Optimizing Workforce Utilization in Motorcycle Component Assembly Using Simulation

Nornajhan Abdul Latip[1], S. Sarifah Radiah Shariff[1,2](✉), Siti Meriam Zahari[1], and Nurul Nadiah Abdul Halim Zahari[1]

[1] Centre for Statistics and Decision Science Studies, Faculty of Computer and Mathematical Science, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia
shari990@uitm.edu.my

[2] Malaysia Institute of Transport (MITRANS), Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

Abstract. The lack of resource utilization has resulted in manufacturing staying at the same level for a long time. This problem cannot be solved simply by adding machines and hiring more labor. There is an urgent need for innovation and more investment in the development of manufacturing systems. Therefore, a strategic approach is needed to plan and handle the motorcycle component assembly process. This research aimed to evaluate the current workforce utilization of motorcycle parts assembly line, and put forward a feasible plan for the assembly company to achieve their best production based on limited workforce resources. The study specifically targeted assemblers located in Port Klang, Selangor. The data used for the research is the auxiliary data in a three-month time span and is recorded in the assembly company. Simulation is applied in this research to grasp the current situation and Arena simulation software tool is used. The improvement models are proposed by reallocating the workers into their designated workstations. The findings found that by setting a group of workers that operate in a cyclical manner assisted the assembler to maximize the workforce utilization rate. In order to make future research completer and more thorough, more exploration is encouraged by adding related measures (such as applied inventory practices, production and other related costs, and larger sample sizes). The results from this study can help the assembler management to make better decisions thus upgrading the motorcycle component assembly system.

Keywords: Optimisation · Workforce utilization · Simulation · Motorcycle · Assembly

1 Introduction

As Malaysia plans to move forward, the country stress a focus on the services and manufacturing sectors and innovation will play a crucial role in increasing the overall efficiency and productivity of the sectors (Prime Minister's Department 2015). According to Productivity Report 2018/ 2019, productivity helped to determine how optimal the resources have been used by measuring the output respectively to the input (Malaysia

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Production Corporation 2019). A significant level of productivity development allows a firm to gain over competitive advantage with regards to resources such as labor, capital and machinery (Malaysia Production Corporation 2019). The report also stated that a major driving force for industrial growth is the presence of an efficient and dynamic workforce that capable to meet the requirement of the job market. To address this, Malaysia Productivity Blueprint (MPB) has outlined Thrust 1: Building Workforce of the Future, which restructure the workforce by "raising the number of high-skilled workers, tightening the entry of low-skilled workers and meeting future economic demands in the labor market".

Besides, the main resources in the manufacturing industry, such as raw materials, components and manpower, need to be allocated and managed in a specific way so that the resources can be used continuously and at full capacity. In this study, main focus is to optimize the workforce utilization thus improving the productivity level of the motorcycle component assembler. It is a worrisome situation when the motorcycle component demand keeps increasing as time passed by yet, the progress remains the same. The assembler is concerned whether the demand can be fulfilled or not. Adding with limited workforce hired by the assembler and constricted with cost, the assembler has to plan some strategies in order to solve the workforce productivity issue. As a way to improve the productivity level, the existing assembly line system must be modified and upgraded to solve the workforce productivity issue. In addition, the analysis done will assist in identifying the suitable initiative for handling slow productivity and thereby fulfil any gaps. Therefore, the current system is analyzed to determine the assembler's current workforce resources utilization, and feasible initiatives for achieving the optimal workforce resources utilization are proposed. In order to achieve that, simulation method will be used in this study.

1.1 Literature Review

A study by Tan et al. (2019) on the challenges faced by the Malaysian automotive industry, found that the obstacles are technological progress, lack of R&D capabilities and fierce competition in a limited market space. In addition, Akademi Sains Malaysia (2018) pointed out in the "Automotive Industry Sector Final Report" that the Malaysian automotive industry is facing major changes in demand, consumer expectations and new technologies. The report also highlighted major gaps in Malaysia's industrial ecosystem, which may hinder the country's manufacturing growth. The gap exists in tool manufacturing, machinery manufacturing, design capabilities, casting and die-casting, forging, ferrous metal raw material production, non-ferrous metal material production and engineering polymers. Many studies have explored and claimed that simulation is the best approach as it will not affect the real system, yet several possibilities can be considered. Ho et al. (2019) used Arena software to study the line balance synchronization of powder coating production in order to find the best synchronization by considering the conveyor speed, the number of operators and the configuration between the three product models (small, medium and large). Meanwhile, Rane et al. (2017) developed a simulation-based model to help in reducing the cycle time and time loss during operation hours.

In jewelry production, Supsomboon (2019) proposed a simulation model to be done in order to reduce bottlenecks and improve productivity level by using line balancing.

Bae et al. (2015) implemented discrete event simulation model to propose alternative systems for vehicle axle and spring assembly lines to increase the productivity as well as accommodate the increasing demand. There were three different factors that need to be focus on; Arrival rate, Batch size and Operator resource and utilized them to create different scenarios which each of them varied at the same time in order to find the best possible settings. Meanwhile, Neungmatcha et al. (2020) proposed a simulation to increase the efficiency of motorcycle headlights production by balancing the assembly line to reach maximum utilization of manpower. Modifications done on number of manpower (add one more worker) and number of task (eliminate a sub-task), followed by rebalancing the assembly line. It is quite clear that simulation model is suitable to apply with intends to optimize the workforce and capable to generate a credible result. In order to achieve the expected goals, many strategies were applied and for this study, a simulation model is selected to help evaluate the workforce utilization and propose effective plans to achieve the best production level.

2 Methodology

The data used for this study is obtained from a motorcycle component assembler located at Port Klang, Selangor. Time spans of the data is only three months, starting from August 2020 to October 2020. In order to build a reliable simulation model, data is collected to gather valuable information needed. Number of workers hired by the assembler is 26 with majority of them are in Production Department and followed by Store, Quality Assurance (QA) and Packing Departments. Regarding gender, there are 25 male workers hired while only a female worker working in the company. In addition, it is recorded that number of local workers are higher that foreign workers. Working hours is eight hours per day with an hour staff break times for six days in a week. There are six components assembled by the assembler and each has their own demand, process flow and processing time. A list of components, number of steps and time taken to finish assembling one unit are presented in Table 1.

The data covers monthly demand for each model starting from August 2020 up to October 2020. The monthly increase in number of demands for all components can be

Table 1. Number of steps and processing time of each component

Component	Number of steps	Time taken to complete/worker/unit (in minutes)
B17	23	6.05
55D	13	3.5
2WB	13	3.5
BF4	12	2.68
B92	12	2.53
BBM1	8	1.65

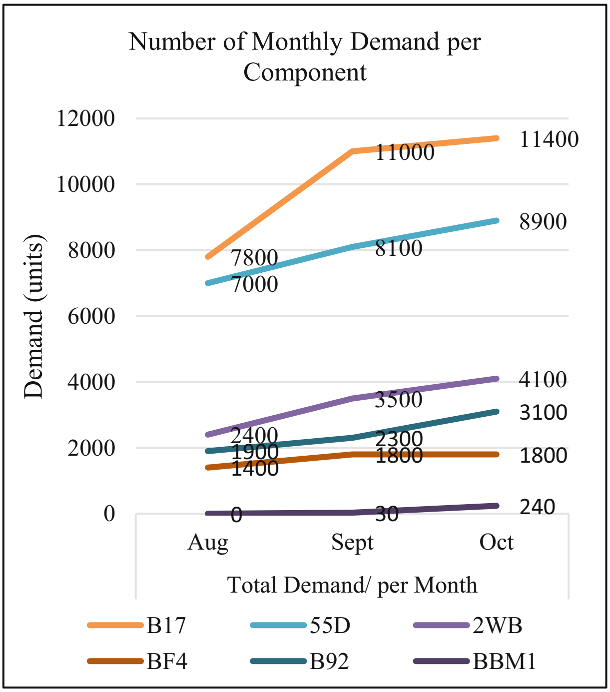

Fig. 1. Monthly demand for each component

seen in Fig. 1. The monthly demand is gradually increased month by month and the largest contributor is B17 component and followed by 55D and 2WB. In addition, the highest monthly demand also recorded in October 2020 for all components.

Even though there are six components assembled by the assembler, only B17 component is being studied and analyzed since it is noted by the assembler of the significance and importance of it. Adding with high demand per month and long processing time, the assembler concerned whether B17 component current productivity can satisfy the rising the demand and simultaneously identify solution to optimize workers utilization. Both machines and workers are included for each process the component assembly line. There are six machines and 23 workers assigned for assembling B17 components throughout the time of the data being collected. There are three parts of the component production; front, rear and clutch hub to complete the whole component.

2.1 Simulation Model Development

The objectives are to analyze and evaluate the resources utilization, specifically workforce resources. Another objective of this study is to propose an efficient solution to improve the motorcycle component assembly process productivity so that the company can satisfy the demand regardless of the limited workforce resources. Simulation is conducted by using Arena software in order to imitate the real system of the component assembly process. The reasons for choosing Arena are due to its suitability, simplicity and capability.

In order to build a simulation model in the Arena software, there are several steps to be taken first:

i. Selecting a module from a template panel.
ii. Placing the selected module on a graphical model canvas.
iii. Connecting the modules graphically to indicate the flow of the control path.
iv. Parameterization of modules using a text editor.
v. Run the Arena model.

Furthermore, some assumptions and constraints need to be set up so that the simulation can be customized to real-world system, and assigned values and constraints to the variable that can be controlled. The constraint of the simulation model and assumptions of this research are described as follows:

- Each process time is independent from one another.
- The assembly activities are done in semi-automation mode by both workers and machines without any idle time in between the activities.
- The machines are fully operated during working hours only.
- The assembly line consisted of six machines and 23 workers, which all of them are responsible in assembling, quality checking for all of the components.
- The assembly line is operated only 8 h per day with one hour period for staff break times.
- The assembly line will not be operated after working hours, on Sunday and public holiday.
- Components assembly process are done as long as the daily demand is fulfilled.
- All the materials required for the assembly process are sufficient and enough for production.
- This study is focused until the assembly process of the components is finished.

2.2 Model Verification and Validation

Both model verification and validation are crucial in simulation study since they helped in determining the consistency, validity and credibility of the model. As stated by Jilcha et al. (2015), performing consistency checks on the statistics assists in assessing the correctness of the model. In this study, Little's formula is applied for verifying the simulation model and its equation can be observed in Eq. 1. Note that both sides must be approximately equal in order to ensure the model verification.

$$\overline{N} = \lambda \overline{W} \quad (1)$$

where,

$\overline{N}$ = Average number of entities in the system
λ = Average arrival rates to the system
$\overline{W}$ = Average time an entity spends in the system.

To validate the model, the widely used equation of difference in validity is presented in Eq. 2. When the value has different by 10% or less, the simulation model can be deemed as suitable enough to replace the real system. If the value generated is greater than 10%, the conceptual model has to be reconstructed, then model verification and validation step will be redone.

$$difference\,(\%) = \frac{|simulation\,output - actual\,output|}{actual\,output} \times 100\% \quad (2)$$

2.3 Determining Current Workforce Resources Utilization

After the simulation model is proven to be verified and validated, next step would be identifying the current resources utilization. This analysis can help to measure whether the resources have been fully utilized. In addition, any crucial gaps can be discovered through this stage and any actions can be planned to handle it. Only utilization of the workforce will be measured and focused on.

In a study conducted by Cartwright et al. (1958), available labor time utilization rate is calculated simply by dividing utilized labor time with available labor time. In a simplified term, workforce utilization rate can be calculated as presented in Eq. 3.

$$Workforce\ utilization\ rate = \frac{Busy\ working\ hours}{Total\ working\ hours} \quad (3)$$

2.4 Improvement Models and Identify the Best Improvement Model

In order to accomplish the second objective of this study, improvement models will be established to improve the current system performance. The improvement will be made to the simulation model while maintaining the process flow of motorcycle component assembly to resolve productivity problems. The modifications done are inspired by a study conducted Neungmatcha et al. (2020) which focused on maximizing the manpower utilization through modifications on number of manpower and number of tasks. The selected criteria of this study to improve the current system are the number of workforce and number of component assembly process assigned. After both variables are altered, the models will perform simulation runs and then, the improved simulated output will be analyzed to resolve the productivity issues. Output generated by the software and together with the actual model will be reviewed and analyzed. Then, the best improvement model will be selected based on the maximum utilization of the workforce, the lowest waiting time, the lowest total time and the highest number of outputs produced.

3 Results and Findings

3.1 Model Verification and Validation

After the model is done being set up, verification and validation of the model was determined before proceeding with the study. Verification can be calculated by using

Table 2. Comparison between Simulated Output and Real Data

Component part	Real data (in minutes)	Simulated output (in minutes)	Difference (%)
Front	3.13	3.13	0.00
Rear	1.66	1.66	0.00
Clutch hub	1.26	1.26	0.00

Eq. 1 as mentioned before. $\overline{N}$ is average number of B17 component in the system which amounted to 9.9079 units. Meanwhile, $\lambda = 1.65$, which is average arrival rate of the component into the system ($\lambda = \frac{700}{7\times60} = 1.6667$). $\overline{W} = 6.05$ minutes is the average total time spent by the component to finish the assembly process. In order to verify the model, both sides must be approximately equal. With $\lambda\overline{W} = 10.0833$, Eq. 1 is satisfied and thus declared the model as verified.

Regarding model validation process, time taken spent by the component to be assembled is used to compare between simulated output and real data. Table 2 is the summary of the result of model validation process. Since all the differences are less than 10%, the model is proven to be valid and reliable to use.

3.2 Simulation Model Result (Current Workforce Resources Utilization)

After the model is proven to be reliable and accurate to portray the real assembly system, next part is to determine the current utilization of the resources which is also the first research objective of this study. Note that, there are 23 workers and six machines included in assembling B17 component. In fulfilling the purpose of first objective of this study, current workforce resources utilization is determined and measured by using resources utilization rate and the result is displayed in Table 3.

There were only a few workers optimized significantly, namely Worker 1, Worker 6 and Worker 14, which came from graphic affixing stage for front part and tire fitting and quality assurance stage for both front and rear parts. This result indicated that only graphic affixing and tire fitting and quality assurance inspection stages are fully utilized. In addition, some of the workers also reached a sufficient level of utilization rate between 55% and 80%. The lowest utilization rate is at 8.20% for Worker 7 at front steering preparation stage at front part. This rate clearly displayed the imbalance utilization of the workforce for B17 component assembly. For this study, the assembler is majorly concerned about the workforce utilization. With the imbalance task assigned to the workers, some of the workers struggled to properly assemble the component and maximized their capacity. Hence, only workforce variable will be included in the improvement model's proposition.

3.3 Improvement Models

The modifications done are majorly focussed on improving the optimization of the workforce assigned for B17 component assembly. Lower utilization rate occurred due

Table 3. Current Workforce Resources Utilization Rate

Part	Process	Resource	Resource utilization rate (%)
FRONT	Graphic affixing	Worker 1	98.90
	Unpacking	Worker 2	24.71
	Install valve	Worker 3	54.85
	Press Bearing	Worker 4	49.36
	Disc Brake	Worker 5	49.29
	Tire fitting & Quality Assurance inspection	Worker 6	93.04
	Front steering preparation	Worker 7	8.20
	Front steering	Worker 8	71.06
	Axle	Worker 9	62.79
REAR	Unpacking	Worker 10	21.83
	Install valve	Worker 11	51.80
	Press Bearing	Worker 12	57.23
	Disc Brake	Worker 13	57.17
	Tire fitting & Quality Assurance inspection	Worker 14	84.31
CLUTCH HUB	Unpacking & preparation	Worker 15	16.31
	Press bearing & oil seal	Worker 16	21.75
	Set bolt stud	Worker 17	29.86
	Tightening	Worker 18	21.71
	Set plate & sprocket	Worker 19	13.57
	Set nut	Worker 20	27.14
	Tightening	Worker 21	18.99
	Torque	Worker 22	21.68
	Install collar	Worker 23	35.23

to imbalance workload assigned to each worker, so, for improvement assembly system purpose, the workers are either shifted from a workstation to another or adding more workload. In addition, there will be no new workers hired due to cost constraints. The assembler also clarified that the number of workers assigned for assembling B17 component are flexible as long as no added worker.

Model 1

Model 1 is developed by assigning the same tasks to the same worker. Thus, the reallocation made the front part with eight workers, rear part with five workers and clutch hub part with six workers. For Model 1, the utilization rate is unstable and dispersed randomly amongst the workers. Worker 1, Worker 3, Worker 4, Worker 5 and Worker 6 have high utilization rate, roughly between 87% and 99% which portrayed that the resources are fully utilized at the designated workstation. While the others are between 9% and 53%. The bottom three utilization rate are recorded by Worker 10 at 18.07% (Tightening workstation), Worker 12 at 15.63% (Install Collar workstation) and the lowest is Worker 11 at 9.62%, which located at Torque workstation. These three workers are assigned for clutch hub part which implied that, under this model, the last part is the most problematic.

Model 2
Model 2 is developed by assigning a set of sequential tasks to the same worker. By implementing this model, the number of workers are only 11 with six workers for front part, three workers for rear part and two workers for clutch hub part. For Model 2, the workforce utilization rate is spread fairly amongst the workers and in between 63% and 99% utilization rate. This result implied that the workers assigned for this component are fairly utilized. The lowest utilization rate is recorded by Worker 6 (62.79%) who is responsible for Axle stage in front part. While, the highest workforce utilization is recorded by Worker 8 at 99.15% for Press Bearing and Disk Brake stages at rear part. Overall, the labor utilization rate is quite good and remarkable.

Model 3
Regarding Model 3, it is developed by combining both modifications done on Model 1 and Model 2. The same tasks along with the sequential tasks are assigned to the same worker. The worker assignment is done by observing the assembly layout as well as considering the cycle time at each stage.

For front part, there are five workers, three workers for rear part and four workers for clutch hub part. The utilization rate is in ranges of 28% to 99% which signified that the rate is pretty much scattered among the workers. The bottom three rates are recorded by Worker 6 (56.39%), Worker 9 (45.69%), and lastly, the lowest utilization rate is recorded by Worker 8 (28.92%). All in all, it seems that clutch hub is the problematic stage since the workforce utilization is not properly utilize. Table 4 summarizes results for all three models.

3.4 Best Improvement Model Identification

In this section, all the outputs from improvement model proposed are compared and analysed to select the best model to be implemented. The variables used to measure the performance of each model are average of worker resource utilization rate, number of workers, number of components produced, total time, and waiting time. Table 5 shows the details result of the best model.

Table 4. Workforce Resources Utilization Rate for Improvement Models

Model 1		Model 2		Model 3	
Resources	Resources utilization rate (%)	Resources	Resources utilization rate (%)	Resources	Resources utilization rate (%)
Worker 1	98.90	Worker 1	98.90	Worker 1	98.90
Worker 2	46.52	Worker 2	79.57	Worker 2	79.57
Worker 3	89.44	Worker 3	98.65	Worker 3	98.65
Worker 4	97.14	Worker 4	93.04	Worker 4	99.56
Worker 5	87.40	Worker 5	79.26	Worker 5	94.80
Worker 6	99.56	Worker 6	62.79	Worker 6	56.39
Worker 7	52.92	Worker 7	73.63	Worker 7	85.97
Worker 8	41.89	Worker 8	99.15	Worker 8	28.92
Worker 9	31.35	Worker 9	69.57	Worker 9	45.69
Worker 10	18.07	Worker 10	73.97		
Worker 11	9.62	Worker 11	96.19		
Worker 12	15.63				

Table 5. Comparison of Improvement Model Outputs

Improvement model	Average of worker resource utilization rate (%)	Number of workers (man)	No of components produced (units)	Total time (minutes)	Waiting time (minutes)
Current Model	43.08	23	683	6.05	0.00
Model 1	57.37	12	303	120.74	114.69
Model 2	84.06	11	563	42.35	36.30
Model 3	76.49	9	303	121.04	114.99

4 Conclusions

In a nutshell, this study has successfully proven that by workforce operating at full capacity, the efficiency of the workers is significantly increased without adverse effect on the worker's wellbeing and quality of the product. Adding with utilizing the current workforce efficiently without hiring more, it surely helped the firm to operate in a cost-efficient manner. Besides, the development of the model will help to bring advantage in competing in a close-knit and intense market. For the organizations to move forward, adding some more variables could help to refine the system more and raise its capability.

The added measure could be inventory practices applied, assorted production and other related cost incurred, salary and bonus paid and more sample size. Besides, by including the supply chain, starting from procuring the related materials up to the end-user, it could help researchers to get a thorough view of the assembly line. In terms of productivity, not only workforce resources utilization can be measured, machinery, raw materials and other technical efficiencies can be included.

Moreover, studies can also be conducted when firms improve their productivity through adapting to new changes such as new assembly process, shift from manual mode to automation manufacturing and implementation of new work culture. Apart from that, factors contributing to the lack of productivity and productivity advancement of a firm or sector can be determined in future research. Even though by adding the related variables will surely complicate the process of developing efficient solutions, it helped to properly grasp the clearer and full picture of the current system implemented and thereby enhanced it, boosted production, increased returns to scale and reduced waste.

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