



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**SIMULATION DESIGN ON WATER LEVEL CONTROL
SYSTEM**

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Robotic and Automation) (Hons.)

by

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Robotics and Automation) (Hons.). The member of the supervisory committee is as follow:

.....

Supervisor

(Engr. Mohd Nazmin bin Maslan)

ABSTRAK

Pada masa kini, sistem robotik dan automasi telah menjadi penjana dalam memudahkan kerja seharian manusia sehingga kepada sektor pembuatan. Cecair adalah salah satu bahan utama dalam industri kerana kebanyakan proses memerlukan cecair yang akan disimpan di dalam tangki tertentu atau dipam ke tangki lain. Berdasarkan keperluan ini, projek ini dijalankan dan menghasilkan satu simulasi baru untuk dijadikan alat bantuan pembelajaran bagi menggantikan set tangki eksperimen yang tidak lagi berfungsi, ProcessLine. Simulasi ini menggunakan konsep tangki eksperimen tersebut dan mengaplikasikan sistem kawalan tertutup dan sistem kawalan terbuka. Sistem ini direka dan dihasilkan dengan menggunakan perisian *Visual Basic 6*. Pelbagai kaedah yang digunakan dalam merekabentuk simulate ini. Setiap kaedah menggunakan PictureBox dalam menghasilkan aliran dan aras air di dalam tangki. Segala kerja penambahbaikan untuk simulasi tersebut merangkumi penghasilan antaramuka yang lebih baik dan juga penghasilan tangki eksperimen berdasarkan simulasi ini.

ABSTRACT

In this day and age, robotic and automation system has been commenced to smooth the progress of humankind from doing everyday errands to the high scale manufacturing. Liquid is one of the main materials in industries as most processes require the liquid to be stored in a specific tank or pumped to another tank. Thus, the liquid level in the tanks must be controlled and the flow needs to be regulated. Therefore, it needs the contemporary and an exceptional automation system. This project is based on that requirement; a new learning kit which is a simulation was created to help the potential students in understanding the systems in water level control. The simulation was designed and created based on an experimental rig that was dysfunction for years, ProcessLine. From this concept, a simulation consists of open loop and closed loop was created using the Visual Basic 6 software. Different types of methods are applied in designing the simulation. Each method uses the PictureBox in order to create the water flow and the level in the tank. The future works for this simulation include designing better interface for the simulation and the recommendations cover the hardware development for future usage.

DEDICATION

This is devoted to my parents and family who never stop encouraging and believing in me throughout my journey to build my dreams.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

UTeM	-	Universiti Teknikal Malaysia Melaka
GUI	-	Graphical User Interface
VB6	-	Visual Basic 6
PC	-	Personal Computer
PID	-	Proportional, Integral and Derivative
VB	-	Visual Basic
RAD	-	Rapid Application Development

CHAPTER 1

INTRODUCTION

This chapter explains about the background of the project, problem statement, objectives and the scope of the project.

1.1 Background of Study

The utilization of control and automation systems is very vital in optimizing production, quality and productivity furthermore lessens manufacturing cost. Process Control System is a system that consists of a computer, process control equipments and a process interface system which may be a part of the special function computer. It can also be an amalgamation between the statistics and engineering discipline that deals with the mechanism, algorithms and architectures to control the process (N. S Nise, 2008).

Process control is very crucial in industrial operations as it contributes in safety, minimizing the environmental impact and optimizing processes by maintaining process variable near the desired values. The controlled system has an input variable and output variable as in Figure 1.1. The response is described in terms of reliance of the output variable that can be described using mathematical equations based on the physical laws.



Figure 1.1: Block Diagram of a Control System

There are some benefits that can be gained from creating a system with input and output variables and symbolizes the system as a block diagram. This representation separates the problem from the exact equipment used and allows the standard view.

In process control system, there are two major types of control system, which are open loop and closed loop. In open loop, there is no feedback system, which differs from the closed loop which has the feedback system. Feedback is a progression of the absolute casual path that leads from the primary detection of the gap to the consequent modification of the gap. In industries, application of water level control system is widely use especially in chemical industries.

For years, the students had been learning about water level system using the previous experimental rig, a product from Intelitek. The Intelitek Water Level and Flow Control (ProcessLine) is an experimental rig that helps students in understanding on control system of fluid as shown in Figure 1.2. This experimental rig makes it easy for the students to understand and demonstrate the level and flow process control Water Level and Flow Control (ProcessLine) as the water level system in this experimental rig uses the open loop control system, on-off control system and Proportional, Integral, Derivative (PID) control. Unfortunately, the Graphical User Interface (GUI) for this rig had encountered a major error and it requires a lot of hard work to integrate a new GUI with the ProcessLine experimental rig. Thus, in order to understand on how water level control system works, a simulation is designed together with its own GUI based on the concept of ProcessLine. This simulation will give a better expose and definition of water level control system as it includes the simulations of open loop system, closed loop system, and water level control system in industrial with different pump setting and level set-point. These simulations and interface will be created and designed using the Visual Basic 6 software and it can be run using Personal Computer (PC).

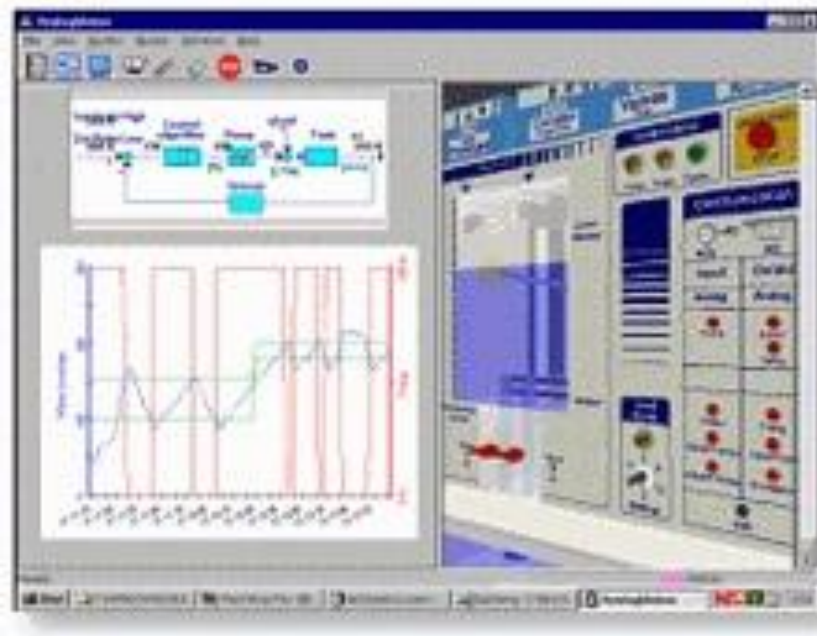


Figure 1.2 : Intelitek Water Level and Flow Control (Intelitek, 2002)

1.2 Problem Statement

The previous experimental rig, ProcessLine, which is a product from Intelitek, had encountered a software failure. Thus, the engineering students are lack of a learning kit that can help them in understanding the water level control system. In order to overcome this problem, a simulation is needed to give a better demonstration to the engineering students on how the control system in water level works. Thus, a learning demonstration using simulation assisted with a GUI needs to be designed in order to aid the process of knowledge sharing.

In this project, Visual Basic 6 (VB6) programming will be used to create both simulation and interface. Visual Basic was devised to be user friendly and utilized by novice programmers. The language not only allows programmers to create simple GUI applications, but to also develop complex applications. Programming in VB is a

combination of visually arranging components or controls on a form, specifying characteristics and actions of those components, and writing further lines of code for more functionality (H. M Deitel, 1999).

1.3 Research Objectives

The main objective of this project is to develop a new learning kit simulation using Visual Basic 6 (VB6) software to aid in understanding water level control system for potential students.

Several sub-objectives identified that must be achieved in order to make this project successful:

1. To demonstrate the systems in water level system; open-loop control system and closed-loop control system.
2. To apply the ProcessLine's concept in the simulation.

1.4 Scope of Project

The scope of this project is to understand the basic simulation and analysis on water level control system that is created in VB 6. The simulation designed should be user-friendly and easy to be used by the students. This simulation matches with most of the water level control system that is implemented in the industries. Thus, by making the similar concept simulation, it will allow the engineering students to understand on how to control the water level system.

1.5 Summary

This chapter had discussed the basic explanation on Process Control System and Water Level System. Along with that, the objectives of the research, the problem statement and the scope of the project included. Overall, this chapter gives an overview of this project.

CHAPTER 2

LITERATURE REVIEW

This chapter explains and proves any information which is related to the project is being studied and summarized it. By referring from past studies, research and books, it will serve as a guidance for the project in the future.

2.1 Introduction

This chapter will appraise previous research which focuses on process control system, open loop system, water level control system in experimental rig and the monitoring system. There are groups of control method of monitoring and controlling the liquid level in the experimental rig system which had been implemented will be discussed.

2.2 Fundamentals of Process Control Technology

Process control is very crucial in industrial operations as it contributes in safety, minimizing the environmental impact and optimizing processes by maintaining process variable near the desired values. Various applications can be seen all around us. The splashing cooling water, the rockets fire, the space shuttle lifts off the earth and a self-guided vehicle are all the examples of control system technology. (Norman S. Nise, 2008)

A control system usually consists of subsystems and processes assembled for the purpose of obtaining a desired output with desired performance, given as the input. Figure 2.1 (a) shows a control system in its simplest form.

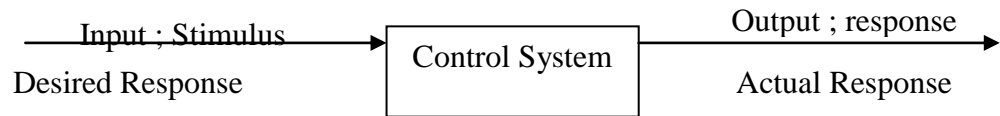


Figure 2.1: Simplified Description of a Control System.

The control system has an input variable and output variable as in Figure 2.1. The response is described in terms of reliance of the output variable that can be described using mathematical equations based on the physical laws.

There are two major way to measure the performances, which are, transient response and steady state error. These two components can be formed into an equation: $y(t) = y_{tr}(t) + y_{ss}(t)$. The transient response is present right after the system is turned on. It is a response of a system to a change of form. Steady state error is the property of the input or out response for a linear system.

Control system is widely used in the industrial for moving large equipments with precision that would otherwise be impossible. Control system is build based on four main reasons which are power amplification, remote control, convenience of input form and compensation for disturbances. Other than that, robots that are designed using the control system can compensate for human abilities as control system can be useful in remote or dangerous locations. Last but not least, control system is able to reimburse for disturbance where the system itself can measure the amount of interruption and return to its position.

2.2.1 Types of Control System

There are two major patterns of control system; open loop and closed loop. These two designs are the internal architecture of the total system. A general open loop system is shown in Figure 2.2.

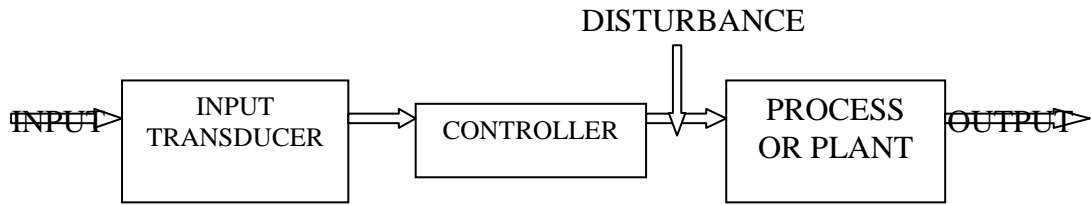


Figure 2.2 : Block Diagram of Open Loop system

The system starts with an input transducer that will convert the form of input to the one that is used in the controller. The controller will control the process or plant. Other signals such as the disturbance will yield the algebraic sum of the input signals using correlated signs.

Open loop system can not compensate any disturbance added like in Figure 2.2. The output of the system will be corrupted as the system can not correct the disturbance. Open loop system is easily commanded by the input. It does not take any command from any sources other than the input. Thus, the system will totally change when there's any disturbance added.

Since the open loop has its weakness towards disturbance and inability to fix it, this situation can be solved by using a closed loop system. An example of closed loop system can be seen in Figure 2.3.

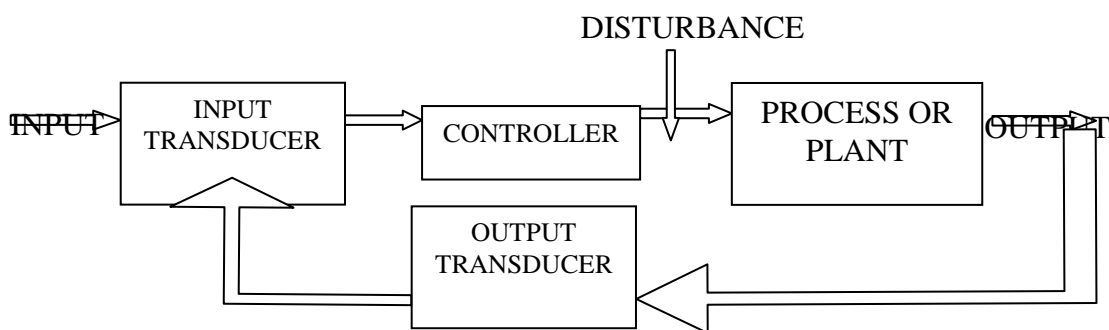


Figure 2.3 : Basic Closed Loop System

The input is converted by the input transducer in a form where the controller will use. Output transducer will then measures the output response and converts it to a form that is used by the controller. A closed loop system can compensate the disturbance by measuring the output response and give the measurement back

through a feedback path. If there happens to have any difference between the responses, the system will drives back the plant.

Pressures, temperature, level and flow rate are often the variables that need to be set on large systems. The setting should not be changed when faults occur. The process control system works by using the controlled variable as the input variable since it is measured by suitable equipment and create the electrical signal. Thus, this will allow the closed-loop controller to control the variable.

Advantages that can be seen when using closed loop system is that it is more accurate compares to the open loop system since it is not easily disturbed in the presence of non-linearity. Moreover, closed loop system has the ability to reduce noise. This is because of closed loop system has the feedback mechanism which can clear out the errors between input and output signals and remain the unaffected to the external noise sources.

As the conclusion, the system that is able to perform as describes measurement and has the ability to correct any disturbance is called as closed loop system or feedback system.

2.3 Water Level Control System

One of the applications of the closed loop system can be seen in Water Level Control System. The feedback control systems are older than humanity. Numerous biological control systems were built into the earliest inhabitants of our planets. Below is the history of liquid level control:

‘The Greeks began engineering the feedback system around 300 B.C. A water clock was invented by Ktesibios operated by having water trickle into a measuring container at a constant rate. The level of water in the measuring container could be used to tell time. For water to trickle at a constant rate, the supply tank had to be kept at a constant level. This was accomplished using a float valve similar to water level control in today’s flush toilets.

Soon after Ktesibios, the idea of liquid-level control was applied to an oil lamp by Philon of Byzantium. The lamp is consisted of the two oil containers configures vertically. The lower pan was open at the top and was the fuel supple for the flame. The closed bowl was the fuel reservoir foe pan below. The containers were interconnected by two capillary tubes and another tube called the vertical riser, which was inserted into the oil in the lower pan just below the surface. As the oil burned, the base of the vertical riser was exposed to air, which forced the oil in the reservoir above to flow through the capillary tubs into the pan. The transfer of the fuel from the upper reservoir to the pan stopped when the previous oil level in the pan was reestablished, thus blocking the air from entering the vertical riser. Hence, the system kept the liquid level in the lower container constant.’ (Norman S. Nise, 2008)

2.3.1 Open Loop Control System in Water Level

An open loop control system exists when the process variables not compared and action is not taken from feedback, instead taken without any regards of the process variable. Once the ratio between output and input is determined, the controller knows how much input is needed to produce the desired system output.

In open loop control, tests are used to determine the typical system response to a particular input. Once the ratio between output and input is determined, the controller ‘knows’ how much input that need to be produced in the desired system output. The open loop controller is set at the beginning of the process and provides a constant input to the system, regardless the system output (H. L. Wade, 2004).

In the level control system, there is a ratio between the flow of the incoming water (q_{in}) and the level of water in the tank (H) as shown in Figure 2.4. This ratio is called as gain. Gain happens when the system is in a steady state, which means that the system output is not changed in time. By knowing the system gain, a proper power setting can be provided to the pump so that it will produce a given flow and maintain the desired water level. This type of control system is a properly functioning open loop control system.



Figure 2.4 : Block Diagram of Open Loop Control System

2.3.2 Closed Loop Control System in Water Level

If the system in Figure 2.4 undergoes a change, the system is unable to return to the desired level. In fact, the system is not even aware about the changes and continues to supply the same amount of energy to the pump. This situation can be fixed by adding a feedback system for the controller to control the water level so that it will scrutinize the change in the water level and then pass the information to the process block that is controlling the pump. Thus, when this happens we can see that the system actually works in a loop, not in a line. This type of system can be called as the closed loop system (C. Wesley, 1998)

In Figure 2.5, we can see that process output (h tank) is measured by the level sensor and the transmitted to the controller. This signal transmitted is called as the feedback signal. In the controller, the measured value or feedback signal is subtracted from the reference value that represents the desired water level. This difference is called error that will serve as the input to the control algorithm. Thus, the controller will decide on what the final element status will be. As for this project, the final control element, pump, will determine the input flow (q_{in}) which eventually will determine the water level (h tank) (H. L. Wade, 2004).

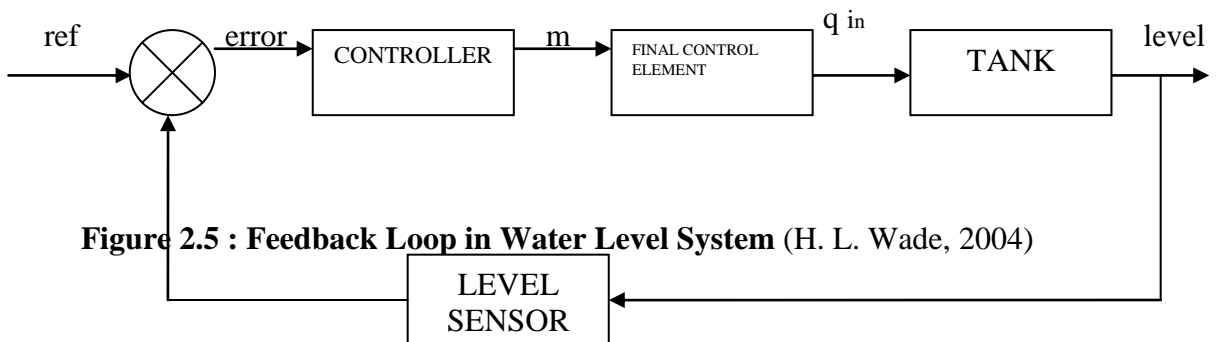


Figure 2.5 : Feedback Loop in Water Level System (H. L. Wade, 2004)

In the closed loop system, there is the on-off control algorithm, which is a common algorithm used in many closed loop systems. It is named on-off control algorithm since the output may be in one off of two states named On and Off. This control algorithm works based on:

1. When the reference value is greater than the measured value, the algorithm output is in one state named Off.
2. When the reference value is smaller than the measured value, the algorithm output is in one state named On.

There is an exception where the device being activated is mechanical, such as the water pump in this project's experimental rig. Since the system response is relatively fast, the pump will frequently modulates between the on and off states. Thus, this will cause wear on the pump after relatively short service. So in such cases, dead band is used to moderate the on-off control. Dead band in on-off control is a range in which the control algorithm output retains its previous state (Intelitek, 2002)

2.4 Liquid-level Control System

Liquid levels or water levels in the tanks and the flow between the tanks have always been the basic problems in the process industries. Liquid is one of the main materials in industries as most processes require the liquid to be stored in a specific tank or pumped to another tank.

Level controllers usually control an integrating process. This is because the accumulated liquid level is simply the integral of the difference between inflow and outflow. Normally, liquid-level control is not critical. In fact, it may be more important to maintain an average liquid level over a longer period of time rather than a precise moment-by-moment liquid level (F.G. Shinskey, 1996)

The size and shape of the process vessel affect the speed of changes in a level control loop. For example, the larger vessels will take longer to fill than smaller ones and the flow rate of the input and outflow pipes. Manufacturers usually will use one of many different measurement technologies to determine level, including ultrasonic, radar, float gauge, and pressure measurement. The final control facet in a level control loop is usually a valve on the input and/or outflow connections to the tank (Figure 2.6). Because it is regularly critical to evade tank overflow, surplus level control systems are sometimes employed (PA Control, 2006).

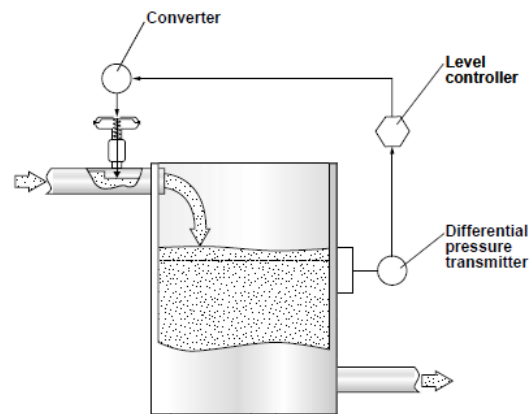


Figure 2.6: A Level Loop (PA Control, 2006)

2.5 ProcessLine Experimental Rig of Intelitek

The ProcessControl package for level includes the ProcessLine panel for the flow and level control. This control panel can be controlled either by a personal computer (PC) or programmable logic controller (PLC). Intelitek Water Level and Flow Control (ProcessLine) uses the open loop control system, on-off control system and Proportional, Integral, Derivative (PID) control .A diagram of all components of the system is shown in Figure 2.7.