

# Optimization of Sand Casting Parameters using Factorial Design



## Engineering

**KEYWORDS :** ANOVA, design of experiments, factorial design

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### ABSTRACT

*This study aims to optimize various significant process parameters of green sand casting of a cast iron alloy (FG 260) flywheel. The process parameters considered are green strength, clay content, and pouring temperature. The result shows that green strength is the significant parameter while clay content and pouring temperature are non - significant parameters.*

### Literature Review

Response surface method (RSM) has been widely used in several optimization problems. Myers et al.(2004) suggest that response surface framework has become the standard approach for much of the experimentation carried out in industrial research, development, manufacturing, and technology. Choudhary and Baradie,(1997) used response surface methodology with factorial design to determine the effects of cutting parameters (feed , speed , depth of cut) on the surface roughness in the turning of steel.

Shaik riyaz hussain, et al (2012) determined the influential process parameters and their optimal levels which will yield optimum quality to the aluminum casting using Taguchi parameter design approach. Sushil Kumar et.al (2010) used the optimization technique for sand casted iron differential housing. Taguchi approach has improved the productivity and stability of the iron differential housing. Mekonnen Liben Nekere, et.al (2012) In this paper Taguchi's robust design approach was used to obtain optimal value of two groups of aluminum black sand casting process i.e. single aluminum blank sand and double aluminum blank sand casting. Singh et al., (2005) developed surface roughness prediction model by using RSM for hard turning of the bearing steel (AISI 52100) with Mixed ceramic inserts, having different nose radius and different effective rake angles.

### 3. Experiments

#### 3.1. Test specimens

The experiments are performed on an automotive flywheel made up of Cast Iron FG(260) Chemical composition of test samples obtained by spectral analysis has been given in Table 1.

Elements	C	Mn	Si	P	S
Percentage	3.5	0.9	1.8	0.15	0.15

#### 3.3. Cutting parameters and their levels

Green sand casting process is widely used manufacturing process for producing parts that cannot be obtained by other process. The quality of products manufactured by sand casting process is result of several parameters. One of the methods to evaluate the quality of casting products is based on the casting defects. Proper selection the casting parameters can yield minimum casting defects. Optimization of these casting parameters based on 2 level factorial design is adopted in this paper to minimize the casting defects. The design factor and their levels are shown in Table 2

**Table 2: Factors and levels of independent variables according to response surface methodology**

Factors	Symbol	Levels	
Green Strength (gm/sq.cm)	A	1000	1350
Clay Content (%)	B	12	18
Pouring Temperature (Degree Centigrade)	C	1380	1430

#### 3.4. Design of experiment

Total 8 sets of experiments were sorted out based on 2 level factorial design using Design Expert 8.0.4.1. The complete design layout for experiments is given in Table 3. The table shows 8 experimental combinations of green strength, pouring temperature and clay content.

**Table 3: Completed design layout**

		Factor 1	Factor 2	Factor 3	
Std	Run	A:Green Strength(mm/rev)	B:Clay Content (mm)	C:Pouring Temperature (m/min)	
	3	1	1000	18	1380
	5	2	1000	12	1430
	6	3	1350	12	1430
	1	4	1000	12	1380
	4	5	1350	18	1380
	7	6	1000	18	1430
	8	7	1350	18	1430
	2	8	1350	12	1380

#### 4. Results and discussion

The results obtained as per the experimental plan is shown in table 4. These results were input into the Design Expert 8.0.4.1 software for further analysis.

Table 5 shows the ANOVA table for response surface quadratic model for surface roughness. This analysis was carried out for a significance level of  $\alpha = 0.05$ , i.e. for a confidence level of 95%.

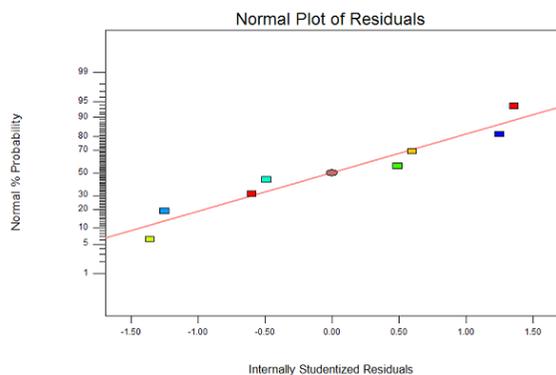
**Table 4: Experimental results**

Std	Run	Percentage Defects
3	1	0.544
5	2	2.565
6	3	4.525
1	4	2.133
4	5	8.369
7	6	3.022
8	7	2.445
2	8	3.590

**Table 5: ANOVA table**

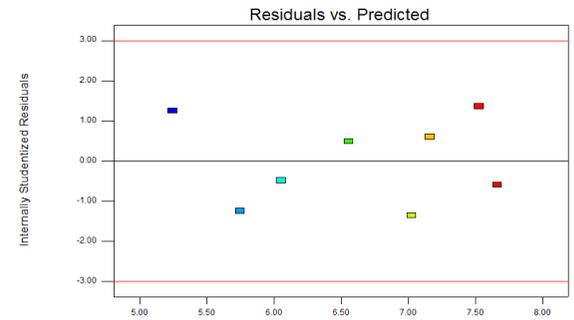
Source	Sum of Squares	Degree of freedom	Mean Square	F Value	p-value	
					Prob > F	
Model	5.34	4	1.34	105.03	< 0.0015	significant
A-Green Strength	4.16	1	4.16	327.36	< 0.0004	
B-Clay content	0.51	1	0.51	39.73	0.0081	
C-Pouring Temp	0.45	1	0.45	35.12	< 0.0096	
AC	0.23	1	0.23	17.92	0.0241	
Residual	0.038	3	0.013			
Cor Total	5.38	7				

The normal probability plot of the residuals is shown in Fig.1. The normal probability plot indicates whether the residuals follow a normal distribution or not, if the residuals follow a normal distribution mostly points will fall on a straight line expect some moderate scatter even with normal data. Fig.1, revealed that the residuals generally fall on a straight line implying that the errors are distributed normally. Residuals versus the predicted response plot for surface roughness is shown in Fig.2. It tests the assumption of constant variance. The plot should be a random scatter. Fig.2, revealed that they have no obvious pattern and unusual structure. This implies that there is no reason to suspect any violation of the independence or constant variance assumption. A graph of the actual response values versus the predicted response values is shown in Fig.3. It helps to detect a value, or group of values, that are not easily predicted by the model. The data points should be split evenly by the 45 degree line. Fig.3, revealed that all the data points split evenly by the 45 degree line.

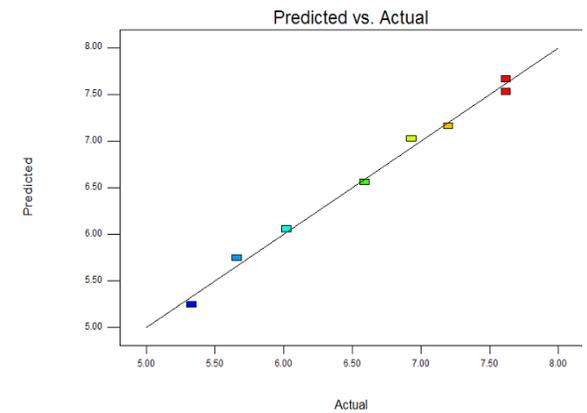


**Fig. 1. Normal probability plot of residuals for percentage**

defects data.

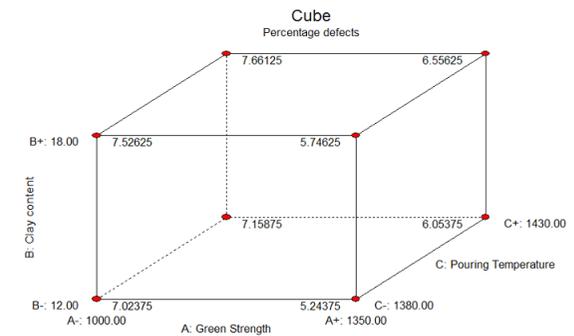


**Fig. 2. Plot of residuals vs. predicted response for percentage defects data.**



**Fig. 3. Plot of predicted vs. actual response for percentage defects data.**

Fig.12, represents the cube plot which shows the three factor interaction among green strength (A), clay content (B) and pouring temperature (C). According to the plot, the defects is significantly minimized (5.24375) when the green strength is set to the highest level (1350 gm/sq cm), clay content is set at low level (12%) and pouring temperature at low level (1380 degree centigrade).



**Fig. 12. Cube plot for percentage defects**

**5. Optimization of cutting conditions**

In the present study, the aim was to find the optimal values of process parameters in order to minimize the casting defects.. The optimal solutions are reported in Table 7.

**Table 7: Optimization results**

Solution no.	Green Strength (gm/sq.cm)	Clay content (%)	Pouring Temperature (degree centigrade)	Percentage Defects
1	1350	12	1380	5.24375

### 7. Conclusions

In this paper, a study has been carried out to investigate the effect of sand casting parameters on casting defects during casting of FG260. An attempt has also been made to optimize the casting parameters to obtain minimum defects using response surface methodology. The experimental study has led to the following conclusions.

1. The RSM technique is an effective tool for investigating the influence of various machining parameters on surface roughness.
2. The value of "Prob. > F" for green strength were found to be less than 0.05, which indicate their significant effect on defects.
3. The value of "Prob. > F" for clay content and pouring temperature and clay content which is higher than 0.05, which indicate that clay content and pouring temperature has no significant effect on the casting defects.
4. The results clearly illustrate that defects decreased with increasing the green strength.
5. The casting defects is significantly minimized (5.24375%) when the green strength is set at 1350, clay content at 12% and pouring temperature at 1380 degree centigrade

## REFERENCE

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