INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

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ANALYSIS OF CASTING DEFECTS OF DIVERTER WHEEL AND CREDENTIALS OF CORRECTIVE ACTIONS

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Accepted Date: 03/07/2014; Published Date: 01/08/2014

Abstract: Paper presents analysis of casting defects and identification of remedial measures carried out at Jadaho Alloy steel Ltd, Amravati, Maharashtra, India. Analytical study carried out on Diverter Wheel Castings revealed that the contribution of the four prominent defects in casting rejections are blow hole, pinhole, and Shrinkage. It was noticed that these defects are frequently occurring at particular locations. Systematic analyses were carried out to understand the reasons for defects occurrence and suitable remedial measures were identified. The artifact presents method selected for the construction of models of reasoning, i.e. the method based on Taguchi Analytical Method. The solutions based on the use of Taguchi Analytical Method have already found some approval in a number of practical applications.

Keywords: Recognize of casting defects, identification of defect causes, Taguchi Analysis, ANOVA's

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Access Online On:

www.ijpret.com

How to Cite This Article:

Petle SB, Shirbhate A, Vidhate NR; IJPRET, 2014; Volume 2 (12): 24-31

PAPER-QR CODE

INTRODUCTION

Foundry industries in developing countries suffer from poor quality and productivity due to involvement of number of process parameters in casting process. Even in a completely controlled process, defects in casting are observed and hence casting process is also known as process of uncertainty which challenges explanation about the cause of casting defects. Casting defects analysis is the process of finding the root cause of occurrence of defects in the rejection of casting and taking necessary steps to reduce the defects and to improve the casting yield. Techniques like cause-effect diagrams, design of experiments (DoE), casting simulation, if-then rules (expert systems) and artificial neural networks (ANN) are used by various researchers for analysis of casting defects. In this paper, a new method of casting defects analysis is proposed which is combination of DoE (Taguchi method) and computer aided casting simulation technique and discussed in the following sections.

In this proposed method of casting defect analysis, the DoE (Taguchi method) is used for analysis of sand and mould related defects such as sand drop, bad mould, blow holes, cuts and washes, etc. Whereas computer aided casting simulation technique is used for methoding, filling and solidification related defects such as shrinkage porosity, hot tears, etc.

The literature review indicates that the Taguchi method is the best option for design of experiments when number of process parameter are involved in the process. Taguchi approach is suitable in experimental design for designing and developing robust products or processes irrespective of variation in process parameter (within set limits) and or variation in environmental conditions. The present research as associated with sand casting process which involves various parameters at different levels and affects the casting quality. Considering these features of Taguchi method, it is used to reduce the % of rejection due to sand and moulding related defects by setting the optimum values of the process parameters of the green sand casting.

Dr. Taguchi of Nippon Telephones and Telegraph Company, Japan has developed a method based on ORTHOGONAL ARRAY experiments which gives much reduced variance for the experiment with optimum settings" of control parameters. Design of Experiments (DOE) with optimization of control parameters to obtain BEST results is achieved in the Taguchi Method. "Orthogonal Arrays" (OA) provide a set of well balanced (minimum) experiments and Dr. Taguchi's Signal-to-Noise ratios (S/N), which are log functions of desired output, serve as objective functions for optimization, help in data analysis and prediction of optimum results. The Taguchi method is a technique to find out the optimum values of the control factors to

make the product or process get affected minimally by the noise factors. The Taguchi method is mainly based upon the technique of matrix manipulations. The experimental matrices are special orthogonal arrays, which allow the simultaneous effect of several process parameters to be studied efficiently. The purpose of conducting an orthogonal experiment is to determine the optimum level for each factor and to establish the relative significance of the individual factors in terms of their main effects on the response. Taguchi suggests signal-to-noise (S/N) ratio as the objective function for matrix experiments. The S/N ratio is used to measure the quality characteristics as well as the significant machining parameters through analysis of variance (ANOVA). Taguchi classifies objective functions into three categories such as smaller the better type, larger the better type and nominal the best type. The optimum level for a factor is the

level that results in the highest value of S/N ratio in the experimental region.

III. DESIGN OF EXPERIMENT METHOD FOR CASTING DEFECTS ANALYSIS OF DIVERTER WHEEL

Process parameters of green sand casting that influences the identified defects in casting Diverter Wheel with their levels are shown in table 1.1 Out of four selected process parameters, all parameter is at two levels. Therefore, L orthogonal array is selected for the experimentation. Two parameters interactions such as A*B and A*C was considered. The response variable was the % rejection of casting due to defects which is ratio of rejection due to considered process parameters to the quantity poured. As per L8 orthogonal array 8 experiments were performed randomly. Each experiment was performed thrice and average % of rejection in each experiment was considered as the response variable. Methodology used to achieve optimized process parameters using DoE is as given below:

Table 1 Optimization Factor

Sr. No	Factor Name	Notation	Level (High)	Level (Low)
1	Pouring Temperature	A	1380 ^{o}C	1360 ^{o}C
2	Pouring Time	B	16 s	14 s
3	Sand Grain Size	C	60 AFS	45 AFS
4	Mold Hardness	D	95	85

IV. Taguchi Design for Optimizing the Factor like Sand Grain Size, Mold Hardness, Pouring Temperature & Pouring Rate

Taguchi Orthogonal Array Design

L8 (2**4) Factors: 4 Runs: 8

Columns of L8 (2**7)

Table 2 Orthogonal Arrays L8

Sr. No.	Pouring Temp.	Pouring Rate	Sand Grain Size	Mold Hardness
1	1	1	1	1
2	1	1	2	2
3	1	2	1	2
4	1	2	2	1
5	2	1	1	2
6	2	1	2	1
7	2	2	1	1
8	2	2	2	2

Table 3 Experimental Arrays L8

Sr. No.	Pouring Temp.	Pouring Rate	Sand Grain Size	Mold Hardness
1	1380	16	95	60
2	1380	16	85	45
3	1380	14	95	45
4	1380	14	85	60
5	1360	16	95	45
6	1360	16	85	60
7	1360	14	95	60
8	1360	14	85	45

Table 4 Experimental Trials Results and S/N Ratio

Sr. No.	Trial 1	Trial 2	Trial 3
1	10	20	40
2	60	10	10
3	10	20	100
4	10	20	40
5	13	10	0
6	10	20	0
7	20	0	0
8	40	0	0

Average Trials 19.29

Standard Deviations 23.16

Table 5 Average effects of factor and interaction

Sr. No	Column Factor	Level 1 (L1)	Level 2(L2)	L2-L1
1	Sand Grain Size	- 30.84	- 22.56	8.2
2	Mold Hardness	- 25.30	- 28.10	- 2.7
3	Pouring Temperature	- 27	- 27.41	.58
4	Pouring Time	- 26.16	- 26.24	- 1.07

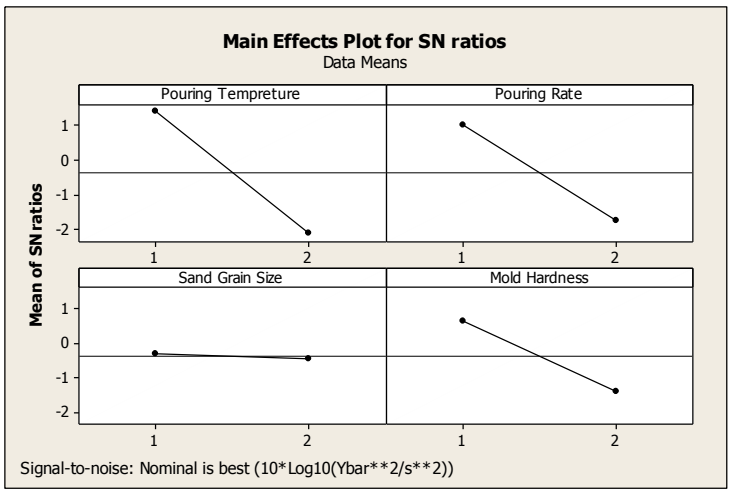

Fig. 1 Main Effects Plot for SN ratios

Table 6 No. of Interaction between two factors calculated = 6.

#	Interacting Factor Pairs (Order based on SI)	Columns	SI(%)	Col	Opt.
1	c x d	3 x 4	74.99	7	[1,1]
2	b x c	2 x 3	74.73	1	[1,2]
3	b x d	2 x 4	35.79	6	[1,1]
4	a x d	1 x 4	28.39	5	[2,1]
5	a x c	1 x 3	25.26	2	[2,2]
6	a x b	1 x 2	5.32	3	[2,1]

Table 7 ANOVAs Table

Col # / Factor	DOF (f)	Sum of Sqrs. (S)	Variance (V)	F - Ratio (F)	Pure Sum (S')	Percent P(%)
1 a	1	136.993	136.993	8.71	121.266	59.786
2 b	1	15.648	15.648	.994	0	0
3 c	1	.696	.696	.044	0	0
4 d	1	2.309	2.309	.146	0	0
Other/Error	3	47.181	15.727			40.214
Total:	7	202.83				100.00%

Table 8 ANOVAs Result Optimal condition and performance factor (S/N) Ratio

Column # / Factor	Level Description	Level	Contribution
1 Pouring Tempretur	1360	2	4.138
2 Pouring rate	16	1	1.398
3 Sand Grain Size	85	2	.295
4 Mold Hardness	60	1	.537
Total Contribution From All Factors.....			6.367
Current Grand Average Of Performance...			-26.705
Expected Result At Optimum Condition...			-20.337

RESULT

By conducting the Taguchi analysis it is found that required parameter for reducing the percentage defects are 2 1 2 1 that is Pouring Temperature is 1360, Pouring Rate is 16, sand Grain Hardness is 85 and Mold Hardness is 60

CONCLUSION

Design of experiments method such as Taguchi method can be efficiently applied for deciding the optimum settings of process parameters to have minimum rejection due to defects for a new casting minimum rejection due to defects for a new casting as well as for analysis of defects in existing casting. With Taguchi optimization method the % rejection of castings due to blowholes short pouring and pinhole related defects is reduced from 10 % to a maximum up to 3.59 %.

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