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Throughput Rate Improvement in a Multiproduct Assembly Line Using Lean and Simulation Modeling and Analysis

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Abstract

It has been a real challenge to improve the throughput of multiproduct assembly lines due to the complexity of the multiproduct assembly processes. In this paper, we used pull simulation module to mimic a real engine assembly line where 114 different products are being assembled. Line balancing and controlling the work in process (WIP) were found to be the driving elements to improve the throughput rate. Developing effective design of experiments for the simulation modelling and analysis helped in validating the impact of the changes. Recommended solutions have helped the engine assembly line to increase its throughput rate by 14%.

Keywords: *Throughput rate, work in process, design of experiments, six sigma, simulation modeling, lean manufacturing*

1. Introduction

Multiproduct assembly lines consist of sequential organization of workers, tools, machines and parts. There can be hundreds of parts assembled together to build a final product. These parts are required to be assembled precisely following certain sequences. Variation in customer requirements can become more significant due to the different applications that customers are using the products for. This variability has a direct impact on the multiproduct assembly line processes and performances. Lean tools and simulation modeling can be used to improve multiproduct assembly lines in the most cost effective manner. The term 'lean' refers to the methodologies and tools used by the Toyota Motor Company [1]. Under the lean umbrella, line balancing and controlling work in process (WIP) are generally used for improving flow of an assembly lines [13, 14]. The design of experiments (DOE) is a systematic method to determine the relationship between factors affecting a

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process and the output of that process [3]. This information is needed to manage process inputs in order to optimize the output. Simulation modeling is used to mimic the existing processes and validate changes and impact. In this paper, we walk through a simulation model that was developed to understand line balancing activities and to optimize work in process by using a design of experiment analysis [6, 7]. Following this section is a literature review of lean and simulation modeling, overview of the business under focus and problem statement, the methodology used, and finally followed by results and conclusion.

2. Literature Review

Lean manufacturing is a management philosophy derived mainly from the Toyota Production System (TPS) in which the focus is on improving the "flow" or smoothness of work [1]. It is a systematic method to eliminate waste within a manufacturing system. It reduces waste created by overburden (Muri) and wastes created by unevenness in workloads (Mura) [13, 14]. Lean works from the perspective of the client who consumes a product or service. Lean manufacturing distinguishes between value added activities and non-value added actives. It defines the value-add by the activities that the customers are willing to pay for [11]. Simulation in manufacturing systems is the use of oriented programming to create computer models of manufacturing systems to analyze and thereby obtain important information. This will help to understand the change to the whole system via the what-if analysis. It will make it easier to understand the difference made by changes in the systems [4]. Typical measures which can be obtained by a simulation analysis are: evaluating potential alternatives to determine the best approach to optimizing performance; understanding system performance based on key metrics such as costs, throughput, cycle times, equipment utilization and resource availability; reducing risk through rigorous simulation and testing of process changes before committing significant capital or resource expenditures; determining the impact of uncertainty and variability on system performance; running "what-if" scenarios to evaluate proposed process changes; and visualizing results with 2D and 3D animation [5]. Some other benefits include Just-in-time manufacturing, calculation of optimal resources required, validation of the proposed operation logic for controlling the system, and data collected during modeling that may be used elsewhere.

3. Overview of the Business & Problem Statement

This study is based on a company which is a leading manufacturer of construction and mining equipment, diesel and natural gas engines, industrial gas turbines and diesel-electric locomotives. The value stream under the focus is an assembly line for diesel engines. There are 3 different platform product types are being assembled on this line. These platforms are diesel engines size 7 litters (C7), diesel engine size 13 Litters tier 3 and tier 4. Out of these 3 platforms, there are 114 different engine products (engine configurations for different applications) in total are being produced. The plant is expecting an increase in the customer demand for engine size 13 tier 3. This increase will require the daily production output to raise from 60 engine per day to 70 engines per day to meet the new demand. It has been a challenge to increase the capacity of the line in the most cost effective way to meet the customer demand because of the complexity of the process and the high variability of the engines set up arrangements. The project objective was to improve the line performance to meet the customer demand by performing line balancing and controlling the work in process (WIP) by using simulation models and design of experiments (DOE).

4. Methodology

Value stream mapping is one of lean tools that was used for the assembly line to visually depict the current state. The total available production time is set to be 570 minutes per day. The current customer demand is 60 engine per day. Therefore the *Takt* time is 570 minutes/60 engines (9.5 min/engine). The average overall equipment effectiveness (OEE) is 85% for the assembly line. It was necessary to set the cycle time for the station to be at 85% of the *Takt* time. Thus, the current target cycle time is 8 min. The daily average throughput rate is 5.8 engines per hour. The current average employee productivity was calculated by dividing the total number of