KITTING AND TIME EFFICIENCY IN AUTOMOTIVE ASSEMBLY LINE USING COMPUTER SIMULATION AND LINE BALANCING

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Abstract: Most of the industries in Thailand are now facing the new challenge of production performance. In the assembly line usually, enhance the longest cycle time due to it is impacted to increase the capacity This paper applies a line balancing method for solving a bottleneck problem. Process simulation can be usefully applied for studying and analyzing to the whole system. Firstly, of the purpose of this research, collecting the actual data, and making the data fit distribution in the Minitab software. Secondly, the simulation model of the subgroup streamline is set up and, the bottleneck is shown and analyzed with the resource statistics chart and study in alternatives plan Next, the reconstructed strategy based on the principles of ECRS (Eliminate, Combine, Rearrange, Simple) and the theory of line balancing is provided and evaluated by the model Finally, comparing with the current production line, implementation of the new design makes the production efficiency. This research is adopted simulation tools of Technomatrix in order to less modification After the modeling can represent the real system, its ability to recover the bottlenecks in order to increase productivity before implement in the existing system accordingly.

Index Terms: Automotive Assembly Shop, Line balancing, Plant Simulation, Process Simulation, Analysis, Bottleneck, Subassembly, ECRS, Case Study

I. INTRODUCTION

In recent years, the Thailand automotive industry has been grown up rapidly. To be competitive in global market industry 4.0 that everythingcan be connected and monitored the whole processes and also leads to more investment in high technology. The less decision time is shorter, the more profit gets higher. Automotive competition is depending on time, considering on processing time is very matter.
The automotive manufacturing is based on intermittent production system. It consists of 11 stations that the raw materials will be pass through each task of workstation.The author focusses on highest working time and blocking proportion to increase resource utilization on some processes.
The main of motorbikes in sub-assemblies can be summarized into two main phases:
1.The sub-assembly line which is used for many small components and assembly some operationas following procedure.
2.The kitting supply which is used for transportation between the small line to the final conveyer assembly line. The individual carrier will pick the part as the specific quantity every station.However, the travel time is not over the cycle time so that it can be neglect.

The most challenging of the subassembly is instantaneous supply to the main line as the speed of conveyor or task time. The frequency of assembly problems has existed on assembly line. It is the unsuitable workload on each station somehow more or less 50% of utilization. The highest production time happens in some sequence or some operation. So, it can be lead to make the blocking or waiting time that means the completed component cannot supply to the main line.

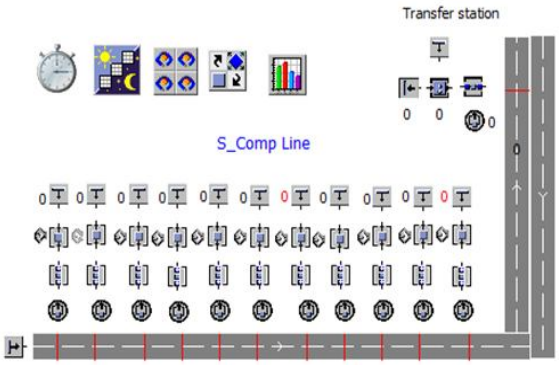


Figure. 1 The Sub-component line layout (current model)

Linebalancing theory has been adopted for solving the longest cycle time or highest workload in order to increase the efficiency in the whole process.
Simulation is a tool for making the modeling of production systems that can monitor the whole process system. To help users understand the problem and to recognize an overview for troubleshooting and long-term planning. Simulation is an important tool in the current study and problem solving in production management also less modification in the real production line.

Hence, for reducing the cycle time at the bottle process or balancing the processes with high workload, the simulation tooling involved in the cycle time to related with the performance areas. These will be result from improvement the output of process such as the throughput.

II. LITERATURE REVIEW

The advantage of kitting method isshorter distances between parts presentation and assembly unit so that the time is decreasingly spent to fetch partswhen compared with keeping parts in the racks.[1] R. Hanson and L. Medbo

It will be more benefit whereas implement simulation tools in the real production planning are presented by Artid T. et al [2]. Their goal is to reduce the paint shop process. bottleneck problem. The method starts with input data collection, data fitting. After that, they built simulation model, validated model, identified bottlenecks, and developed methods to improve production performance.

Some case study for the optimization of the assembly line,after solving the line balancing, the production rate is significantly increased by the combination of the line balancing. Zupan, H. et al [5] however, L. Li et al [6]they also use the line balancing and discrete event simulation model by creating the simulation modeling as the real system. All of the cycle time which is collect the data from the workstationand applied ECRS (Eliminate, Combine, Rearrange, Simple) method to rebuilt and minimized workstation.

III. OBJECTIVE

The aim of this research is studying in cycle time total 11 workstations which are conducted for operation time and kitting part by simulation and analysis the new concepts before implementation without any changing the whole process to meet the economic reason industry.

The main concepts derived from the simulation of each operation. It can make the better workflow to reduce bottlenecks and improve the performance systems in order to meet the target of average working utilization at 80%.

The Siemens PLM software, Technomatrix Plant Simulation V.14.1 was used in this study.

IV. INPUT DATA COLLECTION AND DATA FITTING

A crucial step modelling is the data acquired to input in simulation modelling, A total of eleven stations information which needs to be collected for the model was determined.

3.1) Probabilistic data, which is studied on working time. The random variable is derived from the data distribution.

3.2) Deterministic data, which is transport from the sub-component line to transfer station also the area.

All the data should be gathered for making the simulation model work.

3.3) Input Distribution ten samples of processing time data sets, received from the data chart were imported to Minitab, the statistical software, to specify the distribution that best fits to the data. (See Table I and Fig. 2)

TABLE I STATISTIC DATA GENERATED BY MINITAB

Station	Process	N	Mean	SD	Min	Max
1	Canister Brake	10	6.08	1.04	4.90	8.20
2	Instrument Panel	10	6.19	0.61	4.80	7.00
3	Side Stand	10	5.41	0.86	4.50	7.00
4	Vertical horizontal	10	4.07	0.63	2.90	5.00
5	Airbox	10	10.25	1.80	8.12	13.00
6	Cover Airbox	10	6.14	0.86	5.27	8.00
7	Foot peg	10	17.37	0.78	16.30	18.35
8	RR M/G	10	10.17	1.21	8.00	12.00
9	RR Indicator	10	6.01	0.53	5.50	7.30
10	Number plate	10	8.58	0.88	7.50	10.12
11	Tail light	10	2.20	0.44	1.80	3.00

The unit is minute.

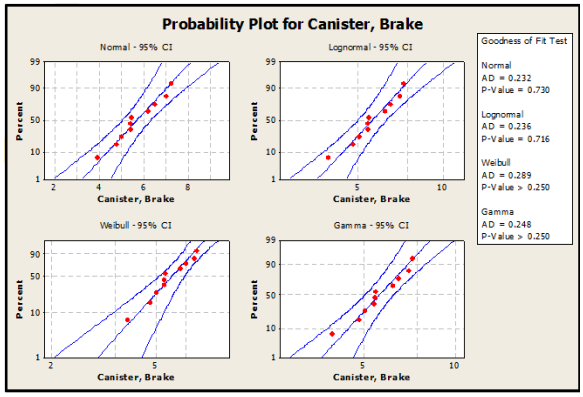


Figure. 2 An example of identifying the bestdistribution fitting for Canister brake process

Distribution Summary:	
Canister:	Normal
Instrument Panel:	Normal
Side Stand:	Lognormal
Vertical Horizontal:	Lognormal
Airbox:	Lognormal
Cover Airbox:	Lognormal
Foot peg:	Normal
RR M/G:	Normal
RR Indicator:	Lognormal
Number plate:	Lognormal
Tail light:	Lognormal

V. BOTTLENECK IDENTIFICATION

a bottleneck is one process in manufacturing that its limited capacity obstructs the capacity of the whole manufacturing. The statistical data of station utilization which was recorded during the simulation run can be displayed by the useful feature of the software. The blocking percentage of station can identify the spot of the bottleneck.

The process capacity can be calculate as following.

$$\text{Capacity} = \frac{\text{Working time } (\frac{\text{min}}{shift})}{\text{Maximum Cycle time } (\frac{\text{min}}{\text{bike}})}$$

VI. EXPERIMENTAL DESIGNS

Two design alternative model duplicates and modifies the current model and there's no impacting to the quality of product with labor and engineers 'opinions. (fig.1) that represented the existing production line, every workstation is separated by worker and workstation. After finishing their tasks, the component parts will flow to keep on the shelf for lining picking up. The carrierwill arrange part in the kitting cart and then releases parts to the main conveyor production line.

From table II, it shows all of the cycle time which are highlighted workload at highest workstation No.7 and lowest workstation No.11 that be shown you approximately.

In practice,the fourprinciples of ECRS (Eliminate,Combine,Rearrange,Simple)and the method of work study was selected to improve the subgroup.

Step 1- Eliminate: By studying the operating processes of each worker, found that workstation No. 11 has a lot of wastes as a waste of waiting and so on. Even though there are many nonvalue operations for the product, we should eliminate these wastes. For example, in the operation of station number 11, there is a waste of waiting for a carrier to pick the part for 11 minutes. And this waste can be eliminated.

Step 2- Combine: We can analyze the condition of the operations which are necessary and can combined together. The combination of some operations can save time and simplify it. For example, the workstation No.7 can be combine the operation to workstation No.11 by using the same of tooling.And the same is true for some other working.

Step 3- Rearrange: Rearrange the remaining located part that cannot be get rid of operation and combined to make the sequence of operations properly. E.g. rearranging the part location of workstation No.7 can make the sequence as well.

Step 4- Simple: It is important to resolve a simple method to complete the work after all implement have been eliminated, combined and rearranged. For example, to add newtools or jig and fixture, use automatic machines, simplify operationmethods and so on. All of the ideas can improve the efficiency of the subassembly line.

After taking the four principles of ECRS (Eliminate,Combine, Rearrange, Simple) and the concept of work study, we can improve the efficiency of the kitting component subgroup.

The CT of each operation after improved is as Table 2and calculated by formula as following.

$$\text{Line balancing} = \frac{\Sigma CT_i + CT_j + \cdots}{\text{n}}$$

TABLE II Workstation cycle time and line balancing1st

Station	Cycle time (Current)	Line balancing 1st
1	6.08	6.08
2	6.19	6.19
3	5.41	5.41
4	4.07	4.07
5	10.25	10.25
6	6.14	6.14
7	17.37	10:18
8	10.17	10.17
9	6.01	6.01
10	8.58	8.58
11	2.20	10:18

The unit is minute.

Workers are able to operate all station.

After the first line balancing was adopted, the bottleneck and idle time were reduced also.

The workstation No.5 becomes a bottleneck which is consumed working time 10.25 minute so that we will keep improving the process by using possible common tooling and taking line balancing again as same as first time adopted.

This table shows you the next result from the second line balancing. This workload No.4was eliminated waste of waiting time to combine some common tooling to put part togetherthat comes from station No.5.These parts will be rearranged the location at workstation No.4continuously.

The concept of cycle time after improved is as Table 3 and calculated working time by using formula as same as first balancing.

TABLE III Workstation line balancing1st and 2nd

Station	Line balancing 1st	Line balancing 2nd
1	6.08	6.08
2	6.19	6.19
3	5.41	5.41
4	4.07	7.16
5	10.25	7.16
6	6.14	6.14
7	10:18	10:18
8	10.17	10.17
9	6.01	6.01
10	8.58	8.58
11	10:18	10:18

The unit is minute.

Workers are able to operate all station.

VII. RESULT AND DISCUSSION

From the 3 types of simulation with working time 510 minutes or 9 hours 30 minutes, including 1-hour break time, under workers stand by all stations, the average values are as follows.
All the conditions have been set the sufficient worker as 11 people.

By its current situation modelling, the result average utilization is approximately 40.84% and it peaks utilization at 89.47%.

After comparison the current simulation model with model A, by balancing the working time between station No.7 and No.11. Found that the bottleneck from 17.37 minutes to 10.18 minutes, Consequences the average of model A is 68.81%, it is higher than the previous 27.97%.This is a reasonfor decreasinga waste of waiting time from workstation No. 11 gets more balance. Also, the throughput is turned into 28 to be 49 bikes/dayas the following capacity formula.

$$\text{Capacity (LB\#1)} = \frac{working\ time(\frac{\min}{shift})}{CT_5(\frac{\min}{\text{bike}})}$$

After the first line balancing is adopted, the bottleneck was changed to become the workstation No.5.

It was considered to improve with the longest cycle time 10:25 minutes. Therefore, after the observation at the previous station, it was found that the workstation No.4 had approximately 50 percentage of the wasted time, so it could be improved. In addition, the workstation No. 5 can be divided into sub-parts to the previous station because the tooling is also common using.

Subsequently, the second line balancing is chosen. The average utilization model B has been increased by 0.32% or about 69% that yields is equal to 49 units per day as model A (based on the maximum utilization 89.47%), however, an average utilization gets better balancing system.Also, the highest cycle time is reduced to 10:18 minutes.

TABLE IV Comparison after running thesimulation.

Scenario		Current	Model A	Model B
Man Power (Person)		11	11	11
Working utilization (%)	AVG	40.84	68.81	69.13
	MAX	89.47	89.47	89.47
Throughputs/Shift		28	49	49
Longest cycle time (Min)		17:37	10:25	10:18

The simulation tooling was used to run the current production line(Fig.3).

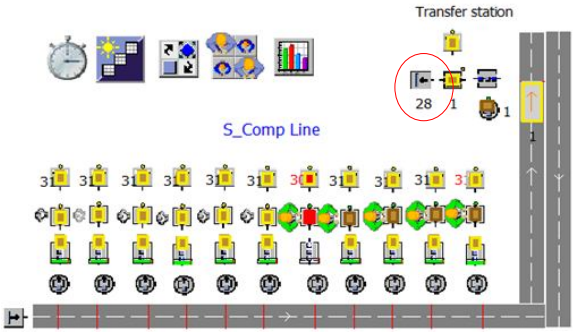


Figure. 3 The result of line balancing (current)

(Fig.4) is shown the sharing workstation after line balancing is adopted.

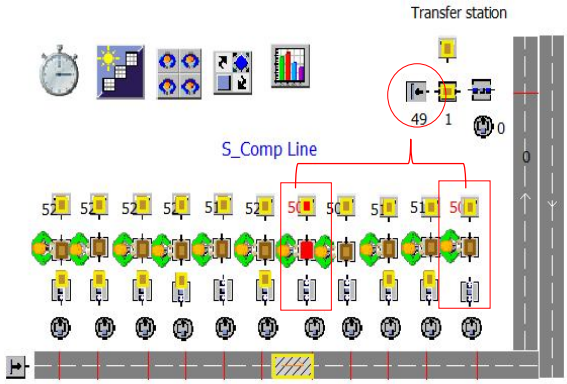


Figure. 4 The result of line balancing after adopted.

Fig.5 is shown the current simulation model. The workload at station no.7 has been the highest load at 90% because an average cycle time is also longest (17:37 minutes) and the station no.11 was the highest blocking (Idle time) about 85.67% due to an average cycle time is shortest (2:20 minutes).
The result of simulation shows the working proportions of station 1,2,3,4,6,9,10,11 are all under 50%.Evidently,these operations haveextra production capacity.
Fig. 6 is shown the Model A simulation. The workstation no.7 and no.11 have been taken ECRS and Line Balancing principles to theirwork to make the utilization as same as leveling.Also, the workflow isconstantly from reducing the blocking time of station no.11.
The result of simulation shows that the working proportions of station no.4 is only under 50%.Obviously, this operation hasredundant production capacity.However, the station no.5 is the next issue for solving the longest cycle time.
Fig. 7 is shown the simulation model B. As be the second line balancing, these workstation no.5 and no.4 are combinedsome job based on ECRS principles.The bottleneck of this system drops from 10:25 to 7:16 minutes and the process utilizationis getting higher from 37.14% to 65.02%.

Even the throughput is a few differences between Model A and Model B but when it compared with the existing of blocking time.It means; the completed

components are stuck on the rack; the next operation does not occur instantaneously.It becomes clear that it has been improved as being the Model B.

Moreover,the result of simulation shows noneof working proportions is below than 50%. Certainly, all workstation can make more efficiency in production capacity.

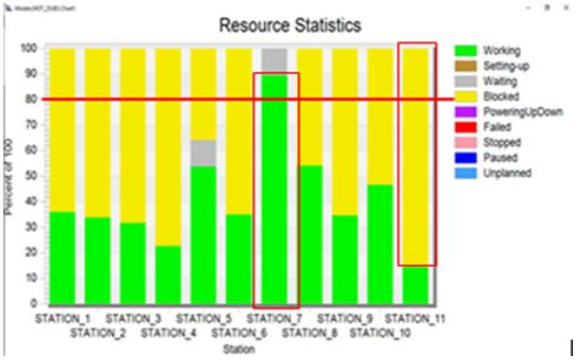


Figure.5Resources utilization (Currentsituation)

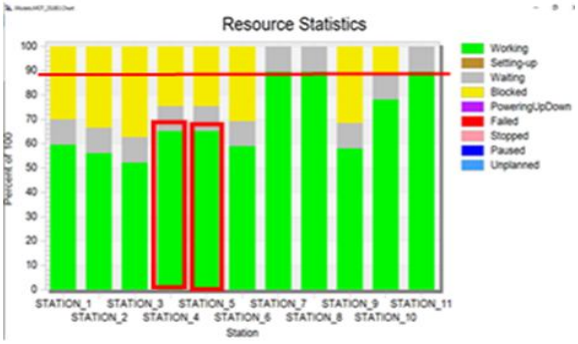


Figure. 6 Resources utilization chart (Model A)



Figure. 7 Resources utilization chart (Model B)

CONCLUSIONS

This paper takes place with the subassemblies of the motorcycles line to analyze the bottleneck of the process and simulates the model by inputting data distribution according to the statistical.

Consequence, the bottlenecks is reduced and the flow production is getting better by dividing the workload of each station based on the common part and tooling in sub-line.

The productivity can be increased from 28 units per day to 49 units per day or around +75%. Obviously, their average performance is approximately 69% that nearly meet the target average working utilization at 80%.

Moreover, we can see the beyond improvement in this process that can make time more effectively in order to meet the target average working utilization within a future plan. Whereas operator can assembly consistently, to install the AGV (Automatic Guided Vehicles or Pick and Place robot) has been interested option in picking the part following the position instead of human doing.

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