Assembly Line Optimization using Arena Simulation

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Abstract—In production system of the automobiles industries, different components of products are assembled on the final assembly lines. The duration time of the process, number of workstation operates, and the operators ability influence the productivity of manufacturing process. Hence, to manage or compete with other manufacturing companies and factories, most of them trying to maintain or improve their productivity. This research describes the improvement activities of the motorcycle industry using a simulation technique. This study proposed to improve the productivity assembly line by using ARENA simulation software, which the main aim is to reduce the number of operation in the workstation and improved the productivity of the product followed by suggesting the improvement way to achieved excellent result in the production. The methods used for the research is qualitative which the process flow of the process was observed and the data was collected according from the needs of the ARENA simulation. ARENA simulation was built according to the data collected and the results were analyse and other simulation was built with improvement to comprised the result.

Keywords—assembly lines; productivity; manufacturing process; simulation; ARENA

I. INTRODUCTION

Industries that utilize the assembly line to obtain their products currently go through great challenges. The first is the need to assemble a large number of product models and their variants in their lines, due to the variety required by the market. Another challenge is the need to maintain an adequate level of manpower occupation and other utilized resources. In this scenario the activity of balancing operations appears.

In order to increase the efficiency and reduce the operating costs of the line, balancing activities among workstations are performed. They can be done by different methods, such as: exact, heuristics, meta-heuristics methods, or simulation [1]. Hence, the aim of the research is to continue the case study from the previous study by applying another method to solve it by applying the ARENA simulation. This research paper shows how ARENA simulation is proposed to solve the problems occurred in one of the motorcycle manufacturing companies.

At the present time productively systems are characterized by extremely short production times for all models, the high level of automation, the needs of new technologies and high expenditures for the construction of the assembly lines. Those features made designers aware of new issues, thereby forcing them to create of new lines and frequent improvements of lines as well as the creation of appropriate and accurate software tools which will make designing the lines easier.

II. RESEARCH METHODOLOGY

A. Conceptual Framework

- Increase the production rate.
- Reduce the duration time of process.

Figure 1 Conceptual Framework
B. Data Analysis

After the data is being collected, all the data is used to make a similar model as the flow of assembly line from the ARENA simulation. In conclusion, from the ARENA simulation a lot of data could be used such as the researcher could know the queue or waiting time of production and also could know whether it is validated or not validated.

First step is by determine the problem occurs in the industry which is the queues time and also the number of the production produced. Next step is collecting data by observation and stopwatch was used to collect the time taken of each process, then develop a model. Leader of Plant 3 department, Final Assembly Department was interviewed by the researcher to get more information about the problems and also the flow of the process. The model is computerized by using the ARENA simulation. Then checking the model after the data was inserted. If the data was valid then start to design the flow of model also formulate how the simulation run. Finally, analyse output data and the simulation then complete.

III. RESULTS AND DISCUSSIONS

Therefore, further design of a complicated simulation model is required before the real application in the plant. The new model should include paper roll production schedule as well as roll inventory level to determine the movement of orders when comparing with the original process. The purpose of this study was to simply demonstrate that process improvement can be effectively accomplished with an integrated approach of using proposed computer-based such as ARENA [2].

In the conclusion, most of the assembly line in the production require a lot of improvement for them to achieve the quality of products. By achieving the target, this research using ARENA simulation as a model to manage the flow of assembly line and also knowing the suitable number of workstation require solving the problems in the production and reduce the ineffectiveness of the redesigned operation in the real world.

This study was conducted at motorcycle industry. The factory divided into three department which are Plant 1 for Painting Department, Plant 2 for Machining Department and Plant 3 for Final Assembly Department. In manufacturing of motorcycle, there are different types of motorcycle produced every day according to the demands which are CT100, MR1, Ace, and DINAMIK.

The manufacturing system that was used in the industry is a grouping manufacturing system where many products need to be produced according to their batches at the same time. The product then passes to several processes starting from painting the body of the motorcycles and engine parts are processed in the machining department. In painting department there are certain work is done by the operators and machining department uses various of machine to generate the product until finish. Last process is the final assembly which all the parts and engine is combined together to become motorcycles. The process was done by 42 operators and with the help of machine.

For this study, only one type of motorcycle production was studied which is DINAMIK motorcycle because this motorcycle production show maximum cycle time compared others. Moreover, the studied done only in Plant 3 which is Final Assembly Department.

A. Production Problem Identification

A general information and observation at the production has been carried out. There were some production problems has been identified which are the conveyor move slow in the production hence the operators has time to lack off during free time. Beside there were low productivity which the production did not reach the target. Moreover there were problem in production output and the utilization of the machine. To overcome the problems, ARENA is used in this study. The utilization and cycle time of the operators and machines needed to be increased to optimum the output result.

B. Simulation of Original Time in Assembly Line Process

Figure 2 shows the simulation in the run mode. There were 42 processes that need the product to finish in the simulation and each of them moved according to the time taken. The time taken was used using the stopwatch and the mean of the time was required in the simulation.
C. Queue Result From Arena Simulation

The queues result for each of the production of DINAMIK motorcycle by using ARENA simulation software shown in Figure 3.

![Figure 2 Simulation in the run mode](image)

**Figure 2 Simulation in the run mode**

![Figure 4.2 Queue time of each process](image)

**Figure 4.2 Queue time of each process**
D. Time Result from ARENA Simulation

Figure 4.3 below show the total time result of the simulation that already analyse.

![Figure 4.3 Total time result](image)

E. Result Analysis

From the result above figure 4.3 shows the queues times for every process in 24 hours of production. It proves that most of the process had their own waiting time and in this study, ARENA simulation software helped to notice the delay time during the manufacturing process. In addition, the total time shows the part of body and tyre were not produced in the minimum of cycle time. The utilization of machine and also the operators should be increased to get the optimum and maximum number of product produced. As the result, by having excellent machine movement and operators with good handle capabilities will produce higher production with lower unit cost. In reducing the cost, the manufacturing company should hired only the capable operators to undergo the process.

For the queues result in Figure 4.2, the highest waiting time is at the operation seat assembly. The queue result is 1.53 hours. From the results, it shows that the waiting could be reduced by increased the speed of machine and operators so they will be more parts of tyres can be produced at one time. The second highest is the operation sub kick pedal group and assembly which is 1.46 hours and third highest is the operation grip frame assembly and sub cowling assembly which is 1.36 hours.

Moreover, the total of waiting time for the part of body and part of the tyre were 18.5044 hours and 12.3861 hours. From the result above, the waiting time was higher than the minimum of the cycle time, and it proves that there a lot of waste time every day during the production. For the total time of the simulation shows they used half of the cycle time which was actually could be faster and minimized the time. The total time from the simulation for the part of the body is 19.2988 hours which it could minimize the result below the 8.5405 hours so it could show faster speed of the cycle time. In addition, the total time from the simulation for the part of tyre is 13.0502 hours, which also could be minimized to 4.5487 hours. From the result obtained, some improvement should be made in order to reduce the queues time. The other model was made to solve the problems that happen in the original simulation.
F. Simulation Improvement

Figure 4.4 shows the changes in number of operation for producing DINAMIK motorcycles which already being combined from 42 to 36 operation because some of the operation were being combined together according to the amount work process. For the improvement, the operation that being combined together were nipple inst Fr half front and back tyres, nipple inst Fr complete front and back tyres, rim balancing front and back tyres, sub air filter and air filter assembly, sub cowling and cowling assembly, and finally was sub head and head lamp assembly. The results were improved due to duration time taken during the operation being combined and not taken in long period also the productivity of the product could be increases.

Figure 4.4 Simulation after improvement

G. Number Of Entities Out From The Process

Figure 4.5 Number of entities from original simulation

Figure 4.6 Number of the entities out after changed in simulation

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**H. Discussion**

From the both simulation, it shows that there were improvement in the queues time between them. The objectives of this study were already obtained which were to reduce the number of operation. For example is the operation for the seat assembly. Before the changes was made, the queues time was 1.53 hours but after the improvement and changes was be made the queues time has decreased to 0.96 hours. Moreover, the other highest operation which was sub kick pedal group and assembly which is 1.46 hours also decrease to 0.81 hours and for the operation grip frame sub cowling assembly reduced from 1.36 hours to 1.02 hours.

For the waiting time, the result shows the waiting time decreases. This is because the waiting time and the queues time are proportional to the cycle time. For this study, it focused on reducing the queues time. The queues time result is just for the information to be known.

The total waiting time for the part body and part of the tyre for the original simulation were 18.5044 hours and 12.3861 hours. After the improvement, the waiting time was reduced to 8.5412 hours for the part body and 6.7309 hours for part of tyre. Hence, in the total entities per arrived in part of body, the time could be reduced. In addition, the total time of the part of body and tyre per entities were 19.2988 hours and 13.0502 hours. After the improvement, the total time decreases to 9.3190 hours for part of body and total time for part was 7.2582 hours.

Moreover, if the improved suggestion were applied at the manufacturing process, so all the machines and also operators could improve better result. Furthermore, the cost of the machining could reduce if there were increasing of the productivity at the machine and operators. Furthermore, from the Figure 4.4 and Figure 4.5, the number of the entities increases from 8 entities per day to 10 entities per day. As the conclusion, when the operation being reduced, there were no lacking time during the process hence the productivity of the production will increased. Moreover, if the improved suggestion were applied at the manufacturing process, there will be some changes in improving the results.

**IV. CONCLUSION AND RECOMMENDATION**

**A. Conclusion**

In our country Malaysia, manufacturing process are very common in manufacturing industries and the production process such as the production of the motorcycle was introduced in this study. The experiences that gained from this study could be applied in the working sector and provide the extra knowledge in managing and handling the manufacturing system in the future.

From this study, ARENA software was introduced using some of the basic process of the manufacturing operation in the MODENAS. From the simulation, the real process of the assembly line produced as a model in the software and the result and objectives of the study would be achieved for this study. Through the ARENA software, the queue time of each process will be obtained by this results and the company itself could improve more. The next step was, the results have been compared to each other, which from the original results with the improvement made. There is some suggestion provided in order to increase the capability of the machine and also human workforce and also maximize the productivity of the manufacturing company which is MODENAS.

However, there was some extend of limitation. The limitation is during collecting the data, which may affect the accuracy of this study. Stopwatch was used to collect the time taken for every operators done their work and also the machine operation. May be there was some error occur during the time taken. Furthermore, ARENA simulation software (student version) had some limitation and weakness such as:

a) Not the actual machine that it replicates and it can be difficult to read the results of a simulation model test, which would make it less successful for development purposes.

b) It can be expensive to measure how one thing affects another, to take the initial measurements, to create the model itself.

c) To simulate something a thorough understanding is needed and an awareness of all the factors involved, without this a simulation cannot be created.

d) ARENA simulation software in student version does not suitable for the usage for the engineer because in the industry, ARENA professional version is more suitable which have three dimensions objects and also the simulation is more clear and advanced.

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B. Recommendation

There are various types of solutions that could be recommended in this study in improving the productivity of the assembly line in MODENAS. There were ten recommendations of this study to improve the productivity.

i. Use best possible line layout

Line layout means placing of machines and centre table (trolley with wheel) as per style requirement. The main purpose of choosing a better layout is to reduce transportation time in the line as much as possible. A stable line is not a good idea if you produce multiple products in a same line. A straight assembly line with centre table at left side is good for a product that has no preparatory work and individual operation is nearby the pitch time.

ii. Scientific workstation layout

The workstation layout defines from where an operator will pick up work and where they will dispose. A scientific layout is defined as minimum reach for picking up and disposing of components. Every component and tools must be kept within operator reach. The purpose of designing a good workstation layout is to minimize the material handling time as much as possible. Thus you can reduce operation cycle time. Secondary benefit of good workstation is operators can work at same pace without fatigue. When designing a workstation layout do not forget to consider ergonomics.

iii. Improve line balancing

Purpose of balancing a line is to reduce operator’s idle time or maximize operator utilization. In a balanced line work will flow smoothly and no time will be lost in waiting for work [5], [6] and [7]. At time of line setting select operators for the operation matching operator skill history and skill required. Following this method you will select highly skilled operators for higher work content operations. Once you start increasing operator utilization through line balancing you will get extra pieces from the same resources in defined time.

iv. Training for Line supervisors

Line supervisors are shop floor managers. So each supervisor must be trained with fundamental management skills and communication skill. Their main job is providing instruction, transferring information. For which communication skill training is required for supervisors. Secondly, supervisor should understand the fundamental of industrial engineering like operation bulletin, skill matrix, workstation layout, movement, capacity study and theoretical line balancing and others. If they understood these, they can help engineers or work study to improve line performance. The above training will bring changes in managing and controlling the lines and will improve labour productivity.

v. Training to operators

Operators are main resources in the apparel manufacturing. They are most valuable resource to the company. So, factory must work on developing operator skill where required. “Training is not cost but an investment” said by many experts. Production from an operator depends on his skill level to the task. A low skilled operator will consume higher resources (time) and give less output. You will find quality related issues with low skilled and untrained operators. As the skill level of the operators is increased through training lines output will improve. Training does mean lot of time and money. Training should be given only on specific tasks that will be performed by the operator.

vi. Installing better equipment

A low performing machine is not acceptable where some of your good machines are idle in the same building. Use the best of your resources. If machines or equipment don’t perform well operator motivation goes down. Repetitive breakdown of machines increase the loss time and bring down overall line efficiency and labour productivity.
vii. Inline quality inspection at regular interval

Traffic light system is the most effective inspection tool to reduce defect generation at source. Less number of defective seam is made less the time will be lost in repairing it. Inline checking system will alert operators in concentrating their job. It also helps in other way. May be at the start of the style an operator not understood the specification, an interaction with quality inspector will make an operator clear about the quality requirement. Poorly managed factory loses productivity up to 10% due to repair and reject as mentioned by Dr. Bheda in his article “Productivity in Apparel Manufacturing”.

viii. Operator motivation

Operator’s will is the most crucial part in productivity improvement. If they are motivated, they will put enough efforts on the work. Employee motivation generally depends on various factors like work culture, HR policies, bonus on extra effort or achieving target. In automotive manufacturing company, operator’s motivation come through extra money. Operator motivation can be improve by sharing certain percentage of you profit made from operator’s extra effort. We need to understand that employees come for work in your organization for money. Initially you may think that an incentive scheme may reduce your profit. But in real it works in opposite direction, provided that incentive system is fair for the workers and has been implemented intelligently.

ix. ARENA Professional Edition

ARENA professional simulation software is most effective when analysing complex, medium to large scale of projects involving highly sensitive changes related to supply chain, manufacturing, processes, logistic, distribution, warehouse and service system. Moreover, ARENA professional version is most effective when analysing complex simulation. It can also be used to create customized modelling product that was focused on specific applications or industries.

x. Improve the conveyor speed

In the assembly line, the torque in the conveyor’s motor should be improve using motor with high torque speed of motor such as Bosch Warmgear Motor which contain higher torque and speed. Unfortunately, there were a lot of other motor that could use in the automotive industry. Hence the manufacturing company should choose the suitable torque for their conveyor’s motor.

REFERENCES


BIOGRAPHY

Dr. Abdul Talib Bon is Professor of Technology Management in the Faculty of Technology Management and Business at the Universiti Tun Hussein Onn Malaysia. He has a PhD in Computer Science, which he obtained from the Universite de La Rochelle, France. His doctoral thesis was on topic Process Quality Improvement on Beltline Moulding Manufacturing. He studied Business Administration in the Universiti Kebangsaan Malaysia for which he was awarded the MBA. He’s bachelor degree and diploma in Mechanical Engineering which his obtained from the Universiti Teknologi Malaysia. He received his postgraduate certificate in Mechatronics and Robotics from Carlisle, United Kingdom. He had published more 150 International Proceedings and International Journals and 8 books. His research interests include manufacturing, forecasting, simulation, optimization, TQM and Green Supply Chain. He is a member of IEOM, IIE, IIF, TAM, MIM and council member’s of MSORSM.