Reduction of work in process and finding critical machines and bottle necks using simulation and Design of Experiments

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Abstract - This project work is carried out at axle factory, it is a production plant, which mainly manufactures various sizes of wheels and axles, through the forging process in axle shop and casing in wheel shop. Apart from that the company manufactures various types of axles, currently this company is facing lot of work in process at various areas in the shop floor. In order to reduce work in process. There is need to understand the system behavior and factors which affect the system behavior. Work in process due to various factors such as variability due to process time, setup time, time between failures, down time and travel time, to understand how this set of factors play a role in affecting the work in process it would be essential to conduct simulation and design of experiment. In this study simulation model was created for various bottle neck areas and system was analyzed by changing the various factors by using design of experiments approach. The necessary improvement was suggested based on the simulation, ANOVA results, main effect plot and interaction plot.

Key Words: DOE, Simulation, Work in process, Etc.

1. Introduction

Axles:

The manufacturing industry procures high-quality vacuum-degassed steel blooms from large-scale steelmakers. Axles are manufactured from billets cut from the blooms. These blooms are forged in a precision long-forging machine. The billets are heated in a rotary hearth furnace to forging temperatures. Billets are then forged in axles on a special purpose long forging machine. The forged axles are gas cut to required length. The axles are heat treated through various heat treatment processes. The physical properties are confirmed before machining of the axles. The forged axles are machined on various machines. The operation consists of end machining, rough turning; finish turning, spm machining, grinding and burnishing. Internationally standardized tests (ultrasonic, magnetic particle, etc.) are used to confirm the quality of the axles.

2. Project problem definition

The main purpose of this project is to reduce the work in process of manufacturing system, so the project's objective is to understand the behavior of manufacturing system and hence identifying the factors which play a vital role in affecting the System behavior. In addition to that due to change in demand variety there is also a need to understand the performance of the system under there kind of scenarios. Works in process are partially finished goods waiting for completion and eventual sale or the value of these items. These items are either just being fabricated or waiting for further processing in a queue or in a buffer storage. These set of objectives can be accomplished by the use of simulation and the results obtained would be able to understand performance under various scenarios. Hence project problem can be defined as “Reduction of work in process and finding the critical machines and bottle neck using simulation modeling and design of experiments”.

3. Methodology

To achieve the objective of the project, a nine step methodology will be followed. The flow chart gives a pictorial representation of the methodology.
By the help of Pareto diagram the critical lines are identified and solved out by using simulation and design of experiments.

4. Results

RESULT FROM ARENA SOFTWARE

MODEL 1
1. The model 1 shows how the material flows from blooms yard to conveyor of Rotary hearth furnace machine
2. Here from the model we can see that the actual output after billet cutting near conveyor RHF machine is 136 parts for a shift but RHF furnace can process only 90 parts in a shift the remaining billets have wait for their turn hence this causes work in process
3. After billet cutting machine if a conveyor connect to the conveyor of RHF then result says one billet cutting can supply to two RHF furnace and two forging machines
4. EOT crane can be used for other purpose

MODEL 2
1. The model 2 shows how the material flows from conveyor of RHF machine to forging machine
2. Here from the model we can see that there are lot work in process due forging failure maintenance and RHF maintenance.
3. From model we can understand that 4.1 minutes time for avoids work in process between RHF, forging in axle forge shop
4. If we avoid maintenance and if maintenance reduces 0 we can produce extra 190 axles in a month.

Analysis of Variance
Table 4.1: $2^3$ design of Anova table for finding out major cause for work in process.

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Adj SS</th>
<th>Adj MS</th>
<th>F-Value</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>7</td>
<td>302186</td>
<td>43169</td>
<td>606.13</td>
<td>0.000</td>
</tr>
<tr>
<td>Linear</td>
<td>3</td>
<td>282174</td>
<td>94058</td>
<td>1320.64</td>
<td>0.000</td>
</tr>
<tr>
<td>Batch size</td>
<td>1</td>
<td>261822</td>
<td>261822</td>
<td>3676.17</td>
<td>0.000</td>
</tr>
<tr>
<td>Iat between batches</td>
<td>1</td>
<td>1854</td>
<td>1854</td>
<td>26.03</td>
<td>0.000</td>
</tr>
<tr>
<td>Iat between forging</td>
<td>1</td>
<td>18498</td>
<td>18498</td>
<td>259.72</td>
<td>0.000</td>
</tr>
<tr>
<td>2-Way Interactions</td>
<td>3</td>
<td>19786</td>
<td>6595</td>
<td>92.60</td>
<td>0.000</td>
</tr>
<tr>
<td>Batch size*Iat between batches</td>
<td>1</td>
<td>2202</td>
<td>2202</td>
<td>30.92</td>
<td>0.000</td>
</tr>
<tr>
<td>Batch size*Iat between forging</td>
<td>1</td>
<td>17459</td>
<td>17459</td>
<td>245.14</td>
<td>0.000</td>
</tr>
<tr>
<td>Iat between batches*Iat between forging</td>
<td>1</td>
<td>125</td>
<td>125</td>
<td>1.75</td>
<td>0.187</td>
</tr>
<tr>
<td>3-Way Interactions</td>
<td>1</td>
<td>226</td>
<td>226</td>
<td>3.18</td>
<td>0.076</td>
</tr>
<tr>
<td>Batch size<em>Iat between batches</em>Iat between forging</td>
<td>1</td>
<td>226</td>
<td>226</td>
<td>3.18</td>
<td>0.076</td>
</tr>
<tr>
<td>Error</td>
<td></td>
<td>232</td>
<td>16523</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>239</td>
<td>318709</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From the table 4.1 seeing the p value we can conclude all are significant.

Main Effects Plot
The Main Effects Plot plots means of factor levels and it is used to visualize the magnitudes of main effects. The following figures show you how to interpret different types of Main Effects Plot.
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5. CONCLUSION
By the usage of simulation and design of experiment approach it was found that the work in process near billet has been significantly reduced. The major factor that affect work in process include batch in size, interarrival between the batches and inter arrival time between forging out of these three factor the batch size has huge reduction for work in process, especially batch 2 reduced the work in process to 2. This shows batch size can be used to reduce the work in process, it is also seen from the maintenance down time and time between failure are significant in reducing work in process. Reducing the down time as minimum as possible and increasing the up time would fetch a huge improvement in throughput and reduction in work in process.