CLOTHING INDUSTRY PRODUCTIVITY IMPROVEMENT USING TOYOTA SEWING SYSTEM AND SIMULATION

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ABSTRACT *Productivity is the measure of the efficiency of production in the workplace. Being productive can help the firm to produce profitable goods and/or services which leads to better customer satisfaction. However, implementing change for any organization can be a difficult task, either being too costly or involving a long lead time. Therefore, simulation plays a vital role in the improvement process. Simulation can be used to study and compare different alternatives in order to troubleshoot the existing system. In this study, Toyota Sewing System and ARENA simulation were used to explore opportunities to increase manufacturing productivity in the clothing industry. The simulation model was validated against the actual production system prior to experimenting with five different scenarios. As a result, the proposed Toyota Sewing System showed a labor productivity increase of 183% and a work in progress reduction of 72%. The manufacturing efficiency was also significantly improved from 34.52% to 98.26% using a one-piece flow system, resource sharing, and U-shaped layout design.*

KEYWORDS: Productivity, Toyota Sewing System, Simulation, ARENA software

1.0 INTRODUCTION

Productivity improvement is one of the core strategies for manufacturing excellence and commonly is related to the good financial and operational performance of the industry [1]. In order to be competitive, most industries continuously seek to maintain or improve their productivity. According to Islam et al. [2], the clothing industry is one of the major industries in the world and is also a part of the supply chain of the textile industry. Like other industries, the clothing industry also needs to improve its productivity. The clothing industry is also known as garment manufacturing turns raw materials into wearable garments and known as one of the labor-intensive manufacturing that contributes to Malaysia's economic growth. The production process of the clothing industry can be divided into 4 main phases; (i) designing and generating the clothing pattern, (ii) fabric spreading and cutting, (iii) sewing and ironing, and (iv) packing.

The clothing industries which still operate using the traditional method are facing challenges like long production time, high rework, high worker absenteeism, weak line balancing, and a lack of standardized work processes. Moreover, these issues are also related to poor resource utilization (space, labor, machine, and time). Furthermore, production operations without standard times and target settings based on guesswork or experience are among the factors that affect productivity in the clothing industry. However, through the application of lean manufacturing tools and simulation, there is an opportunity to improve the clothing manufacturing productivity issues where proper solutions can be determined [3].

'Lean' is the term being used to explain the Toyota Production System (TPS) where the focus is on waste elimination and value generation through the efficient use of resources. Glover et al. [4] pointed out that Toyota Motor Corporation establishes the Toyota Production System (TPS) to enhance an organization's productivity. These authors also mentioned the Just-in-time (JIT) as a tool being widely used in the TPS to achieve leaner production.

Colovic [5] explained that Toyota Sewing System (TSS) is a modular system that the Toyota firm first implemented as part of JIT in 1978. The principle of workflow in the modular garments production system uses a Pull system and manufacturing is based on the actual order of the garment. Thus, in this type of manufacturing system, the workflow is non-stop as long as there is demand. The workers normally operate as 'Stand up' or 'Sit down' units. Based on the sequence of the garments operations and the standard time to perform each operation, a module can be divided into a few work zones. A work zone consists of a group of garment operations that follow a certain sequence. Workers can freely move from one operation to another as they are trained to perform the operations within their work zone and adjacent operations in the adjoining work zones [6]. Therefore, the TSS is a self-balancing system. The whole production line will only remain stable and balanced when the system's intersection positions become stable and determined through several trial runs. Consequently, every operator is multi-skilled and will be rated according to their working ability. To improve the whole production efficiency, the most skillful operator is always positioned at the tail of the production line. TSS uses the assumption that there is no buffer area between stations and there is no extra work-in-progress material.

Computer simulations, statistical analysis, and lean tools are among the tools to improve productivity. Many operational problems and productivity improvements in the fields related to the manufacturing system, supply chain management, and services, including different industries and construction can be modeled and solved using computer simulations. Along with the practice of computer simulation in the manufacturing system, advantages such as investment cost saving, process cycle time reduction, resource utilization, and throughput could be achieved [7].

The paper by Mourtzis *et al*. [8] reviewed the major breakthrough in the development of simulation technologies. The author described simulation modeling and analysis as the process of constructing and testing a physical system using a computerized mathematical model. By using simulation, product, process, and system design and configuration can be tested and validated.

Rashid [9] highlighted that discrete event simulation (DES) has proven as a useful tool able to anticipate the overall system performance. DES is useful in determining bottlenecks, evaluating proposed solutions to eliminate bottlenecks, identifying utilization of resources, and determining buffer sizes. To carry out testing in real-world system, simulation tools allow users to examine many diverse process systems for production plants without having to spend a large amount of money.

2.0 METHODOLOGY

A productivity analysis was carried out to determine the current productivity of a selected case clothing industry. Data gathered include information on the product, material flow, and process layout. Using the work-study method, data were collected at the production line to obtain the standard time for each operation. Then, improvement was proposed by identifying the potential contributors to the productivity loss. The Toyota Sewing System (TSS) and Simulation modeling using ARENA were used as tools to evaluate the productivity of the selected Sewing Department production process. During the simulation phase, the five different scenarios evaluated and compared with the initial validated model include:

i. Scenario 1 - Reduce 50% of the inter-arrival time
ii. Scenario 2 - Introduce TSS one-piece flow vs batch flow
iii. Scenario 3 - Sharing of resources vs specialized task
iv. Scenario 4 - Fix transportation time between work-stations
v. Scenario 5 - Combine scenario (1) to (4) and use a U-shape layout

3.0 CASE STUDY ON THE CLOTHING INDUSTRY

This study was conducted in a clothing industry located in the southern part of Malaysia. The company was established in the year 2000 as a manufacturer, exporter, and wholesale supplier of garments and textile products. The company exports products to South-East Asian, European and Middle-Eastern countries. Products are manufactured in batches, according to the daily production schedules. Examples of the types of clothes manufactured in this company are round-neck, V-neck, and polo shirts. The production is divided into five departments which are the Material Preparation Department, Cutting Department, Printing Department, Sewing Department, and Packaging Department.

This study aims at improving the round-neck T-shirt process due to this product has the highest customer demand. Further, the sewing department was selected since the production process is the bottleneck with a cycle time of 6 days which is more than double of the other production departments.

3.1 Data Gathering

Figure 1 shows the layout and process flow of the sewing department. This production layout information was mapped to record the configuration of workstation and equipment, with particular emphasis on the movement of work (materials) through the system. The transfer of work was by manual passing where the operator will transfer the task upon completing a batch of 25 pieces of the round-neck T-Shirt. The case company had a relatively small layout (20ft x 45ft) for the sewing department. Hence, in the actual production, all machines were close to each other. Extra machines were on standby if any of the machines were broken. In another word, the rate of machine breakdown was considered negligible. A small table was placed next to the machine which acted as a buffer or container. For the purpose of the simulation model development, 7 workstations and 7 workers were used with an 8 hours shift per day and 6 working days.

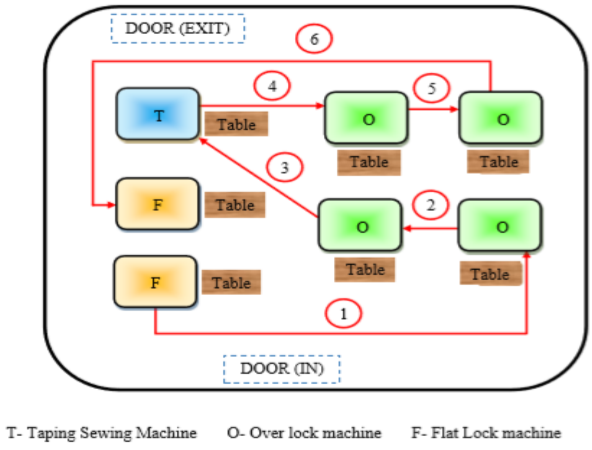

Figure 1: Sewing Production Layout and Process Flow

3.2 ARENA Simulation Modelling

The data gathered using the work-study method was used as an input for the simulation model using the ARENA software. Table 1 presents the calculated standard time.

Table 1: Standard Time for Sewing Operation

No	Process	Standard Time (sec)
1	Sleeves Stich	3.29
2	Shoulder Joint	12.80
3	Neck Collar	15.09
4	Taping for Shoulder and Neck	10.93
5	Sleeves and Body Joint	25.08
6	Side Joint	27.71
7	Bottom Finishing	12.18

The arrangement of the module was according to the original layout of the company. The distance between the machines was also considered in this simulation. The simulation was allowed to run for one day and 8 hours for one shift. The material transfer used in this simulation model was 25 pieces in one batch. The model verification and validation were done together with the company's management by closely monitoring the simulation flow and the output performance. The output result bias was set to not exceed 5% of the expected output per day. The product inter-arrival time was calculated using the determined Takt time of 38.4 secs per unit.

3.3 Evaluating Alternative Scenarios

Five scenarios were explored using the ARENA computer simulation model and the results were compared to the validated sewing department simulation model. Table 1 summarises all the four simulation model scenarios and compared them to the original validated model of the sewing department manufacturing process.

In scenario 1, the inter-arrival time of the products was reduced from 38.4 seconds per unit to 15 seconds per unit. The results in scenario 1 show that the proposed model produced a larger output and better resource utilization. This was because the material arrival was faster causing the worker's idle time to decrease. However, there was an increase in the work-in-progress material due to the higher rate of material arriving at the system causing an increase in the total cycle time. On the other hand, the resource utilization improved significantly as the operator has sewn more units than the initial model.

In scenario 2, the TSS one-piece flow was introduced. The results show a significant reduction in the work in progress and also the cycle time. However, there was no major difference in the resource utilization since the work rate was still the same and the workers had to wait for the worker from the previous process to finish their work.

Table 1: Results of Sewing Department Simulation Model Scenarios

Item		Initial Model	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Input (seconds per unit)		38.4	**15**	38.4	38.4	38.4
Output (pieces)		675	1225	766	750	675
Material Flow (pieces/batch)		25	25	**1 piece flow**	25	25
Work Flow of Operator		Specialised	specialised	specialised	**Shared work**	specialised
Transport time		unspecified	unspecified	unspecified	unspecified	**2 seconds**
Work in Progress (pieces)		61.5	388.1	4.1	21.7	61.1
Cycle Time (seconds)		2497.7	6277.3	152.5	817.4	2462.4
Resource Utilization for each operation (%)	Bottom Finishing	25	45	28	34	24
	Neck Collar	30	77	32	33	30
	Shoulder Joint	25	66	27	32	25
	Side Joint	52	**94**	**58**	32	52
	Sleeve Stitch	17	21	17	**41**	17
	Taping	26	67	28	32	26
	Sleeve and Body Joint	48	**95**	53	32	**48**

In scenario 3, all the 7 workers were grouped together and work was shared among the team as compared to the initial model where each worker specialized in one type of operation. The result of this modification showed an overall positive impact. Other than reduced work-in-progress material, the average total cycle time also decreased significantly. This was because the workers continued to work on other material once they had completed the task on hand. In terms of resource utilization, the proposed model contributed to a more balanced workload. The shared work also resulted in the total busy time of each operator being almost equal from one to another.

In scenario 4, the transportation time between stations was set uniformly to 2 seconds in the proposed model. This was because in the proposed model, the machines were arranged close to each other and the movement of workers was facilitated by introducing the rotary chairs. Results for scenario 4 show that there was not much improvement or difference between the initial and the proposed models. Reduced transportation time means the material will reach the workstation faster. However, with the same inter-arrival rate used, the worker was idle immediately and had to wait for the next material to be available.

In scenario 5, all four scenarios were combined in the new proposed model. Hence, the new proposed model was built by considering the working distance, flow of material, and worker's capability. By referring to TSS, the design of the production line was arranged in the U-Shape where materials were transported in the anticlockwise direction from the sleeve stitch station to the bottom finishing station. The layout was changed to reconstruct the workflow to minimize the transportation time between stations. The inter-arrival time distribution in the ARENA software was set at 15 seconds, achieved by pumping materials as much as possible into the system. Further, tasks were assigned to any workers who were available as they were trained to multi-task. Only one piece of material flowed from one workstation to another instead of moving in batches.

The results from the proposed model show the output of the proposed model improved significantly to 1916 units (183%) and the work in progress (WIP) material was reduced to 17 units (72%). Further, there was also a significant increase in resource utilization. Figure 2 illustrates the proposed model's workstation utilization. The work was more balanced among the 7 workers with the utilization ranging from 82.75% to 88.32%. The average for the overall resource utilization improved significantly from the original model of 31.47% to 86.40% for the proposed model. Table 2 shows the productivity comparison between the initial and proposed models.

4.0 CONCLUSION

The productivity of the clothing manufacturing company understudy was able to be improved with the use of TSS and ARENA simulation software. The work-study was done and production data were used as inputs to the ARENA simulation model. Five simulation scenarios were run and compared against the validated initial model and the best alternatives were proposed to the company's management to maximize the production output, labour productivity, work in progress, and line efficiency. With the implementation of the proposed model, the clothing company will be able to enjoy a significant productivity improvement of 183% and a material WIP reduction of 72%. The line efficiency will also improve from 34.52% to 98.26% through the sharing of resources and the one-piece flow system.

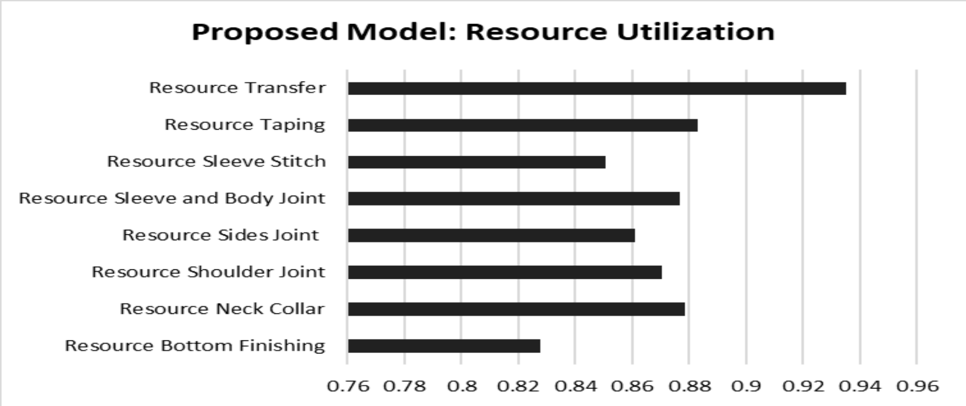

Figure 2: Scenario 5 of Sewing Department Simulation Model

To further improve this study, a predetermined time standards study will need to be done on the manual operations where detailed work activities and accurate time measurement can be obtained. In addition, experience at the Sewing Department can be extended to other departments in this company to further prove the applicability of TSS and simulation in order to promote further improvements in the overall company's productivity.

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