"PARAMETRIC OPTIMIZATION OF SAND CASTING FOR ALUMINIUM"

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ABSTRACT

To study in depth the industrial casting methodology adopted by jay metal industries .The study casting defects by using Radiography Method and find ways to minimize the defects of Aluminum alloys 2011 Casting by conducting various experiments at different level of process parameters. For this Experiment we used Melting temperature, pouring temperature and solidification time as input process parameters. The importance of sand casting process is that without it no products reach to customer satisfaction. Hence for the Engineers it is importance to convert design into actual product and this one possible only when we go through suitable sand Casting process parameters. Hence sand casting process is value addition process in which raw material gets converted into finished goods.

Keyword: *Sand casting, Aluminum, Melting Temperature, Pouring Temperature Solidification Time, Radiography*

1. INTRODUCTION:

Sand casting, the most widely used casting process, utilizes expendable sand molds to form complex metal parts that can be made of nearly any alloy. Because the sand mold must be destroyed in order to remove the part, called the casting, sand casting typically has a low production rate. The sand casting process involves the use of a furnace, metal, pattern, and sand mold. The metal is melted in the furnace and then ladled and poured into the cavity of the sand mold, which is formed by the pattern. The sand mold separates along a parting line and the solidified casting can be removed. The steps in this process are described in greater detail in the next section.

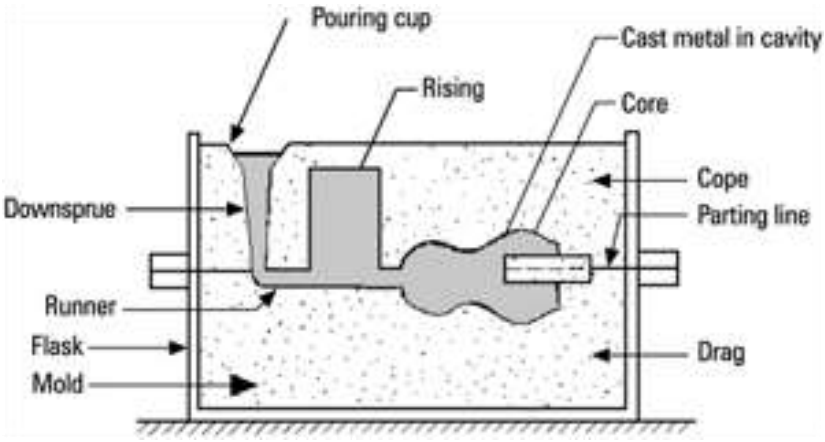

Figure1: Sand Casting Overview

Components of Sand Casting:-

- Furnace- furnace is used for the melting of material. Crucible furnace temperature capacity 900 ºC and storage capacity 20 kg.
- Pattern – an exact replica of the object you want to cast. It is made of an easy to work material (often wood). The pattern is used to make moulds for casting.
- Pouring Cup – basically a funnel that provides an easy target for the metal to be poured into themould.
- Sprue – a hole where the metal enters the mould. It is ideally tapered to prevent air from entering the casting.
- Well – forms a cushion for the metal pouring through the sprue so the sand is not washed into the casting (see the diagram under "Rules for Gating."
- Runner – a channel for the metal to get to the negative space left by the pattern.
- Gate – the place or places where the metal enters the casting.

History of Sand casting:-

Clay molds were used in ancient China since the Shang Dynasty (c. 1600 to 1046 BC). The famous Houmuwu ding (c. 1300 BC) was made using clay molding.
The Assyrian king Sennacherib (704–681 BC) cast massive bronzes of up to 30 tones, and claims to have been the first to have used clay molds rather than the "lost-wax".

In 1924, the Ford automobile company set a record by producing 1 million cars, in the process consuming one- third of the total casting production in the U.S. As the automobile industry grew the need for increased casting efficiency grew. The increasing demand for castings in the growing car and machine building industry during and after World War I and World War II, stimulated new inventions in mechanization and later automation of the sand casting process technology.

Advantages:-

It is able to deliver close dimensional tolerances.

Both ferrous and non-ferrous metals can be casted using investment casting.

It delivers a good as-cast finish.

With investment casting, complex shapes, intricate core sections, finer details and thinner walls are possible.

It offers a flexibility in design and is a useful process for casting alloys that are difficult to machine.

Disadvantages:-

- Sand casting's dimensional accuracy is less than that delivered by other processes.
- This process requires large tolerances.
- The surface finish for ferrous casts delivered by this process usually exceeds 125 RMS.
- Castings produced with this proceed usually exceeds the calculated weight.

Applications:-

Sand casting is extensively used, for cast iron and steel parts of medium and large size where surface smoothness and dimensional precision are the main concerns. Sand casting is also used to make large parts in material like bronze, brass, aluminum, etc. Also used for casting sculptures this can have a certain amount of rough surface finish.

Castings are used extensively in engines, machine tools, Aeroplanes, Automobiles, Household Appliances and many other fields.

2 LITERATURE REVIEW:

Rajesh rajkolhe, J.G. khan: Foundry industries in developing countries suffer from poor quality and productivity due to involvement of number of process parameter. Even in completely controlled process, defect in casting are observed and hence casting process is also known as process of uncertainty which challenges explanation about the cause of casting defects. In order to identify the casting defect and problem related to casting, the study is aimed in the research work. This will be beneficial in enhancing the yield of casting. Beside this, standardization (optimization) of process parameter for entire cycle of manufacturing of the critical part is intended in the proposed work. This study aims to finding different defects in casting, analysis of defect and providing their remedies with their causes. In this paper an attempt has been made to list different types of casting defects and their root causes of occurrence. This paper also aims to provide correct guideline to quality control department to find casting defects and will help them to analyze defects which are not desired

Abhijeet B. Vante, G.R.Naik: Casting defects reduces the total output of castings. It is essential to understand the causes behind these defects. This paper discusses the research carried out in the foundry to control the increased rejection. The component under study is 3 cylinder metric block. The dimensional variations in casting wall thickness are analyzed as major defect contributing in rejection. Quality control tools such as Pareto analysis, cause and effect diagram, why-why analysis, are used for analysis of casting defects. Remedies to minimize the rejection are suggested and implemented. Various chaplets are tried and tested as remedies. The previously used 3 disc round chaplet is replaced by rectangular v-make chaplet. This change contributed in reduction in rejection as well as cost of poor quality. Rejection due to water jacket wall less is reduced from 7% to 2.13%. Reduced rejection indicates better control resulting in quality improvement of 3 cylinder metric block.

Udhaya Chandran.R.M: In this paper mainly focused to minimize the casting defects such as, sand drop, sand blow holes, scabs, pinholes. An optimization technique for process parameters of green sand casting process. In that by using Taguchi method is a powerful problem solving for improving quality of the product. The parameters considered are moisture content (%),green strength(g/cm^2),mould hardness, sand practical size(AFS).The Taguchi approach is used to capture the effect of signal to noise ratio of the experiments based on the orthogonal array used due to optimum conditions are found. The outcome of this paper that the selected process parameters continuously affect the casting defects in foundry. The improvement expected in reduction of casting defects is found to be 47.66 percent.

Mr. Patil Sachin S., Prof. Naik Girish R: In India many foundries have followed conventional and manual operations. Foundry industries suffer from poor quality and productivity due to large number of process parameters combined with lower penetration of automation and shortage of skilled worker. Mould shifting, sand inclusions, poor surface finish, shrinkage, porosity, cold shut and flash are common casting defects in casting. Since casting process involves complex interaction among various parameters and operations related to metal composition, method designs, melting, pouring, shake-out, fettling and machining and hence need to improve. This Paper prescribes comprehensive review of work pertaining to process improvement techniques used for defect minimization in casting.

M. Viquar Mohiuddin, A. Krishnaiah, and S.Ferhathullah: Aluminum alloy castings are extensively used in general engineering, automobile, aerospace industries due to their excellent cast ability, machine ability, corrosion resistance and high strength-to-weight ratio. Keeping in view the increase in demand for the use of aluminum in manufacturing of various components, aluminum foundries have to focus on producing quality castings. Sand mould casting process involves parameters like sand grain size, clay content, moisture content, permeability, green compression strength, mold hardness, number of ramming, shatter index, type of mold, etc., just to mention a few. Based on literature survey, brainstorming and experimental constraints; Grain size, Clay content, Moisture content and Number of ramming has been selected as process parameters keeping other parameters constant. Experiments were conducted as per Taguchi's L9 orthogonal array. Castings are made under the constraint of process parameters at three different levels. Results were evaluated to optimize the process parameters. The optimum levels are found to be: Grain size-55, Clay content-12%, Moisture content-13%, Number of ramming's-2. Confirmation test is conducted based on the optimum level of process parameters and result is found to be in confidence level.

Rasik A Upadhye, Dr. Ishwar P Keswani: The purpose of this paper is to optimize the sand casting process parameters of the casting manufactured in iron foundry by maximizing the signal ratio and minimizing the noise factor using Taguchi method. A Taguchi approach is used to capture the effects of signal to noise ratio of the experiments depending upon orthogonal arrays used, An analysis of variance and optimum conditions are found. This paper demonstrates a robust method for formulating a strategy to find optimum factors of process and interactions with a small number of experiments. The process parameters considered are moisture, sand particle size, green compression strength, mould hardness, permeability, pouring temperature, pouring time and pressure test. The result indicated that the selected process parameters significantly affect the casting defects in the foundry. The improvement expected in reduction of casting defects is found to be 37.66%.

U.G.Mulla J.G, V.V.Potadar, S.S. Kulkarni: Die casting is a manufacturing process that can produce geometrically complex parts through the use of reusable moulds or dies. Accuracy and quality are the first need of customers that must be fulfilled by offering high quality products. The different process parameters like Melt temperature, Holding time, Injection pressure, Rate of cooling, Velocity of flow of molten metal etc., need to be set correctly in order to get desired quality at optimum cycle time and hence in this way we can achieve the desired production rate. For die casting process, there are various techniques by which we can improve the quality of die cast product. In my dissertation work I am going to optimize the process parameters by using analytical methods i.e.-Statistical modeling for historical data, for the same I got sponsorship from Advent Tool Tech Pvt. Ltd., Pune and new case study is considered for this work. Initially using Taguchi method, Design of Experimentation (DOE) performed, for this Minitab software is used for arriving at the optimum level for the factors for the same historical data for similar components have been referred. Finally the results obtained by DOE have been used as input parameters for the machine and component is produced accordingly, then for getting optimum value, each parameter is varied from set value to its minimum/maximum value by keeping other parameters to its constant value, simultaneously component is checked for quality. Minimum or optimum value is the second last value at which we get defect free part at optimum cycle time. The same procedure is repeated for other parameters for getting their optimum values. Finally the results obtained by analytical and experimentation found good agreement with least deviations.

Harvir Singh, Aman Kumar: This paper is relates with casting defects like pinholes, scabs, sand holes, slag, mould shifting, parting line defects, runner & riser defects which mainly occurs in valve casting in foundry. The research on controlling the casting defects in foundry shop which comes in various check valves -PN 10 and these causes may results the reduction of quality of casting. Here we have studied minimize the casting defects using Taguchi's method through change in various parameters like as pouring temperature, green strength, mould hardness and permeability. These experiments were conducted based on standard acceptable and foundry men experience in this casting organization for casting check valves -PN 10 of various sizes & types Significant changes are taken during controlling the parameters. First we collected the data as casting defects from AVVALVE Pvt. Ltd, Agra. Identify the major defects which are scab, cold shut and shrinkage. Complete this task we analyze the cause of this casting defects with the help of fish bone diagram. So we conclude that there are four parameters responsible for these casting defects. 1. Pouring Temperature (^{O}C) 2. Sand Particle Size (AFS) 3.Mould Hardness Number 4. Permeability Number First we define the range of these parameters and

then we perform the casting process at different trial and find that average percentage rejection is 6.25 of the casting product. Then we apply the Taguchi's method and use of MINITAB 17 software to find out the optimum solution. These optimum solutions were applied on casting process and the calculated the percentage rejection 4.416 Of the products. Thus we could improve 1.25% in casting defects.

3. METHODOLOGY:

- Taguchi has designed a number of orthogonal arrays to aid in the development of experiments
- These arrays are essentially balanced fractional factorial designs.
- He suggests using two array matrices for each designed experiment.
- The inner array is used to study the effects of the design parameters we wish to study.
- An outer array is used to model the noise factors that may impact the performance of the product in the field.

4. EXPERIMENTATION:

Material selection: Aluminum comes in many different shapes and grades. The type of aluminum grade you choose ultimately depends on how you intend to use the metal. We choose Al-2011 because of its Good Formability and Workability. The chemical composition of Al-2011 is given bellow table:

Table-1: Chemical Composition of Al-2011

Metal	Sn	Cu	Ni	Si	Mn	Al	Zn	Fe	Ti	Pb	Mg
%	0.007	3.72	0.010	1.89	0.127	93.28	0.081	0.711	0.016	0.082	.027

Experimental Details: The experiments has to carry out on 3 Process parameters using Melting temperature, pouring temperature and solidification time.

1) **Selection of Process parameters and Levels:** Process parameters and their range were determined by the Literature review and by taking the review of experienced people working at sand casting foundry.

Table-2: Experimental parameters and Level

Sr. no.	Parameters	Level-1	Level-2	Level-3	Level-4	Level-5	Level-6	Level-7	Level-8	Level-9
1	Melting temp.(ºC)	800	750	700	650	600	550	500	550	650
2	Pouring temp. (ºC)	780	780	720	700	700	570	580	700	750
3	Solidification time (min.)	10	20	30	40	50	60	70	80	90

2) **Selection of Orthogonal Array:** Selection of orthogonal arrays for the experiments is the done on the basis of the process parameters and its levels. As number of process parameters is 3 and number of levels 3, L9 orthogonal arrays are selected.

Table- 3: Experimental setup

Sr. no.	Melting temperature (ºC)	Pouring temperature (ºC)	Solidification time (min.)
1	802.4	776.3	1.48
2	729.1	720.5	2.29
3	750.5	705.1	2.00
4	775.2	592.0	1.35
5	617.6	592.5	1.19
6	569.1	577.0	1.17
7	578.3	574.3	1.15
8	665.4	668.9	1.00
9	668.9	715.1	1.50

5. RESULT AND CONCLUSION:

L_3 level of Temperature:

Taguchi method of design of experiment is used to reduce the number of experiments, yet cover the all three parameters and design orthogonal array. And take a Main effect plot ration between Melting and pouring Temperature.

Table-4 Experimental value and Result

Sr. No.	Melting temperature (ºC)	Pouring temperature(ºC)	Solidification time(min.)	Observation	Remarks
1	802.4	776.3	01:48	Pin holes	Not acceptable
2	729.1	720.5	02:29	Porosity II	Not acceptable
3	750.5	705.1	02:00	Porosity I	Not acceptable
4	775.2	592.0	01:35	Sand blow	Not acceptable
5	717.6	592.5	01:19	Misruns	Not acceptable
6	569.1	577.0	01:17	Misruns	Not acceptable
7	578.3	574.3	01:15	Sand blow	Not acceptable
8	665.4	668.9	01:00	NSD	Acceptable
9	668.9	715.1	01:50	NSD	Acceptable

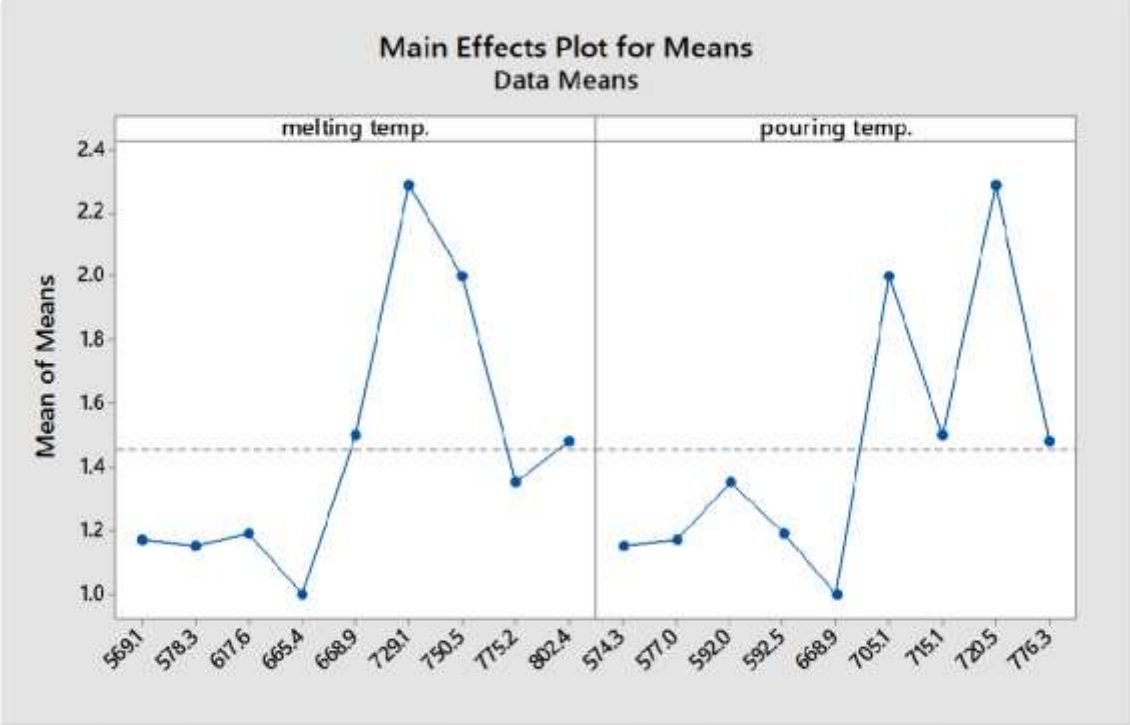

Fig-2 Main effect plot ratio for means

Table no.4 shows the different value of melting temperature, pouring temperature and solidification time of 9 different experiments carried out. And also shows the result of casting behavior according the all three parameters.

6. CONCLUSION:

In this experiment of parametric optimization of sand casting we observed that different parameters affect the quality of casting. For aluminum-2011 alloy the optimum value of the melting temperature 665.4 ºC, pouring temperature 668.9 ºC and solidification time is 1.00 min for experiments 8 and the other optimum value is 668.9 ºC, 715.1 ºC and solidification time is 1.50 min. we observed that higher pouring temperature causes shrinkage and due to low poring temperature casting solidifies rapidly and became brittle.

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