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Workload Utilization and Process Reengineering Using Value Stream Mapping In an Electronics Manufacturing Industry

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Abstract: Value Stream Mapping is a lean management technique that investigates the present set-up of the production and schemes a future state for the sequence of activities to transform a product from raw material into finished good. It scrutinizes process utilization and examines non-value added activities. Using the value stream mapping, the organization illustrates and improves the flow of manufacturing set-up and production process as well as the information of material flow.

This study shows considerable improvement in cycle time and standard time to increase productivity. Value Stream Mapping was a useful tool used for identifying the processing wastes and developing the overall effectiveness and efficiency in different types of manufacturing industries. The detailed and current state map was used to identify the flow of the production including the sub-processes and activities of sub line, mainline and final line. A Current State Map was drawn to explain how things actually operate on the assembly line. Future State Map was developed by the researcher to create a lean production flow through the reduction of the root causes of waste and through production improvements.

The collected data signified that the improvement of production cycle time and standard time, proper division of workload and elimination of any waste process step had been successful. Process simulator provides the design with perfect information which pertains to the correct and effective output produced in the alternative designs. The researcher used process simulator to find out the accuracy and efficiency of a new design before the system was actually created. The future state map helped to saved 81.26% reduced the non-value added activities, standard time reduced by 21.85% and increase production output by 8.25%. The improved method had an impact in utilizing man activities and improving the process through the elimination of unnecessary and redundant process steps thus, enhancing the whole production system.

Keywords: Value Stream Mapping, Value Added, Non-Value Added, Production cycle time, Standard time, Process utilization.

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Introduction

Every manufacturing industry is striving hard on getting quality achievement and quality standards. The fundamental goals of any product company are to continuously minimize waste, eliminate non-value added activities, manpower and process utilization, reduce process cycle time and operating cost, improvement process layout and maximize flow which would satisfy the customers by producing right product at the right time with the right quality and quantity. To improve productivity and flexibility, the production management of a company resorts to certain means that could lead to the attainment of these objectives. These can be achieved greatly by adopting value stream mapping which is more than a cost reduction program to describe and develop the flow of manufacturing industries and production line, and the information that directs the flow of materials during the process development.

Workload utilization is the amount of work assigned to or expected from a worker in a specified time period. It is a big help to identify the actual needs of human resources in one specified process and utilize the operation of the production to meet quality and quantity standards. Moreover, it is planned upon determining the place to prevent the delay of performance on every assigned task as well as to enhance labor productivity. Workload information can also be used to predict future employee needs (Hutagalung and Gustomo, 2013).

Process Reengineering greatly increases productivity through the reduction process of time, cost, quality improvement, and greater customer satisfaction. The purpose of business process reengineering is to completely overhaul existing methods. Processes were redesigned from the ground up with a renewed focus on the company's mission and the customers' needs. For most companies, the primary goal of Reengineering is to radically improve productivity, quality and cost efficiency, transforming a company that is barely competitive into a serious contender (Sturdy, 2010).

Lean is defined as the systematic removal of waste by all members of the business organization from all areas of value stream and it is also referred as a cost reduction mechanism. It is rigid and makes organizations more competitive and aggressive in the market by increasing efficiency, declining costs incurred due to minimization of non-value added activities and efficiencies in the processes as well as reducing production cycle times and continuously increasing the organizational profit. Lean manufacturing aims to reduce waste in every area of production including customer and supplier relations, product design and development, and factory management (Ahmad, 2011).

As stated by Erikshammar *et al.*, (2014), Value Stream Mapping (VSM) is an important tool for a continuous improvement in the manufacturing industries. It has become a common tool in implementing lean thinking in manufacturing processes. Also, it is a useful tool for identifying a particular waste and developing its overall effectiveness and efficiency in different types of manufacturing industries (Saraswat *et al.*, 2014). Value Stream Mapping is an essential tool since it helps the company visualize beyond a single process level and determine the area where wasted resources come from. It allows the management to easily see the actual situation in the production area. Hence, its most important goal is to identify opportunities and constraints for productivity improvements in the future. Each step of the production process was examined to determine if it non-value added, slightly non-value added or value added activities to the product. Value Stream Mapping has the reputation of uncovering waste in the manufacturing set-up and business production processes by identifying and eliminating or streamlining non-value-adding activities (Vasnani *et al.*, 2017). Process Simulator can be used to plan make decisions for a range of process improvement purposes, including Value Stream Mapping and Lean Six Sigma. Process Simulator's functionality is tightly integrated with Visio (Solutions, 2005). The researcher used process simulator to find the efficiency and correctness of a proposed design before the system was actually created.

The researcher deemed it necessary to conduct a study with a primary aim which was to identify wastes, unnecessary movements of materials and worker motion, waiting and delays, and over processing.

The primary concern of this paper was to explore how a value stream map would be useful in lean implementation and to develop a future state map that tackles improvement areas between the present state and the new proposed state of XYZ Company.

Related Literature

In the conducted study of productivity improvement using Value Stream Mapping, the researcher aimed to carry out VSM for the production cycle time and standard time. The main objective of this study was to increase the productivity overt the demand. The process of VSM future state map shows significant improvement in the assembly process. Its throughout time reduced from 1018 seconds to 926 seconds, which demonstrates that any delay can be analyzed through value stream mapping (Pambhar and Awasthi, 2017).

According to the study of value stream map, to reduce the lead time and processing time, the work content can be decreased by 30.3 percent, the delivery time by 38.6 percent and in-factory lead time by 68 percent (Smits, 2012).

The purpose of a study made by Stadnicka and Antonelli (2015 was to analyze the Current State Map of the manufacturing process, to determine the existing wastes and unnecessary motion, and to analyze the problems encountered including the present set-up for a value stream development on Future State Map. VSM is a commonly assessed method employed for the analysis of manufacturing processes. The principal asset of the method is its ability to identify wastes. Through lean manufacturing and lean management, wastes can be eliminated. In the paper, the research study of a manufacturing process of sleeves is presented. The current value stream map (CSM) and the future value stream map (FSM) of the sleeve manufacturing process are used. In Current State, it is possible to utilize only 36.61% of the time in Phosphatizing of Internal Sleeve, and 36.33% of time in Phosphatizing of Intermediate Sleeve. In Future State, this value obviously increases to 71.84% of time.

Rauniyar (2007) conducted a study of Value Stream Mapping. Based on the result of the current state map, 53.8 hours reduced of the lead processing time of a product or equivalent of 30.7 days lead time. The processing time and the lead time gives the non-value added time. The mode of production is in large batch sizes. The attain value of work-in-progress inventory is worth 19.55 days which is equivalent of 63.68%.This evidently shows that there is a massive amount of non-value-added activities in the process flow which is in the form of waiting for materials, moving materials and setting-up time. This explains that the company has enough stock of work-in-progress inventory to back up customer demand during lead time.

The implementation of value stream mapping concept is found to lead to a considerable improvement of production line efficiency for one major stamped part in a make-to-order company. Though the overall gain due to the benefit accrued and the cost of resources incurred needs to be assessed precisely, it is likely that the increasing improvement with value stream map application for all the vital items handled by the company is deemed to make a substantial contribution with which the company is expected to enjoy a competitive edge over its rivals. Based on the result, the production line was improved from 48% to 93%, which significantly enhanced the current level of production cycle. The company can be highly benefited for the minor adjustments in the system. Thus, it is evident that with the implementation of the value stream map concept, capacity utilization of resources could be significantly enhanced and the production lot would be greatly reduced (Karim *et al.*, 2012).

According to Habib *et al.*, (2013), value stream mapping has been used to identify the bottleneck of the production process. Traditional printing works in maximum garment manufacturing industries are facing different problems encountered like longer production lead time, low productivity, high rework and rejection, lower quality product, low flexibility, and high non-value added work. Fifty percent (50%) reduction by eliminating bottleneck of the production process, reduction of non-value added activities and unnecessary motion. The final output of processing time was decreased using bottleneck reduction. After the implementation of these tools effectively, the result shows an important improvement of the production than before and these tools give the way to go forward and thrust to reach at the end point. The rejection level was decreased by seventy percent (70%) after the implementation, eighty percent (80%) reduction for repairing of works.

Another study of value stream mapping was presented by Goriwondo *et al.*, (2011) in Bread Manufacturing Industry, the company identified different ways to reduce unnecessary activities and to increase the proportion of the processes that add value to the product. This paper detailed the use of the value stream mapping tool in eliminating waste in bread manufacturing for a company in Zimbabwe. The case study showed how the VSM tool was used to identify and reduce defects by twenty percent (20%), unnecessary inventory by eighteen percent (18%) and motion by thirty seven percent (37%). Waste reduction is essential for incorporates relationship ranking and for the entire management to achieve right and standard quality product and services. The Future State Map signifies an average twenty five percent (25%) waste reduction in the critical areas of defects, unnecessary inventory and motion. This will translate directly to cost savings per given time and passes on from batch to batch and if extended to other product lines, it will yield profitability for the company. There is also an envisaged sixteen percent (16%) increase in throughput in the Future State Map. This was achieved through the application of the Future State Map which has an increased throughput of sixteen percent (16%). It is however noted that there is a major cost to complete any changes required but the increased throughput against the takt time will pay back for the company improvements.

It has been illustrated very clearly in this work that lots of improvement areas were found with the help of current state map. Current state map and future state map were prepared and analyzed to highlight the benefits of a lean system in an electrical control panel assembly. Then, the following conclusions were made: first, inventory of all forms were reduced by implementing lean manufacturing tools. Second, the lead time in an electrical control panel assembly was reduced as a result of work balancing. Next, cycle time of the bottleneck operations were reduced below the takt time, and lastly, the value added ratio was increased after lean implementation (Rajenthirakumar, 2014).

Objectives of the Study

This study focused on workload utilization and process reengineering using value stream mapping. The researcher intended to obtain process maximization and strict utilization of production time and determine the non-value added through the use of lean manufacturing concept and through the aid of value stream mapping hence, attaining optimized process and material flow.

Specifically, this study aimed:
1. To determine the current production system of project S4 in terms of:
1.1 Production flow diagram
1.1.1 Sub line;
1.1.2 Main line; and
1.1.3 Final line.
1.2 Production standard time and manpower requirements in terms of:
1.2.1 Sub line;
1.2.2 Mainline; and
1.2.3 Final line.
1.3 Production Output
2. To identify problems encountered in terms in workload utilization;
3. To present the detailed current state map of sub line, mainline, final line of project S4;
4. To improve the production line of S4 in terms of:
4.1 Production Flow;
4.2 Production Process; and
4.3 Production Output.
5. To assess the benefits of before and after improvement;
6. To validate the result of improvement study using process simulator; and
7. To develop future state map based on the implemented improvement.

Significance of the Study

The output of the study would be beneficial to the company, the customers, the proponent and future researchers. This study would benefit the customers since they could satisfy their need for high quality services and products through the company's improved production process. With the new setup, they would assured that they would be able to acquire the exact number of units they ordered without any delay.

The researcher, likewise, would gain something from this research work because it would broaden his understanding of the concepts and principles of value stream mapping. Moreover, he could apply everything he learned from doing this study into his future careers and endeavors.

Scope and Limitations of the Study

The focus of this research was to identify the significance of value stream mapping as a waste reduction tool at XYZ Company in order to improve its productivity. It had certain limitations that allowed the researcher to only concentrate on the details required in the study. Although there are many areas of work that could be looked into, but the researcher focused only in project S4 and the most recommended model of the company because of the issues of low productivity. Hence, data collection and analysis only took place at the production line of S4 model. The researcher exclusively studied and observed the day shift of production to get information focusing on process, layout and manpower. However, the researcher was not able to gain complete access to other information because of some confidentialities in the company.

The research study would be applicable to all electronic manufacturing industries.

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Materials and Methods

A conceptual framework is an unified set of ideas, knowledge and theories about how a particular functions or is related to its parts. The conceptual framework serves as the basis for understanding the causal or co-relational patterns of interconnections across activities, ideas, observations, concepts, information, interpretations and other components of experience (Reddy and Rao, 2016). Different aspects for the study such as input, process and output had to be considered to achieve reliable results. These became the basis on how the study was conducted to determine what processes would help accomplish the objectives.

Figure 1 shows the conceptual paradigm of the study. The input is consists of the current set up of XYZ Company specifically in the production of S4 such as production flow diagram, process and output which were based on the conducted time study, observations, interviews, and historical data provided by the company. Meanwhile, processincludes the knowledge of the researcher in relation to the lean manufacturing and theories of methods engineering and work measurement. It is composed of the methodologies used in the study such as application of value stream mapping, time study and lean manufacturing.

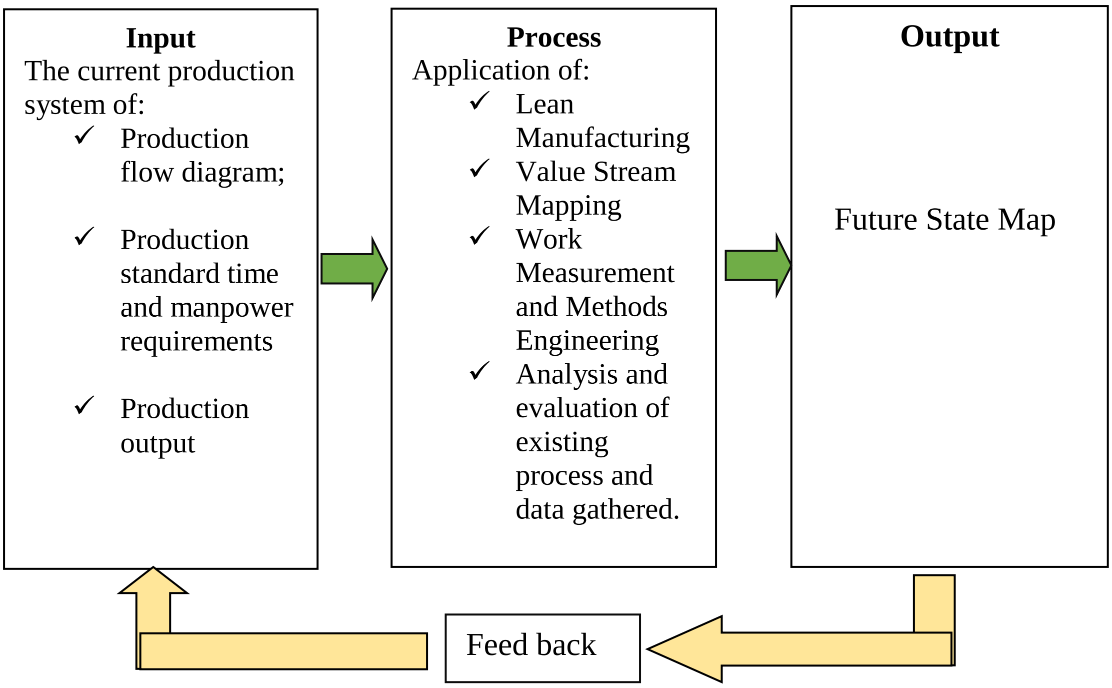

Figure 1. Conceptual Paradigm

It also covers the analysis of the existing process and data gathering procedures to evaluate wastes, standard time, utilization of manpower and methods of improvement for the process. Consequently, all of these would lead to the output of the study which is the productivity improvement, manpower utilization and lean process reengineering of the production of S4 at XYZ Company. The concepts and theories used by the researcher in the application of methods and tools detailed in the process helped him to arise with the output of utilization, increased productivity, reduced non value added activities, and reduced cycle or processing time using Value Stream Mapping.

The researcher used the applied approach in the improvement of process steps in production and the elimination of wastes through the aid of value stream mapping. Applied research refers to scientific study and research that seeks to solve practical problems. It accesses and uses accumulated theories, knowledge, methods, and techniques. The research involved situations in which the plan development process was analyzed and described and the method was evaluated and refined.

The researcher aimed to understand and analyze the data to be collected in the selected area and to create a future state map which would show the optimum process flow for the project S4. Value stream map (VSM) is used as a tool in lean manufacturing, to create improvements in the possible areas of workstation and to build modification from the present or current state to future state which helps in reducing the waste, eliminate non value added activities and increase productivity.

Data Gathering Instrument

The aim of the study was to utilize manpower and to provide process improvement for the line of S4. In order to attain these, the researcher observed and familiarized himself with the process in the production area and the company's work environment. From these observations, the researcher gathered relevant data and proceeded with the conduct of the study.

The researcher obtained historical data from the document control center of XYZ Company to identify the lowest productivity for different model of actuator; he observed the actual operation of project S4, and its flow process which mainly focused on man, machine, material and method; then he illustrated the current state map of production through the use of Microsoft Visio and identified the processing time and conducted an assessment of workload utilization and time study for every process.

Afterwards, the researcher used different engineering tools to deepen his understanding about the factors in the production line; he re-observed the new process of the production. Thus, the comparative analysis was based on the actual data gathered through observation and previous studies; then he showed the comparison between the current state map and the future state map to measure the effectiveness of the study.

Data Gathering Procedures

The researcher gathered the needed preliminary data from the management. These include the record of demand of project S4 for the month of March 2018, the orientation of the processes involved in the production, and other data related to the present scheme of production.

After gathering the preliminary data, the researcher conducted series of observation and time study to determine the effectiveness of the current system. He interviewed a supervisor and some operators to widen his understanding on the production system and the real situation in the production area. After analyzing the system, the researcher formulated alternative layouts in project S4 for the sequence of operator movements and the distance of transportation he covered in performing such activities. Thereafter, the researcher simulated and observed the proper work load of operator and process utilization to determine the process efficiency of the previous and present weeks.

Results and Discussion

Problem Encountered In Workload Utilization

The researcher determined the cause-effect relationship of a problem or a failure event using why why analysis. He identified whatever the real cause of a problem or situation is in terms of process and workload utilization in the sub line, mainline, and final line of S4. Table 1 shows the why why analysis of the production of project S4. The researcher observed and analyzed the situation of the production line. Then, he found out that the major concern in the production line was the improper utilization of workload to operator.

The second why in the said analysis was not a true cause because there was a clear responsibility matrix or job description for the activity sheet. The third why made by the researcher was a true cause because the process is not yet properly established and there is no time and motion study conducted from each line of production. Thus, the researcher proved that the distribution of activities to the manpower was the major concern of the research study. After identifying the problems, the researcher conducted motion and time study to the production line of S4. Then, he designed the detailed and current state map to develop a future state map for the XYZ Company and would also be applicable to all electronic manufacturing industries.

Table 1. Why Why Analysis

Problem	Why 1	Why 2	Why 3	Why 4	Why 5	Validation Tool	Validation Result	Conclusion
Improper workload utilization	Activities are not properly distributed to operator	Activities at the program sheet are not updated	No one updated the program sheet	There is no assigned personnel to update the program sheet	Responsibility is not properly defined	Check the responsibility matrix or job description	Clear the responsibility on daily program sheet	No True Cause
			Process is not yet properly established	There is no time and motion study made on each line	Optimization line is not a prioritized activity	Check the list of productivity projects of the department	There is no project related to line productivity	True Cause

Detailed and Current State Map

The value stream map is the pictorial representation of the data gathered for the given production line of S4 specifically in the three main process: subline, mainline and final line. In particular, the value stream map was performed so as to better understand the actual design of the production process and to identify and eliminate waste. Detailed process mapping provides more detailed activities with a much deeper dive into a process. Figure 2.1 shows the detailed state map of sub line process. The activities of every sub-process were presented in the given figure. The researcher used the detailed process map to determine the value added and non-value added activities of the process.

In conducted study of sub line process, the total value added was 30.29 sec and 5.27 sec for non-value added activities. AF carrier arrange and attach obtained 5.57% of value added while 2.39% for non-value added activities. Coil bonding process obtained 4.7% for value added and 1.91% for non-value added activities. The third process obtained 12.43% value added, and the fourth process obtained 8.97% valued added and 2.73% for non-value added. First coil arrange obtained 3.43% and zero for non-value, bottom spring attach obtained 5.68% value added and zero for non-value, boss melting process obtained 5.51% value added and zero for non-value, 2nd coil arranged obtained 5.96% value added and zero for non-value, coil cutting 6.13% value added and zero for non-value, and thermal welding.

Obtained 1.08% valued added and 2.72% non-value added. AF carrier assy process obtained 5.26% value added and 0.5% for non-value added, coil welding bonding obtained 2.02% value added and for non-value added it obtained 2.17%. The aging process obtained 6.61% and the final process of sub line obtained 9.87% value added and 2.36% for non-value added activities. Through the detailed state map, the researcher found out that the AF carrier and arrange, AF carrier coil bonding, aging, thermal welding, AF carrier assy first visual, coil welding bonding, and made assy visual and made assy detach with 14.82% non-value added activities were not important.

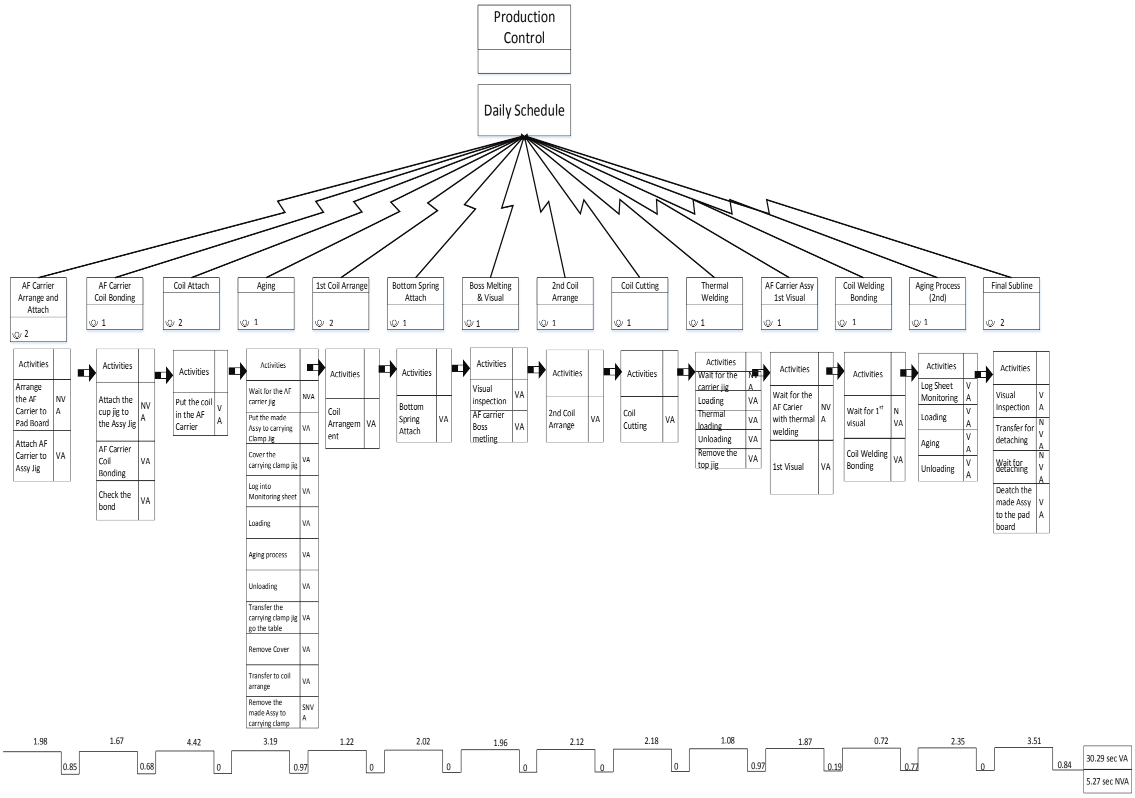

Figure 2.1. Detailed State Map of Sub line Process

Figure 2.2 shows the detailed state map of mainline. The researcher helped the company to eliminate the unnecessary activities using the detailed process mapping of mainline. Based on the existing study, the total amount of value added activities (VA) is 33.60 sec while for non-value added (NVA) it is 5.91sec.

The first process of mainline obtained 9.49% VA and 0.9% NVA, the second process obtained 5.67% VA and zero NVA, third process obtained 3.74% VA and zero NVA, the fourth process obtained 6% VA and zero NVA, fifth process obtained 4.53% VA and zero NVA, sub assy aging obtained 5.95% VA and zero NVA , cover attach obtained 1.14% VA and 3.47% NVA, reverse process obtained 1.92% VA and 3.70% NVA, jig inspection obtained 0.8% VA and 2.76% NVA, auto magnet insertion obtained 4.33% VA and 1.44% NVA, and sub assy cleaning obtained 8.48% VA and 1.29% NVA, bottom side bonding process obtained 5.75% VA and zero NVA, because all activities in this process are important. The contact bonding process obtained 10.05% VA and 1.34% NVA, the causes of unnecessary activities were based on the waiting time. IR base attach was obtained 5.8% VA and zero for NVA, the cover side bonding obtained 6.05% value added, and the last process of mainline was obtained 5.29% value added activities.

The researcher observed that the causes of non-value added activities were based on the different delays in every activity. Waiting time in the production line was the major problem of the production process that causes delay. Then, the researcher also observed the improper location of the materials that are needed in the next process.

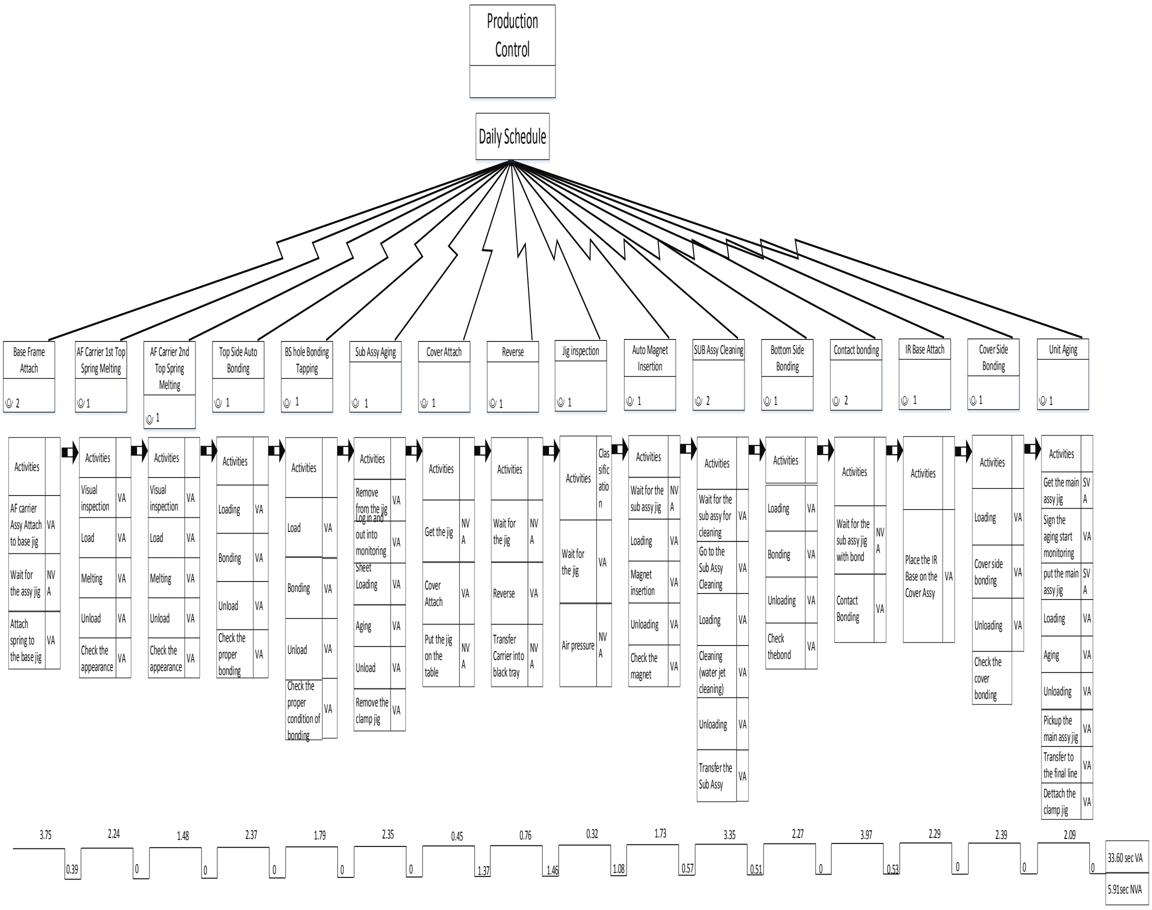

Figure 2.2. Detailed State Map of Main line Process

Figure 2.3 shows the detailed state map of final line. The figure presents the whole process of final line including the different activities of the production line. The detailed process mapping was used to identify unnecessary activities.

In conducted study of the researcher, the total value added activities obtained 23.11sec and the non-value added activities obtained 5.12 sec. Second final visual and final check encountered unnecessary activities, 12.72% VA and 5.42% NVA.

The causes of non-value added activities were based on the improper workload of activities to the manpower

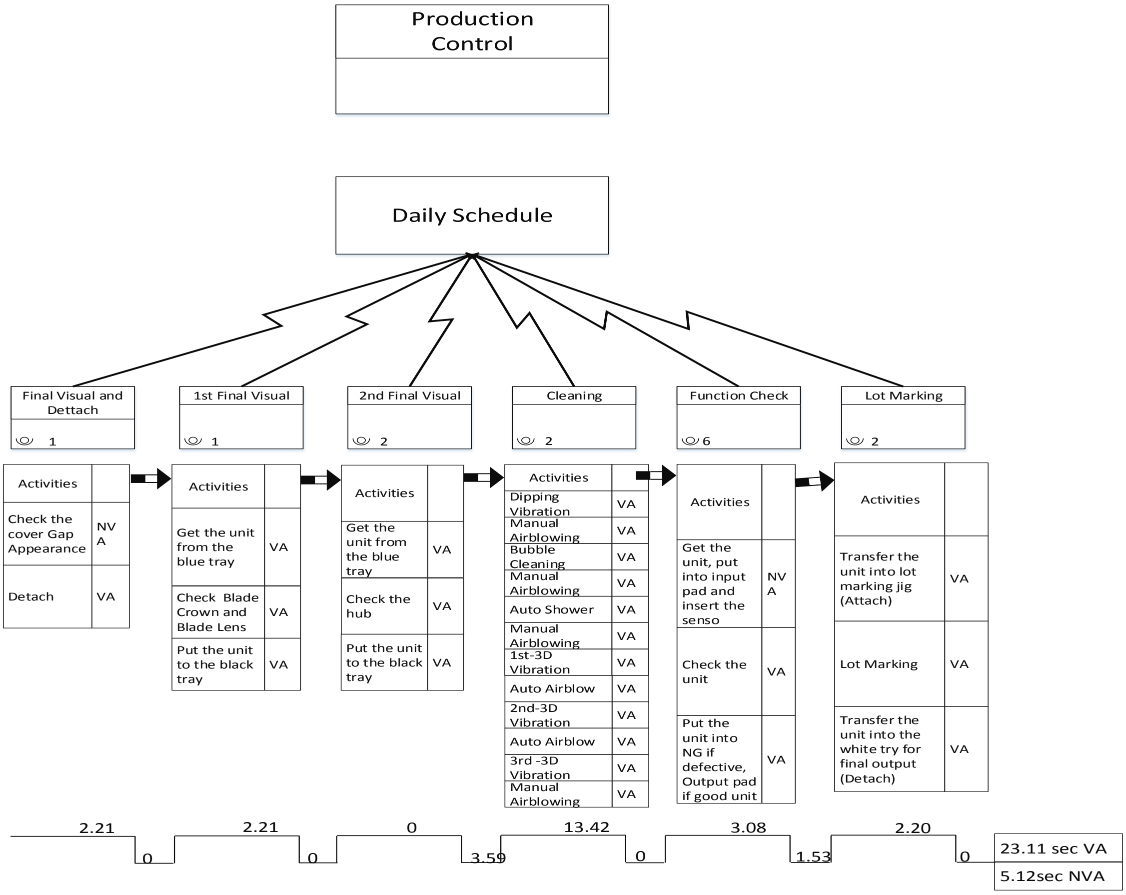

Figure 2.3. Detailed State Map of Final line Process

Improved Scheme

The production analysis was conducted in the process flow of the project S4 in order to improve some of the problematic areas of the research development. Afterwards, the researcher conducted the time study after the simulation of the process in sub line, mainline and final line. Finally, improved alternative solutions were proposed based on the process simulator to validate the process improvement.

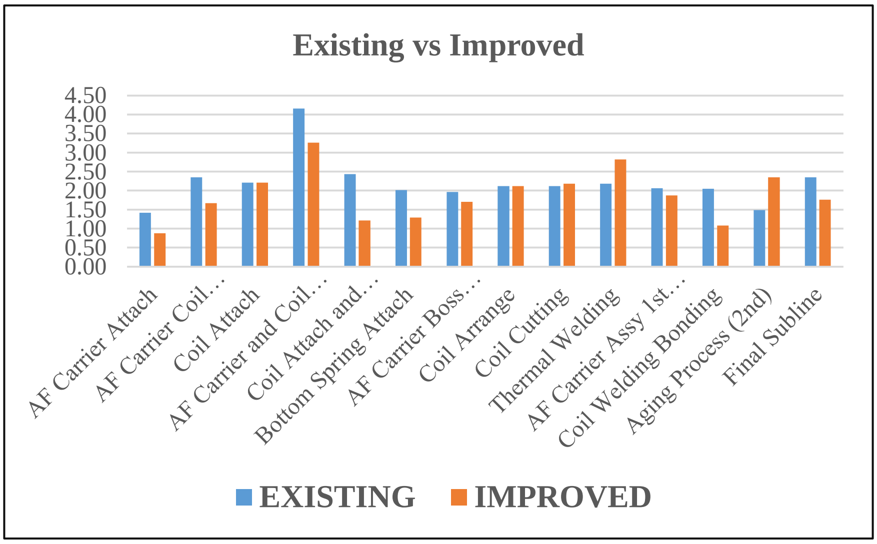

Figure 3.1 Comparison of Existing and Improved Process of Sub line

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Figure 4.2.1 shows the comparison of existing process and improved process of sub line. The first sub-process was improved to 38.03%, the AF carrier coil bonding was improved to 28.94%, AF carrier and coil aging was improved to 21.63%, coil attach and arrange was improved to 49.79%, bottom spring attach was improved to 35.82%, AF carrier boss melting and visual was improved to 12.76%, thermal welding was improved to 68.93%, AF carrier assy 1st visual was improve to 8.78%, coil welding bonding was improved to 27.52%, and the final process in sub line was improved to 18.89%.

The average improvement of this sub line process was 22.22%. Figure 4.2.1 shows the comparison of existing process and improved process of sub line. The first sub-process was improved to 38.03%, the AF carrier coil bonding was improved to 28.94%, AF carrier and coil aging was improved to 21.63%, coil attach and arrange was improved to 49.79%, bottom spring attach was improved to 35.82%, AF carrier boss melting and visual was improved to 12.76%, thermal welding was improved to 68.93%, AF carrier assy 1st visual was improve to 8.78%, coil welding bonding was improved to 27.52%, and the final process in sub line was improved to 18.89%. The average improvement of this sub line process was 22.22%.

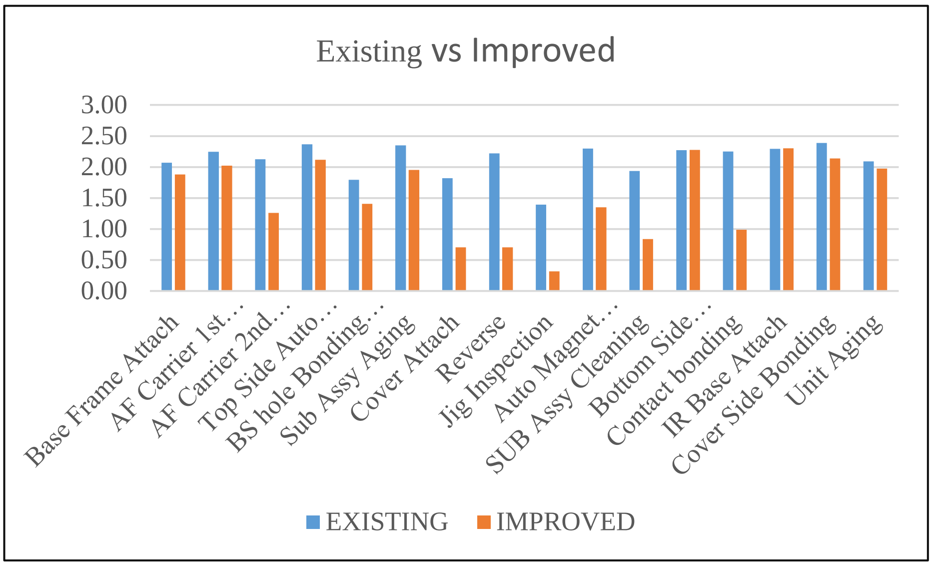

Figure 3.2 Comparison of Existing and Improved Process of Mainline

Figure 3.2 shows the comparison of standard time of mainline. Base frame attach was improved to 9.18%, 1st top spring melting was improved to 9.82%, 2nd top spring melting was improved to 40.85%, top side auto bonding was improved to 10.55%, BS hole bonding tapping was improved to 21.23%, sub assy aging was improved to 17.02%, cover attach and reverse were improved to 61.54% and 68.47% respectively.

Jig inspection was improved to 76.98%, magnet insertion was improved to 41.30%, sub assy cleaning was improved to 56.48%, contact bonding was improved to 56%, cover side bonding was improved to 10.46% and last process of mainline was improved to 5.26%. The average improvement of mainline process was 30.29%. The cover attach, reverse sub-process and jig inspection were the main focus on the improvement of mainline.

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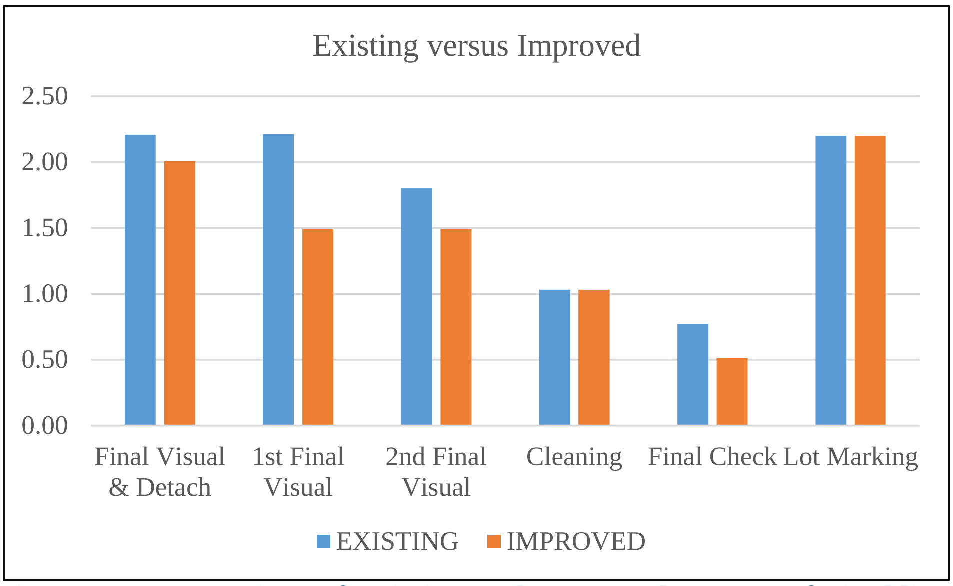

Figure 3.3 Comparison of Existing and Improved Process of Final line

Figure 4.2.3 shows the comparison of standard time in the production process of final line. The first sub-process was improved to 9.05%, and the first final visual and second final visual were improved to 32.58% and 17.22% respectively. Meanwhile, the final check or final function of units was improved to 33.77%. The average total improvement of this process was 15.44%.

Assessment of Before and After Improvement

Table 2 shows the standard time of the existing and improved processes. The data were computed based on the sub line, mainline and final lines were used in hypothesis testing.

Hypotheses concerning parameters such as means and proportions can be investigated. Statistical hypothesis testing is a decision-making process that evaluates claims about a population. In hypothesis testing, the researcher must define the population under study, state the particular hypotheses that will be investigated, give the significance level, select a sample from the population, collect the data, perform the calculations required for the statistical test, and reach a conclusion (Bluman, 2009).

Table 2.Value of Standard Time for Hypothesis testing

Subline	Existing	Improved
AF Carrier Attach	1.42	0.88
AF Carrier Coil Bonding	2.35	1.67
Coil Attach	2.21	2.21
AF Carrier and Coil Aging	4.16	3.26
Coil Attach and Arrange	2.43	1.22
Bottom Spring Attach	2.01	1.29
AF Carrier Boss Melting and visual	1.96	1.71
Coil Arrange	2.12	2.12
Coil Cutting	2.18	2.18
Thermal Welding	2.06	0.64
AF Carrier Assy 1st Visual	2.05	1.87
Coil Welding Bonding	1.49	1.08

Aging Process (2nd)	2.35	2.35
Final Sub line	2.17	1.76
Mainline		
Base Frame Attach	2.07	1.88
AF Carrier 1st Top Spring Melting	2.24	2.02
AF Carrier 2nd Top Spring Melting	2.13	1.26
Top Side Auto Bonding	2.37	2.12
BS hole Bonding Tapping	1.79	1.41
Sub Assy Aging	2.35	1.95
Cover Attach	1.82	0.70
Reverse	2.22	0.70
Jig Inspection	1.39	0.32
Auto Magnet Insertion	2.30	1.35
SUB Assy Cleaning	1.93	0.84
Bottom Side Bonding	2.27	2.27
Contact bonding	2.25	0.99
IR Base Attach	2.29	2.30
Cover Side Bonding	2.39	2.14
Unit Aging	2.09	1.98
Final Line		
Final Visual and Detach	2.21	2.01
1st Final Visual	2.21	1.49
2nd Final Visual	1.80	1.49
Cleaning	1.03	1.03
Final Check	0.77	0.51
Lot Marking	2.20	2.20

Table 3. Result of Hypothesis (Compared T-test)

	N	**Mean**	**StDev**	**SE Mean**	**T-Value**	**P-Value**
Existing	36	1.433	0.1822	0.0304		
Improved	36	1.2304	0.277	0.0462		
Difference		0.2026	0.202	0.0337	6.02	0.00001

95% level of significance, p<0.05 significant

Table 3 presents the results of final observation of production line S4. Based on the calculation made by the researcher, the value was less than to p-value of 5%, the research of the study was statistically significant. The factors to be considered were the proper allocation of activities to the operator and the elimination the unnecessary motion in the production area.

Process Simulation

The researcher used process simulator to determine the correctness and efficiency of a design before the system was actually constructed. Process simulator provides the design with perfect information which pertains to the correct and effective output produced in the alternative designs. In the new developed process flow of the company, it was able to understand the behaviors and interactions of all components including the manpower, process and materials within the process flow. Therefore, it was equipped to counteract the complexity of the overall system of production line of project S4.

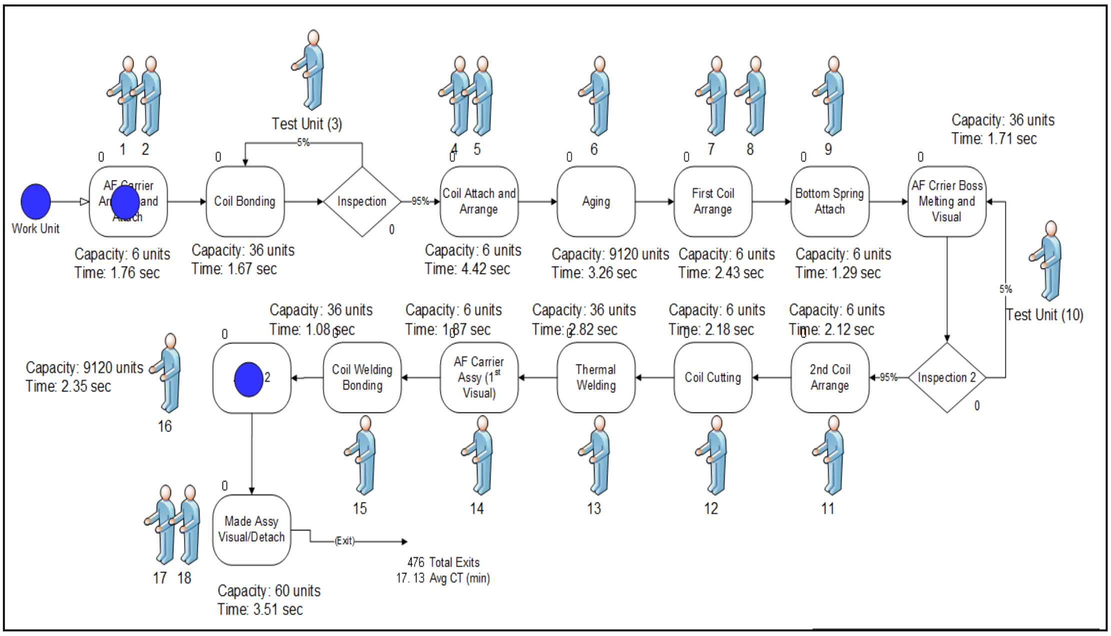

Figure 4.1 Sub line

Figure 4.1 shown the process simulation of sub line process using simulator. Based on the simulation, the total output produced was 476 units with the average cycle time of 17.13 min, equivalent to 1,677 units per hour.

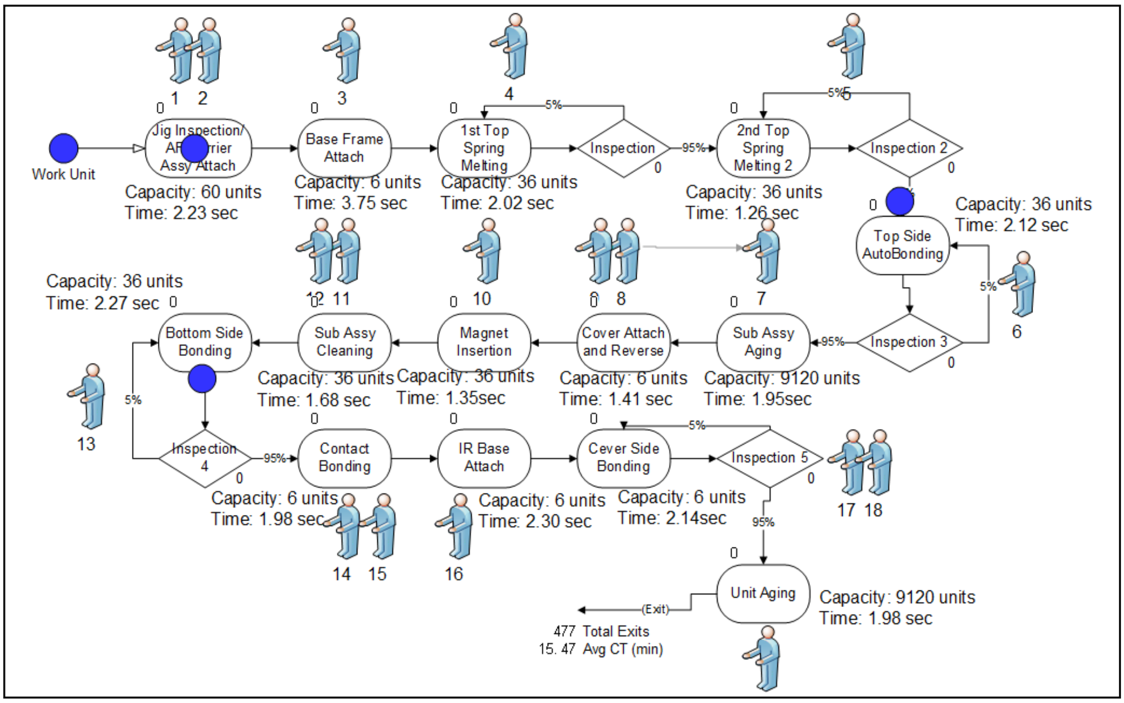

Figure 4.2 Process Simulation of Mainline

Figure 4.2 shows the process simulation of mainline process using simulator. Based on the simulation, the total output produced was 477 units with the average cycle time of 15.47 min, equivalent to 1,850 units per hour.

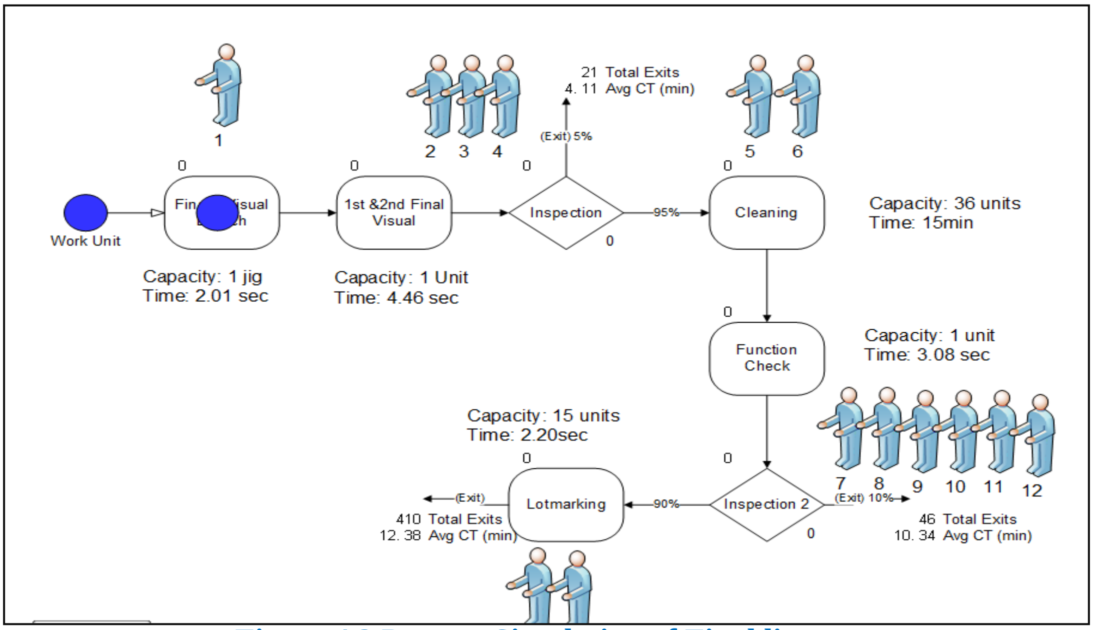

Figure 4.3 Process Simulation of Final line

Figure 4.3 shows the process simulation of final line process using simulator. Based on the simulation, the total output produced was 410 units with the average cycle time of 12.38 min, equivalent to 1,987 units per hour.

Future State Map

The researcher analyzed the current state map and identified the waste in each value stream and came up with possible solutions. Based on the conducted study, the researcher created the future state map with the improvements for sub line, mainline and final line processes. The future state map was used as the guideline of the production process of the company. Figure 7.1 shows the future state map of sub line process.

Through the future state map, the researcher combined some activities of the operator to eliminate the non-value added activities, to reduce the production cycle time in each sub-process and to increase the production output. Based on future state map, the first process increased by 55.56% units, the second process increased by 28.80% units, AF carrier coil aging increased by 23.35% units, coil attach and arrange increased by 50% units, the bottom spring increased by 35.94% units, AF carrier boss melting and visual increased by 15.81% units, thermal welding increased by 69.06% units, AF carrier assy 1st visual increased by 9.12% units, coil welding increased by 41.84% units, and the final sub line which is the combination of made assy visual and detach increased by 20.42% units.

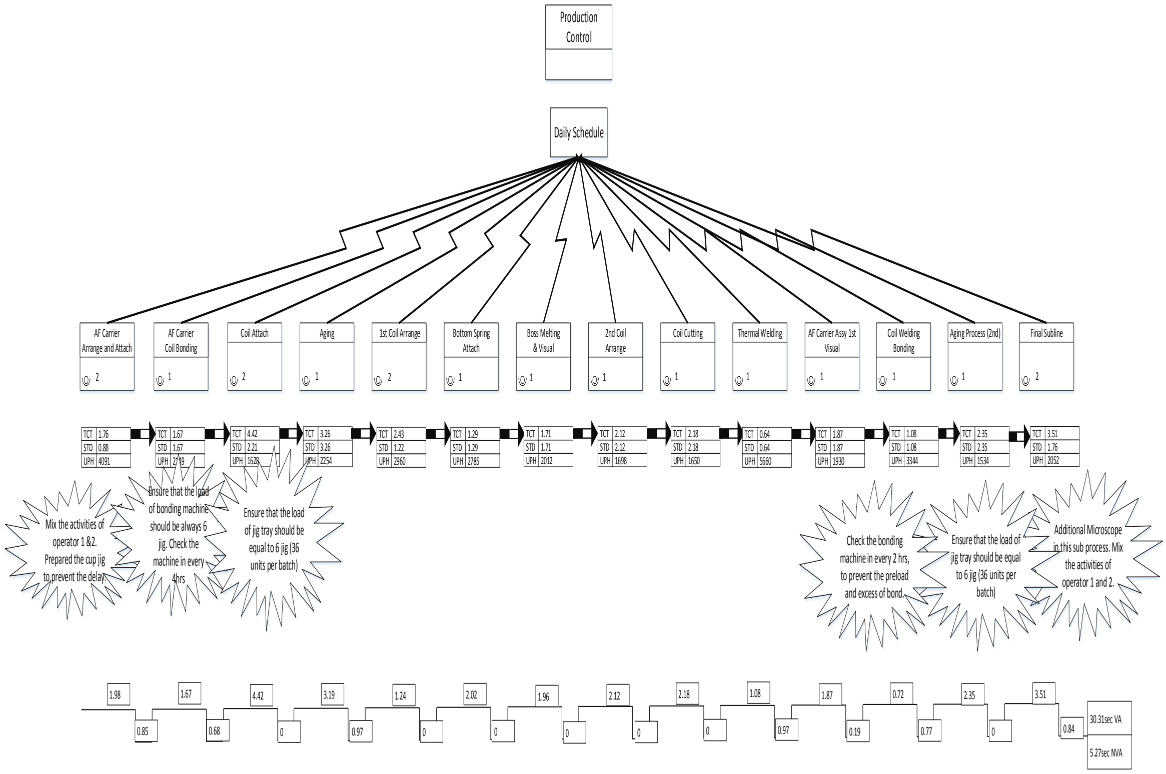

Figure 5.1 Future state map of sub line process

Figure 5.1 shows the future state map of sub line process. Through the future state map, the researcher combined some activities of the operator to eliminate the non-value added activities, to reduce the production cycle time in each sub-process and to increase the production output. Based on future state map, the first process increased by 55.56% units, the second process increased by 28.80% units, AF carrier coil aging increased by 23.35% units, coil attach and arrange increased by 50% units, the bottom spring increased by 35.94% units, AF carrier boss melting and visual increased by 15.81% units, thermal welding increased by 69.06% units, AF carrier assy 1st visual increased by 9.12% units, coil welding increased by 41.84% units, and the final sub line which is the combination of made assy visual and detach increased by 20.42% units. Figure 5.2 shows the future state map of mainline process. Through the improvement of the process flow, the output produced increased, and total cycle time and standard time was reduced. All the improved processes were based on the re-allocation of the position of the manpower and elimination of unnecessary movements.

In the conducted study, the researcher found out the changes of the output produced in every sub-process. The base frame attach increased by 15.77% units, the 1st top spring melting increased by 9.89% units, the 2nd top spring melting increased by 40.71% units, the top side auto bonding increased by 10.47% units, the hole bonding tapping increased by 21.59% units, the cover attach and reverse increased by 61.34% units, the auto magnet insertion increased by 41.19% units, the sub assy cleaning increased by 56.56% units, the contact bonding increased by 55.97% units, the cover side bonding increased by 10.45% units and the unit aging increased by 5.54% units. Figure 5.3 shows the future state map of final line process. The researcher focused on the second and the third sub-processes. He combined the activities of three operators to increase the productive output.

The final visual and detach increased by 10.09% units, the 1st and 2nd final visual increased by 42.55% units, the cleaning increased by 78.44% units, and the final check and lot marking increased by 6.65% units. Through the future state map, the production of every process increased.

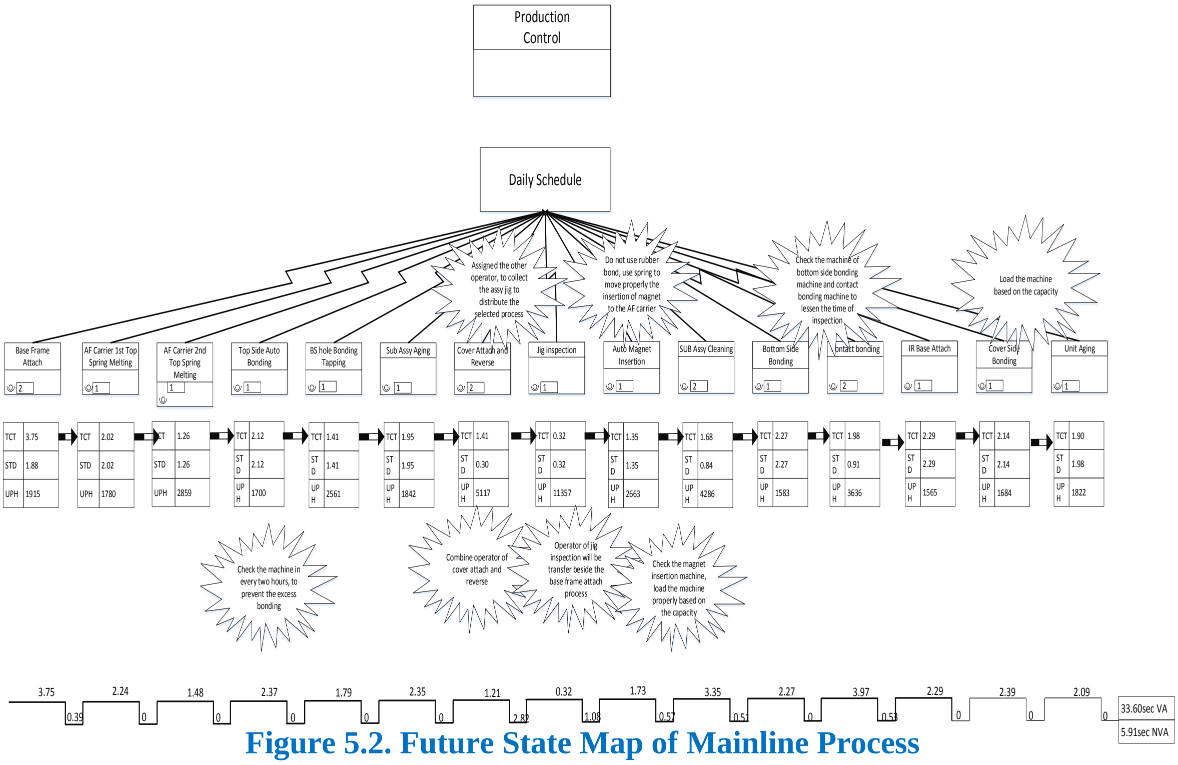

Figure 5.2. Future State Map of Mainline Process

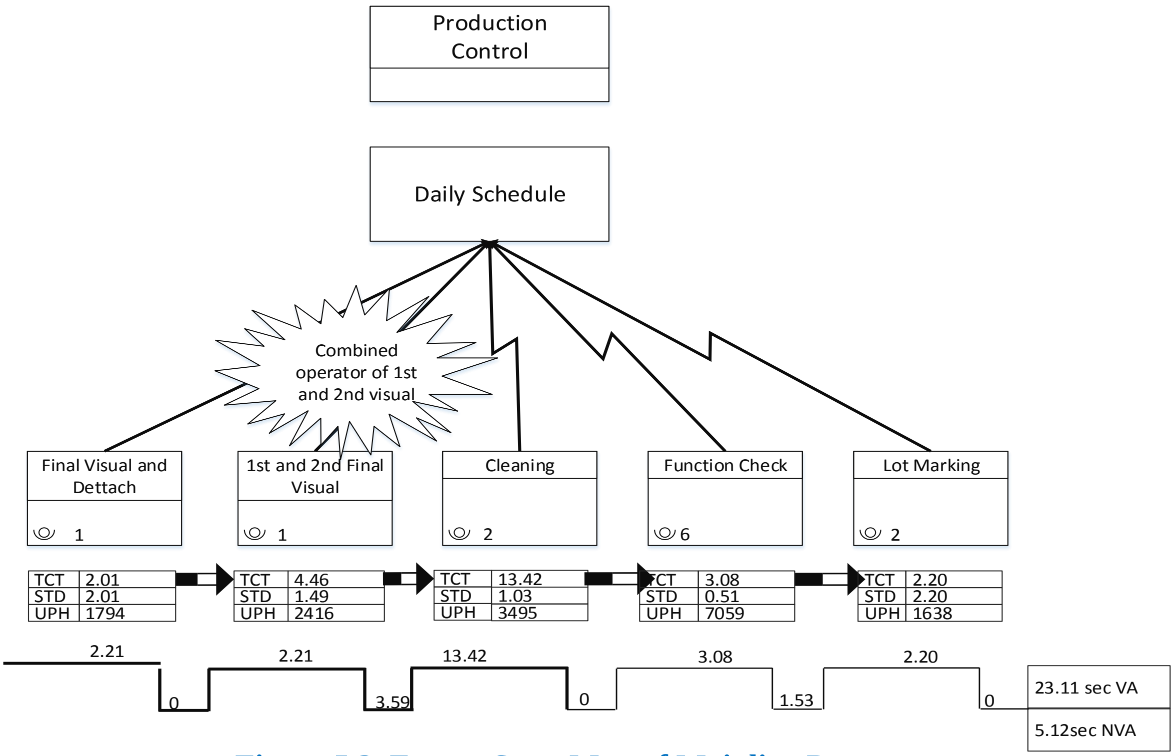

Figure 5.3. Future State Map of Mainline Process

Conclusion

This study focused on the workload utilization and process reengineering of project S4 at XYZ Company. To bring about the desired improvement, the researcher applied value stream mapping. The researcher was able to obtain the following:

1. In the current production system of the selected area, the researcher provided the flow diagram, production standard time and manpower requirements, and production output of S4.

1.1 The researcher examined some steps and procedures to identify the unnecessary activities involved in the production. He eliminated and combined some subsequent processes. By doing of this, he was to recognize the need for possible process flow, process and productivity improvement in the area. Then, the researcher developed a new process flow for the production line of S4. The existing process is composed of 41 sub-processes with 12 inspections, while in the improved process is composed of 36 sub-processes and 10 inspections.

1.2 The researcher utilized the workload of the operator which caused the improvement of production cycle time and standard time. The sub line process was improved to 22.22%, the mainline was improved to 30.29% and the final line was improved to 15.44%.

1.3 In the conducted study, the total output produced was 11,466 units while 10,520 units were produced in the existing study with 8.25% of improvement.

2. In the conducted study, the researcher found out the different problems inside the production process. The workload and activities of the manpower were not utilized, and the insufficient waiting time causes the delays of every process. Using the why why analysis, the researcher was able to solve these problems through the properly assigned activities to the operator, to balance the process flow, and eliminate the unnecessary motion.

3. The detailed and current state map was used to identify the flow of the production including the sub-processes and activities of sub line, mainline and final line. This tool was used to determine the value added and non-value added activities. The current system led to the realization that there could be a better way to improve the productivity of the production.

4. The comparative analysis differentiated the data before and after the implementation of the proposed scheme. The collected data signified that the improvement of production standard time, proper distribution of workload and elimination of any waste process step had been successful.

4.1 The researcher easily developed the appropriate flow of the sub line to improve the smooth direction of the process. The existing process is composed of 16 sub-processes with 3 inspections, while the improved process is composed of 14 sub-processes and 2 inspections.

4.2 The existing process of mainline is composed of 18 sub-processes with 6 inspections, while the improved process is composed of 16 sub-processes and 6 inspections.

4.3 The existing process final is composed of 7 sub-processes with 3 inspections, while the improved process is composed of 6 sub-process and 2 inspections.

5. Based on the result of the study, the company maximized the resources, minimized production cost and increased productivity. The total additional output produced was increased by 8.25% .

6. The researcher used the process simulator to validate the data. He aimed to determine if a particular information is reliable. Based on the results, the sub line process could produce 1,677 units per hour or 476 units per 17.13 min average cycle time, the mainline process could produce 1,850 units per hour or 477 units per 15.47 min average cycle time, and the final line could produce 1,987 units per hour or 410 units per 12.38 min average cycle time.

7. The future state map helped to save 15.19% of standard time. The improved method had an impact in utilizing man activities and in improving the process through the elimination of unnecessary and redundant process steps, thus enhancing the whole production system.

References

1. Bluman, A.G. 2009. Elementary statistics: A step by step approach. 7th Edition, New York, NY: McGraw Hill.

2. Goriwondo, W.M., Mhlanga, S. and Marecha, A. 2011. Use of the value S Treamm Apping tool for waste Reduction in Manufacturing. Case study for Bread, 231-241.

3. Habib, A., Ahsan, N. and Amin, B. 2013. Improving Productivity of Apparelmanufacturing System Using Value Stream Mapping and Production Control tools focusing on printing section, 586–592.

4. Hutagalung, R. and Gustomo, A. 2013. Workload Analysis for Planning needs of employees in the corporate administration unit Pt Timah (Persero) Tbk, 2(19): 2290–2297.

5. Karim, A.N.M., Jaafar, A.A.B., Abdullah, M.A.I., Haque, M., Ali, M.Y. and Azline, S.A. 2012. Applying Value Stream Mapping for Productivity Improvement of a Metal Stamping Industry, 576: 727–730. https://doi.org/10.4028/www.scientific.net/AMR.576.727.

6. Pambhar, D. and Awasthi, S. 2017. A Case Study on Productivity Improvement of Assembly line using VSM Methodology, 58–63.

7. Saraswat, P., Sain, M. K. and Kumar, D. 2014. A Review on Waste Reduction through Value Stream Mapping Analysis, (6): 200–207.

8. Smits, D. 2012. Value Stream Mapping for SMEs : a case study, 2010–2012.

9. Stadnicka, D. and Antonelli, D. 2015. Application of Value Stream Mapping and Possibilities of Manufacturing Processes Simulations in Automotive Manufacturing Processes, 279–286. https://doi.org/10.5937/fmet1504279S.

10. Vasnani, H., Tiwari, A., Kumar, N. and Labana, M. 2017. Production Flow Analysis through Value Stream Mapping. International Journal of Advance Research in Science and Engineering, 6(10): 12-25.