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PARAMETERS OPTIMIZATION OF CENTRIFUGAL CASTING BY MULTIOBJECTIVE TECHNIQUE

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ARTICLE INFO **ABSTRACT** **ORIGINAL RESEARCH ARTICLE**

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Control parameters were used to reduce the defects that occur on the cylinder made by centrifugal casting. The defects of the centrifugally cast samples were decrease the strength and quality of the product. To avoid this defect full factorial design of experiments are proposed to run the procedure of centrifugal casting, to analyses the influence of process parameters on the defects during centrifugal casting three grade of aluminum alloy material is selected. Tests carried out on twenty-seven design of experiment characterized by a different variation of alloy material, Temperature, and speed of machine that solidify with water cooling process and analysis the defects of shrinkage and blowholes. The results of confirmation experiments reveal that grey–fuzzy hybrid method can effectively optimize an optimal combination of the process parameters. After that, the highest grey relation grade and highest GFRG parameters are selected as optimizing process parameter also compare the GRG and GFRG for their variation of a result of closeness.

Introduction

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.[2] 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 the centrifugal casting of hollow sections, nonmetallic inclusions and evolved gases tend toward the inner surface of the hollow casting. The centrifugal force imparted to molten metal enables it to be picked up and held in contact with the rotating mold. The mold is allowed to rotate till the casting is completely solidified. Thus the outer shape of casting takes the shape of the inside of the mold and the bore of casting is truly circular and concentric with the axis of rotation. In case of centrifugal casting, there is no need of runners and risers. The aging heat treatment programs were systematically performed in the as-received alloy after long-term use. The obtained specimens after various aging conditions were investigated and analyzed

Gap analysis and objective

The gap associated with this effect is that there are decreased the best distribution chances because of its disability to carry the load at a higher temperature. Some authors have reported chemical reaction of the surface with the metal but the same has not been considered in the present investigation.

- In past, no researcher has used the full factorial design on centrifugal casting parameters.
- Systematic design of experiment is missing in past literature,
- Optimization technique has used but material are not optimized for specific temperature and speed.

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 the hybrid method.

- Design the experiment as per the requirement of parameters
- Perform the experiment to obtain the defects in specimen
- Optimize the defect by multi-objective technique.

Method and Material

As the properties of a specific Al-Si alloys have been used for Centrifugal casting. it is reported that an increase of the silicon content of the Al-Si cast alloy causes a decrease of casting density and an increase in Young's modulus. The chemical composition of the Aluminum alloy and the heat treatment details are given in Table 1**.** The castings were produced in the form of circular pipe (approximately 2 cm thick by 10 cm outside diameter by 8 cm inside diameter) using two different mold rotation speeds, 800 to 1000 rpm. The current experimental investigation deals with the analysis of the experiment by the Full Factorial methodology.

Table 1 Alloy Composition

Composition	Si	Fe	Co	Mg	Ni	Mn	Zn	Ti
Alloy 1	6.80	0.12		0.61	-	0.01	0.02	0.12
Alloy 2	12.09	0.27	0.58	1.34	1.26	0.09	0.04	0.06
Alloy 3	18.89	0.90	0.52	1.20	1.37	0.12	0.24	0.04

Experiment and Analysis

In prepare automotive parts, it is important to have an intimate knowledge of how alloy solidifies at different cross-sections of the cast part and how this influences mechanical properties. The present experiments were designed to apply the on full factorial design to establish the effects of casting parameters on the mechanical properties of aluminum alloy during casting. In this process, the specimen dimension is 50 mm inside diameter 65 mm outside diameter and 100 mm length. The common principle of the variation of the parameter is to develop an understanding of the individual and combined effects of a variety of design parameters from a minimum number of experiments. In horizontal centrifugal casting machine, the centrifugal force is generated by a rotating cylindrical mold to throw the metal against the mold wall and form the tubular shape. The shrinkage defects are obtained by veneer caliper to measure the thickness of cylindrical piece in millimeter of every 20mm distance finally the defects are obtained by an average of five measurements, similarly, defects are found for blowholes. Electron microscopy was performed using a Hitachi S900 scanning electron microscope (SEM) equipped with a field emission gun and an energy-dispersive X-ray (EDS) microanalyzer. From these microscopic procedures find a number of pinholes defects in per centimeter of cylindrical parts of respected casting specimens shown in table 2. Pinholes or blow holes defect was found by counting of holes through a microscope.

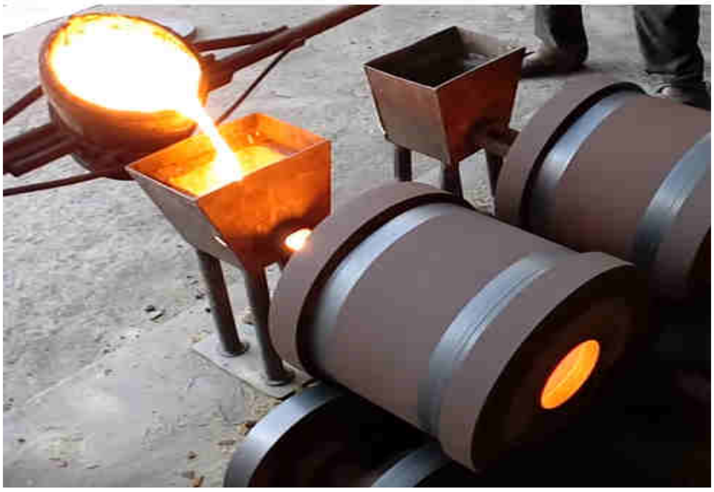

Fig 1 Horizontal Centrifugal Machine

Table 2 Defects Found in Specimen

S. No.	Material (M)	Temperature (T) ^oC	Revolution RPM	(Sd) mm	(Bh)
1	Alloy 1	700	1400	1.2	3.8
2	Alloy 1	700	1500	1.24	3.4
3	Alloy 1	700	1600	1.34	4.2
4	Alloy 1	800	1400	1.1	5
5	Alloy 1	800	1500	1.36	4
6	Alloy 1	800	1600	1.36	4.2
7	Alloy 1	900	1400	1.52	5.8
8	Alloy 1	900	1500	1.32	5.8
9	Alloy 1	900	1600	1.16	5.8
10	Alloy 2	700	1400	1.36	6
11	Alloy 2	700	1500	1.5	5.4
12	Alloy 2	700	1600	1.32	5.8
13	Alloy 2	800	1400	1.08	5.4
14	Alloy 2	800	1500	1.26	4.6
15	Alloy 2	800	1600	1.32	5.2

16	Alloy 2	900	1400	1.32	4.8
17	Alloy 2	900	1500	1.16	6
18	Alloy 2	900	1600	1.56	5.8
19	Alloy 3	700	1400	1.4	6.6
20	Alloy 3	700	1500	1.24	6.2
21	Alloy 3	700	1600	1.24	6.6
22	Alloy 3	800	1400	1.38	6.4
23	Alloy 3	800	1500	1.1	6.4
24	Alloy 3	800	1600	1.28	5.2
25	Alloy 3	900	1400	1.12	5
26	Alloy 3	900	1500	0.96	6
27	Alloy 3	900	1600	1.42	6

Optimization

The grey means the primitive data with poor, incomplete, and uncertain information in the **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 is 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. (2), is shown in table 5.4.
- Computing grey relational coefficients from the normalized values using Eq. (3), is shown in table 5.5.
- 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.
- Conducting confirmation test and verifying the optimal setting of process parameters.

Results of casting defects are presented in terms of GRFC which shows the variation of the different parameter with different temperature, speed and cooling for the specimen. For the alloy 1, speed 1500 rpm and 700^{o}C temperature of mold give a low GRFC value which shows it has better output in all over the combination. At higher temperature and higher speed casing will produce pin average holes and low shrinkage. From table 3 it is confirmed that 700^{o}C temperature and 1500 rpm is the best combination for centrifugal casting.

Table 3 Optimize Result

S. No.	**Material (M)**	**Temperature (T) ^{o}C**	**Revolution RPM**	**GRG**	**GFRG**
1	Alloy 1	700	1400	0.677778	0.745556
2	**Alloy 1**	**700**	**1500**	**0.758621**	**0.834483**
3	Alloy 1	700	1600	0.553922	0.609314
4	Alloy 1	800	1400	0.590909	0.65

5	Alloy 1	800	1500	0.577922	0.635714
6	Alloy 1	800	1600	0.547619	0.602381
7	Alloy 1	900	1400	0.374419	0.41186
8	Alloy 1	900	1500	0.427273	0.47
9	Alloy 1	900	1600	0.5	0.55
10	Alloy 2	700	1400	0.404762	0.445238
11	Alloy 2	700	1500	0.400794	0.521032
12	Alloy 2	700	1600	0.427273	0.555455
13	Alloy 2	800	1400	0.579365	0.753175
14	Alloy 2	800	1500	0.535714	0.696429
15	Alloy 2	800	1600	0.462567	0.521032
16	Alloy 2	900	1400	0.493939	0.452567
17	Alloy 2	900	1500	0.490476	0.483939
18	Alloy 2	900	1600	0.366667	0.480476
19	Alloy 3	700	1400	0.369369	0.356667
20	Alloy 3	700	1500	0.440439	0.452567
21	Alloy 3	700	1600	0.425287	0.379369
22	Alloy 3	800	1400	0.382246	0.450439
23	Alloy 3	800	1500	0.514822	0.435287
24	Alloy 3	800	1600	0.47723	0.524953
25	Alloy 3	900	1400	0.576087	0.633696
26	Alloy 3	900	1500	0.690476	0.759524
27	Alloy 3	900	1600	0.387845	0.426629

Conclusion

The computational analyses have shown that a uniformly casted concrete pole will not suffer from excessive tensile stress formation by uneven shrinkage. Some conclusion points are;

- The experiment of centrifugal casting gives the material knowledge where increase the silicon in aluminum will decrease the bulk modulus.
- Defects should be minimizing by optimization technique, the process parameter of the centrifugal casting process. Optimization method not only reduces the defect but also enhances the mechanical property of the casting product.
- Optimize parameters are obtained for centrifugal casting. The centrifugal effect seems to be alloyed sensitive. Alloy 1 is much more sensitive than alloys 2 and 3.

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