UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Development of Water Level of Wastewater Treatment Plant Monitoring System by using PLC with HMI Features

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours

by

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ABSTRAK

Pada masa kini, pencemaran air merupakan salah satu masalah serius di Malaysia. Masalah pencemaran air meningkat dengan pesat terutamanya dalam kawasan industri kerana kilang-kilang tidak menyaring air buangan sebelum melepaskannya ke sungai / laut. Tujuan loji rawatan air kumbahan adalah untuk menghapuskan pepejal terampai sebelum effluen dikeluarkan semula ke alam sekitar. Oleh itu, dalam projek ini, tahap sistem pemantauan loji rawatan air sisa menggunakan Programmable Logic Controller (PLC) dengan ciri Human Machine Interface (HMI) dibangunkan. Objektif utama dalam projek ini adalah untuk merekabentuk sistem pengawasan paras air berdasarkan Programmable Logic Controller (PLC). Selain itu, objektif dalam projek ini juga termasuk mengkaji tentang sistem yang dapat memantau paras air sisa di loji proses dan melaksanakan ciri-ciri Human Machine Interface (HMI) pada sistem pemantauan paras air. Peralatan / komponen yang digunakan dalam projek ini ialah PLC, sensor kapasitif, sensor tahap air ultrasonik, skrin sentuh OMRON HMI, injap paip solenoid DC, pam air, lampu perintis, tujuh segmen paparan dan buzzer. Untuk perisian pula, CX-Programmer dan NB-Designer telah digunakan dalam projek ini. Selepas itu, data dicatatkan dalam jadual atau carta dan dianalisis. Kesimpulannya, sistem pemantauan paras air berasaskan PLC yang dapat memantau tahap air sisa dengan ciri HMI telah dibangunkan.

ABSTRACT

Nowadays, water pollution is one of the serious problems in Malaysia. The water pollution problems increase rapidly especially in the industry areas due to some of the factories do not filter the wastewater before discharge them to the river/sea. The aim of wastewater treatment plant is to remove the suspended solids before the effluent is discharged back to environment. So in this project, the water level of wastewater treatment plant monitoring system using Programmable Logic Controller (PLC) with Human Machine Interface (HMI) features is developed. The main objective in this project is to design a Programmable Logic Controller (PLC) based water level monitoring system. Moreover, the objectives in this project are also include to study about system that able to monitor the water level of wastewater at process plant and to implement Human Machine Interface (HMI) features on the water level monitoring system. The equipment/components that used in this project are PLC, capacitive sensors, ultrasonic level sensor, OMRON touch screen HMI, DC solenoid water pipe valve, water pump, pilot lamps, seven segment displays and buzzer. For the software, CX-Programmer and NB-Designer were used in this project. After that, the data were recorded in tables or charts and analysed. In conclusion, a PLC based water level monitoring system that able to monitor the water level of wastewater with HMI features was developed.

DEDICATION

This project is dedicated to:

My parents,

My sister,

My brother,

My supervisor,

My lecturers,

And all my friends,

Thank you for the encouragement and support.

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First of all, I would like to thank my supervisor, Mr. Shahrizal bin Saat for giving me the chance to have my final year project under his supervision. I would also like to express my appreciation towards him by giving me the motivation, guidance and discussion along with this project. He managed to guide me along by suggesting me the solutions for every challenge that I had faced despite he is being busy with his jobs and duties.

I acknowledge my sincere appreciation to my parents for their sacrifice, love, and dream in my life. I can't find the suitable words that may appropriately portray my gratefulness for their assistance, commitment and confidence in my capacity to accomplish my aims. Special thanks must be given to my coursemates. I like to appreciate their ideas and comments that were significant for the effective accomplishment of this final year project.

The following category is the individuals who aid me to influence besides raise further in my project and constantly help me in order to finish this project. I truly appreciate the information and thought given. Through this final year project, I had gained valuable knowledge and I hope that I am able to apply it in the future.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

CPU	-	Central Processing Unit
CST	-	Communal Septic Tank
CWPH	-	Clear Water Pump House
DC	-	Direct Current
DOE	-	Department of Environment
DSC	-	Data logging and Supervisory Control
DSL	-	Digital Subscriber Line
ETP	-	Effluent Treatment Plant
FPGA	-	Field-Programmable Gate Array
GPIO	-	General-purpose input/output
HMI	-	Human Machine Interface.
IEEE	-	Institute of Electrical and Electronics Engineers
IoT	-	Internet of Things
IPH	-	Intake Pump House
IT	-	Imhoff Tank
IWK	-	Indah Water Portal
I/O	-	Input/Output
LED	-	Light-Emitting Diode
LoRa™	-	Long Range Radio
MPM	-	Mechanical Plant with Media
MPWM	-	Mechanical Plant without Media
NEDQS	-	National Effluent Discharge Quality Standards

OP	-	Oxidation Pond
PC	-	Personal Computer
pH	-	power of Hydrogen
PID	-	Proportional–Integral–Derivative
PLC	-	Programmable Logic Controller
PWM	-	Pulse Width Modulation
RAM	-	Random-Access Memory
RIO	-	Remote I/O
SB-RIO	-	Single Board- Remote I/O
SCADA	-	Supervisory control and data acquisition
WSN	-	Wireless Sensor Network
WTP	-	Water Treatment Plant

CHAPTER 1

INTRODUCTION

1.0 Introduction

In this project, the water level of wastewater treatment plant monitoring system can be used to measure water level of tank. Many industries process especially the water treatment industries are using the tank system to control the water level. The water level must be controlled by a proper controller to maintain at a certain level. [1] This thesis describes about development of water level of wastewater treatment plant monitoring system by using Programmable Logic Controller (PLC) with Human Machine Interface (HMI) features.

The dual tank aerated water treatment system or twin tank system is built up by two plastic or concrete tanks. The twin tank system is ideal in ground installation. It has high reliability and high performance. [2] So in this project, the water level of waste water treatment plant monitoring system is developed by using the concept of twin tank system.

A programmable logic controller (PLC) is a controller that receives inputs and generates outputs from system. The input/output (I/O) PLC architecture is shown in Figure 1.01. [3] Input signals are received from machines, sensors, or process and produces the output signal to system. [4]

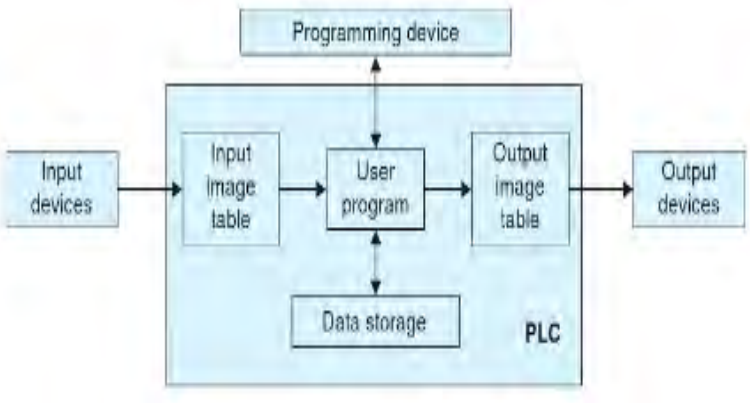

Figure 1.01 Input/output (I/O) PLC architecture [3]

A Human Machine Interface (HMI) is the user interface that can monitor and control the operation of system. User can see schematics of systems, switches condition, pumps condition, raise or lower temperatures and so on. HMIs are usually communicating with Programmable Logic Controllers (PLC).

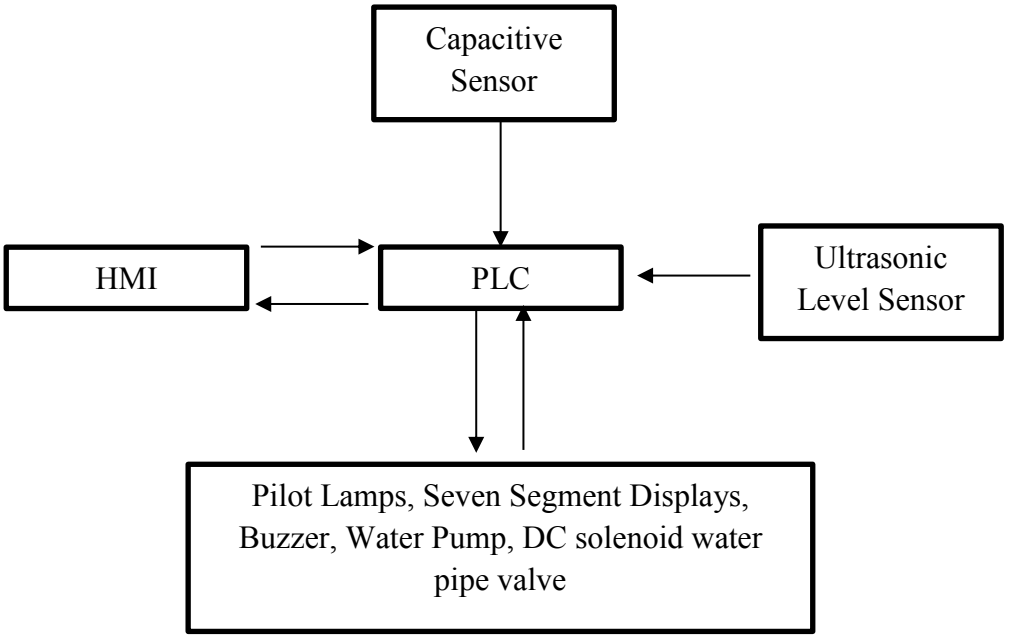

Figure 1.02 Block diagram of process flow

1.1 Problem Statement

The main problem that embarks the idea to develop the water level of wastewater treatment plant monitoring system is water pollution. Water is important to all living things. Yet water pollution problems is keep increasing. Water pollution happens when toxic substances enter lakes, rivers or oceans. Moreover, pollution also will cause the quality of contaminated water we use in our daily activities degraded. The water pollution problems increase rapidly especially at the industry areas. Some of the factories do not filter the wastewater that produced before discharged to the river/sea. The wastewater contains sulphur, asbestos, mercury, nitrates, phosphates and other harmful chemicals. It may cause the death of aquatic (water) animals, diseases and destruction of ecosystem. Wastewater treatment plant can be used to remove the pollutants before they discharged to water bodies. However, water level measurement is involved in the wastewater treatment plant to measure the volume of water which discharged to lakes, rivers or oceans. So, this project only focus on the water level measurement in the wastewater treatment plant monitoring system.

1.2 Objectives

The intention behind this project is to design water level of wastewater treatment plant monitoring system by using PLC with HMI features which can achieve the following objectives:

i. To study about system that able to monitor the water level of wastewater at process plant.
ii. To design a Programmable Logic Controller (PLC) based water level monitoring system.
iii. To implement Human Machine Interface (HMI) features on the water level monitoring system.

1.3 Scope of Work

In this project, the water level of wastewater treatment plant monitoring system will have characteristic such as:

a) Water level Measurement

The water level of wastewater treatment plant monitoring system measures the percentage of water level in lower tank by using capacitive sensors. There are 6 capacitive sensors used in this project and each of the sensors represent different percentage of water levels which is from 0% to 100%.

In addition, the ultrasonic level sensor in the monitoring system is used to measure the water level in upper tank.

c) PLC

The water level of wastewater treatment plant monitoring system is controlled by using PLC. It used PLC to switch on/off the power supply and includes the inputs and outputs of the hardware.

d) HMI

The operation of the water level of wastewater treatment plant monitoring system can be controlled by user using touch screen HMI. The status of push buttons, pumps, pilot lamps, the water level, volume and change in height of water level in the tank can be shown in real time through the touch screen HMI.

1.4 Report Layout

This report generally is about development of water level of wastewater treatment plant monitoring system by using PLC with HMI features. There will be five chapters that will explain about this project.

Chapter 1 explain about the introduction of water level of wastewater treatment plant monitoring system using PLC with HMI features and the important

objectives of the project. Besides that, the problem statement and scope of the project are added on this topic.

Chapter 2 compiles the literature review, generally on the existing projects, components and the technology that used in this project. This chapter concentrates on the theory of all aspects of the monitoring system. Sources from journals, books, thesis and website that covering all the information connected to the project are included. The comparison of the related technology used also included in this chapter.

Chapter 3 describes the methodology of the project on the hardware and software part. This chapter concentrates on the procedure to execute the project from the primary design until the end. Strategy and time management are presented in this part. The project Gantt chart and the flowchart in process are also added here.

Chapter 4 gives some prior results and discussion of the current work. This chapter is generally about the findings of this project.

Chapter 5 draws the conclusions of Chapter 1 to Chapter 5. The conclusion and recommendation will be concluded here.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

The water level of wastewater treatment plant monitoring system by using PLC with HMI features that have the ability and capability to monitor the water level in tanks. This chapter will discuss about the method that used in this project based on the information and the sources gathered from books, journals or website. This section also includes the comparison of the technology used with the previous related research as a reference.

2.1 Type of sewage treatment plant in Malaysia

2.1.1 Communal Septic Tank

Communal Septic Tank (CST) is a main components of a septic system. The Communal Septic Tank (CST) make up 53% from all treatment plants in Malaysia. It is a small scale sewage treatment system. In addition, it is primary treatment system with two chambers. First, the effluent enters into first chamber to avoid overflows happened to second chamber. Then, the treatment process happened in the second chamber. After that effluent is discharged to the drain. [5]

2.1.2 Imhoff Tank (IT)

The Imhoff tank is a system that has a V-shaped settling compartment above a tapering sludge digestion chamber with gas vents. Imhoff tanks are using mechanical methods for collecting the sludge continuously, which is moved to separate digestion tanks.

According to Noor Wahyu (2010), the effluent from the IT will not meet the environmental requirement of the Department of Environment (DOE). Besides, IT is the popular method of servicing small communities since its investment cost is low and the system operation is simple. [5] [6]

2.1.3 Oxidation Pond (OP)

The oxidation pond is the combination of a septic tank with lagoon. OP can be used to transfer the effluent sorts. The oxidation ponds are easy to construct, low cost and low maintenance cost. It is ideal for small communities that have huge land area. [7]

2.1.4 Mechanical Plant with Media (MPM) and Mechanical Plant without Media (MPWM)

Mechanical plant is necessary infrastructure used in operation and maintenance of a given facility. Sewage treatment plants are mechanical plants that can be used to accelerate the sewage breakdown. Treatment process without media is the most common process that in Malaysia since it can be used in long term. [8]

2.2 Background of previous related research

2.2.1 Effluent Treatment Plant Using PLC

E.Kumar, S.Jungral and T.Singh (2016) proposed "Effluent Treatment Plant Using PLC". In the project, at first, the pump was controlled by PLC to pump the water. The following stage consists of the filter membrane which is used to filter water. The system also enables the sedimentation to take place as the heavier particles settle at the base of the tank. The next stages consists of the flocculation, coagulation and continued by water treatment processes and the disinfection of water takes place by adding Alum, Sodium Bi sulphate and chlorine. The PLC was also used to control the solenoid valves in various stages. Moreover, the level sensors were used in final tank to check the total amount or level of the wastewater treated. The pH estimation of the treated water is checked before discharged. If the pH value that stored in the treated water tank does not fulfil the pH criteria, it will be pumped back to the waste water supply and the whole process for effluent treatment is repeated again. By using PLC, the cost to develop the system is low and the user can troubleshoot the error during process easily. [9]

2.2.2 Water Treatment Plant Intelligent Monitoring in Large Gas Refinery

A. Firoozshahi (2010) proposed "Water Treatment Plant Intelligent Monitoring in Large Gas Refinery". In the project, the paper focuses on an intelligent monitoring system for Water Treatment Plant by PLC. This monitoring system is able to control by user in the control room. In the main control room, the process of the plant is directly controlled and monitored by PLC so it is an intelligent system for user to save the time and energy in controlling and monitoring the system. [10]

2.2.3 PLC & SCADA based automation of Filter House, a section of Water Treatment Plant

A.ArchanArchana and B. Yadav (2012) proposed "PLC & SCADA based automation of Filter House, a section of Water Treatment Plant". In the project, there are 3 sections in the system which are Intake Pump House (IPH), Water Treatment Plant (WTP) and Clear Water Pump House (CWPH). The system is controlled by using PLC. From the SCADA Main Screen, it is Filter House section, user is able to view status system. The user of this system can recognize any cautions from the main screen. This screen also shows time left for all of the sequence in the system. [11]

2.2.4 SCADA System for Water Treatment Using LabVIEW

M. Saleh and N. A. Daher (2005) proposed "SCADA System for Water Treatment Using LabVIEW". SCADA design was applied into a water treatment plant in the project. In the project, it used NI single board RIO instead of PLC. It is a manual water treatment system where the chemical substances are added manually. The dosages of the chemical substances are determined based on calculations. In addition, the pumps, filters and softeners are activated manually. The single board RIO collects the input signal from the sensors and transfers it to the web of HMI. [12]

2.2.5 A Remote System for Water Tank Level Monitoring and Control- a Collaborative Case-study

N.Brito, P.Ribero and F.Soares (2009) proposed "A Remote System for Water Tank Level Monitoring and Control- a Collaborative Case-study". This project is about development of level of a two-tank monitoring system. The system is controlled using an on-off controller and a PID algorithm. The remote user can test change level values and set the output data. The system includes two tanks. A pump is used in the system to circulate the water from the lower to the upper tank. Two ultrasonic level sensors

are used to measure the levels from lower tank and upper tank. An electro valve is used to stop the flow of water between the upper and the lower level tank and a manual. The upper tank is being controlled and the lower tank acts as buffer. The 8 bits Atmega 16 microcontroller is used as actuator. From the Watch Tank, the user can choose or modify the level of the upper tank. The data is sent to the microcontroller and sent back to the PC. The pump actuation is performed by Pulse Width Modulation (PWM) so that the speed of pump can be modified. [13]

2.2.6 Internet of Things (IoT) Enabled Water Monitoring System

T. Perumal, M. N. Sulaiman and C. Y. Leong (2015) proposed "Internet of Things (IoT) Enabled Water Monitoring System". In this paper, an IoT based water monitoring system that measures water level in real-time was developed. Ultrasonic sensor and water level sensor are used in this project by apply IEEE802.11 communication standards. Cloud server is acts as data repository. Water level sensor is used to detect the water level. If the water level reaches the desired parameter, the signal feeds in real time to website. The measurement of the water levels are displayed in remote dashboard. [14]

2.2.7 Automation of Tank Level Using PLC and Establishment of HMI by Scada

R.Das, S.Dutta, A.Sarkar and K.Samanta （2013）proposed "Automation of Tank Level Using PLC and Establishment of HMI by Scada". In this project, PLC is used to communicate with the system through a Human Machine Interface. Four sensors is used to detect the presence of water. The ladder logic was created by using SIMANTIC manager and the HMI programming was created by WINCC Explorer. This system is able to control and monitor the liquid level of the tank continuously. This system can be used in industrial application. It can be used to prevent industrial

accident by overfilling of any open container, to prevent overfilling of any closed container thereby creating overpressure condition. [15]

2.3 Comparison of the technology used on previous related research

2.3.1 LABVIEW (The NI single board RIO)

The user of this system with NI single board RIO can enter data with several parameters continuously. The LabVIEW web publishing tool interacts the user with monitoring system over the internet and VI. In addition, the user of this system is able to see the historical data previously saved by the DSC module. So they can refer the historical data whenever they want. [12]

2.3.2 PLC

The system that developed by using PLC is easy to use for the operator or control engineer. Operators are working by this system easily and satisfied. The operators can to troubleshoot the error in process of this system easily. This kind of implementation can remote monitoring of plants such as water treatment plant and so on. [9] In addition, PLC is safe to use and save the cost of implementation. The reliability of control system that implemented PLC is high due to the repetition of system can be in several levels. [10] Nowadays, PLC is widely used in the automation industry. Most of the machines used in the automation industry are using PLC. [11]

2.3.3 SCADA

SCADA (supervisory control and data acquisition) design can be implemented to the system to save time. [12] In addition, the SCADA monitoring system is flexible