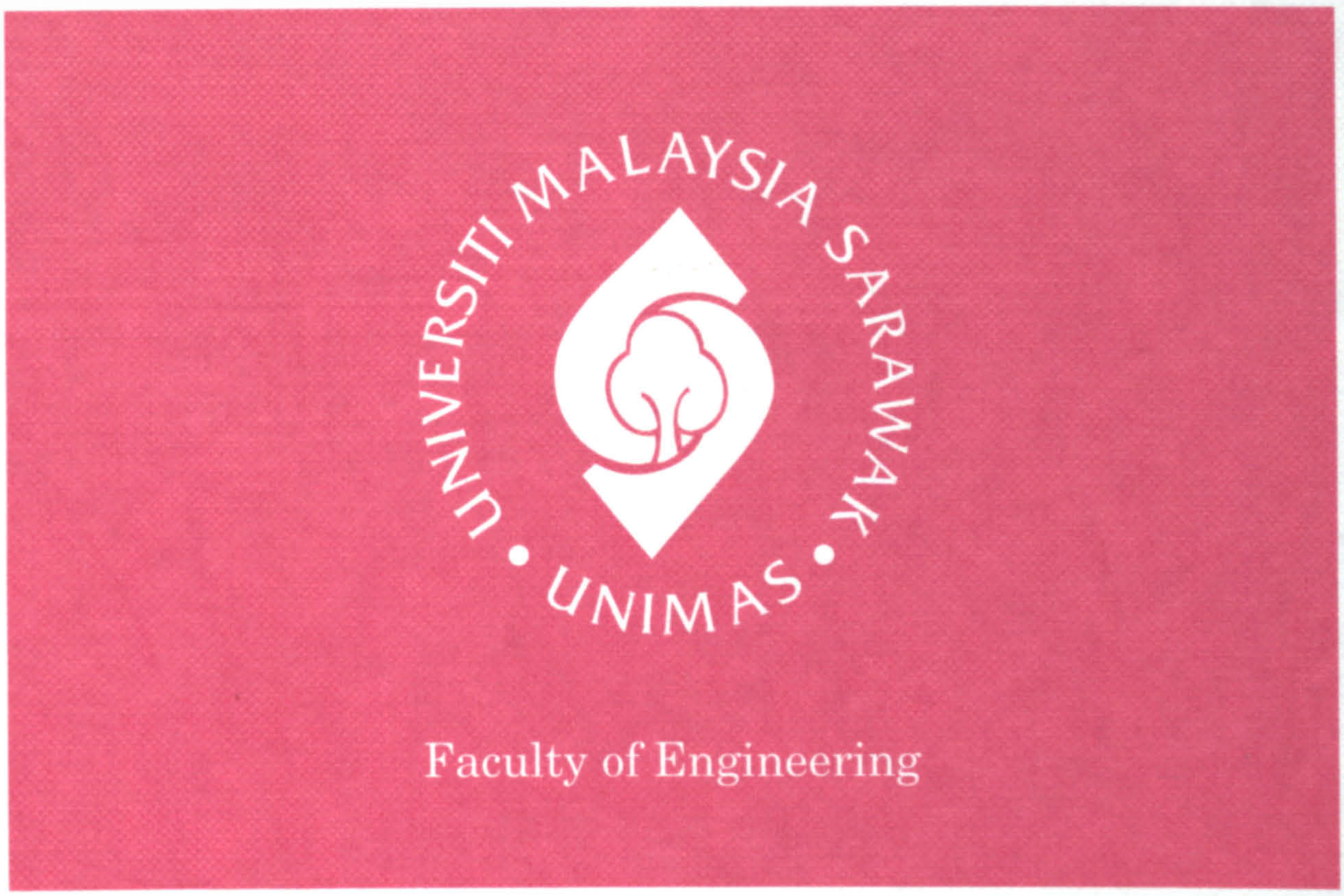

FEASIBILITY STUDY ON IMPLEMENTING MODULAR PRODUCTION SYSTEM

Mohammad Bakhtiar B. Johari

Bachelor of Engineering with Honours
(Mechanical Engineering and Manufacturing Systems)
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UNIVERSITI MALAYSIA SARAWAK

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FEASIBILITY STUDY ON IMPLEMENTING MODULAR PRODUCTION SYSTEM

MOHAMMAD BAKHTIAR B. JOHARI

This project is submitted in partial fulfillment of
the requirements for the degree of Bachelor of Engineering with Honours
(Mechanical Engineering and Manufacturing System)

To my beloved Mom and Dad..

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ABSTRACT

The market place in which manufacturing firms are operating becomes more competitive. The local manufacturers become more internationally competitive by outperforming their international competitors in terms of one or more of the competitive priorities This thesis introduces manufacturing paradigm based upon on building production systems from standardized modular machines and is termed as Modular Production Systems. Moreover, this thesis studies the current manufacturing approach of a manufacturing firm and proposes to implement the Modular Production Systems approach to the manufacturing firm. Through the interview, the firm is using Just-In-Time approach and there were several problems that the firm faces by using the approach. As there is potential to implement the Modular Production System, this thesis show the steps to built the approach which include three phases to build the modular system which is modular product analysis phase, product representation for modular production system design phase and Modular Production System Synthesis phase. Included in this thesis, there are few recommendations for those who are interested to pursuing this project to a more advanced level and such recommendations are computer simulation.

ABSTRAK

Persekitaran pasaran di mana kilang-kilang pembuatan beroperasi menjadi semakin kompetetif. Pengilang-pengilang tempatan berupaya untuk bersaing di peringkat antarabangsa dengan menggalakkan persaingan di dalam salah satu atau beberapa bidang yang berkepentingan kompetitif. Tesis ini memperkenalkan model pembuatan berdasarkan pembinaan sistem produksi daripada mesin yang distandard berdasarkan modul dan ianya dikenali sebagai kaedah 'Modular Production Systems'. Tambahan pula, tesis ini mengkaji kaedah pembuatan yang digunakan oleh kilang pembuatan yang mengambil bahagian dalam tesis ini dan mencadangkan penggunaan kaedah 'Modular Production Systems' ke atas kilang tersebut. Melalui temuduga yang dijalankan, didapati kilang tersebut menggunakan kaedah 'Just-In-Time' dan menghadapi beberapa masalah dengan menggunakan kaedah tersebut. Didapati juga kilang tersebut mempunyai potensi untuk menggunakan kaedah'Modular Production Systems'. Tesis ini juga membincangkan fasa-fasa yang perlu disempurnakan untuk membina kaedah tersebut dan terdapat tiga fasa yang utama iaitu fasa 'modular product analysis', fasa 'product representation for modular production system design' dan fasa 'Modular Production System Synthesis' Dalam tesis ini juga terdapat beberapa cadangan kepada sesiapa yang berminat untuk membuat kajian yang lebih mendalam mengenai tajuk ini dan antara cadangan tersebut ialah dengan menggunakan simulasi komputer.

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CHAPTER 1

INTRODUCTION

The market place in which manufacturing companies operate are becoming more competitive with the increasing threat from international competition and customer demand for swift on time delivery, consistent quality, low cost and customer specified product design and functionality (Slack, 1995). For those means, the manufacturers are facing with greater product variety and innovation, shorter product life cycle, lower unit cost and high product quality.

In order to improve the effectiveness of manufacturers to meet these new objectives, many concepts and approach of manufacturing had been proposed and implemented. Such approaches are Computer Integrated Machine and Concurrent Engineering. However, for further progress, these concepts are limited by the fundamental structure and methods of manufacturing business (Rogers, 1993). The Concurrent Engineering for example, even though its benefits the manufacturer in many ways, but it needs good relationships and sharing information among the members. But there is lot of issues in an organisation that hinder the sharing of information and such issue is structure of the organisation that prevent some information to be spread at the lower level of the structure.

To overcome these problems, Modular Production System which is based upon building flexible production systems from standardized modular subsystems been introduce (Rogers, 1993). Moreover, he states that this approach provide a

systematic link between product design and production system design in order to enable the new manufacturing demands to be met more effectively.

1.1 Modular Production System

The Modular Production System approach comprise of four categories which are Process Machine Primitives, Modular Actuator Elements, Modular Tooling and Jigging, and Configurable Control Systems modules (Rogers, 1993). The appropriate selection of modules from these categories will enable a diverse range of efficient, automated and integrated production systems to be built.

The Process Machine Primitives indicates the process machine while Modular Actuator Elements are used to build transfer system. Modular Tooling and Jigging used for 'tailoring' Process Machine Primitive and Modular Actuator Element modules and Configurable Control Systems are for programming and synchronizing the whole system.

1.2 Problem Statement

Currently, most manufacturer implement Computer Integrated Machine or Concurrent Engineering approach to overcome the challenge of global competition. But as been mentioned before, these approaches are limited by the fundamental structures and methods of manufacturing business for further progress. For further understanding why these approaches are limited, it is essential to highlight the reasons that underlying behind.

1.2.1 Computer Integrated Manufacturing

Computer Integrated Manufacturing denotes the pervasive use of computer system to design the products, plan the production, control the operations and perform the various business-related functions needed in a manufacturing firm (Groover, 2001). Before that, the Computer Integrated Manufacturing concepts arise from the desire to automate all aspects of manufacturing. Groover also stated that the reasons used to justify the automation are:

1. Automating a manufacturing operation usually increases production rate and labour productivity
2. Automated assembly systems generally produce products at high quality and consistency but at a lower cost than those produced using manual procedures.
3. Automation helps to reduce manufacturing lead time by reducing the elapsed time between customer order and product delivery.

However, Tsukune (1993) points out that automation remains limited to highly repetitive specialized work and is not useful for multiproduct, small-quantity manufacturing. Moreover, the automation of a production requires high implementation cost and complex in terms of mechanism and software. Sometimes, the cost for custom software can be much higher than the robots itself.

1.2.2 Concurrent Engineering

According to Groover (2001), Concurrent Engineering refers to an approach used in product development in which the functions of design engineering, manufacturing engineering and other functions are integrated to reduce the elapsed time required to bring a new product to market. In other words, the Concurrent Engineering approach ensured that all product life-cycle requirements such as quality, production, sales and process planning are considered at the product design stage. The benefit of this approach is mainly in reducing the product launch time compared with traditional product development cycle.

In particular, the Design For Manufacture elements in the Engineering approach can result in significant reduction in manufacturing cost and product lead-times. While other elements such as Design For Quality, Design For Cost and Design for Life Cycle ensures the quality of the product, competitive cost to produce the product and the product's life cycle issues.

In order for Concurrent Engineering approach to be implemented successfully, there is a need for good communications and teamwork between all the personnel involved. However, there are several issues that would hinder the Engineering approach to be fully implemented. Such issues are:

1. Information can be dispersed between many locations and therefore, it is difficult to access
2. The work structures of an organisational can be barriers to free information flow between groups.
3. The Design For Manufacture requires detailed manufacturing process knowledge. All the design alternatives and theirs implications to manufacture must be carefully considered.

1.2.3 Modular Manufacturing

According to Huang (2000), modularity is typically introduced into a manufacturing operation to increase the flexibility of the operation both in terms of its range of functions and also its ability to be easily reconfigured in the face of changing conditions. Modularity almost always leads to a distribution of functionality (not necessarily a physical distribution). Modularity is not a new concept in manufacturing, nor is the necessary distribution of functions or processes. Some existing examples of modular, distributed systems in manufacturing can be found in areas of control systems, equipment design, and human resource development.

Figure 1.1 illustrates a set of necessary components required to support a modular production unit or activity. It is critical that equipment, control/decision processing and human input are all co-ordinated to support the material transformation process and to maintain the functions of the unit. Equally an emerging set of approaches to the design and operation of manufacturing processes have been identified in which modularity and distribution concepts are being explicitly exploited in an integrated manner to improve production responsiveness to external demands and internal disruptions.

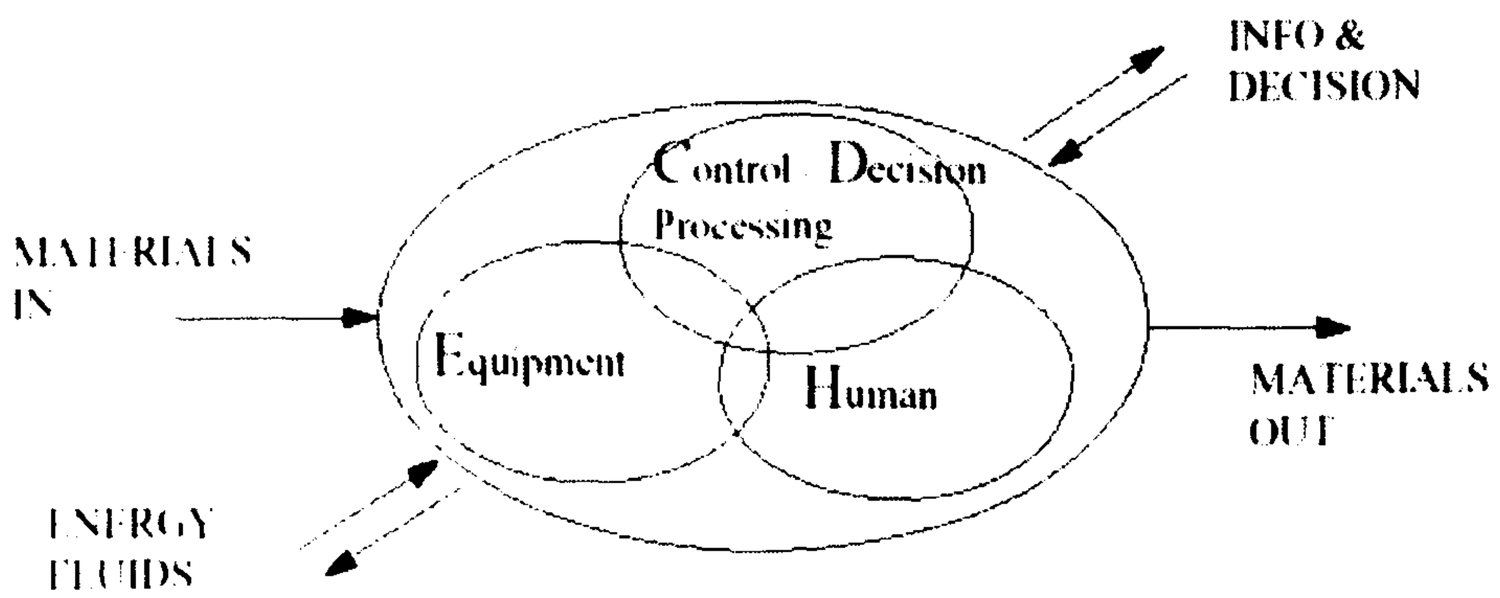

Figure 1.1 Modular Manufacturing Units

However, the Modular Manufacturing concepts still has it own drawbacks (Huang, 2000). One of the drawbacks of this concept is the use of large number of machines to meet the desired production and thus makes the design of the production system and controls are difficult. From the drawbacks of Modular Manufacturing concept, the idea of Modular Production System comes which overcome the drawbacks of the Modular Manufacturing concept with some modification for it to be more efficient.

1.3 Objectives

This study is concern with the Modular Production System as a new approach in manufacturing system. The study will go through the manufacturing system of the participating manufacturer and will look into any potential in implementing the Modular Production System approach.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

Before the discussion of Modular Production System is further, it is essential to understand where such ideas arise. The idea of Modular Production System comes from the modification of Modular Manufacturing concepts (Rogers, 1993).

2.1 Modular Manufacturing Concepts

In the context of engineering product design Stoll (1986) has noted that modular construction enables 'standardized diversity' by using different combinations of standard components. He also notes that modular design resists obsolescence, shortens redesign, enables new designs to be realized by using existing modules, reduces costs and eases maintenance. Moreover, where modular construction methods have become widely established the design process is generally assisted by sophisticated design and verification tools.

With regard to manufacturing machinery construction the modular concept has been used for many years. For example, many machine tool manufacturers produce customized machine tools largely by configuring their existing machine sub-systems (Hu, 1993). Automation equipment suppliers supply proprietary modular hardware, such as actuators units and grippers, for building modular work handling

systems. Moreover, although traditionally associated with 'hard automation', this modular manipulator approach is gaining recognition as an alternative means of achieving the promised flexibility of anthropomorphic robots, albeit by configuration (Canny, 1992, Weston, 1989).

Modular concepts are also utilized in the construction of entire production systems. Noted benefits of this approach include:

1. Providing greater scope in the way production is organized and the opportunity to readily reconfigure production to meet both short and long term objectives (Merchant, 1985).
2. Enabling the use of the simplest integrated combination of processes, machine systems, tooling, people, organizational structures, information flows, control and computer systems necessary to perform a given task (Davis, 1991).
3. Helping to eliminate islands of automation and further the re-use of machinery (Tsukune, 1993).

However, Tsukune (1993) also notes that there are significant problems currently limiting the progress of modular manufacturing, namely:

1. The large number of manufacturing machine elements currently in use makes modular production system design and control difficult.
2. The design, production and control processes are based on completely different models; this results in complex transformations between the 'idealized world' in which design tools operate and the 'real-world' in which manufacturing occurs

These problems stem principally from the fact that there are no standards for modular machinery. Moreover, there is no agreement on what the building elements should be. For example, a 'machine module' currently encompasses everything from a complete machine tool, such as a robot with an integrated controller, to a machine building element, such as an actuator unit, motor or transmission system. Indeed, such diversity of manufacturing machinery and hardware for constructing machinery exists principally as a result of the wide diversity of production requirements.

2.2 Modular Production System

According to Rogers (1993) the Modular Production System concept has been proposed as a way of overcoming the limitations resulting from a lack of modular machine standards. Moreover he also states that Modular Production System seeks to provide a radical new manufacturing business framework suitable for the 'agile' manufacturing era. The module categories comprise four classes; process machine primitives, motion units, modular fixturing and configurable control system. The appropriate selection of modules from these categories will enable a diverse range of efficient automated and integrated production system to be built.

2.2.1 The Principal Modules Used for Building a Modular Production System.

Before the Modular Production System been further introduce, it is necessary to introduce the principle modules that will be the element for this approach.

Process Machine Primitives

These are the principle material processing sub systems that operate upon and change the state of materials. For many processes, such as drilling, pressing and injection moulding, the modules are functionally similar to existing process machinery.

Modular Actuator Elements

These are for the provision of motion tasks and perform two central roles and this approach includes:

1. In association with modular tooling and jigging, Modular Actuator Elements are used to build simple material and component transfer systems
2. When appropriate Process Machine Primitives do not exist, Modular Actuator Elements are used with modular tooling and jigging to form the basis of new special-purpose process machinery.

Modular Tooling and Jigging

The tooling and jigging hardware are for 'tailoring' the Process Machine Primitives and Modular Actuator Elements units to perform specific functions such as been mentioned before.

Configurable Control Systems

This module provides the communication network for programming, commanding and synchronizing the various Modular Production System subsystems.

2.2.2 The Principles

The function of the Modular Actuator Elements, together with associated tooling and fixturing is to provide material manipulation, Process Machine Primitives material and component loading and unloading operations. Furthermore Modular Actuator Elements provide the motion elements for building special-purpose process machinery when appropriate Process Machine Primitives does not exist.

The main underlying objective of the Modular Production System approach is to enable construction of totally integrated component production and assembly system with a minimal requirement for specially designed machine elements, tooling, software and others.

At first sight, the idea of building production systems from a limited range of elements may appear restrictive but the potential benefits of this approach include:

1. Provision of a generic basis to production system design and construction appropriate to a wide sector of discrete goods industry.
2. A systematic basis to production system design. This will enable computers to play an increasingly important role in the design and control of all aspects of production.
3. The biggest problem in the automation of assembly, namely, the need for component orientation and feeding system can be eliminate virtually. It is possible as the Modular Production System approach of manufacturing users