ed. Aluminum Verlag, Düsseldorf, Germany, 2002.

[2]. G.K. Sigworth, F. Dehart, Recent Developments in the High Strength Aluminium-Copper Casting Alloys A206, AFS Transactions 111, 2003, 341-354.

[3]. C.H. Cáceres, C.J. Davidson, J. R. Griffiths, Q.G. Wang, The effect of Mg on the microstructure and Mechanical behaviour of Al-Si-Mg Casting Alloys, Metallurgical Material Transaction, 30A, 1999, 2611-2618.

[4]. K. Müller, W. Reif, Einfluß von Begleit- und Spurenelementen auf die Kornfeinunghochsilizium Al-Si-Guslegierungen auf Reinstbasis, Metall 51, 1-2, 1997, 25-32.

[5]. K.G. Basavakumar, P.G. Mukunda, M. Chakraborty, Influence of grain refinement and modification on microstructure and mechanical properties of Al-7Si and Al-7Si-2.5Cu cast alloys, Materials Characterization, 59, 2008, 283 – 289.

[6]. S.G. Shabestari, S. Ghodrat, Assessment of modification and formation of intermetallic compounds in aluminum alloy using thermal analysis, Materials Science and Engineering A 467, 2007, 150–158.

[7]. J. Pavlovic-Krstic, R. Bähr, G. Krstic, New Casting Technologies and prediction of casting properties using advanced computational simulation technology, International PhD Foundry Conference, June 1.-3. Brno, 2009, 117-125.

[8]. Gao, J. W. and Wang, C. Y., “Modeling the Solidification of Functionally Graded Materials by Centrifugal Casting”, Material Science and Engineering, A292, pp 207-215, 2000.