Faculty of Manufacturing Engineering

DESIGN OF A CONTROL SYSTEM FOR A RECONFIGURABLE CONVEYOR SYSTEM USING PLC

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DESIGN OF A CONTROL SYSTEM FOR A RECONFIGURABLE CONVEYOR SYSTEM USING PLC

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DECLARATION

I declare that this thesis entitled “Design of a Control System for a Reconfigurable Conveyor System using PLC” is the result of my own research except as cited in the reference. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ……..

Name : Victor Abraham Lim Su Kang

Date : ……..

APPROVAL

I hereby declare that I have read this dissertation/report and in my opinion this dissertation/report is sufficient in terms of scope and quality as a partial fulfilment of Master of Manufacturing Engineering (Manufacturing System Engineering).

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

DEDICATION

To my beloved parents,

Lim Sih Ei and Sailin Binti Salim

ABSTRACT

Reconfigurable is used by a manufacturing system to emphasize the importance of being able to change and improve the functionality of the system. This report presents the work done on the control system of the Reconfigurable Conveyor System (RCS) using Programmable Logic Controller (PLC). Due to the customer demand in a variety of products, a manufacturer needs to find alternatives to provide flexibility and reconfigurability to the manufacturing system. Design for reconfigurability is essential in manufacturing because customer demand in product variety is increasing. Thus a control system becomes the main role in the reconfiguration of manufacturing systems. The flexibility of the system will determine the system performance in the manufacturing industry. The objective of this project is to design the control system using a Petri Net (PN) model and generates Ladder diagram (LD) PLC. PLC system becomes essential in the reconfigurability to control the operation through the cx-programmer software. The programming software generates a different modification method to determine the changeability. The PLC is used for the communication between the cx-programmer software and RCS by using Local Area Network (LAN) cables. The integration between PLC and RCS established by using the Function Block (FB) instruction to enables the data transfer and exchanging data. Therefore this project used PLC to design the control system that capable of supporting the changeability and quick reconfiguration of the RCS. The design control system in RCS enables the control system to be flexible and effective to performed multiply of tasks. It is hoped that this project able to give a beneficial for efficient material system.

ABSTRAK

Konfigurasi semula digunakan dalam sistem pembuatan adalah untuk menekankan kepentingan dapat mengubah dan menambahbaik fungsi system. Laporan ini membentangkan hasil kerja yang dilakukan terhadap sistem kawalan yang boleh dikonfigurasikan semula (RCS) dengan menggunakan Pengawal logik boleh atur cara (PLC). Disebabkan permintaan pelanggan dalam keperlbagaian produk, syarikat pengeluaran perlu mencari jalan alternatif yang fleksibel dan boleh dikonfigurasi semula didalam industri pembuatan. Reka bentuk dalam konfigurasi semula adalah penting dalam pembuatan kerana permintaan pelanggan dalam kepelbagaian produk yang semakin meningkat. Oleh itu sistem kawalan menjadi peranan utama dalam pembentukan semula di dalam sistem pembuatan. Fleksibiliti sistem akan menentukan prestasi sistem di dalam industri pembuatan. Objektif projek ini adalah untuk mereka bentuk sistem kawalan dengan menggunakan kaedah Petri Net (PN) model bagi konfigurasi semula sistem kawalan dan menghasilkan gambar rajah logik tangga (LD) PLC. Sistem kawalan PLC adalah penting dalam konfigurasi semula untuk mengawal operasi melalui perisian Cx-programmer. Perisian pengaturacaran akan menghasilkan kaedah pengubahsuain yang berbeza untuk menentukan kebolehubahannya. PLC digunakan untuk berkomunikasi diantara perisian Cx-programmer dan RCS dengan menggunakan Local Area Network (LAN). Integrasi diantara PLC and RCS akan dibangunkan dengan menggunakan arahan fungsi blok (FB) bagi membolehkan pemindahan data dan pertukaran data dapat dilakukan. Oleh itu, projek ini menggunakan sistem PLC untuk mereka bentuk sistem kawalan yang mampu menyokong perubahan konfigurasi semula RCS. Reka bentuk sistem kawalan di RCS membolehkan sistem kawalan menjadi lebih fleksibel dan berkesan dalam melakukan pelbagai tugas. Diharapkan projek ini dapat memberikan manfaat kepada sistem pengendalian bahan dengan lebih cekap.

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A/D	-	Analog/ Digital
CIP	-	Common Industrial Protocol
CMND	-	Command
CPU	-	Central Processing Unit
DC	-	Direct Current
EPROM	-	Programmable Read Only Memory
EEPROM	-	Electrical Erasable Programmable Read Only Memory
FB	-	Function Block
FBD	-	Function Block Diagram
FINS	-	Factory Interface Network Service
FMH	-	Flexible Material Handling
I/O	-	Input/ Output
IEC	-	International Electrotecnical Commission
IL	-	Instruction List
IP	-	Internet Protocol
LABVIEW	-	Laboratory Virtual Instrument Engineering Workbench
LAN	-	Local Area Network
LD	-	Ladder Diagram
mA	-	Milliampere
M1	-	Module One

M2	-	Module Two
M3	-	Modules Three
M4	-	Module Four
M5	-	Module Five
M6	-	Module Six
MP1	-	Master Project One
MP2	-	Master Project Two
NG	-	Not Good
P	-	Places
PN	-	Petri Net
PLC	-	Programmable Logic Controller
RAM	-	Random Access Memory
RCS	-	Reconfigurable Conveyor System
RECV	-	Receive
ROM	-	Read Only Memory
SFC	-	Sequential Function Chart
S1	-	Sensor One
S2	-	Sensor Two
S3	-	Sensor Three
S4	-	Sensor Four
S5	-	Sensor Five
S6	-	Sensor Six
ST	-	Structured Text
T	-	Transitions
TCP	-	Transmission Control Protocol

UART	-	Universal Asynchronous Receiver Transmitter
UDP	-	User Datagram Protocol
USB	-	Universal Series Bus
UTeM	-	Universiti Teknikal Malaysia Melaka
WAN	-	Wide Area Network

CHAPTER 1

INTRODUCTION

This chapter gives an overview of the proposed project. This control design system could transform the material handling to be more reconfigurable and flexible. The content which will be discussed in this chapter is the background of the study, problem statement, objective and scope.

1.1 Background of Study

Within the current industrial environment, manufacturing companies are facing variable changes forcing the manufacturing to improve their standard in designing and managing products and processes. High flexibility, high market demand, continually growing adaptations, high-quality products, flexible batches and short product life cycles are the key factors in the transition from traditional manufacturing systems to Next Generation Manufacturing Systems (Bortolini et al., 2018). To stay competitive, companies need to develop manufacturing systems that produce not only high quality products at low cost but also enable rapid response to market changes and consumer needs. Responsiveness refers to the speed at which a plant can meet changing business goals and produce new product models. Re-configurability is engineering technology that enables cost-effective and rapid responses to market and product changes (Koren and Shpitalni, 2010).

Nowadays, reconfigurable conveyors are increasingly being used in a variety of industries due to their flexibility in adapting new products and product lines, as they offer considerable flexibility in adapting to newer products and product lines; while taking full advantage of the available space and all these possibilities the costs that would otherwise be incurred if a completely new conveyor system is installed (An et al., 2011). To quote from the article Dynamic Conveyor Corporation (2010), the critical factor in a truly reconfigurable modular conveyor system is the ability to connect and reconnect a wide variety of modules and accessory modules that allow engineers the freedom to tweak production lines when necessary without need the new setup of conveyor and saving the cost of the material and component.

The RCS is the combination of physical and logical configuration. The physical conveyor is known as the external hardware of the conveyor such as conveyor components, types and system design, while the logical conveyor unit is the controller that controls the movement of the transport element by the conveyor system (Wentzel et al., 2012). Even though the configuration can be conducted by rearranging the modular system, the programming still needs to be done manually, which is time-consuming for a broad system application. In this project research, a control system is developed to reconfigure the conveyor system based on the programmable logic controller (PLC) to control the movement and operation of a conveyor system which can be modified without stopping the operation. A control program must be changed when rearranging the layout of the physical conveyor module based on the input and output signals (Schreyer and Tseng, 2000). The PLC was selected to be the controller for this project.

PLC is an industrial computer control system that continuously monitors the status of input devices and makes decisions based on a user program to manage the status of output devices. Almost any production line, machine function, or process can be

significantly enhanced using this type of control system. However, the most significant advantage of using a PLC is the ability to change and modify a process or process when collecting and transmitting vital information. Another advantage of a PLC system is that it is modular which we can mix and match the types of input and output devices that suit your application system (Bhiungade, 2015).

1.2 Problem Statement

Conveyor systems are one of the most commonly used equipment in almost every industry to handle different kinds and quantities. Modular conveyors help in achieving the flexibility that is required for various operations (Hill, 2018). As the conveyor system is used widely in production, the ability and flexibility to quick changeover between products and adaptability for future products are very important because of the increasing needs of rapid response to the changing customer need. The process is unpredictable and constantly changing markets, where parts are required to arrive at the work station exactly when they are needed. Besides that, recent technologies are moving fast with the increase of control and component such as sensors, networking, and acquisitions system thus creates a competitive challenging in the industry today, and companies need to move forward and quick adapting with the technology so that the manufacturing process can be optimised at the maximum.

A design PLC control system for a RCS between hardware and software becomes important that can reduce the uncertainty of managing the control software development which can change, modify or add any features or instruction of the control programs easily. A reconfigurable controller can process the input signal and delivers controls signal to actuators to control the operation system. Thus, this approach allows changeability that allows conveyor system more significant, flexibility, and efficient.

1.3 Objective of the Study

The objectives of this study are:

i. To design a control system for a RCS using PLC

ii. To verify the developed control system and its performance.

1.4 Scope of the Study

This thesis is focus to design the control system for a RCS by using PLC. The primary purpose is to prove the reliability of reconfigurable and operation conveyor system so that the control design can be achieved and the control able to adapt new configuration. Therefore, the project scope will cover:

i Using PLC to reconfigure and control the conveyor system.

ii To study and understand the concept of the reconfigurable controller.

iii Designing a reconfigurable controller between hardware and software

iv Experimental work on a belt conveyor is conducted without any load to the container.

1.5 Chapter Summary

In this chapter, the proposed research is introduced. The background of the study that is related to research title is “Design of a Control System for a Reconfigurable Conveyor System using PLC” is described. The problem statement, objective and scope of the project is discussed in this chapter.

CHAPTER 2

LITERATURE REVIEW

This chapter provides a literature review in which the sources and information are obtained from the internet, journals, articles, and others. This chapter focuses on RCS, material handling, control system, and design of system reconfigurability based on PLC.

2.1 RCS

In the manufacturing system, RCS are increasingly moving towards due to their flexibility and efficiency to adapting the new product and product lines, which will utilise the space and save cost. According to An (2011), in the reconfigurable system is the ability to connect and reconnect a variety of modular that give the engineer to alter production lines without the cost for a new conveyor. RCS can be used in manufacturing, which will result in system efficiency and reduce the operating cost.

Conveyor system plays important roles in the industrial processes with the integration of industry component such as sensor, actuators, receiver and transmitter to achieve high reliabilities flexible configuration. According to Kuruvilla et al (2008) with the integration of the technologies in the manufacturing system, it will benefit the process such as affords finer grain control, reconfigurable topologies, improved the diagnostics and reduced the lifecycle cost. Hayslip (2006) stated that Coupled Conveyors scheme is an emerging technology that can use to achieved RCS because it represents the significant

departure from the current practice in a critical application domain. The conveyor scheme is based on three-unit called Segment, Turnaround and Crossover that shown in Figure 2.1.

Basically, three-unit has a fixed sensor and actuators where *u* is the upstream sensor, *d* is the downstream sensor, and *a* is the actuator that moves the conveyor. Each of the sensor and actuators are wired to the controller and integrated with the low power radio transceiver to achieve the system.

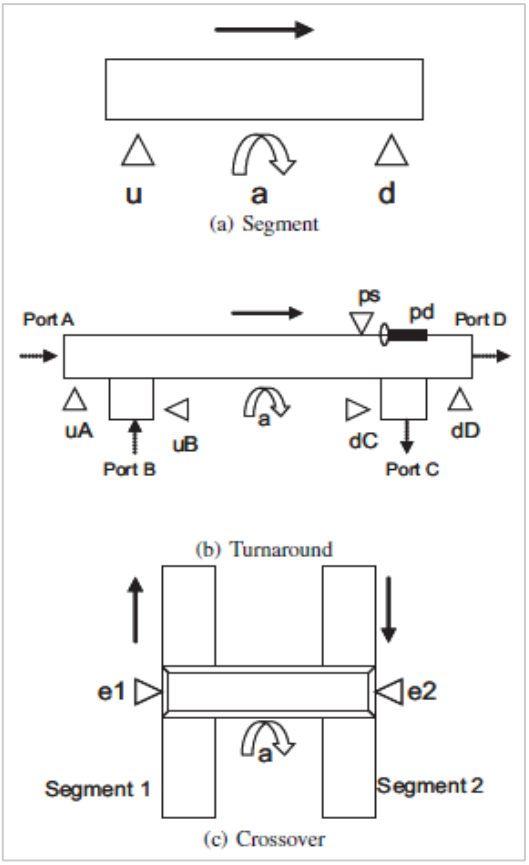

Figure 2.1: Reconfigurable conveyor using Segment, Turnaround and Crossover (Kuruvilla et al., 2008)

As manufacturing faced rapid changing product in the market continually, especially in a production environment to replace both, the material and technologies. According to Heragu and Ommeren (2001), two keys enabling technologies to overcome