

Flash Reduction In Pressure Die Casting Using Taguchi's DOE

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Abstract - The prime objective of today's manufacturing industries is to produce low cost, high quality products in minimum time. Taguchi's parameter design is a powerful tool for robust design and it offers a simple and systematic approach to optimize a design for performance, quality and cost. However, the key element for achieving high quality is Design of Experiments (DOE). The present work analyses different parameters of manufacturing processes to minimize the defects. With optimization of controllable parameter we can achieve good surface finish with required tolerances. Moreover, by selection of optimum process parameters defects are minimized. The effects of selected process parameters on defects and subsequent setting of parameters with the levels have been accomplished by Taguchi's parameter design approach. The experiments have been performed as per the combination of levels of different process parameters suggested by orthogonal array [2]. Analyses of variance is been performed for mean and signal to noise ratio to estimate the percent contribution of different process parameters.

Key Words: Taguchi's Design of experiment, optimum process parameters, orthogonal arrays.

1. INTRODUCTION

Aim of today's manufacturing processes is to deliver a product within minimum possible process time[1]. Also while manufacturing the same the rejection has to be minimum in order to get maximum profit. So in order to achieve the same manufacturing process(s) has to be robust. This quality of mfg. process can be achieved by technique like Design of Experiment [5]. There are various types of DOE's viz. Full-factorial DOE, Taguchi's DOE, Screening DOE. In present project, Taguchi's DOE is implemented for selecting optimum parameters and their corresponding levels. The processes are then analyzed using statistical software 'MiniTab-18'.

Taguchi's design of experiment approach offers a systematic method for optimization of various parameters with regard to performance, quality and cost [3]. For improving the

productivity of various company-wide activities the quality of design can be improved by improving the quality and reducing the cost. The activities which are concerned with quality include quality of product planning, product design and process design. Taguchi's parameter design approach can reduce number of experiments to optimize design for performance, quality and cost. Two major tools used in robust design are Signal to Noise(S/N) ratio and orthogonal array (OA). S/N ratio measures quality with emphasis on variation, and OA accommodates many design factors simultaneously. Taguchi method offers the quality of product is measured by quality characteristics such as: nominal is the best, smaller is better and larger is better.

2. METHODOLOGY

A cause and effect diagram (Ishikawa diagram) has been shown in Fig. 1 to identify the casting process parameters that may affect pressure die casting defects. The process parameters have been segmented and listed in four categories[4].



Fig -1: Cause effect diagram

The range of High speed plunger position is selected as 240 mm to 270 mm. the High speed plunger velocity is selected as 2 m/s to 3.5 m/s. The selected casting process parameters, along with their ranges, are presented in Table I.

TABLE I

Sr. No.	Parameter	Level 1	Level 2	Level 3	Level 4

1.	High speed plunger position (mm.)	240	250	260	270
2.	High speed plunger velocity (m./s.)	2	2.5	3	3.5

3. EXPERIMENTAL DESIGN

The experimental region has been decided as per Taguchi design of experiment approach. The number of levels for each controllable process parameter has been defined by table I. A wide experimental region has been covered so that sensitivity to noise factors does not alter with small changes in these factors settings and to obtain optimum regions for the process parameters. Therefore, each parameter was analyzed at different levels of the process parameters. The effect of inter action among the dependent parameters has also been studied for the output.

TABLE II

Sr. No.	High speed position of plunger (mm.)	High speed velocity of plunger (m/sec)
1	240	2
2	240	2.5
3	240	3
4	240	3.5
5	250	2
6	250	2.5
7	250	3
8	250	3.5
9	260	2
10	260	2.5
11	260	3
12	260	3.5
13	270	2
14	270	2.3
15	270	2.5
16	270	2.8

4. ANALYSIS AND INTERPRETATION

The experiments are conducted ten times for the same set of parameters using a single-repetition randomization technique. The flashes that occur in each trial conditions have been measured and designated by a number in between 1 to

16. The flashes for each repetition are determined for each trial conditions as shown in Table III

To study the process parameter characteristics and optimum setting signal-to-noise ratio has been calculated instead of average in Taguchi method for the results of different trials based on L16 orthogonal array. Average and the variation of the quality characteristics both are replicated by S/N ratio. Since the problem is of minimization of defects in pressure die casting, therefore, the relation "lower is better" is selected to minimize the flashes.

TABLE III

High Speed Position	High Speed Velocity	Flash Level	S/N Ratio	Mean
240	2.0	13	-22.2789	13
240	2.5	12	-21.5836	12
240	3.0	10	-20.0000	10
240	3.5	14	-22.9226	14
250	2.0	2	-6.0206	2
250	2.5	5	-13.9794	5
250	3.0	9	-19.0849	9
250	3.5	15	-23.5218	15
260	2.0	4	-12.0412	4
260	2.5	7	-16.9020	7
260	3.0	8	-18.0618	8
260	3.5	11	-20.8279	11
270	2.0	1	0.0000	1
270	2.5	3	-9.5424	3
270	3.0	6	-15.5630	6
270	3.5	16	-24.0824	16

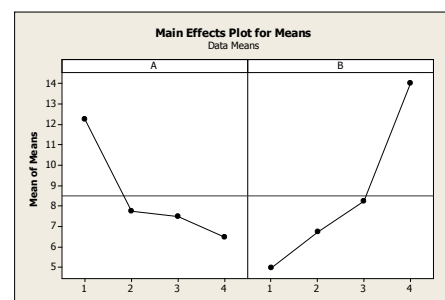


Fig. 2: Mean values of casting defects for each parameter at different levels

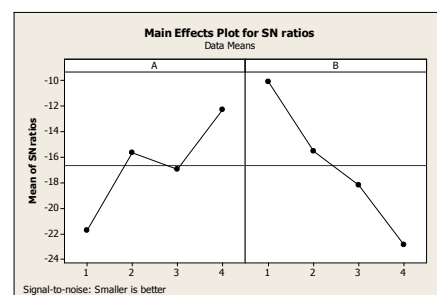


Fig. 3: S/N ratio values of casting defects for each parameter at different levels

From the graph it can be seen that among the 16 experiments performed and from 320 components produced an optimum level of the process parameters obtained from the plots suggest level 4 for high speed position i.e. 270 mm and level 1 for high speed velocity i.e. 2 m/s give minimum flash in the casting.

5. CONCLUSIONS

Experiments have been performed at different combination of process parameters as suggested by L16 orthogonal array by Taguchi methodology for the pressure die casting of gear case sag of Al alloy.

The present work suggests how to use Taguchi's parameter design to obtain optimum condition with lowest flash with minimum number of experiments and industrial engineers can use this method.

Optimum combination of process parameters like high speed position of plunger, high speed velocity for minimum casting defects has been calculated using Taguchi methods. An optimum level of the process parameters obtained from the plots suggest level 4 for high speed position i.e. 270 mm and level 1 for high speed velocity i.e. 2 m/s give minimum flash. The plot of S/N ratio as shown by fig 3 also indicates similar result.

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