UNIVERSITI PUTRA MALAYSIA

A KNOWLEDGE-BASED SYSTEM FOR MATERIAL-HANDLING SELECTION OF DISCRETE PART MANUFACTURING

MAZNAH BINTI ILIYAS AHMAD

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By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Science

March 2009

DEDICATION

Thanks to ALLAH for giving me the strength ness and knowledge to complete this research successfully.

This research work is dedicated to MY BELOVED HUSBAND AND MY FAMILY

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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March 2009

Chairman : Associate Professor Datin Dr. Napsiah Ismail

Faculty : Engineering

Material handling is one of the production functions that have been the focus of attention for many manufacturing industries especially discrete parts manufacturing. Generally, the design of material handling system can be divided into four phases namely; conceptual design, detailed design, launching and fully operational. The focus of this research is on the conceptual design phase. Since there are hundreds of equipment types and procedures to choose from, the selection activities are usually complex and difficult. Therefore, quick and appropriate material handling selection is important in a production system, since it can increase productivity, flexibility of the manufacturing time and it also reduces cost. Hence, development of a decision

support system to aid in the selection of the material handling equipment is a significant contribution in manufacturing operations.

In this research work, the selection system was developed using Kappa-PC expert system shell. It uses forward chaining for inferencing. In the forward reasoning stage, the developed system attempts to deduce a material handling equipment type recommendation based on user specified requirements. The selections of the material handling equipment are based on the move attributes and characteristics of material to be handled, operation requirement and area restriction. The recommendation from the knowledge-based system is refined through application of simulation modeling techniques. The simulation was carried out using Arena 9.0 software package. The material handling selection system assist design engineers in selecting the most suitable and appropriate material handling equipment type for the task being considered. The advantages of the developed system are; it considers both selection and configuration analysis, it can be immediately implemented in factory operations; it is modular and user friendly. The system was successfully validated through a case study. The case study was carried out on Sharp Manufacturing Corporation Sdn. Bhd., in Malaysia. Through the case study, a total of 5.20s of the transfer time and RM 9.00 per cycle of the transportation cost of the current Sharp Manufacturing System will be reduced. This result in 72.22 and 75.00 percent of improvement on the transfer time and transportation cost respectively. By the reduction and improvement on the transfer time and transportation cost, the efficiency of the material flow and productivity of the Sharp Manufacturing system will increase and the production cost will reduce.

Abstrak tesis dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

SISTEM BERASASKAN-PENGETAHUAN UNTUK PEMILIHAN PENGELOLAAN-BAHAN BAGI PEMBUATAN KOMPONAN DISKRET

Oleh

MAZNAH BINTI ILIYAS AHMAD

March 2009

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Pengelolaan bahan adalah salah satu fungsi pengeluaran yang diberi perhatian oleh banyak industri pembuatan terutamanaya pembuatan komponen diskret. Pada umumnya rekabentuk system pengelolaan bahan terbahagi kepada empat fasa dinamakan rekabentuk gagasan, rekabentuk perinci, rekabentuk pelancaran dan operasi keseluruhan. Fokus penyelidikan ini adalah pada fasa rekabentuk gagasan. Oleh kerana terdapat beratus jenis peralatan and tatacara untuk dipilih, aktiviti pemilihan menjadi komplek dan rumit. Oleh yang demikian, pemilihan pengelolaan bahan yang cepat dan tepat adalah penting didalam system pengeluaran, ini kerana ia berkeupayaan meningkatkan pengeluaran, masa pembuatan adalah pelbagai dan juga mengurangkan kos. Dengan itu, pembangunan satu system bagi menyokong

keputusan untuk membantu dalam memilih peralatan pengelolaan bahan adalah sumbangan yang amat bererti dalam operasi pembuatan.

Di dalam kerja penyelidikan ini, sistem pemilihan tersebut telah dibangunkan dengan menggunakan kelompang sistem cerdik iaitu Kappa-PC 2.4. Ia menggunakan perantaian ke hadapan untuk penyimpulan fakta. Di dalam fasa ”forward reasoning”, sistem yang telah dibangunkan cuba untuk menyimpulkan cadangan jenis peralatan pengelolaan bahan berdasarkan keperluan yang ditentukan oleh pengguna. Pemilihan peralatan pengelolaan bahan adalah berdasarkan pada sifat pergerakan, ciri-ciri bahan yang akan dikelola, keperluan operasi dan batasan kawasan. Cadangan daripada sistem berasaskan pengetahuan ditapis/dicari semula dengan mengaplikasikan teknik memodel penyelakuan. Penyelakuan dijalankan dengan menggunakan perisian Arena 9.0. Sistem pemilihan peralatan pengelolaan bahan ini membantu jurutera rekabantuk memilih jenis peralatan pengelolaan yang sangat sesuai dan tepat bagi tugas yang sedang dipertimbangkan. Kebaikan system yang telah dibangunkan ini adalah ia menitikberatkan kedua-dua pemilihan dan analisis konfigurasi, boleh dilaksanakan secara terus dikilang, mesra pengguna dan mudah diubahsuai. Kajian kes untuk mengesahkan sistem tersebut telah berjaya dilaksanakankan. Kajian kes tersebut telah dilaksanakan di Sharp Manufacturing Corporation Sdn Bhd. di Malaysia. Daripada kajian kes yang telah dilaksanakan, di dapati sebanyak 5.20s daripada masa pengagihan dan RM9.00 per pusingan daripada kos pengangkutan bagi sistem pembuatan Sharp semasa akan berkurang. Dimana 72.22 and 75.00 peratus pembaikan daripada masa pengagihan dan kos pengangkutan masing-masing akan diperolehi. Daripada pengurangan dan

pembaikan terhadap masa pengagihan dan kos pengangkutan maka keeffisenan pengaliran bahan dan produktiviti sistem pembuatan Sharp akan meningkat dan kos pengeluarannya akan berkurangan.

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Finally the most acknowledgements go to my friends who have given me moral support to complete my work within the time frame.

I certify that a Thesis Examination Committee has met on 23 January 2009 to conduct the final examination of Maznah binti Iliyas Ahmad on her thesis entitled "A Knowledge-Based System for Material-Handling Selection of Discrete Part Manufacturing" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

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Date: 21 May 2009

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of requirement for the degree of Master of Science. The Members of the Supervisory Committee are as follows:

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School of Graduate Studies
Universiti Putra Malaysia

Date: 8 June 2009

DECLARATION

I declare that the thesis is my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

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MAZNAH BINTI ILIYAS AHMAD

Date: 2 May 2009

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LIST OF ABBREVIATIONS

AGV	Automated Guided Vehicle
AHP	Analytical Hierarchy Process
AI	Artificial Intelligent
ASME	American Society for Mechanical Engineers
AS/RS	Automated Storage and Retrieval System
CAD	Computer Aided Design
CICMHE	College-Industry Council on Material Handling Education
DES	Discrete-event simulation
FMC	Flexible manufacturing cell
FIFO	First-in First-out
KAL	Kappa-PC Application Language
KBS	Knowledge Based System
LIFO	Last-in First-out
LIPS	List Processing
MHESS	Material Handling Equipment Selection System
PROLOG	Programming in Logic
SCOR	Supply chain operation reference
SD	System dynamic
TRIA	Triangular

LIST OF PUBLICATIONS

Maznah, I.A., Napsiah, I., Tang, S.H., *Development of Material Handling Equipment Selection System.* Proceeding of International Advanced Technology Congress, IOI Marriott Hotel, Selangor, 6-8 Disember 2005, pp65.

Maznah, I.A., Napsiah, I., Tang, S.H., *Development of material handling equipment selection system.* Proceeding of National conference on design and concurrent engineering, Century Mahkota Hotel, Malacca, 9-10 August 2006.

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CHAPTER 1

INTRODUCTION

1.1 Background

Material handling equipment selection is an important activity in the design of an effective manufacturing system. Handling activity generally account for 30 to 40% of production cost and efficient material handling can be primarily responsible for reducing the production cost by 15 to 30% (Kulak, 2005). Material Handling Industry of America (Groover, 2001) defines material handling as the movement, storage, protection and control of material throughout the manufacturing and distribution process including their consumption and disposal.

In the actual implementation, various material handling equipment are aggregated or combined into a materials handling system for a specific purpose. As such, appropriate specifications and a suitable configuration of the system are important aspects that must be addressed in order to satisfy the requirements of a particular application.

The design of the material handling system depends on the material to be handled, quantities and distances to be moved and type of production facility served by the handling system. Usually, the design of material handling system is divided into four

phases. These are conceptual design phase, detailed design phase, launching phase and fully operational phase (Ulgen and Upendram, 1995). The first and the most important phase is conceptual design. Conceptual design is done at a high abstraction level. In general, the conceptual design phase involves issues such as; what a material handling system is, what it can do and how it is intended to be used.

Different types of material handling equipment are used for different types of manufacturing environments. As an example, the specifications for material-handling equipment that is used in discrete parts manufacturing environments are different from those used in continuous processing industries.

Discrete part manufacturing is defined as the manufacture of individual parts that are clearly distinguishable such as circuit boards or engine blocks (Askin and Standridge, 2003). The type of material handling equipment to be used is not only dependent on the manufacturing environment but also depend on the section of manufacturing system in which it will be used. For example, the material handling equipment that are used in raw material storage are different from those used in the shop floor area.

With the elapse of time as well as the rapid technological advancements, the number of material handling manufacturers, which offer different kinds of handling equipment, has increased. As a result, material handling equipment with different capabilities and specifications are available for a wide range of applications. Therefore, the selection of material handling equipment to suit a particular

application, from among the large number available in the market, has become a difficult task. Various considerations such as the efficiency and effectiveness of a production system and other economic issues need to be considered before a suitable material handling equipment can be selected. Albeit, some of the material handling attributes such as the move attributes, operation, area and the characteristic of material to be handled are influenced by the type of the production system.

In light of the above discussion, it is not possible for an individual or a team to take all of these considerations into account without the help of computer software packages. The complexity of the problem can be better appreciated when one realizes that there are more than thirty attributes that may have to be considered in the selection of a material handling equipment for a particular application. Therefore, utilization of a material handling equipment selection system is a must for selecting the most appropriate material handling equipment for a specific task since selecting and adopting a material handling system that is not suitable for a particular task could affect productivity and profitability.

There are several models for material handling equipment selections that have been suggested in the past 10 years. This research will apply computer-assisted model for material handling equipment selection. The advantage of using computer assistance is that it brings expert knowledge to solve difficult problem. The information contained in the knowledge base help user in selecting material handling equipment. Also, because the selection process is automated, a large number of material handling equipment attributes can be considered.

1.2 Problem Statement

With the wide range of material handling equipment available today in the market, selections of the best equipment alternative that suit particular application and production environment becomes a complex and difficult task. Traditionally, design engineers selected material-handling equipment manually. Their selections were always based on their experience. The design engineer who does the selection based on experience tends to select the equipment, which they are most familiar with and their choice sometimes may not be the most cost effective for the material-handling task being considered. Various considerations such as the move attributes and the characteristics of material to be handled ought to be considered before a best solution can be made. Some of the examples of move attribute that should be taken in consideration are move direction, move level and move height. For the material characteristics are usually material type, material weights, material size and others.

In light of the attributes listed above, considerations of all attributes result in thousands of combinations. Considering such a large number of combinations becomes unrealistic or impractical to predict best solution. As an alternative, these problems can be solved more appropriately with the aid of an expert system. Expert system is a computer program, which uses expert knowledge to attain high levels of performance. However, the equipment that is selected by expert system, gives a general classification of material handling equipment such as power pallet truck, monorail, belt conveyor etc. This general classification does not give the design engineer any guidelines in terms of the specification and configuration of the

material handling system. As a result, the recommendations from the expert system cannot be used immediately. To resolve this issue, simulation-modelling techniques is use in conjunction with an expert system. By integrating an expert system with simulation, material handling system specifications and configuration can be obtained, rather than a general class of material handling equipment.

In order to achieve this, the Kappa-PC expert system shell is used to develop a material handling equipment database and the ARENA 9.0 software is used to evaluate the performance of material handling systems in order to obtain appropriate specifications and configuration.

1.3 Research Objectives

The main objectives of this project are as follows:-

i. To develop a knowledge-based system for material handling selection of discrete part manufacturing.

ii. To model and evaluate the performance of the material handling system using ARENA simulation software.

1.4 Scopes and Limitation

The research focuses on designing a material handling equipment selection system of discrete parts. The key task involved in designing the system includes selection of material handling equipment and specification analysis (performance evaluation) of equipment for handling materials. The focus of this research work is on the conceptual design stage. The scope is limited to production system stage is as shown in Figure 1.1, which are raw material storage, shop floor and finished product. Supply chain and distribution area are not taken into consideration

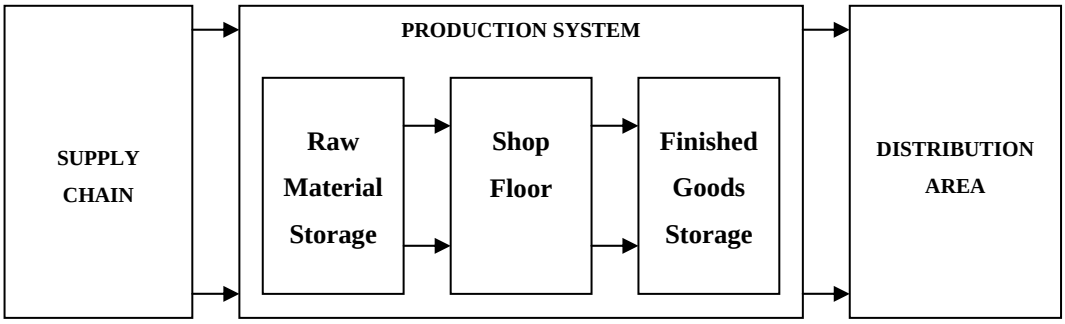

Figure 1.1: The focus area of this research

1.5 Overview and layout of thesis

This thesis is structured into six chapters. The first chapter is the introduction to research. Chapter two presents a review of literature that relates to material handling, material handling system, previous work done, expert system, simulation and software tool used. The description of research methodology is presented in chapter 3. Chapter 4 describe on the development of the material handling selection system

and simulation modelling. The results and case study are presented in chapter 5. Conclusion and recommendation for future research are mentioned in chapter 6.

CHAPTER 2

LITERATURE REVIEW

In this chapter, literature related to the previous work done on material handling equipment selection system is reviewed. Reference is given to categories of equipment, types of equipment for each category, attribute pertinent to each category of equipment, expert systems and the use of simulation modelling techniques. The decisions derive examples from the discrete part manufacturing industry. A description on Kappa-PC and ARENA 9.0 simulation software are also given in this chapter.

2.1 Introduction

Recently, there has been a tremendous growth of material handling equipment technology. Material handling systems have been accepted as an integral part of today's manufacturing systems and are also increasingly playing an important role in the productivity of the plant. Therefore, well-designed material handling systems is important to reduce the cost of production and also for successful implementation.