UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF GENETIC ALGORITHM PROCEDURE FOR SEQUENCING PROBLEM IN MIXED-MODEL ASSEMBLY LINES

ALIREZA NOROZIROSHAN

FK 2009 12

DEVELOPMENT OF GENETIC ALGORITHM PROCEDURE FOR SEQUENCING PROBLEM IN MIXED-MODEL ASSEMBLY LINES

By

ALIREZA NOROZIROSHAN

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

October 2009

DEDICATION

To my dearest parents: for all of the times you were by my side to teach me the value of diligence, courage and decency and help me to celebrate my successes

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

DEVELOPMENT OF GENETIC ALGORITHM PROCEDURE FOR SEQUENCING PROBLEM IN MIXED-MODEL ASSEMBLY LINES

By

ALIREZA NOROZIROSHAN

June 2009

Chairman: Mohd Khairol Anuar Mohd Ariffin, PhD

Faculty: Engineering

One of the most important issues for manufacturing systems is to determine the optimal job sequence over the production period. Mixed model assembly line is a kind of manufacturing systems which is able to deal with variable market demand. In this research, an effective utilization of mixed-model assembly line is considered as problem statement through implementing different production strategies. The problem under study contains set of mixed-model assembly line where finding the optimal job sequence based on different production strategies is the objective of this research. Different production strategies have different objectives to be met, meanwhile the sequence of jobs can be varied based on different production strategies. The main contribution of the study was implementing four production strategies in mixed-model assembly line problems, so the company can take advantage of proposed production model in different situations to meet the challenges. The first production strategy aims to minimize the make span of assembly lines and release the products to the market as

soon as possible. The second production strategies attempts to minimize the make-span, and also balancing the assembly lines. It helps to balance the workload among all assembly lines. Minimizing the variation of completion time is also considered as third production strategy. The last production strategy aims to provide ideal status for assembly lines by minimizing the make-span and variation of completion time, and balancing the assembly lines. Due to NP-hard nature of sequencing problem in mixed model assembly line, a genetic algorithm is applied to cope with problem complexity and obtain a near optimal solution in a reasonable amount of time. All data is taken from literature and the result obtained from genetic algorithm procedure for the first production strategy is compared to study mentioned in literature which represents an improvement of 5% in shortening the make-span for one set of product. For the rest of production strategies, simulated annealing algorithm is applied to check the well performance of proposed genetic algorithm through reaching the same solutions for each production strategy. In all production strategies both GA and SA reaches to the same job sequence and same value of objective functions. It confirms that the proposed genetic algorithm procedure is able to tackle the problem complexity and reach to optimal solutions in different production strategies.

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

PEMBANGUNAN TATACARA ALGORITMA GENETIK BAGI MASALAH PENJUJUKAN DALAM BARISAN PEMASANGAN MODEL-BERCAMPUR

Oleh

ALIREZA NOROZIROSHAN

Jun 2009

Pengerusi: Dr. Mohd Khairol Anuar Mohd Ariffin, PhD

Fakulti: Kejuruteraan

Salah satu isu yang paling penting dalam sistem pembuatan adalah untuk menentukan jujukan kerja optimum sepanjang tempoh pengeluaran. Barisan pemasangan model bercampur adalah sejenis sistem pembuatan yang boleh menangani kepelbagaian permintaan pasaran. Dalam kajian ini, keberkesanan penggunaan barisan pemasangan model bercampur dijadikan sebagai pernyataan masalah melalui pelaksanaan strategi pengeluaran yang berbeza-beza. Masalah yang dikaji mengandungi satu set barisan pemasangan model bercampur dan objektif penyelidikan ini adalah mencari jujukan kerja optimum berdasarkan perbezaan strategi pengeluaran. Strategi pengeluaran yang berbeza perlu memenuhi objektif yang berbeza manakala jujukan kerja boleh dipelbagaikan berdasarkan perbezaan strategi pengeluaran. Sumbangan utama kajian ini adalah melaksanakan empat strategi pengeluaran menangani masalah barisan pemasangan model bercampur supaya syarikat boleh mengeksploitasi cadangan model pengeluaran dicadangkan dalam situasi berbeza untuk menghadapi cabaran. Strategi

pengeluaran pertama bertujuan meminimumkan tempoh buatan barisan pemasangan dan mengeluarkan produk ke pasaran secepat mungkin. Strategi pengeluaran kedua cuba untuk meminimumkan tempoh pembuatan serta mengimbangi barisan pemasangan. Perseimbangan beban kerja antara semua barisan pemasangan sememangnya membantu. Strategi pengeluaran ketiga ialah meminimumkan perubahan masa. Strategi akhir pengeluaran bertujuan untuk memberikan status yang ideal barisan pemasangan dengan meminimumkan tempoh pembuatan dan variasi masa penyiapan, dan mengimbangkan barisan pemasangan. Disebabkan oleh sifat masalah penjujukan kaku NP dalam barisan pemasangan model bercampur, satu algoritma genetik telah diaplikasikan untuk mengatasi kerumitan masalah dan memperoleh penyelesaian hampir optimum dalam masa yang bersesuaian. Semua data diambil daripada rekod bertulis dan keputusan yang diperoleh daripada tatacara algoritma genetik bagi strategi pengeluaran pertama dibandingkan dengan kajian yang dibincangkan dalam rekod bertulis yang menunjukkan 5% peningkatan dalam memendekkan tempoh-buatan bagi satu set produk. Bagi strategi pengeluaran yang selainnya, simulasi algoritma penyepuhlindapan diaplikasikan bagi menyemak prestasi baik algoritma genetik yang dicadangkan dengan mencapai penyelesaian sama bagi setiap strategi pengeluaran. Bagi semua strategi pengeluaran, kedua-dua GA dan SA berakhir dengan jujukan kerja dan nilai rangkap objektif yang sama. Ini mengesahkan bahawa tatacara algoritma genetik yang dicadangkan mampu menangani kerumitan masalah dan mencapai penyelesaian optimum dalam strategi pengeluaran yang berbeza.

ACKNOWLEDGEMENTS

I take this opportunity to sincerely express my gratitude to Dr. Mohd Khairol Anuar Mohd Ariffin for chairing my committee and advising this project. I am grateful to him for spending time with me and helping me. I am indebted to him for his whole-hearted support, enthusiasm and inspiration throughout my graduated study.

I am also grateful to Prof.Madya Datin Dr. Napsiah Ismail for her valuable advice and suggestion during the graduate study and for her participation in my committee.

I also thank all other faculty members who somehow helped me prepare this assignment.

My last gratitude but not the least, is dedicated to my parents for their love, faith and support.

I certify that an Examination Committee met on **1 of OCT 2009** to conduct the final examination of **ALIREZA NOROZIROSHAN** on his philosophy of Master thesis entitled "**DEVELOPMENT OF GENETIC ALGORITHM PROCEDURE FOR SEQUENCING PROBLEM IN MIXED-MODEL ASSEMBLY LINES** " in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree.

Members of the Examination Committee are as follows:

Prof.Madya Dr.Rosnah Mohd.Yusuff
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Dr. Tang Sai Hong
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Dr.Faizal Mustapha
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Prof. Madya Dr.Shamsuddin Ahmed
Associate Professor
Faculty of Engineering
Universiti
(External Examiner)

BUJANG KIM HUAT, PhD
Professor/Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia
Date:

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

Mohd Khairol Anuar Mohd Ariffin, PhD
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Napsiah Ismail, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

HASANAH MOHD. GHAZALI, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 11 February 2010

DECLARATION

I declare that the thesis is based on my original work except for quotations and citation which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

_____

ALIREZA NOROZIROSHAN

Date:

TABLE OF CONTENTS

CHAPTER

4 RESULTS AND DISCUSSIONS

CHAPTER

5 CONCLUSION AND RECOMMENDATION

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ANTBAL	Ant colony for balancing assembly line
Cmax	Make-span time
DIP	Dynamic ideal point
GA	Genetic algorithm
GA-1	Genetic algorithm in first stage
GA-2	Genetic algorithm in second stage
GP	Goal programming
IA	Immune algorithm
IP	Integer programming
JIT	Just in time system
MALBP	Mixed-model assembly line balancing problem
MMAL	Mixed-model assembly line
MOSS	Multi objective scatter search
NC	Numerical control machine
PCA	Principle component analysis
TSP	Traveling salesman problem

CHAPTER 1

INTRODUCTION

1.1 Introduction

As globalization has increased in the past few years, many companies attempts to made appropriate strategic decision to meet with this challenge. Time-based strategy attempts to decrease the time required to complete many activities such as releasing product to the market or rapidly respond to customers demand variability's or developing new products to gain more market share over other competitors who take more time to accomplish the same work. Implementing new technological advances or choosing appropriate production techniques, in process procedures can also yield competitive advantages for companies by increasing productivity and improving processing capabilities (Stevenson, 2007).

Due to significant increase in the market demand changes, many small and medium sized companies have faced with variability in batch size and product variety and it results in increasing the setup time and part movement in manufacturing processes (French, 1982). Implementing an appropriate production strategy can provide means to deal with operational aspect of organization which more relates to the products planning, processing techniques, manufacturing methods, operating resource, sequencing, and scheduling (Stevenson, 2002). Most of the industries make use of assembly lines, to produce and assemble products in the sequential manner which is quite faster than traditional methods.

1.1.1 Assembly lines

An assembly line is consisted of several workstations usually arranged along a material handling system in which parts are consecutively moving along the line from station to station. A particular proportion of assembly operation is done in each workstation and the job will be completed as it reaches to end of line. Those industries that are dealing with mass production system greatly enjoy the benefits of single-model of one homogeneous product (Scholl, 1999). Though assembly line balancing problem has been under study for 40 years, the number of studies on mixed model assembly balancing problems is relatively small. Since the manufacturing industries face the variable demands of producing several different products to attain higher customer satisfaction , mixed model line is widely used in industry (Gokcen and Erel, 1997). Line balancing improves productivity and decrease wasting on employees, time, equipments and operators. The longest completion time of multiple lines determines the overall make-span of multiple lines (Pinedo, 2002).

1.1.2 Mixed-model assembly line

The mixed-model assembly lines are widely implemented in wide area of industries and its popularity in increasing. In a mixed-model assembly line, workstations can be flexible and supporting enough to produce or assemble variety of different product models concurrently and continuously while in single model assembly line, workstations are designed to perform a predetermined operation to produce one

variant model (Groover, 2001). As the mixed-model assembly line is dealing with variety of product models, the job sequencing in mixed-model assembly lines is considered as a critical factor for efficient utilization of the lines (Kim et al., 1996).

1.2 Problem statement

In today's customer-driven market, where the products become obsolete in short period of time, releasing products to the market earlier than other competitors with higher diversity of product models have some competitive advantage. Meanwhile mixed model assembly lines can play pivotal role in providing flexibility for manufacturing systems to make manufacturing system efficient. The problem under study focuses on job sequencing problem in mixed-model assembly line in Printed Circuit Board (PCB) assembly. Combinatorial nature of mixed-model line problems makes the sequencing and scheduling difficult to obtain optimal solution. Due to NP-hard nature of sequencing problem in mixed-model assembly line, an appropriate solving procedure is required to be developed to find the solutions in a reasonable amount of time. The job sequence in each line should be determined based on different production strategies. An efficient algorithm for sequencing models to be assembled on the line are recognized as an essential requirements for improving its performance.

1.3 Objectives

The objective of this research is to find optimal job sequence in mixed-model assembly line regarding different production strategies. Thereby the research objectives are as follows:

- Developing a genetic algorithm procedure for sequencing problem in mixed model assembly lines for different production strategies
- Simulating the genetic algorithm procedure developed
- Comparing and verify the results with Simulated Annealing

In this study an effective utilization of mixed-model assembly line is considered as first problem objectives through implementing different production strategies. Those four production strategies which are being taken into the consideration are as follows:

1) Minimizing the make-span for assembly lines.
2) Minimizing the make-span, and balancing the assembly lines
3) Minimizing the make-span and variation of completion time
4) Minimizing the make-span and variation of completion time, and balancing the assembly lines

These strategies help company to quickly release new developed products or services to the market. The first strategy is used to find best sequence of dedicated jobs in which minimizes the make-span in assembly lines. No other consideration is involved in this production strategy except releasing product as soon as possible. Second strategy attempts to find the minimum make-span, and balancing the assembly lines. Line balancing helps companies to improve the accuracy of

production planning and equipment maintenance scheduling through increasing labor productivity, equipment's availability and staff's enthusiasm.

The third object function tries to minimize the make-span with regard to minimum completion time difference between multiple lines. Finding the best sequence of jobs which minimizes all the above objectives together is the last production strategy. The last strategy seeks the best sequence of jobs that keep the system in the efficient state to meet all the above objectives. For each production strategy, genetic algorithm is developed and simulated to find the best job sequence for every single line in order to meet the corresponding objectives of each production strategy. The performance and stability of genetic algorithm is measured by comparing the results obtained with simulated annealing algorithm to verify the accuracy of solution for each production strategy.

1.4 Scope and limitation of the study

The scope of this study is to develop four production strategies for job sequencing for mixed model assembly line problem**.** A genetic algorithm is developed to find the best job sequence within each line. The jobs are consecutively launched down the line and the assembly operations are performed as they move from station to station. As the assembly operation is performed manually, precedence constraints for the tasks for a job are not considered. Hence the focus study is limited to assembly operation without precedence relation. Therefore the findings from this study are not strong enough to be generalized to all types of assembly operations on mixed-model assembly lines.