UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LINE BALANCING USING SIMULATION IN SEMICONDUCTOR INDUSTRY

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Management)

by

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Management). The members of the supervisory committee are as follow:

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ABSTRAK

Line balancing merupakan suatu aplikasi umum dalam *assembly line* di tempat pengeluaran. Pada dasarnya, *line balancing* merupakan cara dalam menentukan operasi pada *workstation* sehingga menjadi setara dan optimum. Sehingga kini, terdapat pelbagai jenis teknik dam algoritma untuk *line balancing* yang telah digunakan untuk penyelesaian optimum dalam pengagihan tugas dalam operasi. Namun demikian, disebabkan teknik yang biasa digunakan merupakan sistem manual dan berorientasikan ramalan, terdapat beberapa kesulitan dalam menentukan keputusan yang bakal berlaku pada masa akan datang jikalau sistem tersebut diubah. Lantaran itu, penerapan pemodelan simulasi merupakan salah satu alternatif yang lain untuk mewakili situasi yang sebenar daripada *assembly line*. Dalam model simulasi yang dibina, proses dimana berlakunya *bottleneck* boleh dikenalpasti. Proses experimen akan dijalankan dalam senario yang bebeza untuk mendapatkan penyelesaian yang terbaik tanpa menganggu sistem produksi yang asal untuk proses *assembly* semikonduktor yang dimodelkan. Penyelesaian untuk *line balancing* diperoleh melalui teknik simulasi dan *simulation runs* untul mengenal pasti tugas optimum untuk *workstation.* Secara keseluruhan, daripada data yang dikumpulkan daripada industri, model simulasi yang mimic kepada *assembly line* yang asal akan dimodelkan. Penemuan signifikan daripada kajian ini berupaya mengenalpasti *bottleneck* pada proses tertentu dan juga untuk mengenalpasti nisbah optimum antara bilangan pekerja dan mesin. Dengan ini, penambahbaikan seperti penukaran jumlah tenaga pekerja atau peralatan akan dicadangkan. Secara keseluruhan, kesan simulasi yang digunakan dalam kajian ini diharapkan dapat menentukan keadaan optimum dalam *line balancing* tanpa perlu mengganggu pengeluaran yang sebenar. Melalui ini, penambahbaikan boleh diajukan dan dicadangkan dalam *assembly line* industri semikonduktor.

ABSTRACT

Line balancing is a common application in assembly line of the production floor. Basically, line balancing is a way in assigning operations to workstations so that it can be optimal and equal. There have been different kinds of line balancing techniques and algorithms developed in order to obtain optimal solutions for the assignment of operations. Nevertheless, due to the manual and predictive oriented systems, there were some difficulties in determining future events if the current system is modified. Therefore, the application of simulation modeling is another alternative to build up the model that represents the real situation. For the simulation model built, the bottleneck area could be identified and the experiment run on different scenarios could produce the best solutions without disturbing the actual production line. In the current situation, there is no proper study in the bottleneck identification and the labor assignment as well as the labor utilization is still unclear. Therefore, in the study, the assembly line of the semiconductor assembly process is modeled. The solution for the line balancing is found through simulation techniques and experiment runs to identify the optimal assignment to workstations. Overall, from the data collected from industry, a simulation model that mimics the real assembly line is modeled. The study is aimed to develop a simulation model based on the necessary steps from the actual flow of the process line. From the simulation runs, the significant findings such as the bottleneck processes as well as the optimum man to machine ratio of the assembly line are obtained. With this, an improvement such as re-assigning the number of labors or equipments through the number of man-to-machine ratio analysis is proposed. Overall, simulation impact used in this study is expected to determine the optimal circumstances for a balanced line without disturbing the actual production line. Through this, improvement can be proposed for the assembly line in the semiconductor industry.

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DEDICATION

To my dearest parents

To my lovely sister and two brothers

To my beloved soul mate

To all my friends

With lots of gratitude and love…

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LIST OF ABBREVIATIONS

LB	-	Line Balancing
ALBP	-	Assembly Line Balancing Problem
C	-	Cycle time
OR	-	Operations Research
SALBP	-	Simple Assembly Line Balancing Problem
GALBP	-	Generalized Assembly Line Balancing Problem
UTeM	-	Universiti Teknikal Malaysia Melaka
MS	-	Manufacturing Specialist
MOST	-	Maynard Operation Sequence Technique

CHAPTER 1
INTRODUCTION

The first section of the report is the overall view of the study that describes on what the research is about, the purpose of the study as well as the limitations or boundaries of the respected study. The structure of the report of the study is briefly explained as well to ensure a better visualization of the sequence of the entire study.

1.1 Background

Semiconductor manufacturing company has been mushrooming over the years due to the rapid enhancement of technology as well as excessive demand from electronic devices manufacturing company in the world today. Due to dynamic and uncertainty, the assembly process is an important sector of the manufacturing of Integrated Circuit (IC) chips. Therefore, in order to control and manage an effective assembly line as well as reducing the piling up of inventory which is a waste, it is necessary to analyze the production system for an optimum outcome.

Commonly, assembly line balancing is a process of assigning operations to workstations along an assembly or production line. Line balancing is performed to ensure an approximate of equal time requirement of workstations. In assembly of product, line balancing has been used to promote a smooth flow as well as to achieve the best possible utilization of both man and machine in the plant.

The general way of line balancing is by subdividing the work into group of tasks and each group is located at a specific location along the line called workstation. Workstations are defined as places where some tasks (operations) on products are performed. Products stayed at each workstation for the cycle time, which corresponds to the time interval between successfully completed units. The workstation could be of single operator or even may consist of a small cluster of operators to perform the operations.

Basically, Line Balancing is often and mostly done in the traditional way by using heuristic and various algorithm models. Simulation models of line balancing are still not commonly used in the assembly area in semiconductor industry. Nevertheless, simulation model is a way to build up models to represent real life scenarios, to identify bottlenecks and to enhance system performance. By using a valid simulation model, it is a plus point in creating a better manufacturing system design in order to improve the performances. The more realistic a simulation representation, the more essential and effective for the design, test and experimentation of large scale engineering system which has greater complexity as time passed.

Simulation is widely used mainly in the application of manufacturing systems. As a result of competitive environment in many industries, a greater emphasis on automation to improve productivity and quality has been practiced. Since automated systems are more complex, it is better to analyze that particular system by simulation. Furthermore, the factor of cost of equipment and facilities are tremendously large especially in semiconductor technology, thus, a relatively small expenditure on simulation has the ability to reduce the risk of failed implementation. Hence, the process industries with a generally high level of automation and capital investment would seem an ideal opportunity to apply the simulation techniques.

1.2 Problem Statement

Line balancing in an assembly line is a common application in the industrial specifically in the production area. Line balancing is applied to ensure the work elements such as the cycle time are equal for each workstation to ensure an equal flow of the products. In the past studies, several line balancing algorithms model has been developed and all these were based on deterministic algorithms which do not usually consider the dynamic nature of a real manufacturing system. In addition to that, no proper study has been done in identifying bottleneck of processes. Apart from that, in usual, equipment utilization would be concentrated most and the issue with labor assignment is still unclear and no proper study has been conducted in labor utilization. Moreover, the in commons found in the different kinds of line balancing algorithms are; these manual methods make it impossible to gain certain results and it is also difficult to predict upcoming events when the production system is modified. Therefore, a simulation modeling technique is proposed for the application of line balancing in the semiconductor assembly area.

In the recent period, there were various researches as well as application of simulation has been conducted in semiconductor wafer fabrication alone. However, as for semiconductor assembly line, limited studies have been conducted by using the simulation techniques because all the while, mostly heuristics and mathematical modeling techniques were applied for the line balancing. Hence, the simulation study would be used for the assembly line balancing in the semiconductor assembly area. In order to develop a simulation model that is approximate mimic the real situation or almost the same as the real environment, a clear understanding of the real environment must be taken into account. From the understanding, the events occurred in the respected area are familiarized before modeling the situation and performing the simulation runs to obtain the required data and analysis.

1.3 Objective

The objectives of the study include:

(a) To study the current process flow of the production line
(b) To gather appropriate data for the simulation model input
(c) To develop the simulation model according to the systematic steps
(d) To perform line balancing and analysis of the simulation model through experiment runs
(e) To recommend improvement based on the line balancing and analysis done in the simulation model

1.4 Scope

The study is on the understanding of the semiconductor assembly line balancing. In here, the discrete event system simulation will be applied in the modeling of the assembly line. A simulation model for assembly line balancing in the semiconductor industry will be developed using WITNESS simulation software. In the study, the plant layout is assumed to be fixed and standardize in the semiconductor assembly area. In addition to that, the throughput, the bottleneck process, equipment utilization as well as the man-to-machine ratio will be analyzed based on a validated simulation model. Required data to be modeled is collected in each process in the semiconductor assembly area such as the cycle time, setup time, overall equipment efficiency, lot sizes number of labors per machine, idle time, available working hours as well as the labor‟s activities. The skills of the operator and absenteeism are not modeled. Besides, warm up conditions must be taken into consideration during the simulation model run to ensure the simulation model mimics the actual production line environment.

1.5 Structure of Report

The study is done for the completion of Final Year Project. To show a better flow of what the report consists of, Table 1.1 below indicates a summary of the chapters available in the study.

Table 1.1: Organization of the Report for Final Year Project I

Chapter	Topic	Description
Chapter 1	Project Background	Elaborations on the overall of the study involving the line balancing as well as the simulation techniques used in manufacturing systems.
	Problem Statement	Describe about the problem that occurs and leading to this study
	Objective	Setting the purpose of the study
	Scope	Involves the scope of the study, the boundaries and the assumption made
Chapter 2	Literature Review	To be exposed to the concepts, the theories and the previous studies made from various sources and to identify the gap in the study
Chapter 3	Methodology	Explain on the method and process used for the study such as the collection of data as well as the steps involved in developing a simulation model.
Chapter 4	Development of the Simulation Model	Describes the systematic steps used in developing the simulation model for the study. Highlights the crucial item in the simulation model development including

		conceptual modeling, important data collected and building the base models of the study.
Chapter 5	Result and Discussion	Provides the result of the study and the simulation runs of the models developed. Discussed on the bottleneck area, the development of the initial models using WITNESS, the experiment runs as well as the recommendation for improvement based on the simulation models.
Chapter 6	Conclusion and Recommendation	Consist of the overall description mainly on the achievement of objectives of study, the recommendation for future work as well as the important lesson learnt from the simulation study.

CHAPTER 2
LITERATURE REVIEW

In this chapter, the literature review explores the dominant themes consist of the studies as well as research from various published materials. The materials namely journals, articles, books and online resources are used as guidance for the next phases of the project. This indeed is an effective way of conducting the study on what has been done and what has yet to be done involving the field the research is on. Furthermore, this section identifies the gap in research whereby any incompleteness of the previous research can be determined. This section can also be linked to the present research that is in the process to be done and the expected achievement in the research plan could be set. Specifically, this chapter will cover areas as well as topics that are in relation to line balancing, the terms and concepts used. In addition to that, the section will also introduce the simulation topic and the sub-topic related to it.

2.1 The Domain of the Project

Every project has its own domain and the domain for this project is work study in Operations Management. In other words, the study will revolve and relate to operational management through the work study tools as well as perspectives. According to Heizer and Render (2009), operations management is the set of activities that creates value in the form of goods and services by transforming inputs into outputs. Meanwhile, the focus of system design and work study is actually on how to develop and increase the efficiency of operation management. To narrow down the scope of this project, the study

will be in a semiconductor assembly industry and it will be the platform to conduct the project as well as the related tasks required in order to achieve the objectives of study.

2.2 The Definition and Concept of Assembly Line Balancing

Assembly lines are flow oriented production systems which are still typical in the industrial production of high quantity standardized commodities and even gain importance in low volume production of customized products. Among the decision problems which arise in managing such systems, assembly line balancing problems are important tasks in medium-term production planning.

Assembly Line Balancing or simply Line Balancing (LB) is the problem of assigning operations to workstations along an assembly line, in such a way that the assignment be optimal in some sense (Falkenauer, 2000). Meanwhile, according to Stevenson (2002), the line balancing can be define as the process of assigning tasks to workstations in such a way that the workstation have approximately equal time requirement. In assembly of the product, the line balancing have been used to make the flow of semi-finished good in the assembly line in smooth condition and also to achieve the best possible utilization of both the labor force and the plant. Assembly lines consist of successive workstations at which products are processed. Workstations are defined as places where some tasks (operational) on products are performed. Products stay at each workstation for the cycle time (C), which corresponds to the time interval between successively completed units (Ağpak and Gökçen, 2005).

Assembly line balancing consists of the basic principles of the division of labor and therefore, when it is applied to mass assembly of manufactured items, it takes the form of the progressive assembly line. The basic principle of division of labor is applied by assigning the set of tasks to the production line in sequences work stations and it is divided to smaller set of tasks. In here the task would be specifically assigned to one operator or worker stationed at each work stations to be performed.

For that reason, the purpose of Line Balancing is to assign the set of tasks to successive workstations in order to meet specific production requirement, for instance, meeting the desired throughput so that the minimum number of workstations are required for the process. A balanced line will ensure the reduction of bottlenecks, resulting in higher productivity as well as lowering cycle time. Apart from that, prior to meeting the demand of efficiency in production, Line Balancing aims to match the throughput rate to the scheduled production plan. It is the major concern during the initial design stage for the flow line of the production system. This is supported by Masood (2006) that assembly line balancing is used to determine optimum allocation of operations at the workstations so as to minimize the cycle time of the line for a given number of workstations, or to minimize the number of workstations for a given cycle time, by equalizing the loads on the workstation.

2.2.1 Characteristics of Assembly Line Systems

As a result of different conditions in the industrial manufacturing, assembly line system and corresponding Assembly Line Balancing Problems (ALBPs) are of varieties. The following section is a brief characterization of the most relevant properties for classifying assembly lines (Becker and Scholl, 2003).

In case of a paced assembly line, the station time of every station is limited to the cycle time, c as a maximum value for each workpiece. Since tasks are indivisible work elements, c can be no smaller than the largest task time $t_{max} = \max \{t_j \mid j=1,...,n\}$. Due to the cycle time restriction, paced assembly lines have a fixed production rate (reciprocal of the cycle time). In the absence of a common cycle time, for example all stations operate at an individual speed, workpieces may have to wait before it can enter the next station and/ or stations may get idle when it have to wait for the next workpiece. These difficulties are partially overcome by buffers between the stations. In this case of a buffered (unpaced) assembly line, the ALBP is accompanied by the additional decision problem of positioning and dimensioning buffers.