INVESTIGATION OF PROCESS PARAMETERS AND EXPERIMENTAL ANALYSIS TO MINIMIZE THE CASTING DEFECTS USING TAQUCHI METHOD

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ABSTRACT

This proposed work is to minimize the casting defects in foundry an optimization technique for process parameters of green sand casting process. Taguchi is a powerful problem solving tool for improving quality of the casting product.it is used to imprisonment the effect of signal to noise ratio of the experiments analysis based on the L $_{27}$ orthogonal array used due to optimum conditions are found. The parameters considered are moisture content (%), green strength (g/cm^2), Permeability (nu), and sand practical size (AFS), Permeability (Nu), Mould hardness (nu), Pouring temperature (^{o}c), Pouring time (sec).The conclusion of this paper that the selected process parameters continuously affect the casting defects in foundry. The consequence of this paper that the selected process parameters always affect the cold shut casting defect in foundry. The improvement expected in reduction of casting defects is found to be 38.43 percent.

KEYWORDS: *Casting defects, Control factors, Iron foundry, Taguchi method.*

1.0 INTRODUCTION

The excellence is must importance of the products. This is used to all the iron casting foundry. Casting defect continuously occurring on the casting components' it's due to some improper sand properties and improper gating system and labor fault. But mostly occurring related to only insufficient of sand reinforcement. The Taguchi is powerful problem solving technique for improving process performance yield and productivity [2,4].some of the application Taquchi's method in the foundry firm have shown that the variation in casting quality caused by uncontrollable process variables can be minimized [5,6 .]Seek 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.

2.0 LITERATURE REVIEW

Green sand casting process is one of the mostly wide ranges of the manufacturing technique used for gray iron castings. 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 approaches. 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.

3.0 METHODOLOGY

The aim of this paper is on investigation of process parameters of green sand casting process including optimum levels in a best 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) Recognize the main function of casting process. (2) Recognize the quality characteristic to be detected. (3) Recognize the control factors and their alternate levels. (4) Recognize noise factors and the testing circumstances 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 experiment and planning future actions. The basic steps for reaching the above objective are summarized below,

1. To select the most significant parameters (Moisture Content, Sand Particle Size, Green Strength, Mould Hardness, Permeability, Pouring Temperature, Pouring Time) that causes variations in the quality characteristics.
2. Cold shut Casting defect have been selected as the most representative quality characteristics in the green sand casting process. The target of the green sand casting process is to achieve "reduce the cold shut casting defect" 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 production difficult shapes of various sizes depending upon the requirements and customer need. The basic requirements casting are sand, sand mixing, pattern making, core making, molding, pouring a molten metal, solidification, shaking out, finishing. The main causes of cold shut in castings are due to variation in pouring temperature, variation in pouring time, improper gating system, improper control of sand parameters, improper molten metal composition. The process parameters of the sand casting can be listed as follows:

- Moisture Content (%)
- Green Strength (g/cm^2)
- Sand Particle Size (AFS)
- Permeability (Nu)
- Mould hardness *(nu)*
- Pouring temperature (^{o}c)
- Pouring time (sec)

For each process parameters three levels are selected which define the experimental area. The levels selected are based on the standards acceptable parameters, along with their ranges are given in Table1.

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Parameter	Range	Level1	Level2	Level3
Moisture Content (%)	3-4.5	3	3.5	4.5
Green Strength(g/cm^2)	1000-1300	1000	1200	1300
Sand Particle Size (*AFS*)	53-60	53	56	60
Permeability *(nu)*	160-225	160	195	225
Mould hardness *(nu)*	60-85	60	70	85
Pouring Temperature (*°c*)	1325-1425	1325	1415	1425
Pouring Time (*sec*)	30-35	30	33	35

Table 1.Control factors of process parameters

4.0 Quality Characteristics

Cold shut casting defect was selected as a quality characteristic to be measured. The most common cold shut casting defect occurring in the foundry was monitored and recorded. The smaller the better number of casting defect implies better process performance.

Smaller is better = -10*log10 (sum(Y**2/n)

. Where *n* is number of experiments orthogonal array and Y the *ith* value measured.

4.1 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, Sand Particle Size, Permeability and orthogonal array is selected with 27 experimental runs and four columns. Taguchi has provided in the assignment of factors and interaction to arrays. The assigned L_{27} 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 L_{27} (control factors assigned)

Trail No	A	B	C	D	E	F	G
	Moisture Content (%)	Green Strength (g/cm^2)	Sand Particle Size (AFS)	Permeability *(nu)*	Mould Hardness *(nu)*	Pouring Temperature(^{o}C)	Pouring Time(sec)
1	3	1000	53	160	60	1325	30
2	3	1000	53	195	60	1415	33
3	3	1000	53	225	60	1425	35
4	3	1200	56	160	70	1325	30
5	3	1200	56	195	70	1415	33
6	3	1200	56	225	70	1425	35
7	3	1300	60	160	85	1325	30
8	3	1300	60	195	85	1415	33
9	3	1300	60	225	85	1425	35
10	3.5	1200	53	160	85	1415	35
11	3.5	1200	53	195	85	1425	30
12	3.5	1200	53	225	85	1325	33
13	3.5	1300	56	160	60	1415	35
14	3.5	1300	56	195	60	1425	30
15	3.5	1300	56	225	60	1325	33
16	3.5	1000	60	160	70	1415	35

Experimental L_{27} Array:

Trail No	A	B	C	D	E	F	G
1	1	1	1	1	1	1	1
2	1	1	1	1	2	2	2
3	1	1	1	1	3	3	3
4	1	2	2	2	1	1	1
5	1	2	2	2	2	2	2
6	1	2	2	2	3	3	3
7	1	3	3	3	1	1	1
8	1	3	3	3	2	2	2
9	1	3	3	3	3	3	3
10	2	1	2	3	1	2	3
11	2	1	2	3	2	3	1
12	2	1	2	3	3	1	2
13	2	2	3	1	1	2	3
14	2	2	3	1	2	3	1
15	2	2	3	1	3	1	2
16	2	3	1	2	1	2	3
17	2	3	1	2	2	3	1
18	2	3	1	2	3	1	2
19	3	1	3	2	1	3	2
20	3	1	3	2	2	1	3
21	3	1	3	2	3	2	1
22	3	2	1	3	1	3	2
23	3	2	1	3	2	1	3
24	3	2	1	3	3	2	1
25	3	3	2	1	1	3	2
26	3	3	2	1	2	1	3
27	3	3	2	1	3	2	1

Table 3: Experimental Orthogonal Array

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17	3.5	1000	60	195	70	1425	30
18	3.5	1000	60	255	70	1325	33
19	4.5	1300	53	160	70	1425	33
20	4.5	1300	53	195	70	1325	35
21	4.5	1300	53	225	70	1415	30
22	4.5	1000	56	160	85	1425	33
23	4.5	1000	56	195	85	1325	35
24	4.5	1000	56	225	85	1415	30
25	4.5	1200	60	160	60	1425	33
26	4.5	1200	60	195	60	1325	35
27	4.5	1200	60	225	60	1415	30

4.2 Experiment Results and S/N Ratios

The experiments were conducted thrice for the same set of parameters using a single-repetition randomization technique [18]. The cold shut casting defect that occur in each trial conditions were found and recorded.

The average of the casting defect was determined for each trial condition as shown in Table 4. The cold shut 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:

$$\eta = -10\log[(\varepsilon_y{}^{2i})/3]$$

$$= -10\log[(5.26^2+5.51^2+4.15^2)/3]$$

$$= -10\log[(27.66+30.36+17.22)/3]$$

$$= -10\log[75.24/3]$$

$$= -10\log 25.08$$

$$= -13.93$$

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

Trial No	% Defects in Experiment 1	2	3	Total	Average	S/N Ratio
1	5.26	5.51	4.15	14.92	4.973	-13.9324
2	4.47	5.25	5.91	15.63	5.21	-14.3368
3	6.99	9.3	6.3	20.59	7.53	-21.2983
4	3.01	3.17	4.41	12.59	3.53	-8.1220
5	8.00	7.61	5.86	19.47	7.156	-20.7860
6	6.29	6.92	5.17	20.38	6.126	-12.0569
7	4.01	4.2	5.12	11.33	4.443	-15.7387
8	4.02	5.61	3.14	12.77	4.256	-12.5800
9	6.99	7.90	8.17	23.06	7.686	-17.7140
10	5.99	5.7	4.14	15.83	5.276	-14.4461
11	6.00	6.99	5.97	18.96	6.32	-16.0143
12	11.1	9.52	8.12	26.74	7.913	-20.0005
13	6.34	7.43	5.23	18.91	6.303	-15.9909
14	7.71	5.3	6.19	17.2	5.733	-17.1676
15	8.2	5.8	4.85	18.85	6.283	-15.9633
16	3.07	5.71	6.13	14.91	4.97	-13.9271
17	8.3	5.73	6.19	20.22	6.74	-16.5732
18	7.2	6.47	8.03	21.7	8.566	-14.5773
19	3.31	4.42	3.81	11.54	3.846	-11.7002
20	4.41	5.14	7.20	16.75	5.583	-14.9374
21	2.2	3.32	5.81	11.33	3.776	-11.5406
22	8.33	7.41	4.90	20.64	6.88	-16.7518
23	3.38	2.83	4.09	10.3	3.433	-10.7135
24	4.49	6.41	6.61	17.51	6.503	-17.8120
25	6.7	7.71	6.07	19.48	7.16	-16.0983
26	2.47	3.74	4.43	10.64	3.546	-10.9948
27	5.71	6.17	5.03	14.91	6.303	-13.4904

Fig 1: Main Effect Plot for SN Ratio

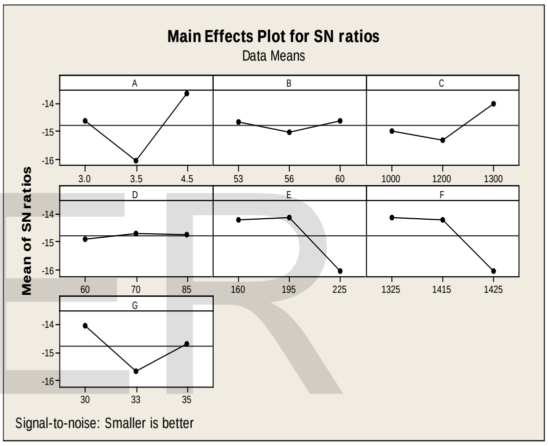
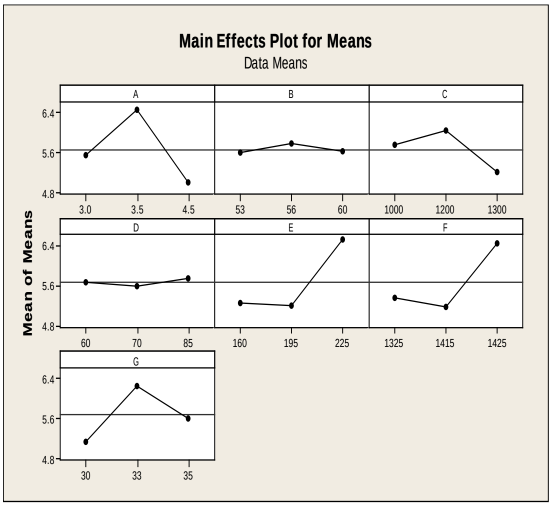


Fig 2: Main Effect Plot for Means



5.0 CONCLUSIONS

The optimum conditions for the parameter computed are given below as

- Moisture Content (%) - level 1 -3
- Green Strength (g/cm^2) - level 1 - 1000
- Sand Particle Size (AFS) - level 2 - 56
- Permeability (Nu) - level 3 - 225
- Mould hardness *(nu)* - level 1 - 60
- Pouring temperature (^{o}c) - level 3 - 1425
- Pouring time (sec) - level 2 - 33

The improvement expected in minimizing the variation is 38.43% which means reduction of casting defects from the present of 7.87% to 5.40% of the total casting product in the foundry. This also reflect that by using Taguchi method the factor levels when optimized will result in reduction of casting defect and increase the yield percentage of the accepted casting without any additional investment. 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, cold shut reduction, reworking of casting and process control.

6.0 REFERENCES

[1] Siekański K., Malcolm Blair,. *Predicting the Occurrence and Effects of Defects in Castings,.,JOM.,march- (2003) METALURGIJA 42, 1, vol- 57-59.*

[2] Guharaja S., Noorul Haq A. S.M.Yoo *".Optimization of casting Process for heat and Abrasion Resistant Large Gray Iron Castings"., Int. J. Adv. Manuf.Technol. (2006), 30, p.1040–1048*

[3] Bates C.E., Monroe, R. W., Lakshmanan Singaram. *"Improving quality of sand casting using Taguchi and analysis". Journal of material processing technology 204, 2001*

[4] Wisam V, SushilKumar P. *"Optimization of green sand casting process parameters of a foundry by using Taguchi's method"., jordan journal of mfg and indu engg.. Dec-2011., ISSN 1995-6665., vol 5*

[5] Siekański K. *"Analysis of foundry defects and preventive activities for quality improvement of castings".,journal of material processing technology 209 (2009)., ISSN 554-56*

[6] Mohamed S, Nazirudeen.D, *"Improving the Quality of Green Sand Castings to Minimize the Defects Using Artificial Neural Network" tsinghua science and technology , ISSN , VOLUME 13, APRIL 2008*

[7] Umezurike C,*"Experimental Analysis of Porosity in Gray Iron Castings" Int J Adv Manuf Technology (2011) DOI 10.1007/s00170-010-3029-0.*

[8] Ishwar P Keswani B, *"Optimization of Sand Casting Process Parameter Using Taguci Method in Foundry ", International Journal of Scientific & Engineering Research. Vol-2, 2011, ISSN 2229-5518. 2011*

[9] Wisam M. *"Studying the Effects of Varying the Pouring Rate on the Casting Defects Using Nondestructive Testing Techniques".135(2003)68-75.*

[10] Kumaravadivel R,*"Optimization of sand-casting process variables a process window approach" Adv science tech.(2012). Procedia Engineering 50 , 88 – 94*

[11] Satish Kumar S, Arun Kumar Gupta A, Pankaj Chandna S *"Optimization of process parameter pressure die casting using Taquchi methodology*

.World Academy of Scienc Engineering and Technology 68 (2012)

[12] Aurel Crisan A, Sorin Ion Munteanu E, Ioan Ciobanu A, Iulian Riposan D *"Optimization of the chemical composition of cast iron used for casting ball bearing grinding disks. tsinghua science e and technology ISSN 1007-0214 09/20 pp164-169 Volume 13, Number 2, April 2008*

[13] Guharaja S. *"Optimization of green sand casting process parameters by using Taguchi's method" ISSN (1897-3310) Volume 12 Issue 1/2012 13*

[14] Bates, C.E., Monroe, R. Satish Kumar.Set , *Optimization of Process Parameters of Pressure Die Casting using Taguchi Methodology.volume-4,2007*

[15] Suyitno C. *"Effect of Pouring Temperature and Casting Thickness on Fluidity, Porosity and Surface Roughness in Lost Foam Casting of Gray Cast Iron". Int J of Engg Research & Tech (IJERT), ISSN: 2278-018, 2001*