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Minimization of the Casting Defects Using Taguchi's Method

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Abstract: *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 AV VALVE 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 (^oC) 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.

Keywords: *Foundry Shop, Casting Defects, Taguchi's Method, Sand Casting, Check Valve PN 10*

I. Introduction

Foundry suffers from weak quality and productivity due to a huge number of process parameters, lower automation and shortage of skilled workers. Defect free products are demanded in market but foundry finds to meet the requirements [01]. In foundry we analyze the defects by non destructive methods and apply its remedies carefully otherwise new defects occur. This is not an easy task. For example, when a gas porosity defect occurs at high pouring temperature and when we decrease the pouring temperature, it may occur cold shut defects. So casting is a very complex process. The success of a casting process depends greatly on the properties of the molding sand. These include (i) Strength, (ii) Permeability, (iii) Deformation, (iv) Flowability, and (v) Refractoriness [02].

II. Literature Review

To reduce the rejection rate of castings, a detailed literature review was carried out for identifying related to rejection control of castings in foundry using different simulation models and also some research papers which gives solutions to solve the major defects during gating and feeding process in castings.

Udhaya Chandran.R.M[6] In this paper mainly focused to minimize the casting Defects such as, sand drop, sand blow holes, scabs, pinholes. 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. 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%**.**

S. V. Sapakal & M. T. Telsang et al. [20] Taguchi optimization method was applied to find the optimal process parameters for penetration. A Taguchi orthogonal array, the signal-to-noise (S/N) ratio and analysis of variance were used for the optimization of welding parameters. A conformation experiment was also conducted and verified the effectiveness of the Taguchi optimization method. The improvement of S/N ratio is 2.13. The experiment value that is observed from optimal welding parameters, the penetration is 5.25mm. & S/N ratio is 14.40.

Joseph I. Achebo [21] In this research study, the structural steel failure problems encountered by a multi-industrial firm operating in the upstream and downstream sector of the Nigerian oil industry was successfully addressed by applying the Taguchi Method. Following the confirmation tests conducted to validate the experimental results obtained, it was observed that there is a significant improvement in the quality of weld produced by using the new optimum process parameters obtained from adopting the Taguchi Method.

Lakshmanan Singaram[13] The Taguchi method is a powerful tool for problem solving for improving for process performance, yield and productivity. Green sand casting process involves many process parameters which affects the quality of products. Analysis of significant process parameters which affects the quality of casting products is appearing on paper. The parameters considered as Green Strength, moisture contents, permeability & mould hardness. The Taguchi methodology is used to improve the quality of casting defects. To aid in the analysis, this article explores common green sand defects, their causes and possible remedies & Green Sand casting defects.

III. Methodology

Experiments were performed in foundry producing cast iron components. The study begins with the manufacturing component check valves PN 10 in foundry where cold shut, scab, shrinkage are most important defects observed, and due to these casting defects in casting the component having highest rejection rate is identified using quality tools such as total rejection sheet, defective factor level sheet, table of defects and causes with diagram. A model is also created for optimization of castings process through simulation and the major causes are predicted and its solutions are given by defect diagnostic approach.

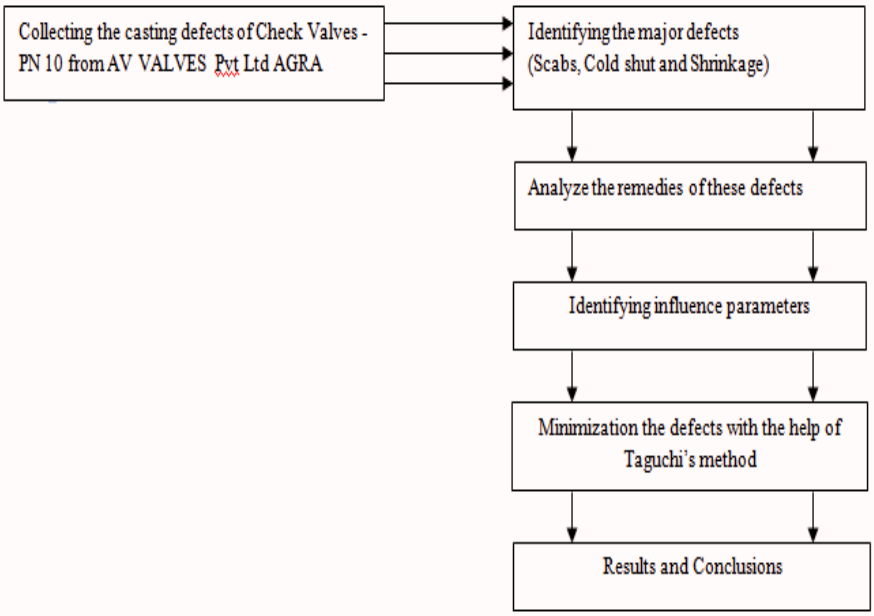

Fig 1: Methodology

3.1 Problem Statement

To achieve or develop quality in casting by minimizing defects

(i) Every 400 casting components 21-25 castings are rejected.
(ii) Affecting defects are cold shut, scab and shrinkage.

3.2 Objective

(i) Identification of defects in check valves PN 10 and analysis its causes.
(ii) Reduction of causes of these defects like pouring temperature, permeability, mould hardness and sand particles through Taguchi's method.

3.3 Data Collection

Simplified data from the total rejection sheet is represented in the following table. Data shows the total production and the data is of three months. Total rejection of check valves PN 10 is given in the following Table-1. We see that approx 80% of the total rejection of the component is due to these defects like cold shut, scab and shrinkage.

Table-1 Rejection data sheet

Total Rejection Percentage In Three Months							
Month	**Total Tested Piece**	**Scab**	**Cold shut**	**Shrinkage**	**Others**	**Total Rejected Piece**	**% Rejection**
December 2015	400	8	5	6	2	21	5.25%
January 2016	400	9	7	3	3	22	5.50%
February 2016	400	11	8	2	4	25	6.25%

We see that many defects occur like cold shut, scab and shrinkage. We find out the causes of these defects like pouring temperature, permeability, mould hardness and sand particles etc

3.4 Design of experiments for casting defects analysis

Process parameters of casting that influences the identified defects of check valves PN 10 with their levels are shown in table-2.

Table 2. List of various parameters on basis of different levels

Parameter	**Range**	**Level A**	**Level B**	**Level C**
Pouring Temperature (^oC)	1300 – 1350	1300	1320	1350
Permeability(No)	130 – 180	130	150	180
Sand Particle size(AFS)	50-55	50	52	54
Mould Hardness (Nu)	50-80	50	60	75

3.5 Quality Characteristics

Casting defects were 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: Smaller is better $\eta = -10*\log_{10} \sum (Y^2/n)$ Maximizing η' 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.

3.6 Experimental orthogonal array and S/N ratios

Here four parameter with at three different levels therefore L9 orthogonal array is selected for the experimental work [22]. As per L9 orthogonal array nine experiments were performed randomly as shown in Table-3.

Table 3. L_9 Orthogonal Array L9 (Control factors assigned)

	Table 3: Experimental Orthogonal Array			
Trail No	A	B	C	D
	Pouring Temperature (^oC)	Permeability (No)	Sand Particle Size (AFS)	Mould Hardness Number
1	1300	130	50	50
2	1300	150	52	60
3	1300	180	54	75
4	1320	150	52	75
5	1320	180	54	50
6	1320	130	50	60
7	1350	180	54	60
8	1350	130	50	75
9	1350	150	52	50

The main aim of the study was to reduce the Casting defects for which the ideal value is zero, the analysis was carried out by using MINITAB-17 statistical software in which the S/N ratio was computed by using the Smaller the better quality characteristics $[-10*\log_{10} \sum (Y^2/n)]$. In the Taguchi method, the signal to noise ratio (S/N) is used as the data transformation method that consolidates the data for each control array row over the various noise levels into one value which computes both the mean and the variation present in the data. The equations for calculating the signals to noise ratios were based on the characteristics of the response variables being evaluated; nominal the best, smaller the better and larger the better. In the present work smaller the best characteristic is used as the main aim is to reduce rejection in frames. The percentage rejection of Check Valves -PN 10 for each trial was evaluated and the report generated was obtained from MINITAB-17 statistical software.

Table 4: Rejection Data Of Trial And S/N Ratio (Check Valves -Pn 10 Casting)

Trial No	% Defects in Experiment				S/N RATIO	Average
	1	2	3	Total		
1	6.50	5.30	6.90	18.70	-15.8898	6.23
2	5.50	3.80	5.30	14.6	-13.7506	4.87
3	7.34	5.60	7.56	20.5	-16.6884	6.83
4	3.50	4.20	4.01	11.71	-11.8213	3.90
5	6.32	4.90	7.14	18.36	-15.7350	6.12
6	7.43	6.67	6.00	20.1	-16.5215	6.70
7	7.12	5.00	5.75	17.87	-15.5049	5.96
8	3.33	7.32	4.50	15.15	-14.0658	5.05
9	3.50	5.60	1.53	10.63	-11.1501	3.61

IV. Discussion And Result

The Taguchi Method is used to optimize the results obtained from each trial. In the present work L_9 orthogonal array is used for the trial purpose [06]. The response of the S/N Ratio, contribution of different process parameters and relation between S/N ratio and the levels of different process parameters is studied and analyzed to obtain optimum process parameters. There are three categories of quality characteristics in the analysis of S/N ratio, i.e. smaller-the-better, larger-the-better, nominal-the-best. As the main aim of the study was to reduce the welding defects for which the ideal value is zero, the S/N ratio for each level of process parameter has been computed by using a quality characteristics smaller-the-better [05].

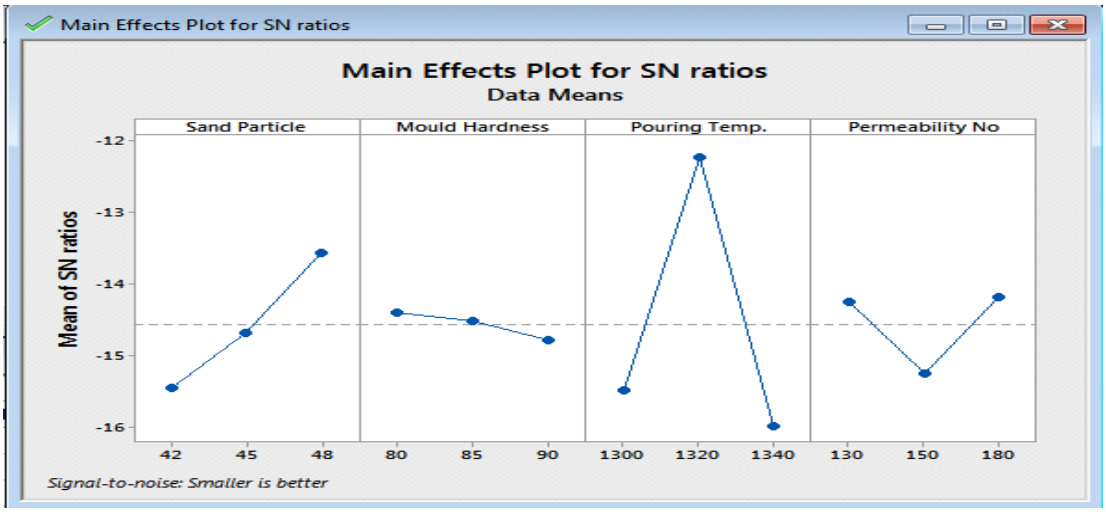

Fig.2: Main Effects for S N Ratios

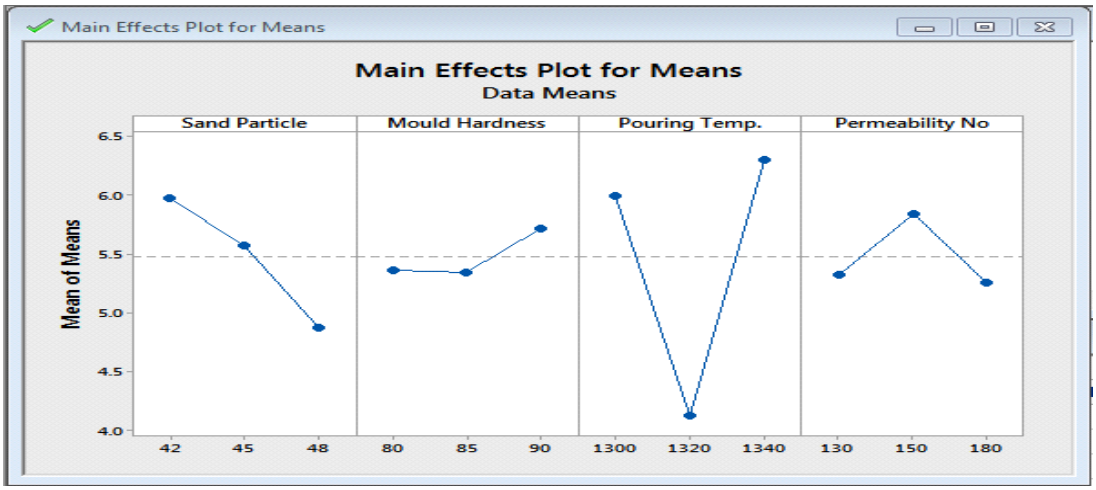

Fig 3: Main Effects Plot for Means

From the Main effect plot shown above it can concluded that the optimum value of Pouring temperature is **1340**, Permeability is **150(No) ,** Sand particle is Size **42 AFS** & Mould Hardness is **Nu 91.132** this combination give the optimum result.

Table 5 Final Result of Confirmation Trial for Valve Casting

BEFORE EXPERIMENT		**AFTER EXPERIMENT**	
Month	% Rejection	Month	% Rejection
December 15	5.25	April 16	5.00
January 16	5.50	May 16	4.25
February16	6.25	June 16	4.00
Average % rejection	**5.667**	**Average % rejection**	**4.416**

Total % Improvement = 5.667-4.416 =1.25

V. Conclusion

After implementation various experiments and Testing techniques it is concluded that the optimum value of Pouring temperature is **1340**, Permeability is **150(No) ,** Sand particle Size is **42 AFS and** Mould Hardness Number is **91.132 .** So, it is helpful to provide minimum defects during the casting done on applying given parameters.

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