KOLEJ UNIVERSITI TEKNIKAL KEBANGSAAN MALAYSIA

Line Balancing Optimization for Single Model Assembly Line

Thesis submitted in accordance with the requirements of the
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By

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ABSTRACT

Manual assembly line technology has made a significant contribution to the development of manufacturing industry in the twentieth century. It remains an important production system throughout the world in the manufacture of automobiles, consumer appliances and other assembled products made in large quantity such as television, cameras, washing machine and audio equipments. This project is about the line balancing optimization for single model assembly line in the production line which a part of the production scheduling. The main objective is to explore the companies with suitable with the project especially use conveyor system, learn and collect data from the existing system using the time study analysis and proposed the optimum system based on parameter such as cycle time, line efficiency, idle time and balance delay. The method that were used in this project are heuristics method consist the 3 algorithm such as Largest Candidate Rule, Kilbridge and Wester Method and Ranked Positional Method. The result from this project should determine the best method from the proposed system based on the parameter states before. The performances of a given line balancing algorithm depends on the problems to be solved. Some line balancing methods works better on some problems while other method work better on other problems.

Keywords: line balancing, cycle time, line efficiency, idle time, balance delay

DEDICATION

For my beloved parents,
Taib bin Hj. Tasrip and Saemah bte Hj. Salleh @ Surathin,
for my kindly sister, Suzi bte Taib and for all my family

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LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

AGV	Automated Guided Vehicle
BD	Balance Delay
BOM	Bill of Material
CALB	Computer-Aided Line Balancing
COMSOAL	Computer Method of Sequencing Operation for Assembly Line
C	Cycle time for the balanced
CT	Cycle time
DFA	Design for Assembly
E_b	Balancing Efficiency
LCR	Largest Candidate Rules
LE	Line Efficiency
MPS	Master Production Schedule
MPR	Material Requirement Planning
N	Theoretical minimum number of workstation
n	number of work elements
PPC	Production Planning and Control System
R_c	Cycle rate for the line
R_p	Average production rate
PSM	Projek Sarjana Muda
RPW	Ranked Position Weight
T	Total time for completing all task
T_{ek}	Time to perform work element k (min)
T_c	Cycle time of the line
T_i	Time for work element
$T_{\max}$	Maximum work element time
T_r	Repositioning time
T_s	Maximum allowable service time

CHAPTER 1
INTRODUCTION

1.1 Background

An assembly line, which consists of a sequence of workstations, is an efficient method of manufacturing high volume products such as automobile parts and microcomputers. In designing assembly line, it is common practice to "balance" the line so that a more uniform flow is maintained.

As in a progressive assembly line where successive production stages (workstation) take the form of the conveyer like system and work is performed continuously, a balance among production stages should be kept in such a way that a smooth material flow is obtained by almost equalizing the production times at all production stages, thus minimizing idle times at the workstations. The line balancing aims at minimum cycle time, minimum number of workstations, optimal grouping of work elements, etc. (Richard C. Doff, Andrew Kusiak, 1994)

1.2 Problem Statement

Design for Assembly (DFA) has received much attention in recent years because operations constitute a high labor cost for many manufacturing companies. Key to successful factor for DFA can be simply stated; design the product with as few parts as possible and design the remaining parts so they are easy to assemble. The cost of assembly is determined largely during product design, because that is when the number of components in the product is determined and decision are made about how these components will be assembled. Once these decisions have been made, there is a little that can be done in manufacturing to influence assembly costs.

1.3 Objective of the Research

There are a few objectives that must be achieved in the project:

a. To understand production line, design for assembly and line balancing algorithms.
b. To identify parameters of design for single model assembly line.
c. To analysis single model assembly line, existing and proposed.
d. To optimize production time in assembly line.

1.4 Scope of the Project

This project shall concern with line balancing effectiveness by grouping sequential work activities into workstation with minimum idle time. The main target is to explore the companies with suitable with this project, learn and collect necessary data from the existing system, and proposed the optimum system based on parameters such as cycle time, line efficiency, idle time and balance delay. From the result, a recommendation regarding implementation plan of proposed system were stated.

CHAPTER 2
LITERATURES REVIEW

2.1 Introduction in Manufacturing Systems

The phrase manufacturing system was employed as early as in 1815 by Owen, a utopian socialist; this term is not new. At that time it mean factory system, or as serious of inventions that was created during the industrial revolution in Great Britain about 200 years ago. Early in this century, the system view in management and manufacturing was emphasized. Nowadays, the term manufacturing system signifies a broad systematic view of manufacturing. It is basically recognized as a production function that converts the raw materials into the finished products, and this function is controlled by the management system that performs planning and control (K. Hitomi, 1975). It should be noted that from a wider viewpoint the manufacturing (production) plays a role in constructing the international structural power together with the financial system, the security system and the knowledge system (S. Strange, 1988)

On the basis of such concepts and views of the meanings of manufacturing and systems so far discussed, manufacturing (or production) systems can now be defined in the following three aspects (K. Hitomi, 1975):

1. *The Structural Aspect of Manufacturing Systems.* Based on structural (or static) definition of the system, the manufacturing system is a unified assemblage of hardware, which includes workers, production facilities (including tools, jigs, and fixtures), materials-handling equipment, and other

supplementary devices. Thus the structural aspect of the manufacturing system forms a static spatial structure of a plant, i.e., the plant layout. This aspect can be viewed as a production system. This phrase appeared in 1907. Since 1943 it has been also used to mean the inference mechanism operated by knowledge based systems in the field of artificial intelligence (a different terminology should be introduced for this meaning).

2. *The Transformational Aspect of Manufacturing Systems.* Based on a transformational (or functional) definition of the system, the manufacturing system is defined as the conversion process of the factors of production, particularly the raw materials, into the finished products, aiming at a maximum productivity. This system is concerned with the flow of materials (or material flow). This is a common method of defining production systems or, in some cases, machining systems.

3. *The Procedural Aspect of Manufacturing Systems.* Based on a procedural definition of the system, the manufacturing system is the operating procedures of production. This constitutes the so-called management cycle, i.e., planning, implementation, and control. This process was recognized in Germany in the late 19th century, and Fayol established the functions of this process in 1916. Planning is selection, from among the alternatives, of the future course of action; implementation executes practical activities according to the plan (schedule); and control is measurement and correction of the performance of the activities to make sure that the management objectives and plans are being accomplished. Hence the manufacturing system plans and implements the productive activities to convert raw materials into products and controls this process to reduce or eliminate deviation of the actual performance from the plan. This procedure-production management-constitutes the flow of information (or information flow) for effective and economical production.

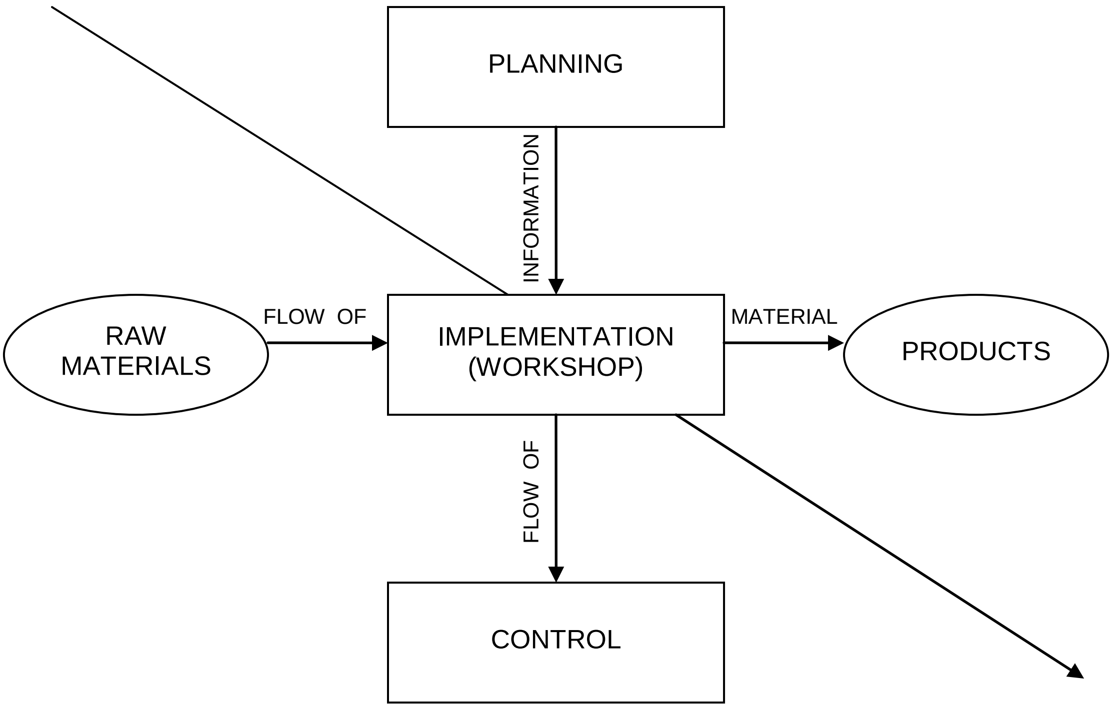

Figure 2.1: Three flows concerning manufacturing: flow of material, flow of information and flow of cost.

As previously mentioned, production management is the procedure of manufacturing systems. This consists of the following five stages, as represented in Figure 2.2 (K. Hitomi, 1978).

1. *Aggregate Production Planning.* This determines the kinds of product items and the quantities to be produced during the specified time periods.
2. *Production Process Planning.* This determines the production processes (or process routes) by which raw materials are effectively transformed into finished products.
3. *Production Scheduling.* This determines an actual implementation plan defining the time schedule for every job contained in the process route adopted, i.e., when, with what machine, and who does what operation?
4. *Production Implementation.* This function executes actual production operations according to the time schedule.

5. *Production Control.* Whenever the actual production progress and performances deviate from the production standards (plans and schedules) set at the planning stages 1, 2, and 3 above, such deviations are measured and modifications are appropriately made.

Stages 1, 2, and 3 constitute planning. Stage 4 is implementation, which forms the flow of materials. Stage 5 is control. In production management, the cycle of planning, implementation, and control plays a basic role in effective manufacturing activities. Stage 2 deals with basic production technology; it is named the flow of technological information. While a series of functions-stages 1, 3 and 5 is concerned with management activities; it is named the flow of managerial information.

The above five steps are operational, which means that the activities are decided and performed inside the firm. At a higher level is located the strategic planning function, which is concerned with strategic issues existing between the firm and its environment (market, competitors, society, etc.), such as long-range planning, profit planning, and pricing of the products to be sold. The strategic and operational phases are fundamental to the effective performance of the firm (H. Huebner, H. Hoefer, 1984).

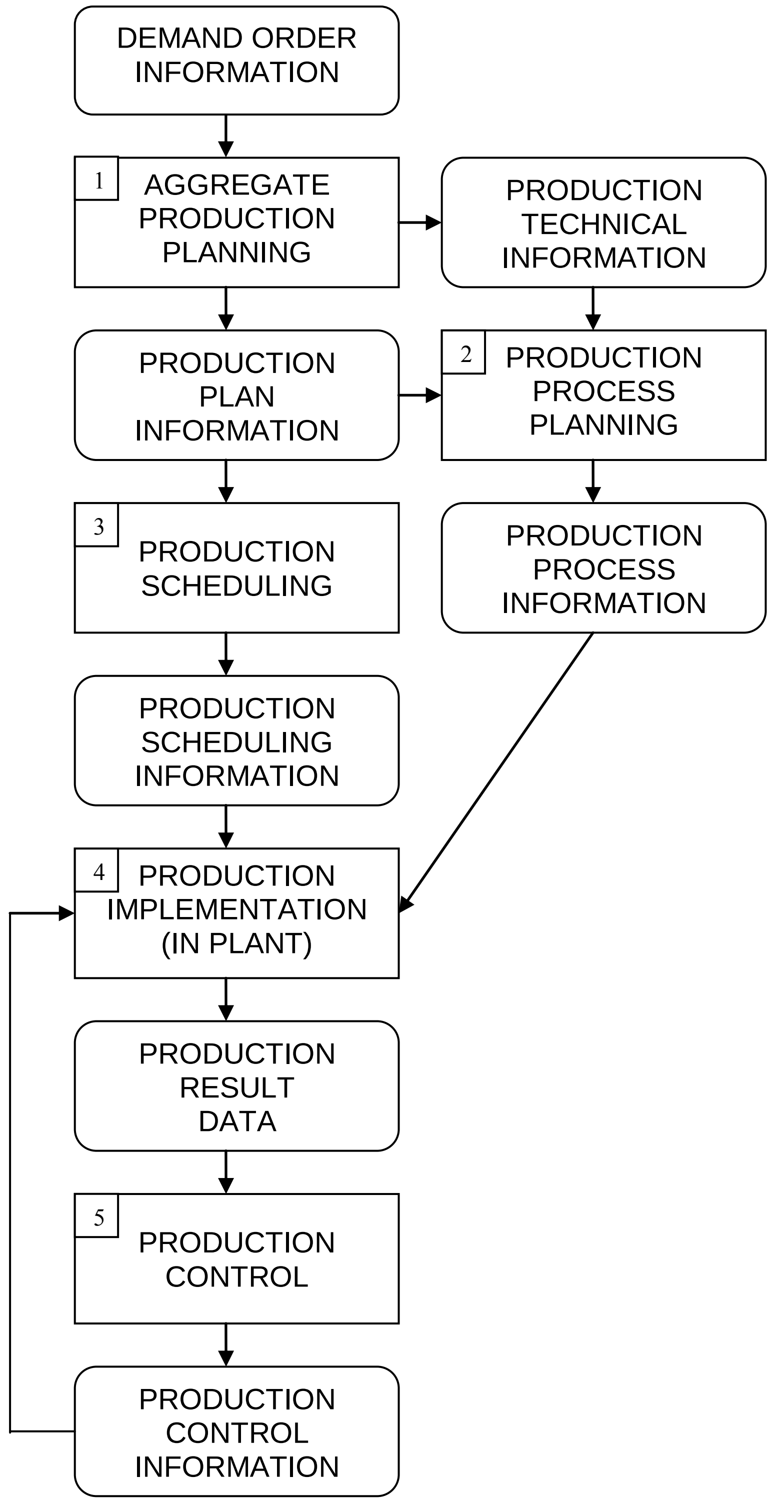

Figure 2.2: The procedural aspect of the manufacturing system: the flow of information

2.2 Production Planning System

Production Planning and control Activities deal with the planning and control of manufacturing processes and therefore include material, machines, operators, suppliers, customers and products. The operational tasks of an industrial enterprise can be referred to as the production planning and control system (PPC), and their problem s encompass a wide range of fields and industries. Their solution strongly depends on many interrelated aspects such as market environment, production environment, production strategy, human resources and degree of automation. Figure 2.3 is outlines the production planning and control framework and follows the one suggested by Vollman (1991).

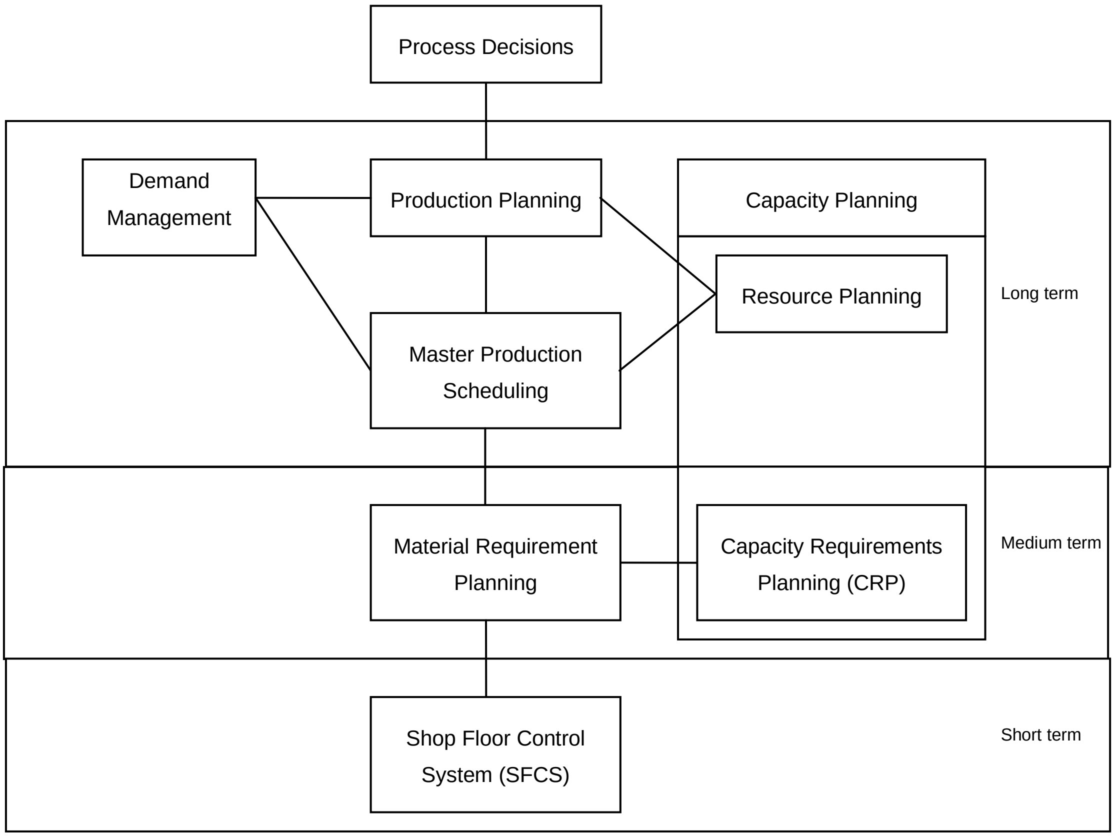

Figure 2.3: Production Planning and Control Framework

With the present trend in manufacturing, products have to be delivered at competitive cost, at the required time and in an acceptable quality to the customer. Competitive cost, timely delivery of products and attainment of high quality require proper planning and effective control of work through a manufacturing system. Production planning is complex because it takes into consideration all the various aspects that are necessary in order to achieve the business and strategic plans of a manufacturing firm. Typically, input to a production planning system is in numeric form such as the number of products to be produced or assembled per week. From this, planned order release has to be determined, each job has to be scheduled and work centres have to be loaded. In each stage, a check on capacity is necessary in order to ensure that equipment and workforce are available to meet production target. Input to a production planning system is composed of forecast from marketing department and also customer orders.

At the top of a production planning and control system is aggregated medium range plan that need to be dis-aggregated into master production schedule. System forecast, customer order, and manual forecast from the marketing/sales department are input into the master production schedule for computing the total demand. The total demand is the net requirement used to drive a material requirement planning system. We now discuss requirement planning functions in more details.

Production planning and control can be subdivided into planning and execution levels and for each level, we have to consider scheduling and capacity. Schedule determines what is to be produced. The equation has to be balanced by considering capacity, which is the consideration of availability of facilities to meet the production level. Table 2.1 shows one method of classifying production planning and control functions.

Table 2.1: Production Planning and Control Component

Schedule	Capacity	Level
Business Plan	Financial planning	Planning
Production Planning	Resource Requirement Planning (RRP)	Planning
Master Production Schedule (MPS)	Rough Cut Capacity Plan (RCCP)	Planning
Material Requirement Plan (MRP)	Capacity Requirement Plan (CRP)	Planning
Final Assembly Schedule	Capacity control	Planning
Stock Picking Schedule	Inventory control	Planning
Order Priorities	Factory order control	Execution
Scheduling	Machine (work-centre) control	Execution
Operation Sequencing	Tool control Preventative maintenance	Execution

Whether at the planning or execution stage, it is important to consider schedule and capacity. It has been observed that most planners ignore planning capacity and execution capacity, and tends to lay emphasis on planning schedule and execution schedule.