REDUCE CASTING DEFECTS IN FOUNDRY BY TAGUCHI METHOD

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ABSTRACT

In this paper the casting defects such as shrinkage, sand drop, blowhole are minimized by using Taguchi optimization techniques. The process parameters selected for the sand casting are Compression Strength (g/cm²), Moisture Content (%), Permeability Number, Mould Hardness number. The Taguchi approach is used to find the signal to noise ratio of the experiments based on the orthogonal array (L9) used to find the Optimum condition. A confirmation run is used to verify the result, which indicated that this method is more efficient in determining the best casting parameters.

Index Terms— Green sand casting, Taguchi Method

I. INTRODUCTION

Foundry industry is a mother industry for all the other engineering and automotive industries. The Taguchi method is powerful problem solving technique for improving the quality of the product and also productivity. A large number of experimental investigations linking green sand casting parameters with casting quality have been carried out by researchers and foundry engineers over the past few decades.

It has been recognized that green sand casting parameters design plays one of the key elements in casting quality. The casting process has a large number of parameters that may affect the quality of castings. Kumaravadivel et al. [1] Optimization of sand casting process variables a process window approach. The optimized parameters obtained using the Taguchi method. Saravan kumar et al. [2] Optimization of casting process parameters using Taguchi analysis and select suitable process parameters in casting industry to produce defect free casting. Sushil Kumar et al.[3] The quality can be improved by Taguchi’s method of parameter design at the lowest possible cost and also optimize the process parameters of the green sand castings process which lead to minimized casting defects. This paper summarizes the following:

i) Improving quality of green sand casting through process control. Keeping the effects of uncontrolled parameters at a minimum level.

ii) Analysis and select the most significant parameters that affect quality characteristics.

iii) Select an appropriate orthogonal array and suitable levels of parameters.

iv) Analysis the data using Minitab and generate interaction graphs, response graphs.

v) Decide on the optimal settings for the control parameters.

vi) Validate the optimum setting levels in reducing the levels of the Quality Characteristics (Casting Defects)

II METHODOLOGY

A. Process parameters of Green sand Casting

Rajesh Rajkolhe et al.[4] The identified factors were analyzed using ‘Design of Experiments’ approach. ‘Signal –to –Noise’ ratio was estimated. The following process parameters are identified as significant and their levels are listed in Table 1:

Table 1: Process Parameters and their Levels

<table>
<thead>
<tr>
<th>S.N</th>
<th>Parameters</th>
<th>Designation</th>
<th>Range</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Compression Strength</td>
<td>A</td>
<td>1000-1200</td>
<td>1000</td>
<td>1100</td>
<td>1200</td>
</tr>
<tr>
<td>2</td>
<td>Moisture Content</td>
<td>B</td>
<td>3-4%</td>
<td>3</td>
<td>3.5</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Permeability Number</td>
<td>C</td>
<td>140-190</td>
<td>140</td>
<td>165</td>
<td>190</td>
</tr>
<tr>
<td>4</td>
<td>Mould Hardness</td>
<td>D</td>
<td>85-95</td>
<td>85</td>
<td>90</td>
<td>95</td>
</tr>
</tbody>
</table>

B. Quality Characteristics

Casting defects was selected as a quality characteristic to be measured. Prasan kinagi et al.[5] Design of Experiment and FMEA techniques are combined to analyze casting defects. To get optimal parameters setting for defects like cold shut and blow hole. The most common defects occurring in the foundry were monitored and recorded. The lower the better number of casting defect implied better process performance.

Lower is better : S/N _LB_ = -10 log (Σy2i/n)

C. Selection of orthogonal array

Table 2: Orthogonal Array L9

<table>
<thead>
<tr>
<th>Trial No</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
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<td>3</td>
<td>3</td>
<td>3</td>
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<tr>
<td>4</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
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<td>1</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
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<td>7</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>2</td>
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<td>3</td>
</tr>
<tr>
<td>9</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
III EXPERIMENTATION
The experimental Orthogonal array will look like as follows:

### TABLE 3: EXPERIMENTAL ORTHOGONAL ARRAY

<table>
<thead>
<tr>
<th>Trial No</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1000</td>
<td>3</td>
<td>140</td>
<td>85</td>
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<tr>
<td>2</td>
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<td>85</td>
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</tr>
<tr>
<td>8</td>
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<td>95</td>
</tr>
<tr>
<td>9</td>
<td>1200</td>
<td>4</td>
<td>165</td>
<td>85</td>
</tr>
</tbody>
</table>

Lower the better S/N ratios were computed for each of the 9 trials and the values are given in the table 4:
For example, for trial no. 1, the S/N ratio is: \(-10 \log \left(\sum y^2/\text{ni}\right)\)

\[
\text{S/N ratio} = -10 \log \left(9.2^2 + 9.7^2 + 9.6^2/3\right) \\
= -10 \log \left(84.64 + 94.09 + 92.16/3\right) \\
= -10 \log \left(270.89/3\right) \\
= -19.55
\]

IV RESULT
Minitab worksheet:
Table 6 shows the average SNR for each at the signal level and factors, respectively.
Table 7 shows the robust design optimum value of factors for maximization of approved castings.

### TABLE 4: MEAN VALUE AND S/N RATIO OF CASTING DEFECTS AT DIFFERENT LEVELS

<table>
<thead>
<tr>
<th>Trial No</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Mean (% of Rejection)</th>
<th>S/N Ratio</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>9.2</td>
<td>9.7</td>
<td>9.6</td>
<td>9.5</td>
<td>-19.5545</td>
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<td>2</td>
<td>7.5</td>
<td>7.8</td>
<td>7.9</td>
<td>7.7</td>
<td>-17.7298</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>8.2</td>
<td>8.3</td>
<td>8.1</td>
<td>-18.1697</td>
</tr>
<tr>
<td>4</td>
<td>8.3</td>
<td>8.1</td>
<td>8.2</td>
<td>8.2</td>
<td>-18.2763</td>
</tr>
<tr>
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<td>7.8</td>
<td>7.5</td>
<td>7.9</td>
<td>7.7</td>
<td>-17.7298</td>
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<tr>
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<td>6.8</td>
<td>6.4</td>
<td>6.9</td>
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<tr>
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<td>7.3</td>
<td>7.6</td>
<td>7.8</td>
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</tr>
<tr>
<td>8</td>
<td>8.3</td>
<td>8.5</td>
<td>8.8</td>
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<tr>
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<td>8.5</td>
<td>8.2</td>
<td>8.3</td>
<td>-18.3816</td>
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</table>

### TABLE 5: MINITAB WORKSHEET

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Mean</th>
<th>SNR A1</th>
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<tbody>
<tr>
<td>1000</td>
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<td>140</td>
<td>85</td>
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<td>9.6</td>
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<td>90</td>
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<td>7.9</td>
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<tr>
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<td>190</td>
<td>95</td>
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<td>-18.5884</td>
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<td>8.3</td>
<td>8.5</td>
<td>8.2</td>
<td>8.3</td>
<td>-18.3816</td>
</tr>
</tbody>
</table>

### TABLE 6: AVERAGE SNR VALUES FOR EACH SIGNAL VALUES AND FACTORS

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>Factor A</th>
<th>Factor B</th>
<th>Factor C</th>
<th>Factor D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>18.44</td>
<td>18.22</td>
<td>18.55</td>
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<td>2</td>
<td>17.50</td>
<td>18.01</td>
<td>18.12</td>
<td>17.25</td>
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<td>3</td>
<td>18.15</td>
<td>17.69</td>
<td>17.80</td>
<td>18.34</td>
</tr>
</tbody>
</table>

### TABLE 7: ROBUST DESIGN OPTIMUM VALUE

<table>
<thead>
<tr>
<th>Factor</th>
<th>SNR</th>
<th>LEVEL</th>
<th>OPTIMUM VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>17.50</td>
<td>2</td>
<td>1100</td>
</tr>
<tr>
<td>B</td>
<td>17.69</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>C</td>
<td>17.80</td>
<td>3</td>
<td>190</td>
</tr>
<tr>
<td>D</td>
<td>17.25</td>
<td>2</td>
<td>90</td>
</tr>
</tbody>
</table>

V CONCLUSIONS
The optimum conditions for the parameters are given below as
Compression Strength (g/cm²) 1100 Level 2
Moisture Content (%) 4 Level 3
Permeability Number 190 Level 3
Mould Hardness 90 Level 2

The improvement expected in minimizing the variation is 10-15 % of casting defects in the foundry.
By using Taguchi method the factor levels when optimized will result in reduction of casting defects 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, scrap reduction, reworking of casting and process control.

REFERENCES


8. Mr. Deepak Kumar, Optimization of sand casting parameter using Factorial Design ; Volume 3, Issue 1, January 2014, ISSN No 2277-8179.