Automotive System Modeling for Scrap Control: Case-Study

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Abstract

In this research work, a current automotive system of the Big-Three facility has been analyzed for the purpose of improvement. Analyzing the system lead to developing a modeling representation using computer software platform, which provides an ability for baseline tests. A set of experimentation has been conducted to discover the inefficiency that is currently involved in assembly process-lines of the automotive system and how detrimental can be to the company. Current lean strategies and production principles have been applied to eliminate waste and increase the total efficiency of the system. Results analysis based on different models shows that by eliminating the double-handling currently existed in the system, it ultimately creates more efficiency and productivity for the system.

Keywords
Double-handling, Inefficiency, System Model, Scrap Section, and Quality Section

1. Introduction

The automotive system that has been modeled is a set of automated process-lines of assembly plant that technically coded as Trim III. It has been validated to establish most accurate representation of what currently exists in the automotive industry. Modeling the current system that thought to be complicated due to associated complexity with automated-flexibility setups. The motivation of this research is to discover the embedded inefficiency that exists in multiplying process-lines of the assembly plant. Also, if the problem addressed, it can be promising to save costs! By analyzing the results of one process-line of the assembly plant, it can provide evidence of what happens if the double-handling reduced within every other process-line for the entire assembly plant, and nationwide.

Therefore, eliminating double-handling as a form of waste in the system can be the main objective for improvement. Double-handling is a state of in the same process-line, the product is handled or manipulated multiple times without adding value. There is an exception when there is additional value-added for the product being completed. However, if there is a state when a product is handled for second time and there is no additional value-added to the product, then the second process is considered waste. Within the scrap system of Trim III, there is a double-handling that is taking place, it takes place because when the product gets rejected, it is first transferred to the quality sections. From the quality, it can either be classified as a satisfying product and is then transferred back to the process-line or is rejected and transferred to the scrap section. In the scrap processing, a deeper test conducted to decide why the product failed inspection and transferred the product back to the supplier. The inefficiency comes obvious when a product is classified as satisfying to be transferred to the scrap section. The inefficiency is that the product is reducing throughput and increasing cycle time when it goes through the entire process-line again, just to be transferred back to the process-line because it classified as a satisfying product. Then, the question is that what is the difference is between the quality section and scrap section?

The quality section pays to operators that go throughout and inspect the product based on fit and physical appearance. Scrap section, however, is another group of hourly workers that select the defects and go into the deeper tests to establish the root cause of the event. This research work applies the current lean approach via designing different alternatives for including/excluding to a process-line in order to analyze the effect on increasing the efficiency of the system. The first design is by removing the initial step which includes the quality section. This can cause products to go directly to the scrap section via skip a step. The results of failed and good products remain the same because the scrap section does a very deep analysis of all the product issues. This improvement comes from eliminating the double handling that is currently limiting the assembly plant to achieving optimum efficiency. This paper has been articulated as follows; section 2 included a literature review of research papers, section 3 involved data collection, section 4 is devoted the system modeling, section 5 is the result analysis, and section 6 closes the papers by drawing a set of conclusion..

2. Works Review

Related research works of different papers have been reviewed based on the problem statement, research objective, methodology, and conclusion determining the trend of tools and approaches used to lean the manufacturing. Review analysis leads to understanding lean and how to apply the approach to real-world problems.

Tansel et al. developed a hierarchical procedure study presented simulation designs and analysis for real-world case study of a flexible manufacturing system. It developed a procedure to reduce expensive simulation experiments with Taguchi design. This approach finds a new design considering discrete factors which affect the performance measures of FMS. Furthermore, an optimal design configuration is obtained for the considered system to improve performance. This proposed system, which was built by the system had a better throughput prates, shorter cycle times, and overall better WIQ. The system has an overall performance improvement of approx. 3.4 times higher throughput, and 2.86 times shorter cycle (Tansel et al., 2014). Li et al. presented on the challenges of production planning, which was quantifying the dependence of the objective criterion upon the decision variable that specify a release plan of jobs. It postulates that current methods are falling short and can't accurately capture this relationship. They used metamodels to support responsive decision making for production planning and related the objective criterion to the decision plan. It put forth future work for this project and data, which was to use this data to move forward and apply this model simulation to real world outputs. The goal is that the empirical data will support the potential to reduce the short comings of previous models (Li et al, 2014). In 2013, Akcay et al. considered newsvendor problem with stationary and temporally dependent demand in absence of information regarding the demand process. The goal of this paper was computing a probabilistic guarantee that could calculate the expected cost. This was done by sampling random variates that matched dependence structure. Another goal was to present on the role of temporal dependence in probabilistic guarantee. A sampling-based method to compute a probabilistic guarantee was proposed. Furthermore, the paper concluded that when there is no temporal dependence probabilistic guarantee takes maximum value (Akaay et al, 2013). Gutenschwage et al. analyzed an approach to managing C02 efficiency. The paper was approaching the shortcomings of simulations when showing certain events. Specifically, the shortcomings of LCA database in conjunction with simulation. There is also a proposal on a data model that enables discrete even simulation of SC logistics. The proposed model has been illustrated to reduce Co2 impact on a distribution supply chain. This allowed for greater accuracy and aggregation, based on a thorough requirement analysis. Future work is to expand this model to other manufacturing processes (Gutenschwage et al., 2010). Fischer et al. analyzed how commercial software is being used to layout a facility in a simulation model. It was proposed that a new algorithm would be able to automatically determine motion paths for moving objects. This algorithm works on a basis of 3-d data for the simulation visualization data. The algorithm was able to produce a fast path of producing moving objects through various lay outs. These results could be expanded out many simulations and manufacturing processes (Fischer et al., 2010). Siego-Vadal et al. performed a study on a real-world scenario to simulate how modeling was used to understand the behavior of simulation systems. The authors of this paper used sensitivity, design of experiments, regression analysis for meta modeling, and optimization to determine critical measures and discover how they relate to output variables. They postulate that typical simulation optimization methods are not of practical value for the application. An optimization tool based on metamodels helped to validate local optimum and establish search regions. The optimization problem was smooth non-linear type that required the use of generalized gradient algorithm. There was an understanding that optimization would be based on various outputs and the potential throughputs would reflect these (Siego-Vadal et al., 2011).

Dengiz et al. proposed a redesign of PCB production line with simulation and Taguchi design. The paper also presented on the problem of determining optimum conditions in manufacturing processes for a company. Essentially, during the optimization phase a Taguchi method is unintegrated with the simulation model considering minimum total cost. The aim was to minimize the costs associated with idle times and resources on the production line and cost of products. When the optimization simulation was running it was seen that the total cost of the system was reduced by 46.63 percent (Dengiz et al., 2010).

Santos and Bispo presented on a simulation-based optimization package for a review on inventory. Inventory is one of the more important things to analyze, as improper inventory controls can result in catastrophic results to lean and six sigma ideals. These presented results allow us to extract useful results about managerial insights and machine usefulness. One of the main insights gleaned was that performance improvements are a result of reduction in inventory buffer variances. By reducing these variances, very favorable results were attained (Santos and Bispo, 2017).

Stefan and Pappert analyzed the results a time bound constraint places on the metallization of an opto-semiconductor FAB presented interesting results on product quality vs time dependent features. They examined planning horizons, influence of dedication, and the capacity loss due to time bounds. Using these examinations, actions were proposed to take direct action in response to the experiments ran. Time bound sequences are a common constraint in semiconductor manufacturing. The constraints represent time bounds which is the number in which steps should be performed. The results of this paper show the importance of controlling the time bound constraints (Stefan and Pappert, 2017).

Finally, Hubl and Altendorfer showed analytical advances in simulation. These advances in production addressed model's ability to be flexible and handle the capacity of a production system. Furthermore, a simulation study for the evaluation of stat probabilities for flexible capacity with one and two switching points is conducted. In a simulation study the state of two probabilities was examined and a high capacity analysis was done on the system metrics (Hubl and Altendorfer, 2016).

3. Data Collection

The product arrives at the first point in the assembly plant system which is a conveyor. Information is required to model the conveyor system to figure out the arrival time of the product. In order to figure out the arrival time, many discussion sessions with the local engineers at the plant have

been conducted to get the current setting of the Trim III process-line. The data that has been provided is the process-line runs at a standard rate of 55 JPH (jobs per hour), therefore, within an hour time, 55 completed jobs will be leaving Trim III and entering into Trim IV.
Given this value, it can be used to calculate an average cycle time per station is 64.5 seconds. The cycle time has been calculated by dividing 60 by 55 and then multiplying the result by 60. The 64.5 seconds is the average time a product stays at each station. The run set up is 7.2 hours. The analysis for 7.2 hours is because the data designed per shift basis in order to analyze the direct effect. The value 7.2 is used because this has been factored in the time that the process-line is not running.
The downtime is 0.8 hours of the breaks received for lunch and two twenty minutes breaks throughout the shift. The model is designed to accurately mimic the outcome of the real-world assembly plant by measuring the real-time represent the process-lines, it is modeled to get as close to system depiction as possible. Since this is the procedure to follow, system verification is possible to be realized. The results validated as have been expected. The assembly plant was scheduled to have 1170 vehicles leave the facility per full day of production. Since the plant runs for three shifts a day, our original production without any bottlenecks has been around the value of 390 units. With original units produced a value of 382 without any product being transferred to the scrap section. Eventually, the model is verified that is the model set-up followed within correct values of the real-world system, and considered valid for research experimentation and analysis.

4. System Modeling

The current assembly plant system has been modeled as it existed in reality; Figure (1) illustrates the system configuration in the real-world. The system has modular logic has been observed for developing the model, vehicles are moved throughout the 16 stations on skillets. Therefore, processing jobs are brought into each station at the same time.

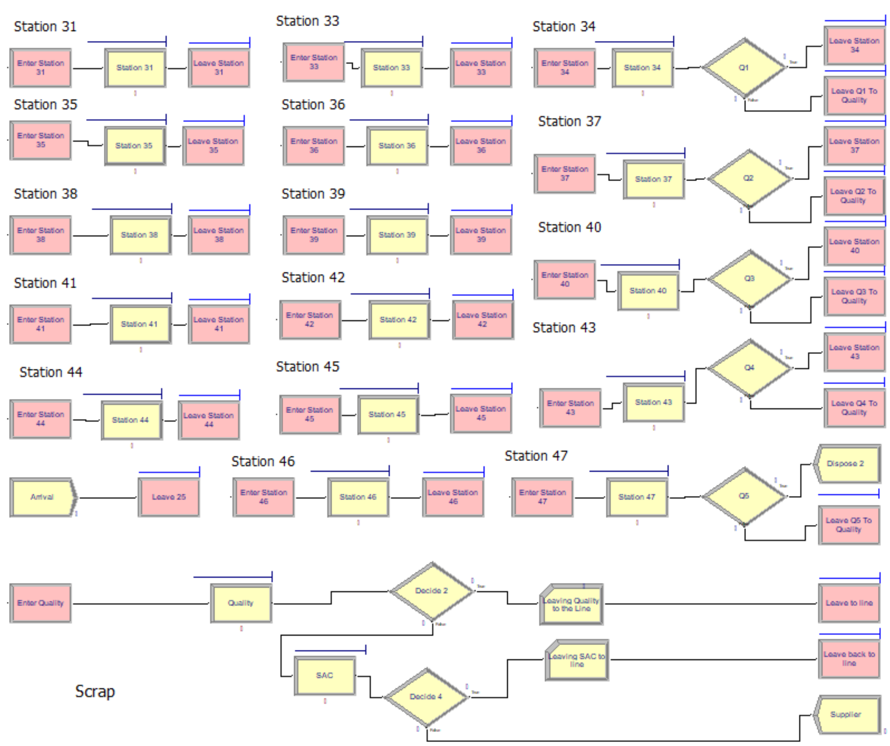

Figure 1: Current System Model with Quality Section and Scrap Section

At the end of each group, an average of every four operations is considered a team of operators, there is a quality check process that takes place. At this location, the product can either be passed as satisfied or failed. If the product is failed, then it is removed from the vehicle and transferred directly to the quality section. Within the quality section, there is a quick test for the product in order to determine if the product can be put onto a vehicle, and if for some reason the system made an error. If the product is ruled as satisfied, then it is placed back into system circulation. If the product is failed, it will be transferred to the scrap section in order to take part in a deep test. From the scrap section, satisfied products will be transferred back to the install of the process-line. However, if the product is failed by the scrap section and ruled that it is not within the quality specifications, it is then rejected back to the supplier.

Figures (2) shows a layout comparison for the current and proposed system for the improvement. The figure illustrates the modifications that have been made to the current system layout of the assembly process-line to increase efficiency. The figure shows a layout comparison for the current and proposed system for improvement. In order to increase efficiency, lean principles have been applied. The main target of the lean strategies is to combat the waste that occurred throughout the assembly plant. By eliminating the double-handling as demonstrated in the objective, it is necessary to remove the quality section from the model. With eliminating the quality section, the scrap section becomes the main point of rejection and approval for all products within the system.

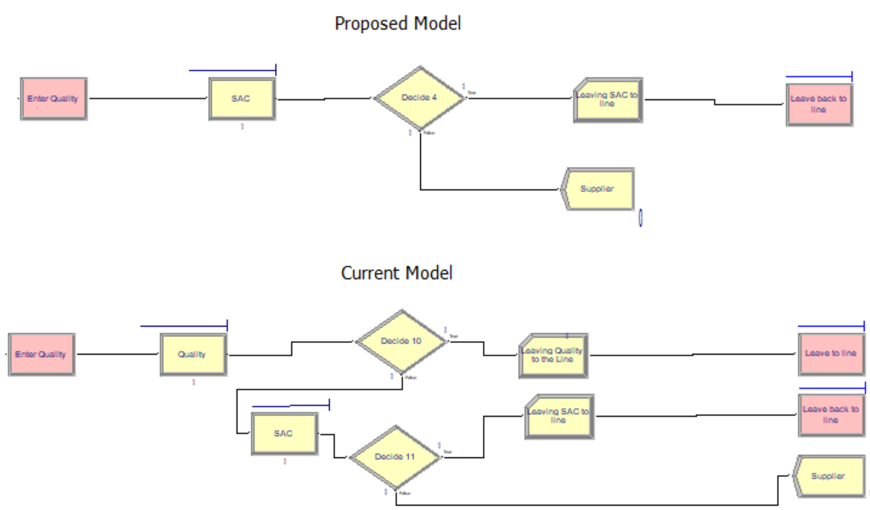

Figure 2: System Layouts Comparison of Scrap Section and Scrap-Quality Section Models

5. Results Analysis

Three different models used for the experimentation and testing the application of lean principles that are the system with no scrap section, the system where failed products can go to both quality and scrap sections, and the system in which the quality section removed and the rejected products can only enter scrap section. The first set of experimentation is to run the model without including the scrap processes. The throughput result of the first run is 382 units. This result set is very close to the schedule, with planned production per shift being 390. Analyzing the result shows reassurance of model validation that data used to model, and experiment are the correct values in addition to validating proposed scenarios of improvement for the assembly processes. Within the large scope, validating values result in that running the model are very accurate compared to the plant floor measurements on a day to day basis.

The second run includes both the quality processes and scrap processes. The throughput results are 302 units. This value also makes sense because with both check sections included, there is a large chance that throughput results out can be less than planned. This is because the process-lines of the assembly plant can produce less when fewer products are leaving the process-lines. The third run is the one in which the lean principles applied and removed the quality section. With only the scrap section being used to check products; 331 units are to Trim IV. The assumption to run the experimentation is that the cycle time of the model directly correlated with the total throughput results of each process-line. The model without any sort of quality and scrap sections had an average cycle time of 16.172 seconds. This is much shorter than the average cycle times of the other two models. The cycle time of the model that included both the quality section and the scrap section is an average cycle time of 71.1974 seconds. The increase in value is reasonable because the products can go through both processes, which increases the total time within the system.

There is a reduction observed however when the quality section is eliminated from the system. The cycle time of the scrap section is 35.6451 seconds. Therefore, when the quality section is eliminated from the system leaving the scrap section as the only quality check station, the products spend less time in the system making it more efficient. Therefore, when double-handling is removed from the system, then it is much more efficient. This result makes sense because when waste from the system is removed, then it is ultimately a leaner system. The system is leaner because it uses fewer resources to create the same if not more throughput. Table (1) shows the result date of the experimentation that used to analyze the improvement scenarios as experimentation setups.

Table 1: Improvement Scenarios with Key results of System Experimentation

Experimentation Setup	Production Units	Cycle Time (second)	Double-handling Products	Rejected Products for Supplier
No Scrap	382	16.172	0	0
Quality & Scrap	302	71.197	18	1
Scrap Only	331	35.645	0	3

With all of this data analyzed, it is reasonable to find that by removing the quality section from the current real-world process, the waste will be eliminated and the company will save valuable cost and other important resources while improving the total production outcome. The main objective of this research work has been to optimize the entire system performance by eliminating the double-handling process. In order to determine proposed solutions can increase efficiency, the model focused on results throughput and cycle time. This allowed to directly compare the effect of involving double-handling in models of process-lines while maintaining the real-world assembly process-line constant. Although statistics of variables such as bottlenecks, WIP, or process-lines balancing can be used to analyze considerable effects on the system, the experimentation analysis does not factor in the variables statistic. Also, in order to validate the representation, variables have been limited, therefore, bottlenecks, WIP, and process-line balancing were left untouched.

6. Conclusion

With the developed models using the computer simulation to present the system configuration in the real-world assembly plant, it is approachable to create improvements and derive recommendations to pursue for the Big-three companies. Eliminating the double-handling within the system increases the productivity and throughput of the systems. Creating a concrete system that is applied to each automotive plant is critical in terms of maintain the consistency within several aspects of the teams and company.

This benchmarking may be time-consuming; however, every automotive plant needs to be on the same board in order to maximize the results. Therefore, more tests need to be run to analyze if there are any drawbacks to completely removing the quality section from the process-lines. Reducing this step can lead to an increase in products that are transferred back to process-line that are failed products but have been overlooked. This creates a problem with the overall quality of the final product which is the main focus of the assembly plants. Therefore, increasing in the risk of having failed products get back into the rotation of the system, then the chance for a quality recall is increased. This will cause the company to have to spend an extra cost fixing very simple issue that have been prevented. Therefore, for the purpose of this research work, it makes sense to remove the quality section as double-handling of products, however, in the real-world, it may not be practical to actually remove this step from the system, because the small decrease of throughput, may be worth the risk of a quality recall.

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