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Lean Implementation in a Low Volume Manufacturing Environment: a Case Study

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Abstract

Lean production refers to approaches initially developed by Toyota that focuses on the elimination of waste in all forms. Lean has been extremely successful in large high volume manufacturers. However, many small to medium size low volume manufacturers have not fully embraced the potential benefits of a lean production system. This paper focuses on the implementation of lean in a small manufacturer of all electric 4-wheel drive vehicles. The goal was to increase the capacity and throughput rates, reduce lead-times, and improve quality and efficiency while reducing operating costs. Through the implementation of basic lean tools such as 5S, standardized work, line balancing, visual controls, point of use storage, and quality at the source, the small manufacturer was able to rapidly increase throughput and reduce quality defects by 80%. Based on observations derived from this case study, hypothesis statements are generated regarding obstacles and solutions to lean implementation in small and medium manufacturing enterprises.

Keywords
Lean Manufacturing, Low Volume Manufacturing, Lean Implementation

1. Introduction
Lean Manufacturing is accepted and widely used by the vast majority of the world's major manufacturers. It comes in many forms and has many names (e.g., Toyota Production System, Nissan Production Way). The basis of Lean Manufacturing, however, always contains the core elements that make it work. Lean contains five primary elements: Manufacturing Flow, Organization, Process Control, Metrics and Logistics [1]. Lean, when properly implemented, allows manufacturers to build quality products faster and more efficiently. It eliminates waste in the system that the customer does not want to pay for. Many small manufacturers have yet to embrace Lean for various reasons. These manufacturers either have never been exposed to Lean or just do not have the knowledge or knowhow to implement it. Some do not see value in sending employees to expensive training because of a lack of knowledge of what Lean is and can do [2].

2. Problem Overview
This paper focuses on an Un-named Small Company (USC) that is a manufacturer of off-road vehicles. Their original product came to the plant 75% assembled and was completed at USC. In the summer of 2009, USC began to manufacture a new product that was assembled 100% in-house. As a result, this product brought new complexities to USC and greatly slowed its assembly.

Mississippi State University's Center for Advanced Vehicular Systems Extension (CAVSE) was asked to help find improvements by analyzing the processes and facility. The main objectives were to:

- Achieve a minimum throughput rate of 12 vehicles per day
- Eliminate overtime
- Improve quality and decrease rework.

3. Current Condition Assessment
Before a Lean implementation, CAVSE needed to assess the current conditions and learn the assembly process. The first step was to understand the layout and basic flow of the plant, as seen in Figure 1. Station 1 has four work areas

that feed two independent, and identical, lines. From there, time was spent with all members of each work station documenting the best practice for each process. This information was used to standardize work between both assembly lines. In addition, observations were made of issues that were detrimental to the efficiency of the system. Some early observations:

- Work stations were very cluttered with scrap and rework parts
- Workers were constantly leaving their work stations to find parts, tools, and/or hardware
- Work load in the stations was not balanced
- Units were being pulled offline to have welding done

The initial production system averaged 3 finished vehicles per shift and showed an average rate of 18 defects per unit.

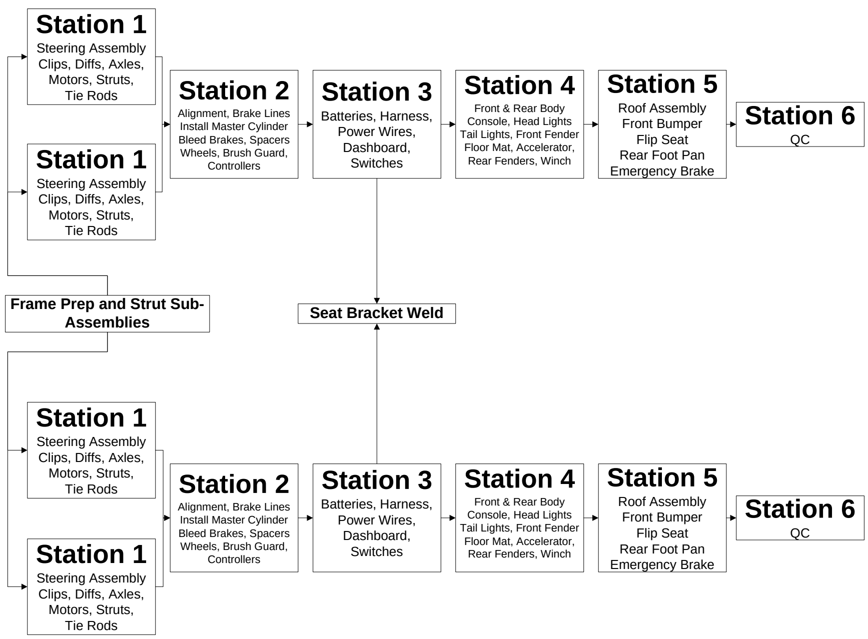

Figure 1: Initial Process Flow

4. Implementation

This section covers the overall approach of the Lean implementation, and issues will be identified along with corresponding solutions.

4.1 Basic Lean Principles

As the process was documented, several issues listed in Section 3 were noted. The first, and most important, step in a Lean implementation is 5S (i.e., Sort, Set in Order, Shine, Standardize, and Sustain). It is a methodology for keeping a clean, organized workstation. Each Station Lead, the designated leader within each station, was tasked with getting his workers to clean their individual areas and to identify only what was needed. To help relieve pile-ups of damaged parts, red tag bins were placed in designated locations on the shop floor. This allowed Station Leads to tag damaged or defective parts with a description of the problem and get them out of the way. This also helps with inventory issues so the parts are accurately managed. Hardware shelves were set up in the stations and labeled bins were put in place for each variation of hardware. Above these shelves, a large process board was installed with a description of the process as well as pictures that detail each step. Shadow-boards were constructed to organize the tools needed in each station. The shadow boards have a marked spot for each individual tool so the Lead can quickly see if something is missing at the end of the day.

A major issue indentified early in the initial assessment was that workers constantly leave their workstations to find parts, hardware, and/or tools. Ideally, the worker should not have to leave the workstation to perform his or her job. The hardware issue was solved by using the organized shelves described previously. Tools were also a large issue;

the workers were constantly borrowing tools from other stations or wasting time looking for tools. Tool lists were compiled by the Station Leads. Once the shadow boards were in place, tools were purchased to replenish missing tools and all tools were marked by station. Finally, parts had to be dealt with. The bill of materials was broken into stations to make individual parts lists. At each station, locations were identified for each part and marked with a label that contained the part number and part description. This not only made it easier for workers to find parts, but also made it easier for the Material Handlers to replenish stock. Station Leads were given material count sheets specific to their stations. These sheets allowed them to take a physical count of what they had on-hand and to request additional parts from inventory based upon the next day's scheduled production.

4.2 Line Balancing and Subassemblies

Once all workstations had everything they needed, production rates began to increase, which exposed bottlenecks. Immediately, it could be seen that Station 3 was slowing down the system. As the process was observed, it became clear that dashboards could be assembled and wired offline which would take a large portion of work out of Station 3. A Dashboard Subassembly Station was created to feed both lines which improved overall throughput down both assembly lines.

When the work in Station 3 was completed, the units were being pulled offline to have the seat brackets welded in, and then they were moved back to the production line, disturbing the flow. This process was inserted in between Station 1 and Station 2, to improve flow and decrease line disruption.

The next bottleneck to surface was Station 5. The roof cage was assembled on the vehicle, adding additional time in station. In order to reduce the bottleneck and labor content, a Roof Cage Subassembly Station was created to feed both lines. As a result this subassembly did not have enough work content to be balanced with the assembly lines, so Winch Subassembly and Passenger Foot Rest Subassembly were added. In addition, it was required to remove Emergency Brake Assembly to meet the target production rate. This was accomplished by creating another subassembly area which fed both lines, further improving overall line balance and flow.

The resulting flow, along with the in-station changes, increased the production rate from 3 to 14 vehicles per day on average while only increasing the manpower by one operator. Figure 2 shows the process flow after the subassemblies were implemented.

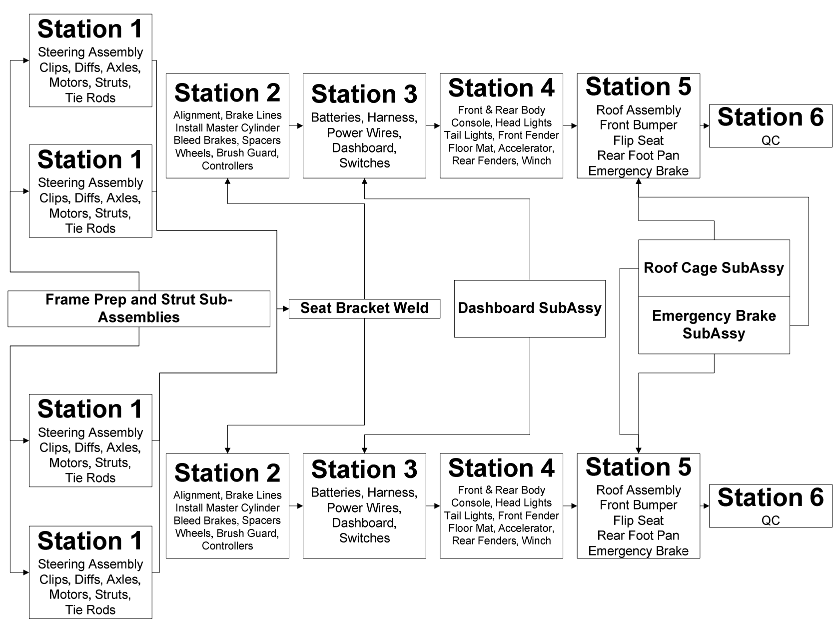

Figure 2: Subassembly Process Flow

Once the new subassembly stations were in place, the desired production rate was surpassed, but the line was still not completely balanced. Station 4's work content was low and contained idle time. Stations 2 and 3 were running slightly faster than Station 5 which was setting the line pace. Rear fender flares and winch install were moved from Station 5 to Station 4 to help balance out the times. This move increased Station 4's time while keeping both Station 4 and Station 5's time under the target.

Due to strong sales, USC asked what could be done to further increase the production rate. After analyzing time studies, it was determined that a new station could be created between Stations 2 and 3 that would match the lowest processing times of other stations. An equal amount of work was pulled from Stations 2 and 3 and a new Station 2.5 was created. This new line configuration did achieve a production rate of 20 vehicles per day and can be seen in Figure 3.

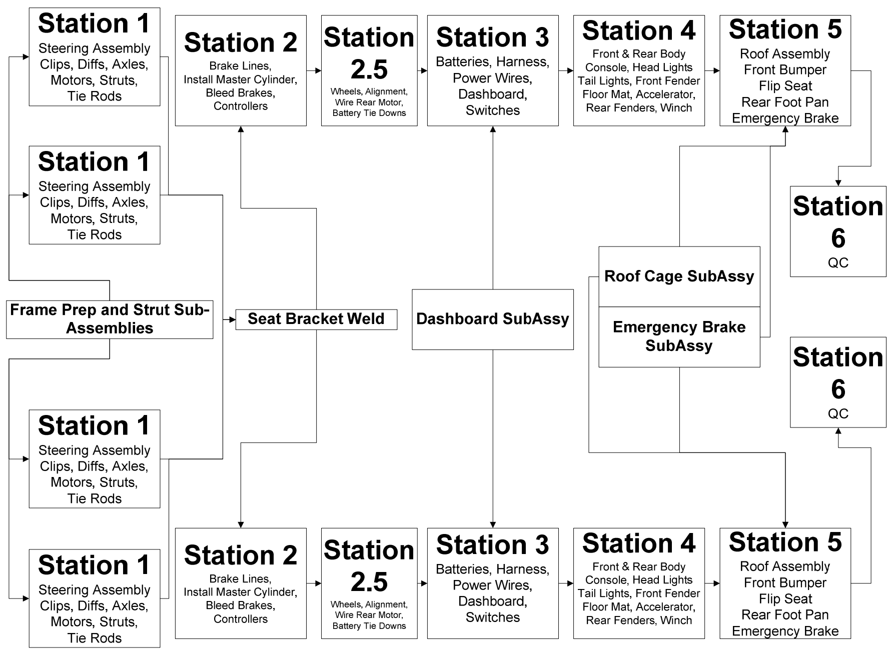

Figure 3: Balanced Process Flow

4.3 Quality Concerns

As stated in Section 3 of this paper, initially the finished vehicles were averaging 18 quality issues per unit. Time was spent with the quality control group to discuss what the quality concerns were and how to resolve them. A Pareto Analysis was prepared to determine the most common quality issues. Once these issues were documented, check sheets for each station were devised that identified key quality characteristics to check before the unit moved to the next station. Station Leads were given responsibility for items on their respective check sheets and held accountable for quality issues found in final inspection. Once the check sheets were implemented and became a normal part of the process, quality improved rapidly. After a few weeks of use, the quality issues per unit dropped from an average of 18 to an average of 3 per unit. The decrease in quality problems also proportionally decreased the amount of rework needed per unit.

4.4 Warehousing and Logistics

An issue that plagued the Material Handlers was the inability to find parts quickly and efficiently. The warehouse at USC was spread across five buildings, with limited organization. Before beginning to organize these warehouses, an inventory of the racks and a layout of each building was drawn in CAD to create a plan. From there, an inventory of all parts was taken, recording not only part quantities, but also locations. This data showed that the warehouses comingled current production parts, obsolete parts and service parts. After analyzing the data, it was determined that the current warehouse space was underutilized and contained plenty of available space. A layout plan was developed to better organize the warehouses. This included removing all obsolete parts, and separating the current model parts from the previous model parts. This new organizational plan is shown in Figure 4.

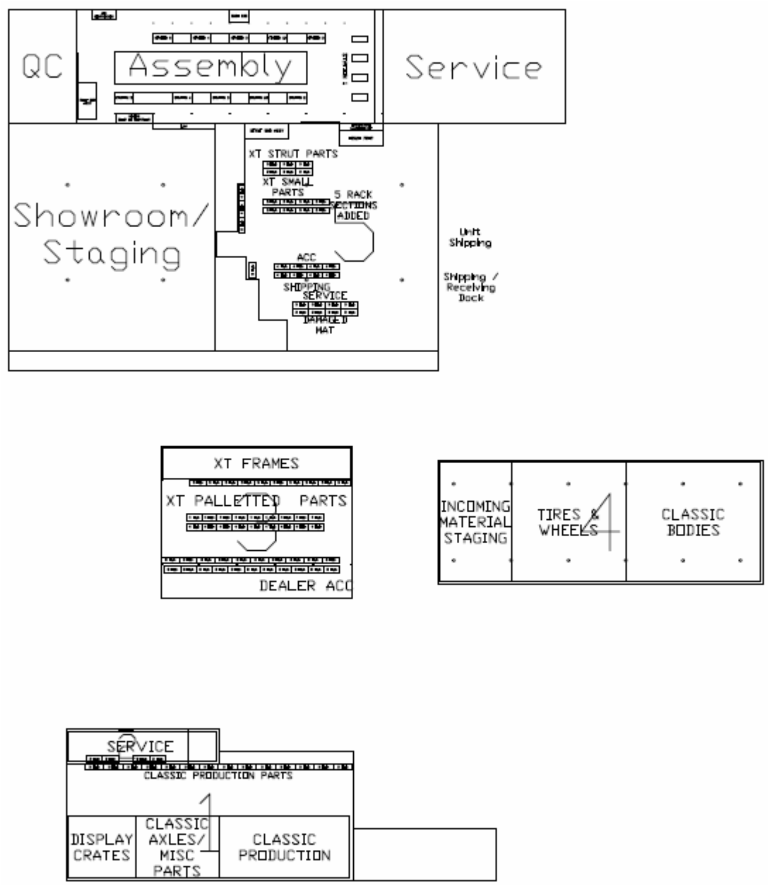

Figure 4: Site Layout with Warehouses

This plan was soon implemented, scrapping all obsolete parts and placing service parts into a specific area. An Incoming Material Staging Area was allocated to allow the unloading of containers, inventorying by part number prior to storage. Afterwards, the warehouses were organized and parts were easier for the material handlers to find.

5. Conclusions

In this project, a Lean Manufacturing implementation was successfully instituted in a small, low volume manufacturer with limited previous knowledge of Lean systems. Many small manufacturers have not had the chance to implement Lean because of a lack of knowledge of Lean, lack of funding for training, or a lack of astute leadership to encourage a Lean implementation [2]. To have a successful implementation, buy-in must exist in the entire organization from top management down to the line workers. Upper management must stay engaged and constantly challenge employees to improve and develop higher value added work. As long as discipline is maintained the Lean tools will continue to work and expose new opportunities for improvement. Employees have to work tighter as a team, but will find that their jobs become easier with improvements.

By attacking the bottlenecks as they appear, throughput was increased rapidly by over 600%. Lean also decreased defects by 83% and improved overall efficiency through the entire manufacturing process in a three month time frame.

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