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APPLYING DISCRETE-EVENT SIMULATION AND VALUE STREAM MAPPING TO REDUCE WASTE IN AN AUTOMOTIVE ENGINE MANUFACTURING PLANT

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ABSTRACT

This paper aims to apply a combination of Value Stream Mapping (VSM) and Discrete-Event Simulation (DES) in an automotive engine manufacturing plant. First, a current state VSM was created and the sources of waste were identified. The Leak Test area and engine impregnation process were identified as major sources of waste. Based on that, two potential improvement scenarios were developed and analyzed using DES. The simulation was used to compare key measures of performance in the current state and the proposed scenarios, using different setting for adjustable system parameters. Results showed improvements of up to 29% in annual engine impregnation cost for one scenario, without detriment to other measures. The study's major takeaway is demonstrating that VSM in conjunction with DES is a powerful alternative in studying changes in production processes, which leverages the advantages of both methodologies.

1 INTRODUCTION

Value Stream Mapping (VSM) is a lean manufacturing tool that has been used by automotive manufactures to identify and eliminate waste in the system. A Discrete-Event Simulation (DES) is often used to verify and analyze potential improvement scenarios before the actual implementation in the factory. The conjunction of VSM and DES can help automotive organizations to analyze and test solutions without interfering with the real system. Both techniques, DES and VSM, have a history of application in automotive manufacturing. For instance, Andrade et al. (2015) combines VSM and DES as a decision making tool of an assembly line of clutch discs in an automotive company. Mahfouz and Arisha (2013) presented a lean assessment framework that integrates VSM with simulation in a tire distribution company. In this work, we use VSM to identify the existing sources of waste within the engine plant and develop a DES model to conduct analyses of multiple improvement scenarios and find the best alternative to reduce waste without compromising other metrics of performance. To the best of our knowledge, this is the first use of "Simulation-aided VSM" applied to engine block machining to be reported in the literature.

The current state VSM of the engine block machining line was constructed and the main source of waste was found to be in the Leak Test area of this line, which causes delays and waste in transportation, creates WIP, and generates extra processing in the form of block impregnation to repair suspected leaky engine blocks. We created a DES model that represented the real system and we proposed two potential scenarios that would re-organize the process. The simulation software used was Simio because it provides an environment for performing validation and executing complex systems. In addition to comparing the two potential improvement scenarios, we were interested in testing the sensitivity of each scenario with respect to three adjustable systems parameters. We performed single-parameter and two-parameter experiments with each of these three parameters for each scenario. These systems parameters were used to compare performance across scenarios and between levels of the parameters within each scenario. The goal was to determine the effect of the variation of these parameters on the measures of performance.

2 THE MACHINING LINE IN THE AUTOMOTIVE ENGINE MANUFACTURING PLANT

The automotive engine block manufacturing plant that we studied for this research is divided into three sections: block die-casting, machining and engine assembly. The scope of this study is limited to the engine block machining line. A high-level current state VSM of this area, which comprises 20 stations, was developed by following a block's production path backwards from customer (Engine Assembly) to supplier (Block Die-Casting). The main source of waste was found to be in the Leak Test area. We decided to develop a DES model of the current state of this area, to estimate the average lead time that a block spends in this area and also to study different scenarios/approaches that could reduce the waste generated here.

3 SIMULATION AND ANALYSIS

There are two leak test machines in this area of study: Machining Leak Test (MC Leak Test) and Die Cast Leak Test (DC Leak Test). Machining Leak Test is considered the Master Leak Test and it is an automated process where the machine makes the decision on the condition of the block. Die Cast Leak Test is operated manually. Both machines test leaks and follow standards to determine the condition of the block. Once an engine block fails the leak test, it is directed to go through an impregnation process to be repaired. The simulation model created to represent the current state VSM of the Leak Test area is titled "Base-Line Model" (BL). Once the model was validated, we were able to test new potential scenarios, which we named Scenario 1 (S1) and Scenario 2 (S2). S1 considers DC Leak Test as a Master Leak Test, preventing unnecessary retests in MC Leak Test. S2 allows DC Leak Test to catch false leakers from MC Leak Test, preventing unnecessary impregnation. The models track five measures of performance (WIP around the area, line throughput, impregnation and scrap rates) that were used to compare the BL model with S1 and S2. In addition to comparing the three models, we were interested in testing the system under different combinations of system parameters (for each scenario). The system parameters, as well as their test levels were chosen in conjunction with the stakeholders to reflect current and potential realistic conditions.

4 CONCLUSIONS

In this study, we have showcased the use of simulation combined with VSM in an automotive manufacturing engine plant. We created a DES model that represented the real system (Base-Line Model) and we proposed two potential sets of changes in the process (Scenario 1 and Scenario 2). The strategy proposed from this study consists of combining VSM and simulation and using this combination as a decision-making tool. This strategy is useful because it combines the high-level results of VSM with a detailed DES analysis of potential scenarios to find a better solution without requiring physical test changes. The value of using this combination is that it helps identify the problem area, and calculate lead times of the Leak Test area and the machining line as a whole. We would have not arrived to this conclusion by only analyzing the VSM or the DES on their own. In this case, the two tools complement each other.

Results from Scenario 1 show that it saves 2.5% in annual impregnation cost. Scenario 2 saves 29% in annual impregnation cost, by scraping no-good blocks earlier in the process and avoiding unnecessary impregnation. Overall, both scenarios showed improvements related to impregnation compared to the Base-Line Model; however, Scenario 2 showed to have a lower impregnation cost and lower impregnated blocks in scrap when compared to Scenario 1. Therefore, we recommended to our industry partners to implement Scenario 2, keeping the current system parameters.

REFERENCES

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