Faculty of Manufacturing Engineering

A CONCEPTUAL FRAMEWORK OF RECONFIGURABLE CONVEYOR SYSTEM TO SUPPORT CHANGEABILITY IN MANUFACTURING

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A CONCEPTUAL FRAMEWORK OF RECONFIGURABLE CONVEYOR SYSTEM TO SUPPORT CHANGEABILITY IN MANUFACTURING

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A thesis submitted
in fulfillment of the requirements for the degree of Master of Science
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DECLARATION

I declare that this thesis entitled "A Conceptual Framework of Reconfigurable Conveyor System to Support Changeability in Manufacturing" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Manufacturing Engineering.

Signature	:	………………..……………………………
Supervisor Name	:	Ir. Dr. Ing. Azrul Azwan Bin Abdul Rahman
Date	:	……………………………………………….

DEDICATION

This report is dedicated especially to my beloved family, my parents

(Encik Mohamad Bin Yaccob and Puan Lijah Binti Mohd)

My husband (Encik Khairul Nizam Bin Abd Ghani)

My sisters and my brothers

And lastly to all my friends that give me a support while doing this project

Thank you very much.

ABSTRACT

Reconfigurable concept has a demand in the manufacturing system in order to support unpredictable customer demand. It is also to improve the changeability and functionality of the system to reduce time and cost-saving. A conveyor system is one of automated material handling systems commonly used in manufacturing industries. Due to the problem such as dynamic nature, space available, and risk operation, these conveyor systems are unable to suit the current market requirement. Therefore, this research aimed to propose a new conceptual framework of Reconfigurable Conveyor System (Re-Con) in order to support the changeability in the manufacturing system. At the end of the study, some case study is carried out to analyze and validate the concept. The study includes both conceptual framework for physical configuration and logical configuration. There are four possible configurations which are closed-loop, L-Shaped, U-Shaped and Straight-Line layout arrangement. For the logical configuration, there are six different modules of Programmable Logic Controller with different control strategies. The program is designed by using IEC 61131 Protocol. Function Block is designed from the program of each controller to make it easier to upload, download, design and redesign the controller when a changeable of layout arrangement is happen. The proposed conceptual framework is validated by using a lab-scale Re-Con. The analysis is conducted by using Maynard Operation Sequence Technique (MOST) analysis and Single Minutes Exchange Die (SMED). The physical configuration of Re-Con takes about 108.42 minutes and the logical configuration of Re-Con takes about 445.69 seconds compared to the lab-scale of the existing conveyor system. From the result, the development of the Reconfigurable Conveyor System can be made in the future study because it can reduce cost saving and time. In conclusion, the research's objective to develop a conceptual framework of Re-Con has been achieved.

ABSTRAK

Konsep pembentukan semula diperlukan dalam sistem pembuatan bagi menyokong permintaan pelanggan yang tidak menentu. Ia juga untuk meningkatkan kebolehan dan fungsi sistem bagi mengurangkan masa dan penjimatan kos. Sistem penghantar adalah salah satu sistem pengendalian bahan automatik yang sering digunakan didalam sistem pembuatan. Disebabkan masalah seperti sifat dinamik, ruang yang tersedia dan risiko operasi, sistem penghantar tidak dapat memenuhi keperluan pasaran semasa. Oleh itu, kajian ini bertujuan untuk mencadangkan rangka kerja bagi konsep baru iaitu sistem penghantar yang boleh dibentuk semula untuk menyokong perubahan dalam sistem pembuatan. Pada fasa akhir pembangunan konsep tersebut, beberapa kes kajian dijalankan untuk menganalisa dan mengesahkan konsep tersebut. Kajian ini merangkumi konfigurasi fizikal dan konfigurasi logik. Terdapat empat konfigurasi iaitu konfigurasi gelung tertutup, konfigurasi bentuk L, konfigurasi bentuk U dan konfigurasi garis lurus. Untuk konfigurasi logik, terdapat enam modul berbeza yang boleh diaturcara menggunakan pengawal logic boleh atur (PLC) dengan strategi kawalan yang berbeza. Program ini diaturcara dengan menggunakan Protokol IEC 61131. Fungsi Blok (FB) direka bentuk berlandaskan sistem kawalan dari setiap modul untuk memudahkan ianya dimuat naik, dimuat turun, direka bentuk dan direka bentuk semula apabila susunan konfigurasi berubah. Konsep rangka kerja ini diuji dengan menggunakan sistem penghantar bersaiz makmal yang boleh diubah suai. Analisa telah dilakukan dengan menggunakan Analisis MOST dan Analisis SMED. Konfigurasi fizikal mengambil masa dalam 108.42 minit dan konfigurasi logikal mengambil masa dalam 445.69 saat berbanding dengan sistem penghantar bersaiz makmal yang sedia ada. Daripada hasil kajian, sistem Re-Con ini boleh dibangunkan dan digunakan pada masa hadapan kerana ia dapat mengurangkan penjimatan kos dan masa. Sebagai kesimpulan, matlamat projek untuk membangunkan konsep sistem penghantar yang boleh diubah telah dicapai.

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LIST OF ABBREVIATIONS

AGV	-	Automated Guided Vehicle
APPC	-	Adaptive Production Planning and Control
DMS	-	Dedicated Manufacturing System
FB	-	Function Block
FMS	-	Flexible Manufacturing System
I/O	-	Input/Output
MOST	-	Maynard Operation Sequence Technique analysis
PLC	-	Programmable Logic Controller
RAS	-	Reconfigurable Assembly System
RE-CON	-	Reconfigurable Conveyor System
RMS	-	Reconfigurable Manufacturing System
RPP	-	Reconfigurable Process Planning
SMED	-	Single Minutes Exchange Die
TRF	-	Transformable Factory

LIST OF PUBLICATIONS

Papers are published:

1. Mohamad, N. R., Abdul Rahman, A. A., Bali Mohamad, B. M., Rahman, M. A. A., Jafar, F. A., Muhamad, M. R., and Md Fauadi, M. H. F., 2018. Architecture of Reconfigurable Conveyor System in Manufacturing System. *Journal of Advanced Manufacturing Technology (JAMT)*, 12(1), pp. 117-128.

2. Abdul Rahman, A. A. and Mohamad, N. R., 2016. Software-in-the-Loop Simulation Techniques to Support Reconfiguration of Manufacturing System. *ARPN Journal of Engineering and Applied Sciences*, 11(16), pp. 9789-9795.

3. Mohamad, N. R., Abdul Rahman, A. A., and Rahman, M. A. A., 2016. A Concept of Logical Reconfiguration. *Proceedings in Innovative Research and Industrial Dialogue, IRID 2016.*

4. Mohamad, N. R., Abdul Rahman, A. A., Bali Mohamad., A. A., Rahman, M. A. A. and Ekhwan, A., 2015. The State of The Art and Future Perspective of Reconfigurable Conveyor Systems in Manufacturing Industry. *Proceeding in International Conference on Design and Concurrent Engineering, IDECON 2015.*

CHAPTER 1

INTRODUCTION

1.1 Background

Manufacturing industries is one of the important industries that play as a company, which manufacture various products. This industry makes a large influence in the country's economic growth. The material handling system is commonly used in the manufacturing process as a delivery and production tools to move the product from the raw material to completion stage. The material handling system can be classified into two categories which are manual and automated material handling system. The example of an automated material handling system is an Automated Guided Vehicle (AGV), conveyor system and robot.

Figure 1.1 shows the revolution manufacturing system. Manufacturing industries have been introduced in the year 1850s. Most of the industries at this year used manual process by handmade. After a certain century, a new assembly line introduced in 1913s. This year is the beginning of mass production. In the year 1955s shows the peak of mass production since this year shows a high rate of production. These periods can be called as Dedicated Manufacturing Line (DML). To solve the problem, some improvement has been made by introducing a new invention of CNC technology in the year 1980s to support the high-frequency of customer's requirements. This system can be called as Flexible Manufacturing System (FMS). In the 2000s, the manufacturing industry needs to face unpredictable, high-frequency market changes, and other challenges due to globalization in this 21st century (Abdul Rahman, 2013). Therefore, a new type of manufacturing system is required in order to make the competition between companies in the manufacturing industry to make it become more responsive to all the market changes (Koren and Shpitalni, 2010). Reconfigurable Manufacturing System (RMS) is introduced to support high-frequency market changes (Abdul Rahman, 2013).

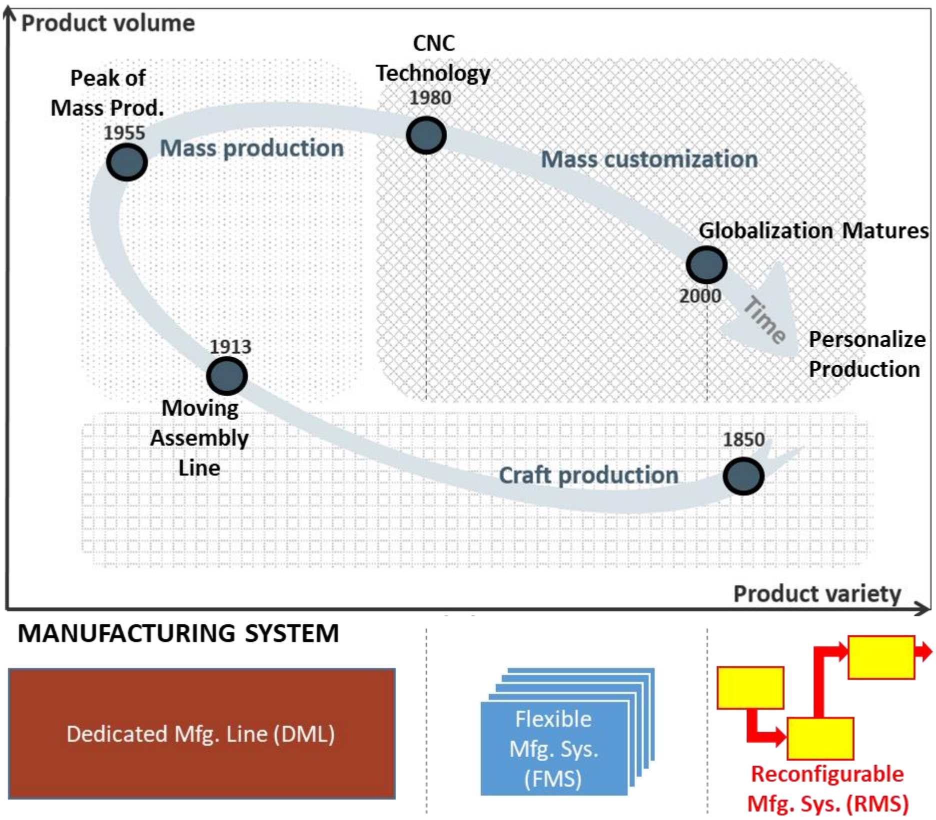

Figure 1.1: Revolution of manufacturing system (Abdul Rahman, 2013)

In this research, the researcher is only focused on the conveyor system because the conveyor system is commonly used in manufacturing industries. In Malaysia industry scenario, about 39.3% of companies in Malaysia used conveyor system as their main material handling system. A conveyor system is used to transport an object from one place to another (Dematic, 2014). Instead of possessing a new manufacturing system, a new conveyor system should be implemented first since the conveyor is a composed of material handling system which occurred in most of the manufacturing system.

There are several advantages by using the conveyor system, which is time and cost-saving and increases productivity at a certain time (An, 2011). In a rapidly changing environment, good coordination of production and logistics at a manufacturing operational level is required to handle rapidly evolving technology, frequently changing customer demand and satisfaction, and remain competitive.

A new concept of Reconfigurable Conveyor System (Re-Con) can adapt for converting the production of new models with cost-effective way by improving the capacity, productivity (Nazzal and El-Nashar, 2007) and functionality of the system to meet the product demand. The manufacturing system is scalable with the integration of technology and produces a variety of products in the rapid pace of change in quantities by reconfiguring the system-manufacturing layout.

This research is proposed to develop a new conceptual framework of Re-Con in manufacturing industries. The proposed framework of Re-Con is shown in two categories, which are physical and logical state.

1.2 Problem statement

Nowadays, the manufacturing industry is one of the important industries and made a large influence in the country's economic growth. It is now moving to adopt the reconfigurable manufacturing system in order to support the rapid changes in the market demands. According to the UNIDO (2016), the annual growth of the world manufacturing value added (MVA) is increased about 2.8 percent compared to the UNIDO estimates in 2015, which is 1.3 percent. These results indicate that there is increased of 1.2 percent compared to 2015. Figure 1.2 shows the estimated annual growth rates of world

MVA by years, at constant 2010 prices and Figure 1.3 shows the estimated annual growth rates of world MVA by years, at constant prices of 2005.

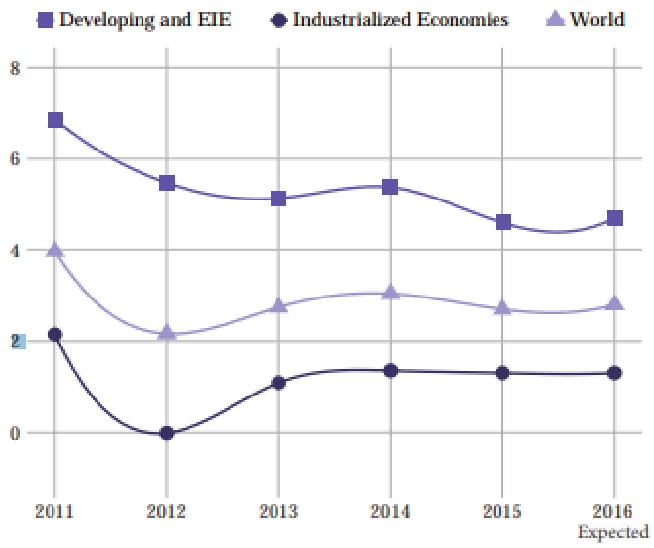

Figure 1.2: Estimated annual growth rates of world MVA by years, at constant 2010 prices (UNIDO, 2016)

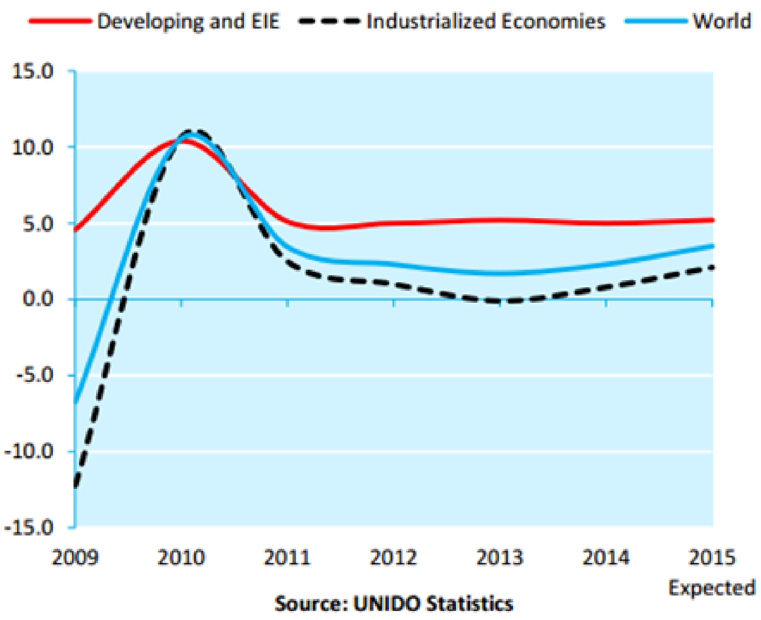

Figure 1.3: Estimated annual growth rates of world MVA by years, at constant prices of 2005 (UNIDO, 2015)

This statistic has proved that manufacturing industries cannot depend on the steady market demand any longer. However, regional conflicts especially in the Middle East and North Africa, as well as financial instability in Europe may adversely affect the growth figures. Global manufacturing output growth further slowed in the second quarter of 2015 as the global economy faced a number of challenges, including significant changes in the value of major currencies, a decline in oil prices, a continued slowdown in China and geopolitical instabilities. Figure 1.4 shows the industrial production in the industrialized country.

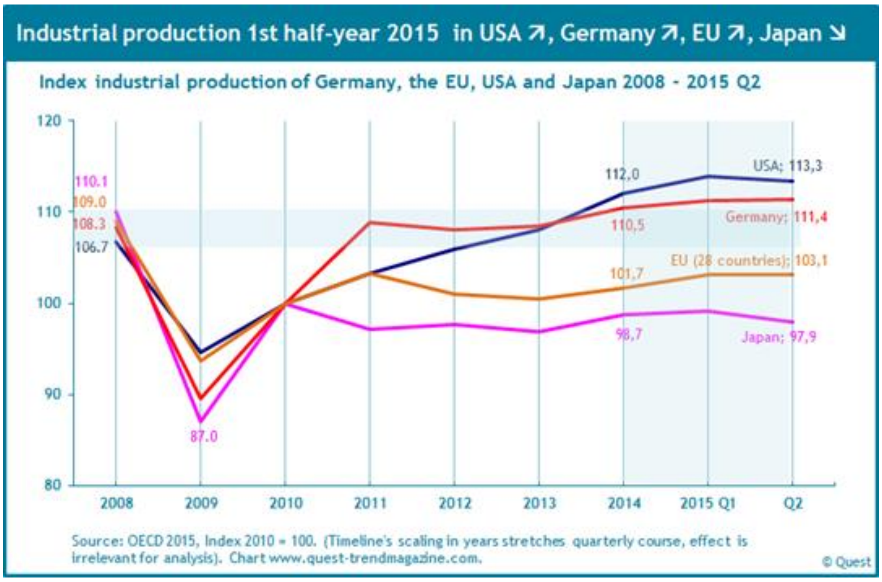

Figure 1.4: Industrial production in industrialized country (OECD, 2015)

For the solution of the problem, a new conceptual framework needs to be designed in order to respond to this sudden change of the market demands. Most of the manufacturing industries uses a conveyor system as their main system. The demand for the use of the conveyor system as one of the material handling system is increasingly moved forward with the technology. A conveyor system is used to transport product from the loading station until the unloading station. The current material handling