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DESIGN AND IMPLEMENTATION OF AN AUTOMATED LIQUID LEVEL CONTROLLER USING SENSOR AND PLC

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"Hereby the author declares that all the material presented in this thesis to be the effort of the author herself. Any kind of materials that is not the effort of the author has been stated clearly in the references."

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Date : 04 MEI 2006

Dedicated to:

Mak, Ayah, Adik-Adik, Kak Na, Kak Rah, Kak Mah, Abang, family and my beloved friends for giving me unconditional love and caring.....

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ABSTRACT

Design and implementation the automated liquid level controller using ultrasonic sensor and programmed PLC (Programmable Logic Controller) is a reverse engineering project, where level measurement can be defined as the determination of the position of an existing interface between two media. The ultrasonic sensor will provide the feedback information required to control the process based on a sound wave emission source and the reflection of a sound wave pulse. The PLC is a self contained, rugged computer designed to control processes and contains a microprocessor that has been programmed to drive the output terminals in a specific manner based on the signals from input terminals. Entirely this project consists two main parts in term of software development for PLC (Programmable Logic Controller), ladder diagram. For this project, the Omron SYSMAC CJ1H-series Programmable Controllers is used with the programming language of CX-One programmer. In term of hardware development it consists of sensor selection and design for automated liquid level controller. This controller can be used to control the water level in tank especially in plant, we have to maintain the water level in water tank that used for emergency case from condensate and also can detect if the tank is leaking.

ABSTRAK

Projek Rekabentuk dan Pembangunan Sistem Kawalan Automatik menggunakan 'PLC' bagi Ukuran Ketinggian Cecair dengan menggunakan pengesan 'Ultrasonic' adalah satu projek pembalikan kejuruteraan dimana ia menerangkan bahawa ukuran ketinggian tersebut boleh ditakrifkan sebagai penentuan kedudukan atau kehadiran permukaan diantara dua perantara. Pengesan 'Ultrasonic' yang digunakan akan mengesan ketinggian cecair tersebut dengan menggunakan sistem gelombang pantulan. 'PLC' adalah satu system kawalan proses dimana ia mempunyai mikropemproses yang telah diprogramkan untuk menjalankan terminal output dalam keadaan yang telah ditetapkan berdasarkan kepada isyarat daripada terminal input. Projek ini mempunyai dua bahagian utama iaitu pembangunan program computer untuk 'PLC'. 'SYSMAC CJ1H-series Programmable Controllers' telah digunakan disamping program daripada 'CX-One programmer'. Bagi pembagunan alatan pula, ia termasuklah pemilihan pengesan yang akan digunakan dan juga rekabentuk system yang dibangunkan. Alat kawalan ini boleh diaplikasikan dengan meluas terutamanya dalam industri petro kimia dimana ia sesuai digunakan untuk mengawal air di dalam tangki yang digunakan untuk kecemasandan juga ia dapat mengesan air yang keluar dari tangki sekiranya terdapat kebocoran.

CONTENTS

LIST OF ABBREVIATIONS

AC	-	Alternate Current
ADCs	-	Analog to Digital Converter
CPU	-	Central Processing Unit
CX-P	-	CX-Programmer
DACs	-	Digital to Analog Converter
DC	-	Direct Current
EEPROM	-	Electrically Erasable Programmable ROM
EPROM	-	UV Erasable PROM
FBD	-	Function Block Diagram
IL	-	Instruction List
I/O	-	Input/Output
LAN	-	Local Area Network
LD	-	Ladder Diagram
P	-	Proportional
PD	-	Proportional + Derivative
PI	-	Proportional + Integral
PID	-	Proportional + Integral + Derivative
PLC	-	Programmable Logic Controller
SFC	-	Sequential Function Chart
WC	-	Water Closet

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CHAPTER 1

INTRODUCTION

1.0 Introduction

Automatic control, by comparison with manual control system, applies to those things that are achieved, during normal operation, without human intervention. This type of control is used where continuous attention to system operation would be demanded for a long period without interruptions. Automatic control does not, however necessarily duplicate the type of control achieved by a human operator. Equipment that employs automatic control is limited to only those things that can be forecast by the input data. Terms such as closed loop control and feedback are commonly used to describe automatic control functions.

The control of liquid level in tanks and flow between tanks is a basic problem in the process industries. The process industries require liquids to be pumped, stored in tanks and then pumped into another tank. Many times the liquids will be processed by chemical or mixing treatment in the tanks, but always the level of fluid in the tanks must be controlled and the flow between tanks must be regulate. Often, the tanks are so coupled together that the levels interact and this must also be controlled.

Level and flow control in tanks are at the heart of all chemical engineering systems. But chemical engineering systems are also at the heart of our economies. Vital industries where liquid level and flow control are essential includes :

- Petro-chemical industries
- Paper making industries
- Water treatment industries

Our lives are governed by level and flow control systems. For example, medical physiology involves many fluid bio-control systems. Bio-systems in our body are there to control the rate that blood flows around our body. The water closet (WC) toilet in your apartment or house is also a liquid level control system. The swinging arm attached to the input valve of the WC water tank allows water to flow into the tank until the float rises to a point that closes the valve. This is the simple and effective level control system for water tanks. Although the WC toilet is now common, but the WC in one of the villages in London was in the *Herrenhaus*. It was a thing of great wonder. Visitors would admire the automatic refilling of the WC tank much more than the beauty of the house and that beautiful countryside.

Tank level control systems are everywhere. All of our process industries, the human body and fluid handling systems depend upon tank level control systems.

Figure 1.0 : An example of a tank level control application

It is essential for control system engineers to understand how tank control systems work and how the level control problem is solved.

1.1 Project Liquid Level Control System Using PLC and Ultrasonic Sensor

This Project Liquid Level Controller System Using PLC and Ultrasonic Sensor will be controlled using PLC (Programmable Logic Controller) as a demonstration. The main concept used in this project is process control concept with industrial measurement techniques that consists of flow and level measurement. Nowadays, many liquid level control system used everywhere especially in chemical industries. But the major function of the liquid level control system using PLC controller is to measure the liquid level in tank continuously, not depend on the highest or lowest point by giving the absolute value of measurement.

This liquid level controller system is not fully automatic system. This hardware can be function as local and remote control. For the local control, this system contain of one batch controller from Burkert as that function as a main controller, one Omron process meter (K3MA-J) to display the level measurement, local button, start button and stop button. We have to set certain value to the batch controller depend to the height of the process tank to allow the water flow through the control valve. The setting value normally set in Liter, but we can choose whether to set it in cm^3, US gallon or IMP gallon. Before that we have to setting all the parameters in the batch controller. The further information about setting parameters can be referred to the Chapter 3. Once, the power supply is on, the start button must be pushed. Then, the water will pump from the storage tank to the flow sensor and then through the control valve. When the water comes to the process tank, the ultrasonic level sensor will detect the height of the water in that tank. The process meter will display the value of height of the water in the process tank. The setting parameter of process meter can be referred to the Chapter 3.

For the remote control system, programming PLC (Programmable Logic Controller) will be used to operate this hardware. The programming used is the ladder diagram programmed and the continuous level measurement detected. By using timer command in PLC, this project can be operated as continuous but it still used the on-off control process concept.

1.2 The Project Objectives

Accurate measurements of level are essential to provide good control in the process industries. Liquid level has no absolute value and is always relative to some reference point such as the top and bottom of the tank. There are several reasons to monitor the level of materials in containers can be divide to :

Monitoring

i. To control and measure the liquid level in tank continuously.
ii. To ensure that enough material is available to complete a particular batch production process.
iii. To determine an inventory of the material in stock.

Safety

i. To prevent an industrial accident by overfilling an open container.
ii. To prevent the overfilling of a closed container or an enclosed system. This situation could cause an overpressure condition that may result in a rupture or explosion.
iii. To monitor tank for leaking.

Economy

i. Good level control of solid is also desirable; excessive built up in hoppers can be expensive to clear.

1.3 Benefit of Liquid Level Controller System

In the oil and natural gas industries, liquid level measurement is necessary have the following benefits;

i. Compute tank inventories of hydrocarbon liquid products and utility liquids.
ii. Protect equipment such as columns, compressor, turbines and pumps from damage.

iii. Protect operating and maintenance personal against injury resulting from hydrocarbon, corrosive or toxic liquid spillage.
iv. Protect the environment from the release of objectionable liquids into the rivers and the sea.
v. Control phase separation processes and product loading operations.

1.4 Scope Project

The project scope for execution this project are ;

i. Design and develop the complete automated system that will control the level by giving the absolute value and continuously in term of hardware and software development.
ii. The hardware development consist of the ultrasonic sensor will detect the level measurement and controlled by PLC, flow sensor that will detect the flow rate of liquid, control valve as the control element, pump and motor.
iii. The software development consists of CX-One programme as the programming language for Omron CJ1H-Series PLC unit and I will use the ladder diagram and Instruction List programming languages for the PLC.

1.5 Problem Statement

The key characteristic of control is to interfere, to influence or to modify the process. This control function or the interference to the process is introduced by an organization of parts (including operators in manual control) that, when connected together is called the Control System. Depending on whether a human body (the operator) is physically involved in the control system, they are divided into Manual Control and Automatic Control. Due to its efficiency, accuracy and reliability, automatic control is widely used in chemical processed. Therefore, for a control system to operate satisfactorily, it must have the abilities of measurement, comparison, computation and correction.

1.5.1 Manual control system

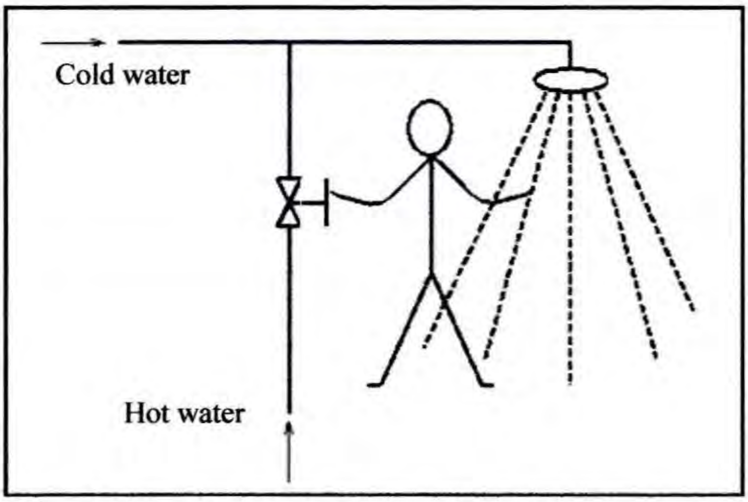

Figure 1.1 : Simple manual control system

To begin with the shower is cold. To start the heating process the valve in the hot water line is opened. The operator can then determine the effectiveness of the control process by standing below the shower. If the water is too hot, the valve should be closed a little or even turned off. If the water is not hot enough then the valve is left open or opened wider. This shows the human aided control used before the automated control system is recognized.

1.5.2 Automatic control system

Liquid level has no absolute value and always relative to some reference point such as the bottom or top of the tank. It is the height or depth of a liquid above a reference point and is specific to a particular vessel.

First we have the Controlled Variable. This is the basic process value being regulated by the system. It is the one variable that we are special interested. In feedback control the controlled variable is usually the measured variable. An important concept related to the controlled variable is the Set point. This is the predetermined desired value for the controlled variable. The objective of the control system is to regulate the controlled variable at its set point. To achieve the control objective there must be one or more variables we can alter or adjust. These are called the Manipulated Variables. Conclusively, in the control system we adjust the manipulated variable to maintain the controlled variable at its set point. This meets the requirement of keeping the stability of the process and suppressing the influence of disturbances.

The main purpose for this project is to measure the liquid level in tank continuously, not depend on the highest or lowest point.