

## OPTIMIZATION OF CASTING PROCESS PARAMETERS USING TAGUCHI ANALYSIS

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**Abstract**-In this paper the casting defects such as, Shrinkage, sand drop, sand blow holes, scabs, pinholes are minimized by using Taguchi optimization technique. The parameters considered are moisture content (%), green strength(g/), 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 to find the optimum condition. The outcome of this paper leads to select suitable process parameters in casting industry to produce defect free castings. The improvement expected in reduction of casting defects is 20-30%.

**Keyword(s):** Casting defects, Control factors, Iron foundry, Sand casting, Taguchi method

### 1. INTRODUCTION

The quality is more important for all the products.. Casting defects continuously occurring on the casting components due to some improper sand properties and improper gating system and labour problems. But most of the defect are occurred due to improper process parameters during molding. The Taguchi is powerful problem solving technique for improving the quality of the product and also productivity. Some of the application Taguchi's methods in the foundry firm have shown that the variation in casting quality caused by uncontrollable process variables can be minimized. This seeks to make both the process and product insensitive to disturbing factors that occasionally or systematically affect the variability of the process that lead to imperfections in the products.

### 2. LITERATURE REVIEW

Green sand casting process is one of the most widely used manufacturing technique for gray cast iron. Umezurike et al [7] Experimental Analysis of Porosity in Gray Iron Castings. This result will help metal casters to reduce porosity defects in gray iron castings when they are poured with cores prepared with Phenolic urethane no-bake binders.

Kumaravadivel et al [10] Optimization of sand-casting process variables a process window approach. The optimized parameters obtained using the Taguchi method and RSM are then tested in an industrial case study. It is validated by proposed process window approach. Manjunath Swamy et al [11] Design Optimization of Gating System by Fluid Flow and Solidification Simulation for Front Axle Housing. Mane et al [12]

The proposed approach overcomes the difficulty of controlling process parameters in foundries with manual processes and unskilled labor, by making the design more robust (less sensitive) with respect to process parameters.

This will especially help SME foundries to significantly improve their quality levels. Suyitno et al [15] proposed the normalization of the fluidity can estimate the fluidity at the different of the thickness. The porosity and surface roughness increase with the pouring temperature.

### 3. METHODOLOGY

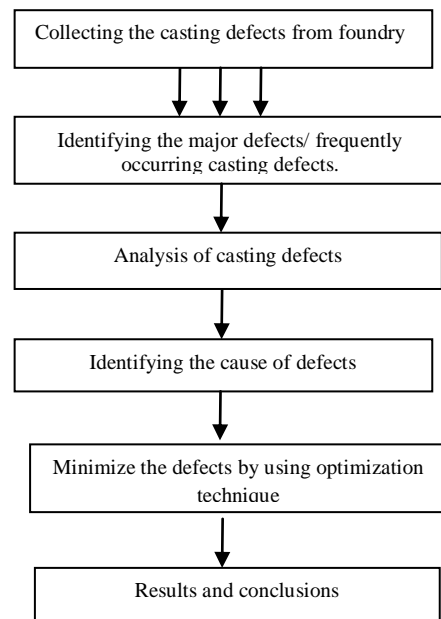


Fig 1: Methodology

The objective of this paper is on optimizing the process parameters of sand casting process including optimum levels and the case study is done in a job foundry in central India. The Taguchi method can be applied by using eight experimental steps that can be grouped into three major categories as follows [8]. :Planning the experiment: (1) Identify the main function of casting process. (2) Identify the quality characteristic to be observed and the objective function to be optimized. (3) Identify the control factors and their alternate levels. (4) Identify noise factors and the testing conditions of the process. (5) Design the matrix experiment and define the data analysis procedure. Performing the experiment (6) conduct the matrix experiment. Analyzing and verifying the experimental results (7) Analyzing the data, determining the Optimum levels for the control factors, and predicting performance under these level (8) Conducting the verification (also called confirmation) experiment and planning future actions. The basic steps to achieve the above target are summarized as follows

1. To select the most significant parameters that causes variations in the quality characteristics.
2. Casting defects have been selected as the most representative quality characteristics in the green sand casting process, as it is related to many internal defects (sand drop, pinholes, scabs). The target of the green sand casting process is to achieve "lower

- casting defects” while minimizing the effect of uncontrollable parameters.
3. Make the green sand casting process under the experimental conditions dictated by the chosen orthogonal array and parameter levels. Based on the experimental conditions, collect the data.
  4. Beside the optimum settings of the control parameters and predict the results of each of the parameters at their new optimum levels.
  5. Verify the optimum settings result in the predicted reduction in the casting defects.

Sand casting is used to manufacture complex shapes of various sizes depending upon the customer requirements. The basic requirements casting are pattern making, preparing a mold, pouring a molten metal, cooling of mold, shakeout, fettling. The main causes of rejection in castings are due to improper pattern, improper gating system, improper control of sand parameters, improper molten metal composition.

The process parameters chosen for the sand casting are Compression Strength (g/cm<sup>2</sup>), Moisture Content (%), Permeability N0, Mould Hardness Number

For each process parameter two/three levels are selected which define the experimental region. The levels selected are based on the standards acceptable and foundry men experience in this organization for engine castings and fittings. Significant interactions within control parameters are also considered. The parameters, along with their ranges are given in Table1.

Parameter	Range	Level 1	Level 2	Level 3
Compression Strength (g/cm <sup>2</sup> )	1000-1300	1000	1260	1300
Moisture Content (%)	3.2-4	3.2	3.5	4
Permeability N0	140-190	140	163	190
Mould Hardness Number	85-95	85	90	95

Table 1. Control factors of process parameters and their levels

### 3.1 Quality Characteristics

Casting defects was selected as a quality characteristic to be measured. The most common defects occurring in the foundry were monitored and recorded. The smaller the better number of casting defect implies better process performance. Here the objective function to be maximized is:

$$\text{Smaller is better} = -10^3 \log_{10} (\sum(Y^{**2}/n))$$

Maximizing  $\eta'$  leads to minimization of quality loss due to defects. Where S/N ratio is used for measuring sensitivity to noise factors,  $n$  is number of experiments orthogonal array and  $y_i$  the  $i$ th value measured.

### 3.2 Selection of Orthogonal Array

Selection of an orthogonal array depends upon the number of control factors and interaction of interest. It also depends upon number of levels for the control factors of interest. Therefore with one control factor moisture percentage of two levels and other control factors sand particle size, green compression strength (GCS), mould hardness number and orthogonal array is selected with 9 experimental runs and four columns. Taguchi has provided in the assignment of factors and interaction to arrays.

The assigned L9 orthogonal array is shown in Table 2 and the experimental orthogonal array having their levels are assigned to columns is shown in Table 3.

Table 2. Orthogonal array L9 (control factors assigned)

Trail No	A	B	C	D
1	1	1	1	1
2	1	2	2	2
4	2	1	2	3
5	2	2	3	1
6	2	3	1	2
7	3	1	3	2
8	3	2	1	3
9	3	3	2	1

### Experimental L9 Array:

Table 3: Experimental Orthogonal Array

### 3.3 Experiment Results and S/N Ratios

Trail No	A	B	C	D
	Compression Strength (g/cm <sup>2</sup> )	Moisture Content (%)	Permeability N0	Mould Hardness Number
1	1000	3.2	140	85
2	1000	3.5	163	90
3	1000	4	190	95
4	1260	3.2	163	95
5	1260	3.5	190	85
6	1260	4	140	90
7	1300	3.2	190	90
8	1300	3.5	140	95
9	1300	4	163	85

The experiments were conducted thrice for the same set of parameters using a single-repetition randomization technique [18]. The casting defects that occur in each trial conditions were found and recorded. The average of the casting defects was determined for each trial condition as shown in Table 4. The casting defects are “lower the better” type of quality characteristics. Lower the better S/N ratios were computed for each of the 18 trials and the values are given in Table 4:

Table 4: Casting Defects Value and Signal to Noise (S/N) Ration against Trial Number

Trial No	% Defects in Experiment	S/N Ratio	Mean
1	9.65	-19.69	9.65
2	7.56	-17.57	7.56
3	8.2	-18.27	8.2
4	4.9	-13.80	4.9
5	7.87	-17.91	7.87
6	6.87	-16.73	6.87
7	3.87	-11.75	3.87
8	2.58	-8.23	2.58
9	4.12	-12.29	4.12

Fig 2: Main Effect Plot for SN Ratio

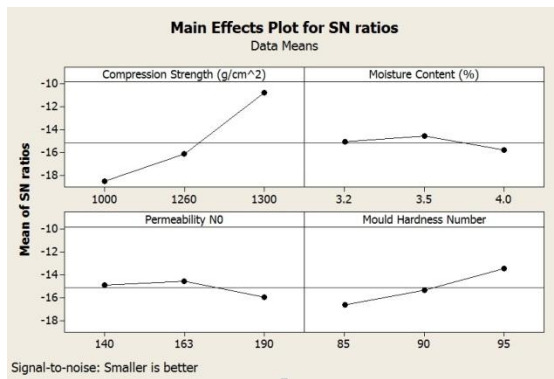
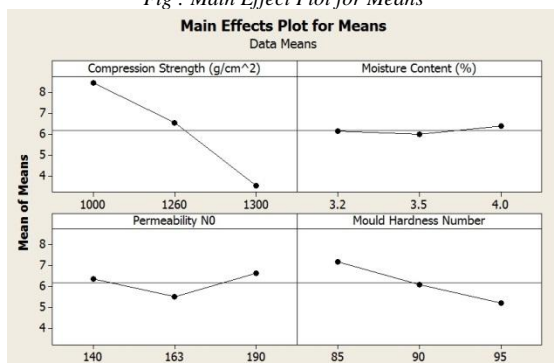


Fig : Main Effect Plot for Means



### 3.4 Regression Model

Also conduct the regression model to find out from optimum value of the s/n ratio of response table to get the 85% regression value. So taken the conducting the experimental percentage of defect value is accuracy and optimized.

## 4. CONCLUSIONS

The optimum conditions for the parameters computed are given below as

Compression Strength (g/cm<sup>2</sup>) - Level 3 - 1300  
 Moisture Content (%) – Level 2 – 3.5  
 Permeability N0, - Level 2 - 163  
 Mould Hardness Number – Level 3 - 95

The improvement expected in minimizing the variation is 20-30 % of casting defects in the foundry. This also reflect that by using Taguchi method the factor levels when optimized will result in reduction of casting defects and increase the yield percentage of the accepted casting without any additional investment. A usage of quality tools like pareto chart is useful for finding the major defects in the daily operations of foundry. Quality of casting can be improved by aesthetic look, dimensional accuracy, better understanding of noise factor and interaction between variables, quality cost system based on individual product, scrapreduction, reworking of casting and process control.

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