PRODUCTIVITY IMPROVEMENT THROUGH LINE BALANCING TECHNIQUE IN A SMALL MEDIUM ENTERPRISE (SME) MANUFACTURING PLANT

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ABSTRACT

Assembly lines are flow-line production systems which are of great importance in the industrial production of high quantity standardized commodities and more recently even gained importance in low volume production of customized products. In Small Medium Enterprise (SME) manufacturing plant, assembly line gives high impact to the productivity of the company. Less of skill and knowledge in management in the company make the SME cannot compete to large company. This project is important to SME company to solve the problem. The main objective of this project is to improve the productivity of the specific company by using software simulation. In this project, line balancing technique will be used and WITNESS software will be act as a simulation tool to find the good solution for this problem. This project will be used WITNESS software to make sure that the arrangement in the line is correct. By defining the problem that happen in the exiting line and give alternative of new assembly line, the problem will be solved.

ABSTRAK

'Assembly line' adalah sistem garisan operasi pengeluaran yang sangat penting dalam industri pembuatan yang membekalkan barangan yang berkualiti tinggi dan barang yang dibuat mengikut pesanan dalam kadar yang rendah. Dalam Industri Kecil dan Sederhana yang berasaskan pembuatan, *'assembly line'* memberikan kesan yang besar dalam penghasilan produk kepada syarikat. Kurangnya kemahiran dan pengetahuan di pihak pengurusan menyebabkan kebanyakkan Industri Kecil dan Sederhana mempunyai kurang daya saing berbanding syarikat-syarikat besar. Oleh itu pentingnya kajian ini untuk membantu menyelesaikan masalah ini. Objektif utama kajian ini adalah untuk meningkatkan pengeluaran dalam syarikat Industri Kecil dan Sederhana yang tertentu dengan menggunakan kaedah simulasi daripada perisian komputer. Dalam kajian ini, teknik garisan keseimbangan digunakan dan digabungkan dengan simulasi perisian WITNESS akan digunakan untuk mencari jalan penyelesaian yang terbaik. Penggunaan perisian WITNESS adalah untuk memastikan susunan dalam garisan tersebut adalah betul. Dengan mengenalpasti masalah yang terdapat dalam susunan yang sedia ada dan memberikan alternatif *'assembly line'* yang baru, masalah yang melibatkan *'assembly line'* ini dapat diselesaikan.

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Cd	=	Cycle Time
N	=	Number of workstation

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Today many of small medium enterprise were developing because of the encouragement from the government and the awareness from the society. Many of the small medium enterprise have a lack of knowledge to manage the company especially in arrangement of the workers or machine in the assembly line or company. Consequently, maximum production cannot be archived. Therefore, this project will help the small medium enterprise company to archive the maximum productivity by using line balancing technique.

1.2 Project Background

Small and Medium Enterprise (SME) manufacturing face the same responsibilities as large enterprise in keeping the development of the country but in order to keeping the development, many of SME less concern about the production rate. Many of SME manufacturing has a lack in used knowledge about to get the maximum production of the company.

To obtain the maximum production, an SME must manage the production line very well. In this case, a systematic technique or approach should be introduced. One of the techniques is line balancing technique. The used of line balancing technique was proved able to increase the productivity for the small medium enterprise. By using the line balancing technique, the production will increase because the arrangement of the line is corrected and the maximum productivity will be archive.

1.3 Project Objective

The main objective of this project is:

i. To recommend suggestion to improve productivity through line balancing technique for a particular Small Medium Enterprise (SME) manufacturing plant.

ii. To verify the recommended suggestion using WITNESS software.

1.4 Project Scope

This research is only focusing on Small Medium Enterprise (SME) manufacturing plant. The recommended suggestion is only valid for specific industry and one assembly line. To verify the result, WITNESS software will be used as simulation tool.

CHAPTER 2

LITERATURE REVIEW

2.1 Assembly Line and Line Balancing

Assembly lines are flow-line production systems which are of great importance in the industrial production of high quantity standardized commodities and more recently even gained importance in low volume production of customized products. Due to high capital requirements when installing or redesigning a line, configuration planning is of great relevance for practitioners. In a manufacturing company now days, the production of the company is depend on the assembly line at that company.

In order to make sure the assembly line can get the maximum production per day, the correct arrangement of the assembly line must be create. To improve the assembly line, many ways can be done. One of that is the line balancing technique. Emanuel Falkenauer [6] define the line balancing problem as, given set of tasks of various duration, a set of precedence constraints among tasks and a set of workstation, assign each task to exactly one workstation in such a way that no precedence constraint is violated and the assignment is optimal.

The optimal criterion given rise to two variants of the problems that is either a cycle time is given that cannot be exceeded by the sum of duration of all task assigned to any workstation and the number of workstation is to be minimize or the number of workstation is fixed and the line cycle time equal to largest summation of durations of task assigned to a work is to be minimized.

Line balancing also can be defined as the process to minimize the imbalance between machine or personnel while meeting a required output from line assembly [7]. Management must know the tool, equipment and work method used. Then the time requirement of each assembly line must be determined. Salveson state that, [11] the assembly line balancing has been described as a combination of optimizing problem for finish first time. The problem of assembly line balancing consists in determining the set of task to be performed for every station in a way that the operation time does not exceed the cycle time and that the technological precedence relation between single task are not violated i.e. that a task preceding an other task has to be perfumed at an earlier station or at the station to which the other task is assigned to at the latest.

Line balancing is operate under two constrains that are precedence requirement express in the form of precedence diagram and cycle time restriction. Precedence diagram is network showing the sequence of task with work element represented by nodes and precedence relationship represented by line. For an example, the A precedence B and C; B & C cannot be done until A is completed. Cycle time is the maximum amount of time a product is allowed to spend at each workstation.

2.2 SME and Productivity Improvement through Line Balancing Technique

Small Medium Enterprise (SME) can be defining in many ways. Different country has a different definition. In Malaysia, SME manufacturing is define as the manufacturing related services and agro-based industries are enterprise with full time employees not exceeding 150 or with annual sales turnover not exceeding RM25 million [1].

In summary, detailed definition on SME is given in Table 2.1;

Table 2.1: Summary of micro, small and medium enterprise

Category	Micro-enterprise	Small enterprise	Medium enterprise
Manufacturing-related services and agro-based industries.	Sales turnover less than RM250000 or full time employees less than 5	Sales turnover between RM250000 and less than RM10 million or full time employees between 5 to 50	Sales turnover between RM10 million and less than RM25 million or full time employees between 51 to 150

Dalitso Kayanula and Peter Quartey [3] stated that the choice of small and medium scale enterprise within the industrial sector based on the following proposition; large scale enterprises has not been an engine growth and good provider of employment and already receive enormous support through general trade, finance, tax policy and direct subsidies. But in small and medium enterprise the mobilize funds which otherwise would have been idle also have been recognized as a seed-bed for indigenous entrepreneurship. Small medium enterprises are labor intensive, employing more labor per unit capital than large enterprise, promote indigenous technological know-how, are able to compete(behind protective barriers), use mainly local resources, thus have less foreign exchange requirements, cater for the need of the poor and adapt easily to customer requirement.

Small medium enterprise also faced the problem in managing the arrangement of the assembly line. This is because lack of knowledge in management to get the maximum production by using minimum man power.

Since SME play a significant role in national economy, there need to help them to improve their competitiveness. Most of SME operate with poor forecasting and planning systems and long cycle times. These result in poor delivery performance and high inventories. Harold T.Amrine [4] suggested that to overcomes these problems, it is important to SME to implant the material management systems based on material requirement planning or just in time concept (JIT)/Kanban or line balancing technique. Many of companies are under constant pressure to maintain high production standard and efficient production process and control system.

In the large company such as Daimler Chrysler or Chevrolet, the assembly line must correct and balanced [7]. The fabrication and assembly line must be balanced. That is, the time spent to perform work on one machine must equal or balance to the time spent on the next machine in the fabrication line, just as the time spent at one workstation by one assembly line employee must balance the time spent at the next workstation by next employee.

In the company, the management goal is to create a smooth, continuous flow along the assembly line with a minimum of idle time at each workstation. A well balanced assembly line has advantage of high personnel and facility utilization and equity among employees work load. Some union contracts required that work loads be nearly equal among those on assembly line.

To know the effectiveness of the assembly line there has a two ways that is by using manual arrangement and using the simulation combine with manual calculation. In using manual arrangement, the layout must be create on the spot mean that the arrangement must be doing in that layout and take the result in the final output. By using simulation, the layout just be made in the software and the best layout will be choosing without doing the arrangement first.

To get the efficiency of assembly line, the manual calculation will involved. There are three steps that involve that is:

1. Calculate the cycle time of the assembly line. Take the unit required per day
   and divide into the production time available per day.

$$\text{cycle time} = \frac{\text{production time per day}}{\text{unit required per day}}$$

2. Calculate the theoretical minimum number of workstation, N. This is the total task duration time divide by cycle time.

$$\text{minimum number of workstation} = \frac{\sum \text{task time}}{\text{cycle time}}$$

3. Balance line by assigning specific assembly task to each workstation. An efficient balance one that will complete the required assembly follows to the specific and keep the idle time in each workstation to a minimum. A formal procedure to doing it must follow this step:

   i. Identify master list of task.
   ii. Eliminate those task that have been assigned
   iii. Eliminate those task that whose precedence relation has not been satisfied
   iv. Eliminate those task for which inadequate time is available at the workstation
   v. Follow the line balancing "heuristics" in Table 2.2

Table 2.2: Line Balancing heuristic

1.	longest task time	Choose the available task with the longest task time
2	most following task	Choose the available task with the largest number of following tasks
3	ranked position weight	Choose the available task for which the sum of following task time is the longest
4	shortest task time	Choose the available task with the shortest task time
5	least number of following task	Choose the available task with the least number of following task

2.3 Verification using simulation technique

A simulation is an imitation of some real thing, state of affairs or process. The act of simulation something generally entails representing certain key of characteristic or behaviors of a selected physical or abstract system [8]. Simulation also is the attempt to duplicate the features, appearance and characteristic of a real system. The idea behind simulation is threefold that is [7] :

i. To imitate a real world situation mathematically.
ii. Then to study its properties and operating characteristic
iii. Finally to draw conclusion and make the action based on the result from simulation.

There are many advantages by using the simulation such as to analyze the utilization or fixed resource and variable resources, do the testing to model without damage or disturb the original model, to estimate the operating characteristic or objective function value and analyze the problem.

Many simulations can be used to get the solution for the line balancing problem such as WITNESS software, SimBax and AutoMod. Simbax allowed quickly evaluating and comparing a variety of alternative scenarios in order to easily eliminate the bottleneck and finds a solution avoiding non-productive occupation of the equipment and resource. AutoMod suite provides simulation software that give 3D visual image of a facility as well as statistics of how the facility will perform and the efficiency of the arrangement.

In this project WITNESS software will be used as simulation tool. WITNESS software can easily calculate the efficiency of the assembly line because the command that used in WITNESS software was easier to understand. WITNESS software has provided a graphical environment to design discrete event simulation model. WITNESS software allows an automating simulation experiment, optimizing material flow across the facilities and generates 3D virtual reality models. T.A. Spedding and G. Q. Sun [12] state that the WITNESS software can develop the 3D model and the model is able to generate accurate result of analysis. By using WITNESS software it also include efficient cost allocation, calculation of surplus capacity, management of quality costs and capital justification.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In order to achieve the objectives and goal of the project, the methodology flow chart has been planned and designed. The main objective to do the methodology flow chart is to be a guideline and direction to make sure the project run smoothly and successfully. In this project many of method will be used such as calculate the cycle time, define the material handling, define the bill of material and calculate the total time. Because a lot of calculation involve in this project, the simulation will be used to make sure the result easier to get and will produce faster. WITNESS software is the software that will be used as a simulation tool.

3.2 Methodology Flowchart

To make sure the project will run smoothly, the methodology flowchart was created. The following step is the method that will be used in this project. The step was:

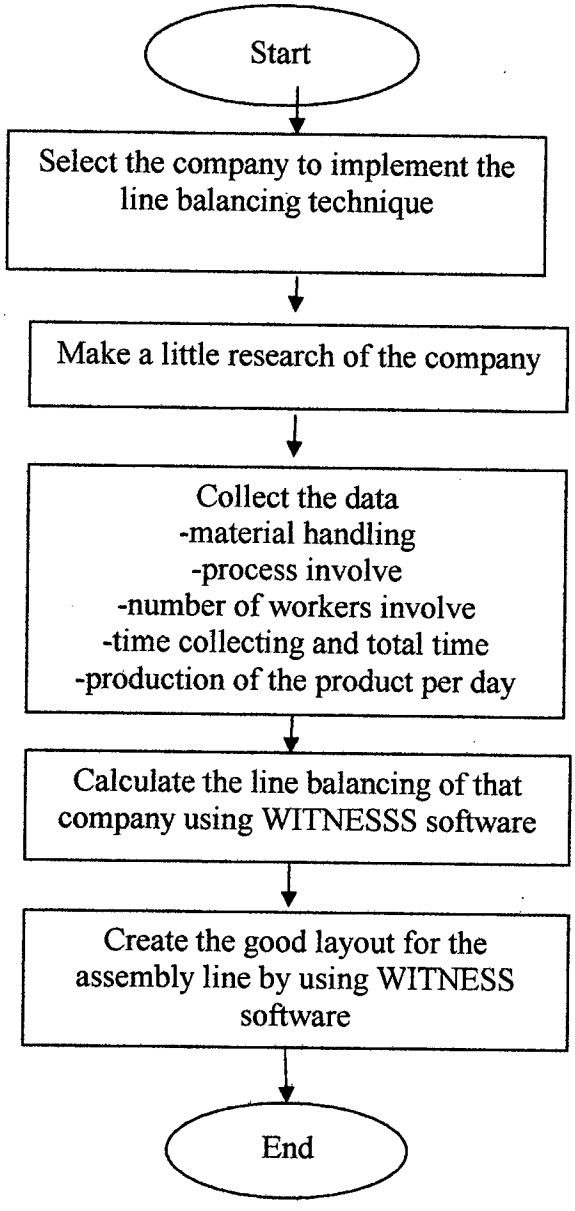

Figure 3.1 Methodology Flowchart

3.2.1 Company choosing

Make a little research of the production rate of the company and the process that involve to make a product because in the company that has many assembly line so that this research is to make sure that the choosing of the assembly line is correct place and correct time to apply the line balancing technique.

3.2.2 Data collection

A material handling system of the assembly line will be identified to know the process involve in the assembly line. Material handling system is the management of the movement in the organization. The function of material handling system is to move the right material to the right place at the right time in the right amount in sequence and in the right position or condition to minimize the production cost. Number of workers also must being identified to know where the place or machine that needed the worker. Total time and time collecting also will be observed and recorded. Total time is the amount of time that the assembly line finishes all task work in all workstation to make one product. Time collecting is the amount of time used to complete the task by one workstation. The step to collect the data was:

i. Define the number of workstation (coded).
ii. Identify the process that involve in that assembly line.
iii. Identify the detail of activities in each workstation.
iv. Recorded the travel time that is the amount of time that the products pass from one workstation to another workstation.
v. Recorded the setup time. Setup time is the time that the workers prepare the thing before assembly it.
vi. Recorded the observed time that is the amount of time that the worker or the machine to do the assembly.

3.2.3 Calculate the line efficiency in that company

To calculate the efficiency of the assembly line in that company, the formula below were applied:

$$\text{efficiency} = \frac{\sum \text{task time}}{\text{no of workstation} \times \text{largest cycle time}} \quad (3.1)$$

To know the no of work station and cycle time, the formula is:

$$\text{cyde time} = \frac{\text{production time per day}}{\text{unit required per day}} \quad (3.2)$$

$$\text{minimum number of workstation} = \frac{\sum \text{task time}}{\text{cycle time}} \quad (3.3$$

The productivity of the assembly line also can be calculated by using this formula:

$$\text{productivity} = \frac{\text{output}}{\text{labor} \times \text{production time per day (hour)}} \quad (3.4)$$

3.2.4 Create the good layout

By using the WITNESS software, the good layout will create and will be perform. Using all the data that already collected, the best layout will be create by using try and error technique in WITNESS simulation in order to get the best layout. The result that develops in WITNESS software will compare to the result of line balancing of that company without changing any workstation or cycle time.

3.2.4.1 Step that involve to developing the layout by using WITNESS software

i. From the information in data collection, make the layout same as company layout

ii. Create the company layout by place the machine and the worker in the right place refer to the real company layout.

iii. Open the WITNESS software.

iv. Go to designer element and click at the machine or worker and put at the layout window.

v. Double click at the machine in the layout window and the put the cycle time of the machine. Cycle time of the machine is total task time in each workstation and the time for product that go from previous workstation to the workstation refer to your data collection. (Cycle time= setup time + observed time + travel time).

vi. If the machine has a labor, click at labor rule and the type the command that is name of labor plus # and the number of labor ;i.e:Labor001#1.

vii. If in the machine have two labors, double click at the labor and put number 2 in the box of amount of labor.

viii. Put in the command for the layout such as to product go from one machine to another machine, the command that will be used is push and pull because to line run smoothly one machine must push to other machine and the machine must pull from previous machine.

ix. If in the workstation has a two machine and the previous workstation has one machine, the command for the previous workstation is sequence mean the product will send to another workstation alternate.

x. For the last workstation, the machine must push the product to store and the command is by using push and ship command.

xi. To know the output number, go to the designer element and the click at variable and then click at the Vinteger and put at the layout.

xii. Change name of Vinterger and double click at the Vinteger at the layout and type command output + 1 in the action rule.