SIMULATION OF ASSEMBLY LINE FOR PRODUCTION PERFORMANCE IMPROVEMENT

MOHD SAIFUL AKMAL BIN RAZALI

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Faculty of Manufacturing Engineering
Universiti Malaysia Pahang

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ABSTRACT

An automotive assembly line is a process in automotive manufacturing system whereby car parts are installed and the semi-finished car body moves from a workstation to another workstation in sequencing manners until the final assembly of the car is produced. This Bachelor Thesis presents the study of the automotive assembly line at the Trim-Chassis-Final Line in a particular automotive manufacturing organization in Malaysia. The objectives of this study are to perform simulation study, evaluate the performance of the current production system and identify the root cause of the problem. The production data were collected and simulated using discrete event simulation. In this project, Siemens Tecnomatix Plant Simulation is used to simulate and optimize the production layout. Then, three improvement strategies are proposed and simulated in order to identify the effect of the improvement strategies on the production performance. The strategies consist of eliminating non-value added sub-processes to the line, adding sub-processes to the line. Elimination of the non-value added sub-processes to the line will reduce the working, picking and walking times. Meanwhile, addition of sub-processes to the line will increase the working, picking and walking times. Simulation results indicate that all of the improvement strategies are able to maximize the productivity and line efficiency, but only one improvement strategy with greater significance will be chosen. This proposed improvement strategy has a better line efficiency and throughput per shift compared to the current production layout and another two improvement strategies.

ABSTRAK

Barisan pemasangan automotif adalah satu proses di dalam sistem pembuatan automotif di mana bahagian-bahagian kereta dipasang dan badan kereta yang separa siap bergerak dari satu stesen kerja ke stesen kerja yang lain dengan cara penjujukan sehinggalah pemasangan yang terakhir untuk kereta tersebut dihasilkan. Tesis Sarjana Muda ini membentangkan kajian mengenai barisan pemasangan automotif bagi Barisan Trim-Chasis-Akhir di sebuah organisasi pembuatan automotif di Malaysia. Objektif-objektif kajian ini adalah untuk menjalankan kajian simulasi, menilai prestasi sistem pengeluaran sedia ada dan mengenal pasti punca kepada masalah yang berlaku. Data-data pengeluaran dikumpul dan disimulasi dengan menggunakan *discrete event simulation*. Dalam projek ini, Siemens Tecnomatix Plant Simulation digunakan untuk mensimulasikan dan mengoptimalkan susunatur pengeluaran. Kemudian, tiga strategi penambahbaikan dicadangkan dan disimulasi untuk mengenal pasti kesan daripada strategi penambahbaikan kepada tataletak pengeluaran. Strategi-strategi ini terdiri daripada menghapuskan sub-proses yang tiada nilai tambah dan menambahkan sub-proses ke barisan. Penghapusan sub-proses yang tiada nilai tambah di barisan akan mengurangkan masa bekerja, mengambil dan berjalan. Sementelah itu, penambahan sub-proses ke dalam barisan akan meningkatkan masa bekerja, mengambil dan berjalan. Hasil penyelakuan menunjukkan bahawa semua strategi penambahbaikan dapat memaksimumkan produktiviti and kecekapan barisan, namun hanya satu strategi penambaikan dengan makna yang lebih besar akan dipilih. Strategi penambaikan yang dicadangkan ini mempunyai kecekapan barisan dan daya pemprosesan per syif yang lebih baik berbanding tataletak pengeluaran semasa dan dua lagi strategi penambaikan yang lain.

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Δt	Time intervals

LIST OF ABBREVIATIONS

AB	Aktiebolag (Swedish term for "limited company" or "corporation")
ABC	Activity Based Costing
AIS	Automatic Identification System
ALB	Assembly Line Balancing
ANOVA	Analysis of Variance
CACI	Consolidated Analysis Centers, Inc. (1967-1973; since 1986, CACI International Inc.)
DES	Discrete Event Simulation
ECU	Emission Control Unit
ED	Enterprise Dynamics
ERP	Enterprise Resource Planning
FIFO	First In, First Out
FORTRAN	Formula Translation/Translator (high-level programming language)
GKN	Guest, Keen & Nettlefolds (British global engineering company)
IPA	IsoPropyl Alcohol
LB	Line Balancing
LIFO	Last In, First Out
LH	Left Hand side
MATLAB	Matrix Laboratory
MU	Mobile Unit
OPC	Operator Balance Chart
OR	Operations Research
PLM	Product Lifecycle Management
RH	Right Hand side

RR	Rear
SIMAN	Simulation Management
SME	Small and Medium Enterprise
SOP	Standard Operating Procedure
SPECO	Sadid Pipe and Equipment Company
SPS	Sub-assembly Packaging System
SWCC	Standard Work Combination Chart
TPM	Tecnomatix Plant Simulation
WIP	Work In Progress
WS	Workstation

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This chapter discusses the project background, problem statement, the objectives, scope of the project, hypothesis, thesis overview and also research question.

1.2 PROJECT BACKGROUND

Nowadays, quality product and ability to deliver the customer demands are pivotal aspect and perspective that should be seriously considered especially in the automotive industry. The management system also plays a crucial rule in order to take control, arranging and measuring parameter related to the areas of performance.

Organization or company ought to realize that the efficiency depends upon how well the production line in term of producing the output [Groover, 2001]. There are three basic types of layout design which are product layout, process layout and fixed-position layout [Heineke and Davis, 2005]. For this particular thesis, product layout is the types of layout that will be investigated.

Product layout can be defined as a layout of flow shop, where a number of machine and work processes are arranged so that the products will pass through several workstations. Due to higher request the resources need to be improved from process layout format to product layout. Thus, it required a succession steps to make product and run the production smoothly, which the industries often call it as an assembly line.

Assembly line systems are generally portrayed as dynamic assembly connected with some type of material handling. This can be discovered, particularly in industries that assembles product, such as electronic gadgets part, automotive component and so on. An example case of product layout is the cafeteria, where customer trays are traveling through the series arrangement of workstations. Nonetheless, the term "bottlenecks" are frequently happened in assembly line and this will cause a delay in term of time and reducing in line efficiency.

Computer simulation is being used in this project in order to investigate and examine the issues that happened in an assembly line. Comparison between the current design and new layout are carried out. Simulation and optimization is carried out by TECNOMATIX Plant Simulation to perform this study.

1.3 PROBLEM STATEMENT

Manual assembly lines technology has made a significant contribution to the advancement of American industry in twentieth century [Groover, 2001]. This phrase indicates the significance of assembly line, especially in the automotive industry and those industries that produced mass quantities product. This emphasizes the success factors are depending on the efficiency of the assembly line.

In order to produce assembly line with high productivity, the ideal amount of resources in terms of labour and workstation will need to be carefully considered. One way to do this is by performing a line balancing study. Line balancing is a capable tool to improve the throughput of assembly line while reducing non-value added activity. Besides, line balancing ensure that the equal amount of processing time in each workstations.

On the contrary, simulation tool can provide a quick and effective implementing change where experimentation in the real life system can be very time-consuming and expensive. Evaluation and optimization of the line throughput, machine utilization and cycle time can be done easily with this simulation tool [Kumar & Mahto, 2013].

1.4 PROJECT OBJECTIVE

The objectives of this project are as follows:

(i) To perform simulation study in an automotive assembly line.
(ii) To evaluate the performance of the production system using simulation technique and to identify the root cause of the problem.
(iii) To propose new improvement strategies in order to increase the performance of the system.

1.5 PROJECT SCOPE

To achieve the objectives of the project, this study will focus on the existing production system at one of the automotive manufacturing company.

(i) Production data such as cycle time, production rate, number of workers and number of workstations are obtained at the automotive manufacturing company.
(ii) Simulation is conducted by using TECNOMATIX Plant Simulation Software.
(iii) The comparison will be made between the existing production layout and the proposed production layout.

1.6 HYPOTHESIS

It is expected from this study that by using simulation study to balance the line, the production performance such as line efficiency and the rate of productivity can be improved.

1.7 THESIS OVERVIEW

Chapter 1 discusses the introduction of this project which covers project background, problem statement, objectives, scopes and research questions. The literature review for this project is covered in ***Chapter 2***. Meanwhile, ***Chapter 3*** highlights the approaches and the method used in this study. ***Chapter 4*** contains the result and discussion. Finally, conclusion and recommendation for future work are reviewed in ***Chapter 5.***

1.8 RESEARCH QUESTION

For this project, there are several questions that need to be answered in order to provide a clear direction of inquiry in this research. There are as follows:

(i) How to translate the real system into the simulation modelling?
(ii) How to do simulation in Tecnomatix Plant Simulation software?
(iii) What type of data used in simulation study?
(iv) What are the input and output variables for the simulation study?
(v) How many data should be collected for the statistical analysis?
(vi) What are the root cause of the inefficiency of the assembly line?
(vii) What is the current performance of the line?
(viii) How can we check the current performance of the assembly line? What method should we use?

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter will provide background of the chosen company, simulation technique, assembly line system, assembly line balancing technique, workstation and also the review from the previous research that is related to this study.

2.2 BACKGROUND OF THE COMPANY

This project has been done at one of the automotive manufacturing company located on a 162 hectare site in Rawang, Selangor. It was established in 1993 and a joint venture company between Malaysian and Japanese partners.

As at end of March 2015, this automotive manufacturing company has sold some 2.5 million units of vehicle of various models with a total number of 11,000 man powers. Besides, the plant currently has the capacity to produce 350,000 units of car per annum.

2.3 ASSEMBLY LINE SYSTEM

An assembly line is a process in manufacturing whereby parts are added as the semi-finished assembly moves from work station to another work station where the parts are added in sequencing manner until the final assembly product is produced [Boysen *et al*, 2006]. It was first proposed by Henry Ford in the early 1900.

The assembly line was designed to be a competent and profoundly productive way of manufacturing a particular product. As highlight by Henry Ford, the principles of an assembly line are as bellows:

(i) Arrange the workers and tools in the sequencing manner of the operation. This approach allows each component part to travel the least possible distance while in the process of finishing.

(ii) Use carrier or work slides. By applying this approach, when a worker completes his operation, he drops the part always in the same place. The place must always be the most comfortable and reachable place in the worker's hand and if possible, utilize gravity to carry the part to the next worker by its own.

(iii) Use sliding assembling lines by which the parts to be assembled are delivered at the convenient distances.

The assembly line consists of a set of workstations arranged in a linear fashion, whereby each station connected by a material handling mechanism. The primary movement of material through an assembly line starts with a part being delivered into the first station at a predetermined feed rate. In assembly line, a station is considered as a place which a task is performed on the part. These tasks can be done either by robots, machinery and/or even human operators. Once the part enters a station, a task is then performed on the part, and the part is delivered to the next operation. The time taken to complete a task at each operation is known as the process time.

2.3.1 Type of Assembly Line Layout

Assembly line layout defines the rules for task processing at workstations. In line balancing, these rules are taken into account principally in the form of problem constraints [Battaia and Dolgui, 2012]. There are several types of assembly line layout which are often considered in the real applications and literature. There are as follows:

(i) Basic straight assembly line

Each workpiece visits a series of workstations in the order of their installation as shown in Figure 2.1. A set of tasks is assigned to each workstation. The tasks are executed one after the other [Battaia and Dolgui, 2012].

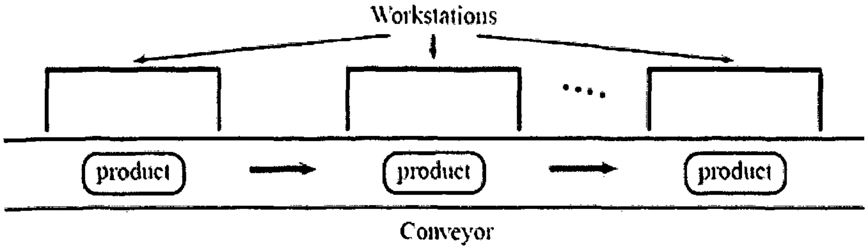

Figure 2.1: Basic straight assembly line

(ii) Straight assembly line with multiple workplaces

Workstations are aligned as shown in Figure 2.2. However, at each workstation, a number of parallel workplaces, serial workplaces or mixed activated workplaces are installed in such a way that the workers or pieces of equipment associated with each workplace can perform simultaneously, sequentially or in a series-parallel way on each workpiece, respectively [Battaia and Dolgui, 2012].

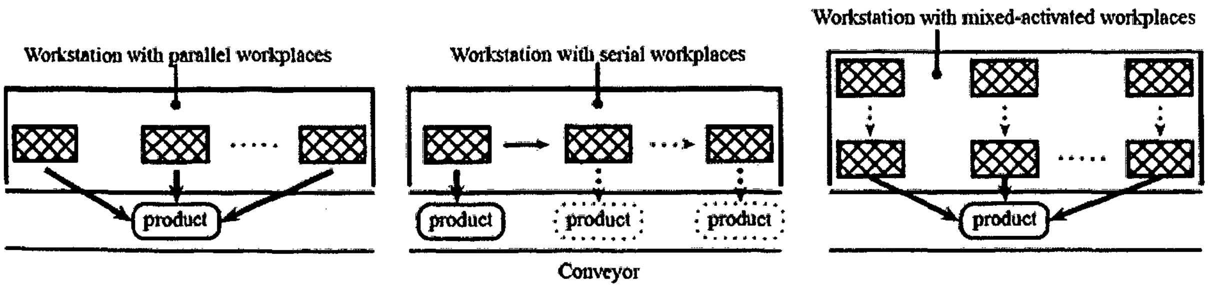

Figure 2.2: Straight assembly line with multiple workplaces

(iii) U-shaped assembly line

These lines have both the entrance and exit in the same place. Workers placed between two legs of the line are allowed to walk from one leg to another as shown in Figure. Therefore, they can work on two (or more) workpieces during the same cycle. In this case, several subsets of tasks associated with different workstations are performed by the same worker. In the mathematical models of these lines, precedence and cycle time constraints are not treated in the same manner as for straight lines [Battaia and Dolgui, 2012]. More than 100 Japanese and American companies have revealed that the U-shaped lines have significant practical importance in reducing the work-in-process levels and improving the productivity measures [Miltenburg, 2001]. A high level of participation of the workers in U-shaped lines improves productivity. The U-shaped line workers are expected to have higher skill levels as they perform a wider range of the tasks. This provides quick response to the changing environments due to the possibility of re-allocating the skilled operators, hence brings higher flexibility. The line can be rebalanced easily by adding or removing workers, hence the changes in the required production rates can be adapted easily [Ogan and Azizoglu, 2015].

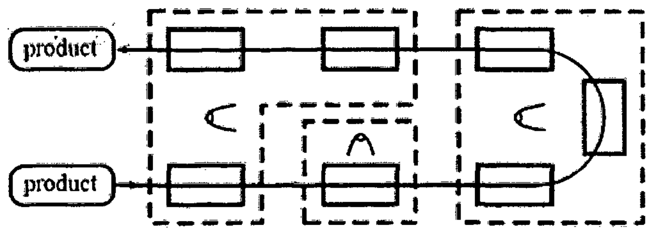

Figure 2.3: U-shaped assembly line

(iv) Assembly line with circular transfer

Workstations are installed around a rotating table which is used for loading, unloading and moving the part from a workstation to another. With regard to the number of turns during which a part stays on the table before being completed, the lines with single and multi-turn circular transfer can be distinguished. If only one part side is treated at each workstation and a single turn is sufficient for completing a product, then this configuration is equivalent to a basic straight line. If several sides of the part can be treated simultaneously, then this configuration is equivalent to a line with multiple parallel workplaces. In the case of multi-turn transfer, the set of tasks assigned to a workstation must be partitioned into the different cycles corresponding to the number of turns of the table [Battaia and Dolgui, 2012].

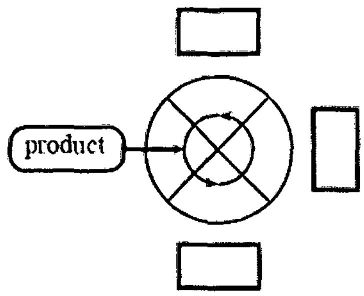

Figure 2.4: Assembly line with circular transfer

2.3.2 Type of Assembly Line Model

An assembly line model can be classed into three categories as shown in Figure 2.5, Figure 2.6 and Figure 2.7. This category is based on the quantities of models assembled on the line and also as per the line pace [Groover, 2001] which are:

(i) Single Model Assembly Line

A single model line can be portrayed as a line that assembles a single model. This line produces various units of one product with no variation. The tasks performed at each station are similar to all units. Products with high volume and demand are intended to this line [Groover, 2001].

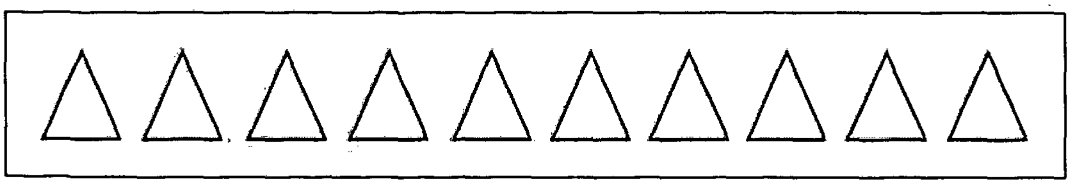

Figure 2.5: Single Model Assembly Line

(ii) Mixed Model Assembly Line

A mixed model line is a line that producing more than one model at the same time [Korkmazel and Meral, 2000]. At the point when one model is working at one station, the other product is made at substitute stations. Subsequently, every station is designed in a way that they can perform various tasks needed to produce any model that goes through it. A lot of products are assembled on this type of model [Groover, 2001].

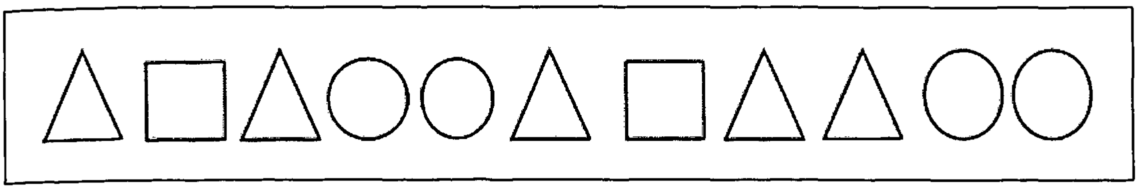

Figure 2.6: Mixed Model Assembly Line

(iii) Batch Model Assembly Line

This line produces each model in batches. Workstations are typically set up to produce the required quantity of the first model, then the stations are reconstructed to produce another model. Products are often assembled in batches when medium demand. It is more cost-effective to use one assembly line to produce several products in batches rather than develop a separate line for each single model [Groover, 2001].

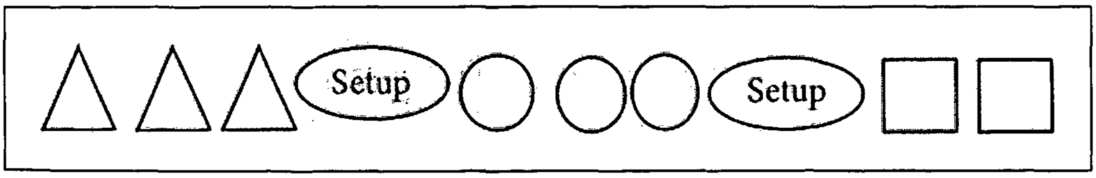

Figure 2.7: Batch Model Assembly Line

2.3.3 Advantages and Disadvantages of Assembly Line

The principles of the assembly line acknowledged the manufacturers to produce mass amounts of products at lower cost and indirectly made for easier maintenance of products after their assembly. While the ideas behind assembly line manufacturing are an important part of the way products are made and assembled today, it is also interesting to consider the disadvantages of these types of production systems.

2.3.3.1 Advantages of Assembly Line