CHLORINATION CONTROL IN WATER TREATMENT PLANT BASED ON PLC AND SCADA

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Submitted by:

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CERTIFICATE

I, Zelalem Fikadu, Roll No. 2K17/C&I/20 student of M. Tech. (in Control and instrumentation), hereby declare that the project titled "Chlorination Control In Water Treatment Plant Based On PLC & SCADA" under the supervision of Assistant Professor Ashish R. Kulkarni of Electrical Engineering Department Delhi Technological University in partial fulfilment of the requirement for the award of the degree of Master of Technology has not been submitted elsewhere for the award of any Degree.

Place: Delhi (ZELALEM FIKADU)

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First, my gratitude goes to my wonderful God who has done great things to me. Next with great the pleasure I want to take this opportunity to express my heartfelt gratitude to all the people who helped me in making this project a great success. I am grateful to Assistant Professor Ashish R. Kulkarni my advisor for his moral and technical support throughout the period of execution of the project. I would like to express my gratitude towards all the people who have contributed their precious time and effort to help me without whom it would not have been possible for me to understand and complete the project work.

ABSTRACT

The drinking water purification industry has become one of the largest industries in the world. Every human being needs to get clean water for its day to day activity. Currently, water purification systems in Delhi Technological University is manual. In the absence of automation, plant operators have to physically monitor performance values of water and equipment to determine the best settings on which to run the production equipment. This report focuses on the design and simulation of a PLC and SCADA-based water chlorination control system. The method used in this project describes the main components used in the system design such as pump, liquid level sensors, and solenoid valves. The ladder logic for the water and chlorine tank filling system was implemented by simulation using a Programmable Logic Controller (PLC). Simulation software was used to demonstrate the automation at tank filling and tank emptying in relation to the valve opening and closing. Flow simulation in the water tank is conducted to analyse the level on the sensors and the water tank is modeled in Simulink. Finally, the PLC ladder diagram is programmed, and the simulation results have verified the effectiveness of the design.

Contents

List of Figure

List of Table

CHAPTER 1

INTRODUCTION

1.1 Overview of The Water Treatment Plant

In this chapter briefly describes the background of this project work. It concerns a water treatment processing unit which is related to the aim and objectives of the project and summarises how the project report is organized.

As the world population is continuously undergoing an exponential rise, the ability to source clean water is becoming a pressing concern. Hence it becomes a challenge to constantly generate the required quantity of water in order to sustain the population and cater to its needs. Delhi Technological University has a lot of students and resident staffs which consumes treated water so to fulfil the need of this clear water the university constructed a water treatment plant. This plant gets untreated water from two different sources the main and common source is from underground and the second one is from outside source mostly this source helps in emergency case which is in case of shortage of water from common supply, when we see the common supply source there are five water pumping station which sucks the water from underground. Then uses three-phase induction motor based derived pump and it controls by star delta starting mechanism then this water passes through different processes and reaches to main water treatment or purification plant. In the water treatment process, there are four basic steps and they are listed below.

i) Coagulation/Flocculation: are used to remove colour, turbidity, algae and other microorganisms from surface waters. The addition of a chemical coagulant to the water causes the formation of a precipitate, or floc, which entraps these impurities. Iron and aluminum can also be removed under suitable conditions. The floc is separated from the treated water by sedimentation and/or filtration, although flotation processes may be used in place of sedimentation.

The most commonly used coagulants are aluminum sulfate and ferric sulfate, although other coagulants are available. Coagulants are dosed in solution at a rate determined by raw water quality near the inlet of a mixing tank or flocculate. The coagulant is rapidly and thoroughly dispersed on dosing by adding it at a point of high turbulence. The water is allowed to flocculate and then passes into the sedimentation tank (sometimes known as a clarifier) to allow aggregation of the flocs, which settle out to form sludge. This sludge will need to be periodically removed.

The advantages of coagulation are that it reduces the time required to settle out suspended solids and is very effective in removing fine particles that are otherwise very difficult to remove. Coagulation can also be effective in removing many protozoa, bacteria, and viruses. The principal disadvantages of using coagulants for treatment of small suppliers are the cost and the need for accurate dosing, thorough mixing, and frequent monitoring. Coagulants need accurate dosing equipment to function efficiently and the dose required depends on raw water quality that can very rapidly. The efficiency of the coagulation process depends on the raw water properties, the coagulant used and operational factors including mixing conditions, temperature, Coagulant dose rate and pH value. The choice of coagulant and determination of optimum operating 3 conditions for specific raw water are normally determined by bench scale coagulation tests. Thus, while coagulation and flocculation are the most effective treatment for removal of colour and turbidity they may not be suitable for small water supplies because of the level of control required and the need to dispose of significant volumes of sludge.

ii) Sedimentation**:** Simple sedimentation (i.e. unassisted by coagulation) may be used to reduce turbidity and solids in suspension. Sedimentation tanks are designed to reduce the velocity of flow of water so as to permit suspended solids to settle under gravity. There are many different designs of tanks and selection is based on simple settlement tests or by the experience of existing tanks treating similar waters. Without the aid of coagulation, these will only remove large or heavy particles, and due to the length of time, this process will take, the system will usually require storage tanks to balance peaks and troughs in demand. Sedimentation tanks are usually rectangular with length to width ratios between 2:1 and 5:1. The depth of the tank is usually between 1.5 and 2.0m. The inlet and outlet must be at opposite ends of the tank. The inlet should be designed to distribute the incoming flow as evenly as possible across the tank width and to avoid streaming which would otherwise reduce sedimentation efficiency. Baffles may be installed to prevent short-circuiting. The outlet should be designed to collect the clarified water over the entire tank width. The tank should be covered to prevent contamination and ingress. Sedimentation tanks require cleaning when performance deteriorates. This will not normally be more frequent than once per year.

iii) Filtration: Turbidity and algae are removed from raw waters by screens, gravel filters, slow sand, rapid gravity filters or cartridge filters. The difference between slow and rapid sand filtration is not a simple matter of the speed of filtration but in the underlying concept of the treatment process. Slow sand filtration is essentially a biological process whereas rapid sand filtration is a physical treatment process. Many small private water supplies will rely on cartridge filters consisting of a woven or spun filter within a standard housing.

iv)Disinfection: Addition of chlorine destroys or inactivates microorganisms remaining after the preceding treatment processes. Additional chlorine or chloramine may be applied to ensure an adequate disinfectant residual during storage or transportation throughout the distribution system to homes, schools, and businesses throughout the community.

Of all the advancements made possible through science and technology, the treatment of water for safe use is truly one of the greatest. Abundant, clean water is essential for public health humans cannot survive without water; in fact, our bodies are 67% water!

In storage and distribution, drinking water must be kept safe from microbial contamination. Frequently, however, biofilms containing microorganisms develop and persist on the inside walls of pipes and storage containers). Among disinfection techniques, chlorination is unique in that a pre-determined chlorine concentration may be designed to remain in treated water as a measure of protection against (re)growth of microbes after leaving the drinking water system. In the event of a significant intrusion of pathogens resulting, for example, from a leaking or broken water main, the level of the average chlorine residual will be insufficient to disinfect contaminated water. In such cases, monitoring the sudden drop in the free chlorine residual provides a critical warning to drinking water system operators that there is a source of contamination in the distribution system.

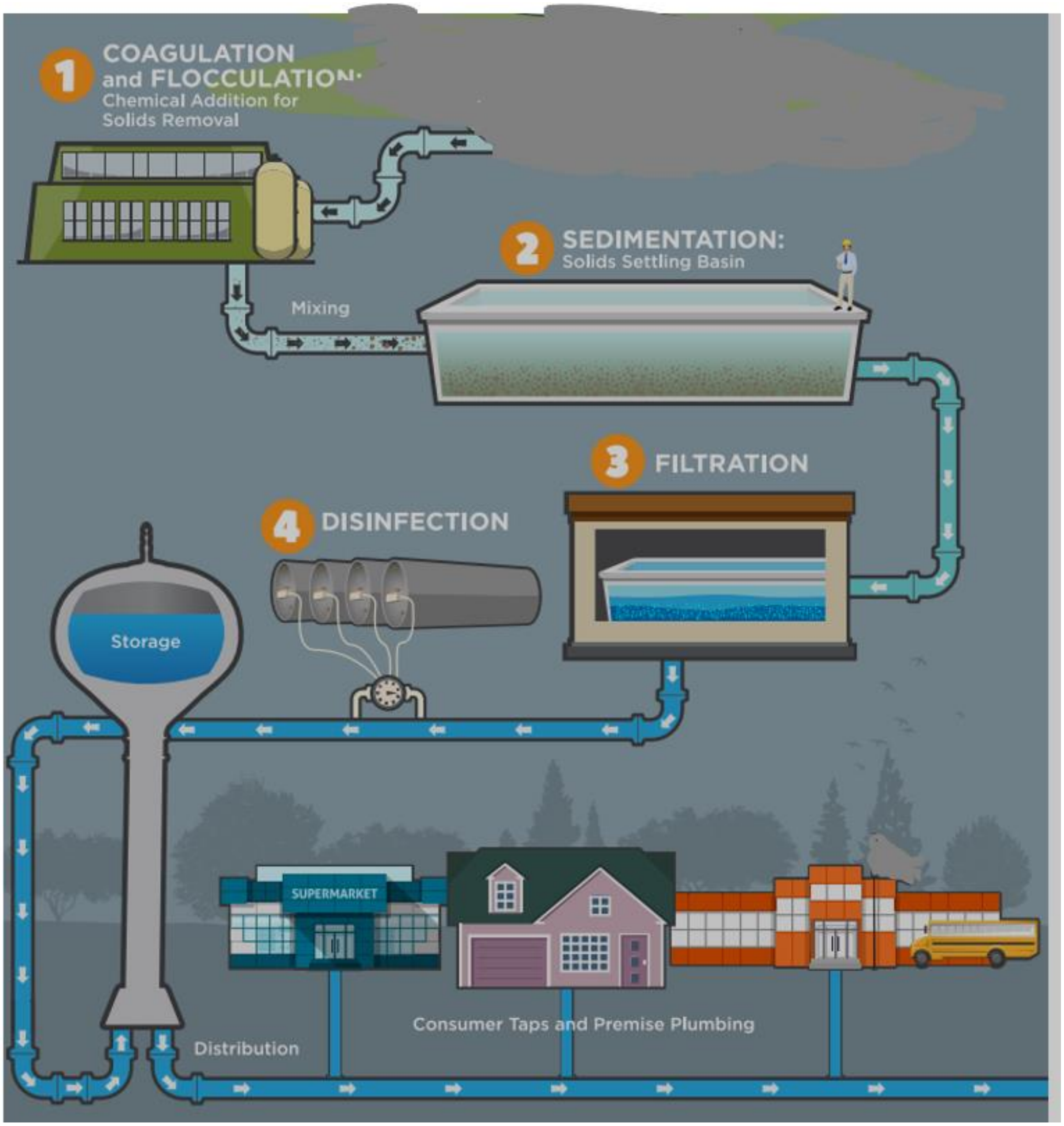


Figure 1 1: Water Treatment Process Steps

The water treatment plant which is constructed in DTU has two underground rectangular form reservoir tanks and the main chlorination process also takes place on each has a capacity of having 2 to 2.5lakh litter of water at a time

Figure 1 2: Underground Tank

And two pumping rooms each have squirrel cage induction motor based derived pump and those two pumps transfer the water from underground tank to overhead tank

Figure 1 3: Water Pumping House

Overhead tanks which store the final product of the treated water this means treated water and like the underground water reservoir tank the overhead tank has similar storage capacity which is 2lakh then, the treated water is distributed to a different section of the compound

1.2 Chlorination

Chlorine, which was first introduced to water treatment as a disinfectant about the turn of this century, Chlorine was first used in the U.S. as a major disinfectant in 1908 in Jersey City, New Jersey. Chlorine use became more and more common in the following decades, and by 1995 about 64% of all community water systems in the United States used chlorine to disinfect their water. is by far the most common agent used to preserve the microbial quality of potable water 1930’s known about the type of chlorine residual produced in drinking water. Free chlorination will remain an important method of disinfecting drinking water for the foreseeable future. A predictive chlorine concentration model, based on a chlorine mass balance utilizing chlorine reaction rates, would provide insights into the spatial distribution of chlorine concentrations in a distribution system. Chlorine is by far the most commonly used disinfectant in all regions of the world. Where widely adopted, chlorine has helped to virtually eliminate waterborne diseases such as cholera, typhoid, and dysentery. Chlorine also eliminates slime bacteria, molds, and algae that commonly grow in water supply reservoirs, Only chlorine-based disinfectants leave a beneficial "residual" level that remains in treated water, helping to protect it during distribution and storage.

The small amount of chlorine typically used to disinfect water does not pose risks to human health. The World Health Organization (WHO) has established a guideline value of 1L of chlorine for 10,000L of untreated water or 5 mg/L for chlorine in drinking water, meaning that such concentrations are considered acceptable for lifelong human consumption Chlorination is the process of adding chlorine to drinking water to disinfect it and kill germs. Different processes can be used to achieve safe levels of chlorine in drinking water. Chlorine is available as compressed elemental gas, sodium hypochlorite solution (NaOCl) or solid calcium hypochlorite (Ca(OCl). While the chemicals could be harmful in high doses, when they are added to water, they all mix in and spread out, resulting in low levels that kill germs but are still safe to drink.

Chlorine levels up to 4 milligrams per litre (mg/L or 4 parts per million (ppm) are considered safe in drinking water. At this level, no harmful health effects are likely to occur. Pathogens may be removed by various treatment processes:

Table 1 1: Treatment Process and Remove Microorganism

Treatment Process	**Microorganism Removal**	**Type**
Screening	10-20%	Physical Removal
Grit Removal	10-25%	Physical Removal
Primary Sedimentation	25-75%	Physical Removal
Chemical Precipitation	40-80%	Physical Removal
Trickling Filters	90-95%	Physical Removal
Activated Sludge	90-98%	Physical Removal
Chlorination	98-99%	Disinfection

1.3 Problem Statement

An automatic water chlorination system using PLC for a drinking water purification unit would help eliminate or reduce a lot of the problems associated with the manual operations. The application of sensors, solenoid valves to monitor and control the water tank filling system will drastically reduce human contact with the operations of the system. And to mix untreated water with chlorine we use a mixer.

1.4 Aim and Objectives of The Project

The goal of this project is to design and simulate a PLC and SCADA based chlorination system.

The specific objectives of the project are as follows:

- To review existing literature and the options available for implementation.
- To test through simulation, the automated chlorination system using the Allen Bradley PLC and SCADA Wonderware software.

CHAPTER 2

LITERATURE REVIEW

2.1 Water Purification Process

This is actually the removal of pollutants from unprocessed water to make it very pure and good for drinking by humans or to be used in the industry. Most drinking water is made pure for human use but the method of purification may vary depending on the area of application

Generally, three main means of water treatment or purification processes are considered and these are physical, biological and chemical processes. These methods are broken down as follows:

- Physical treatments – water filtering, sedimentation, and distillation.
- Biological treatments – sand filtering, lava filtration and membrane filters.
- Chemical treatments – addition of chlorine, flocculation and ultraviolet sterilization.

E. Assare-Mokwah,(2015) [14] when the unprocessed water is purified, pollutants such as algae, virus, bacteria and toxic minerals such as lead and copper, are removed from the water. Some of these pollutants may have come about as result rain water falling nto contaminated surfaces.

J. R. &. S. N. Joyanta Kumar (2013) [10] importance of chemical dosing for a period of time in a water treatment plant. The results reveal that due to lack experience of plant operators of suitable dosing calculation, there is contamination of excess metal in the drinking water and also there is unexpected extra consumption of dosing chemicals. Therefore authors developed dosing calculator software as a tool for chemical dosing calculation in water Industry to support plant operators. In this paper, the authors described the chemical dosing software for design and development of chemical dosing calculator[2].

when the water level in the ground-level storage tank becomes too low, the pump siphons air and shut down, requiring in resident to manually prime the water pump to get it running again. Residents struggle to monitor the water level of the tanks effectively and keep the pump running properly. To remedy the issue, the Automatic Water Pump Controller (AWPC) system monitors the water levels and controls the pump as necessary to prevent breakdown and maximize water storage without overfilling the rooftop tank and wasting water.

S. B. Murphy (1985) [6] A computer model to predict the spatial distribution of chlorine concentrations (residuals) for constant water quality and steady state bulk fluid flow in a potable water distribution system was developed. The model was based on a fundamental plug flow mass balance for the chlorine transport and reaction processes. The chlorine reaction rates were modeled as empirical first or second order processes with respect to chlorine. Constraints and conditions for the use of the program were identified and discussed[4].

H. Ji (2013) [13] In industry, the water level control problem is a typical process control problem, and has been extensively studied in the literature. The report focuses on the design and implementation of a PLC-based water level control system, the water tank is modeled in Simulink, and simulation results have shown that the PID controller can regulate the water level to the desired position. Finally, the PLC ladder diagram is programmed, and the experimental results have verified the effectiveness of the design.

CHAPTER 3

SYSTEM DESCRIPTION

3.1 Block Diagram

In the overall block diagram of the process is started when we start the starting switch at the same time half of the chlorine and untreated water enter into the underground tank then a mixer start running and mix water and chlorine then using pump 3 water goes to the overhead tank then it distributed to all residence and offices.

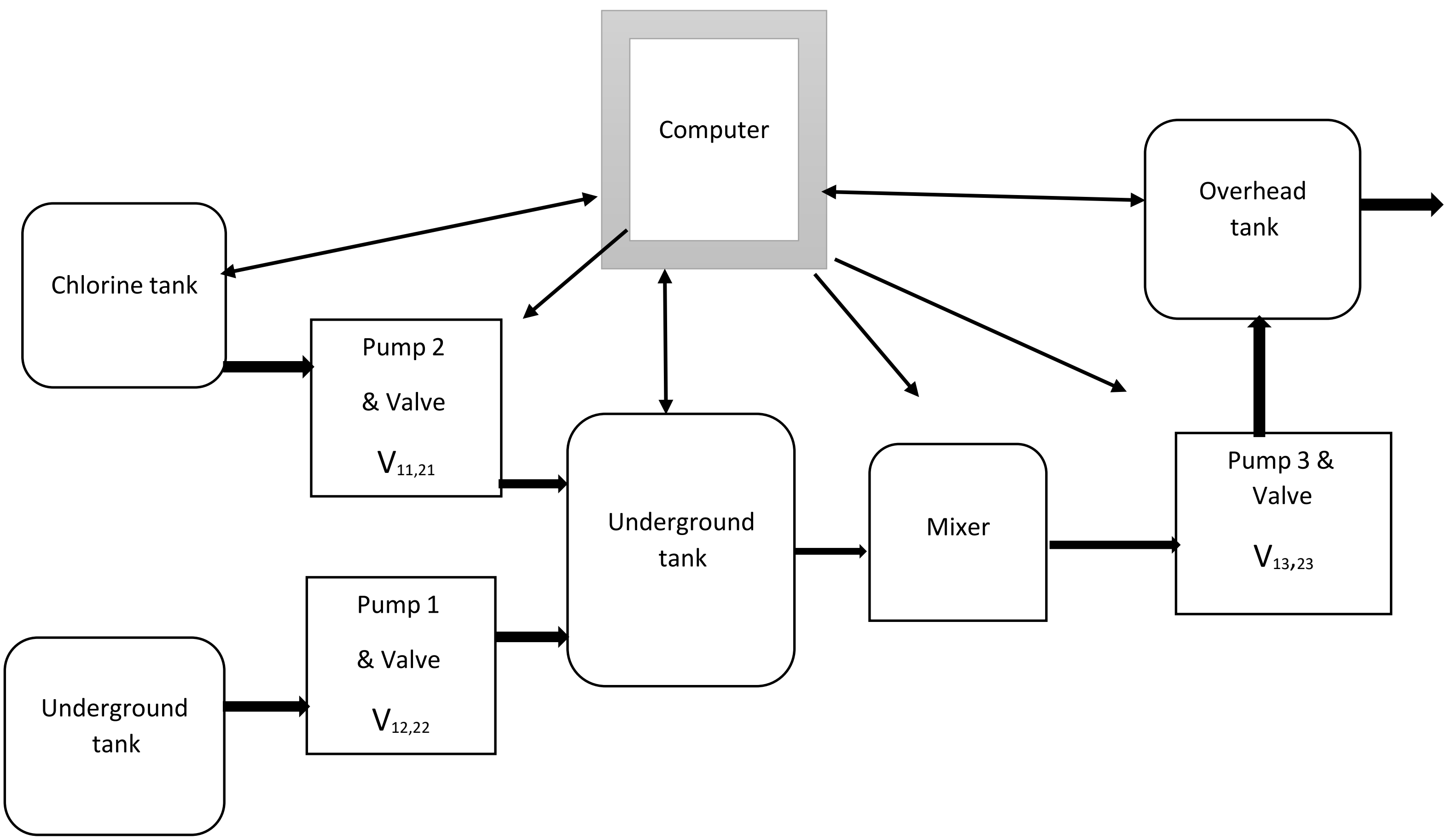


Figure 3 1: Chlorination Control Block Diagram

3.2 Component / Hardware Description:

Level Switch is used for determining the level of the liquid. The tanks contain the two types of Level Switches. They are a high-level switch and low-level switch for indicating the level of the liquid. When the liquid comes at high-level switch then only the motor turn ON and mixing is done. There are two types of level measurements, they are continuous and point level measurements. In this system we use the Point level measurement that only determines if the liquid level is high or low depends on that valve is turned ON/OFF.

I. DC Motor:

DC motor is used for mixing purpose. When the high-level sensor is ON then only motor starts and the mixing process is done with the help of stirrer. The motor will stop according to the time given in the program. For that specific time, the only motor on and the mixing process is done. The motor will operate at the voltage 12 VDC.

II. Control Valve:

Input to the control valve is given by the PLC. Control valves are connected to the liquid tank. When the upper tanks are filled up to the level switch then the only valve is open and liquid comes to the third tank. At the third tank when liquid cones at high-level switch then the third valve is open for the timing set in the program. We can change the ON time as per our requirement.

III. PLC

A programmable logic controller, commonly known as PLC, is a solid state, digital, industrial a computer using integrated circuits instead of electromechanical devices to implement control functions. It was invented in order to replace the sequential circuits which were mainly used for machine control. They are capable of storing instructions, such as sequencing, timing, counting, arithmetic, data manipulation, and communication, to control machines and processes.

According to NEMA(National Electrical Manufacture’s Association, USA), the definition of PLC has been given as “Digital electronic devices that uses a programmable memory to store instructions and to implement specific functions such as logic, sequencing, timing, counting, and arithmetic to control machines and processes.”

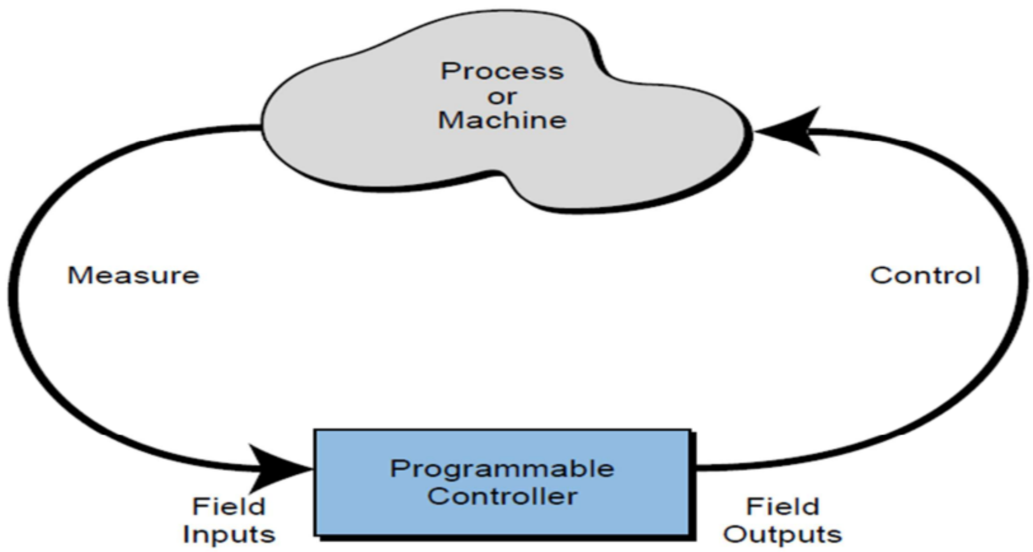


Figure 3 2: PLC Conceptual Application Diagram

IV. Pump

A hydrodynamic pump machine is a device which converts the mechanical energy held by a device into potential and kinetic energy in fluid and Pump is the machine designed to move fluid and add energy to them.

Pumps enable a liquid to:

- Flow from a region or low pressure to one of high pressure.
- Flow from a low level to a higher level.
- Flow at a faster rate.

There are two basic types of pumps: positive displacement and centrifugal. Although axial-flow pumps are frequently classified as a separate type, they have essentially the same operating principles as centrifugal pumps.

Table 3 1: Centrifugal Vs Reciprocating Pump

S. No	**Centrifugal pump**	**Reciprocating pump**
1	The discharge is continuous and smooth	The discharge is fluctuating and pulsating. However, with air vessel, it is uniform
2	Starting torque is more	Starting torque is less
3	Action on the fluid is dynamic	Action on the fluid by the pump is due to positive displacement
4	Used for low heads and large discharge	Used for high heads and low discharge
5	Efficiency is high	Efficiency is low
6	It is compact	It is comparatively large
7	It is a high-speed machine thus can be coupled with the prime mover	It is low-speed machine thus can't be coupled with the prime mover
8	Being a rotary machine, it is smooth in operation without much noise	It is not a smooth operation and much noise
9	Maintenance cost is low	Maintenance cost is high
10	Occupies less space	Occupies more space
11	Installation cost is high	Installation cost is high
12	It can handle high viscous fluids	It can handle only low viscous fluids

3.3 Basic parts of PLC:-

All programmable controllers contain a CPU, memory, power supply, I/O modules, and programmable devices. Basic parts of the PLC are as follows:-

1) Processor

(2) Memory

(3) Input/output devices

(4) Programming panel or unit

(5) Power supply

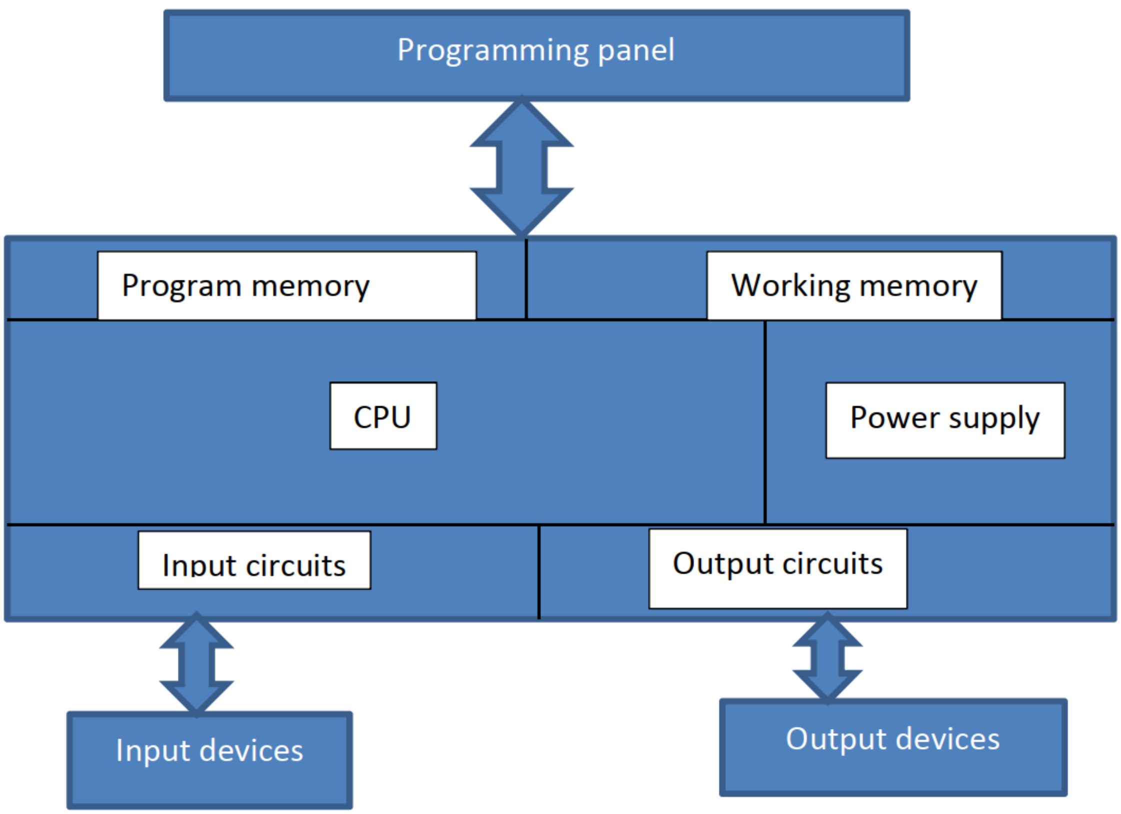


Figure 3 3: Basic Parts of PLC

Processors Module:-

The processor module is the brain of the PLC. The intelligence of the PLC is derived from microprocessor being used which has tremendous computing and controlling capability. Central processing –unit (CPU) performs the following tasks:-

- Scanning
- Execution of program
- Peripheral and external device communication
- Self- diagnose

Power of PLCs depends on the type of microprocessors being used. Small size PLCs use 8-bit microprocessors whereas higher order controllers use bit-slice microprocessor in order to achieve faster instruction executes.

Modern-day PLCs vary widely in their capabilities to control real-world devices, like some processors are able to handle the I/O devices as few as six and some are able to handle 40000 or more. The number of input/output control of PLCs depends on the hardware, software, overall capacity and memory capability of the PLCs.

The CPU upon receiving instruction from the memory together with feedback on the status of the I/O devices generate commands for the output devices. These commands control the devices on a machine or a process. Devices such as solenoid valves, indicator lamps, relay coils, and motor starters and typical loads to be controlled.

The machine or process input elements transmit a signal to input modules which in turn, generates a logic signal to the CPU.CPU monitors the input line selector switches, push buttons, etc. The operating system is the main work house of the system and hence performs the following tasks:-

1. Executions of application program
2. Management of memory
3. Communication between programmable controller and other units
4. I/O handling of interfaces
5. Resource sharing
6. Diagnostics

Input Modules:

There are many types of input modules to choose from. The type of input module selection depends upon the process, some example of input modules is a limit: -switches, proximity switches, and push buttons, etc. nature of input classification can be done in three ways, namely:-

- low/high frequency
- Analog/digital (two-bit, multi-bit)
- maintained or momentary
- 5V/24V/110V/220V switched

Some most industrial power systems are inherently noisy:- electrical isolation is provided between the input and the processor. Electromagnetic interference (EMI) and radio frequency interference (RFI) can cause severe problems in most solid state control systems. The component used often to provide electrical isolation within I/O cards is called an optical isolator. Typically, there are 8 to 32 input points on anyone input modules. Each input point is assigned a unique address by the processor.

Output Modules:-

Output modules can be used for devices such as solenoids, relays, contractors, pilot lamps and led readouts. Output cards usually have 6 to 32 output points on a single module. Output cards, like input cards, have electrical isolation between the load being connected and the PLC. Analog output cards are a special type of output modules that use digital to analog conversion. The analog output module can take a value stored in a 12-bit file and convert it to an analog signal. Normally, this signal is 0-10 volts dc or 4-20ma. This analog signal is often used in equipment, such as motor-operated valves and pneumatic position control device. Each output point is identified with a unique address.

Addressing Scheme:-

Each I/O device has to be identified with a unique address for the exchange of data. Different manufacturer apply the different method to identify I/O devices.

Programming Unit:

It is an external, electronic handheld device which can be connected to the processors of the PLC when programming changes are required. Once a program has been coded and is considered finished, It can be burned into ROM. The contents of ROM cannot be altered, as it is not affected by power failure. Nowadays EPROM/EEPROM is provided in which program can be debugged at any stage. Once the program is debugged, the programming unit is disconnected; and the PLC can operate the process according to the ladder diagram or the statement list.

Communications in PLC:-

There are several methods of how a PLC can communicate with the program, or even with another PLC. PLCs usually built in communication ports for at least RS232, and optionally for RS 485, and Ethernet. Modbus is the lowest common denominator communication protocol. Others are various field buses such as Profibus, inter buss, foundation field bus, etc.

PLCs are becoming more and more intelligent .in recent years, PLCs have been integrated into industrial networks, and all the PLCs in an industrial environment have been plugged into a network. The PLCs are then supervised by a control centre. There exist many types of networks, SCADA (supervisory control and data acquisition)

Operation of PLC:

During program execution, the processor reads all the inputs, and according to control the application program energizes and de-energizes the outputs. Once all the logic has been solved, the processors will update all the outputs. The process of reading the inputs, executing the control application program, and updating the output is known as a scan.

During the scan operation, the processor also performs housekeeping tasks. The inputs to the PLCs are sampled by the processor and the contents are stored in memory. The control program is executed, the input value stored in memory is used in control logic calculations to determine the value of output. The outputs are then updated

The cycle consisting of reading of inputs, executing the control program and actuating the output is known as “scan” and the time to finish this task is known as “scan time”. The speed at which

PLC scan depends upon the clock speed of CPU. The time to scan depends upon following parameter:-

- Scan rate
- Length of the program
- Types of functions used in the program

3.3.1 Allen Bradley PLC

PLC has 20 digital inputs and 12 digital outputs. The entire bottling process is automated by applying the necessary conditions into the PLC using ladder logic. The input/output unit of the PLC acts as an interface to the real world. Inputs from the real world are given to the input unit which is manipulated based on the system requirement, and outputs are given to the real world through the output unit of the PLC.

Table 3 2: PLC Input/output Configuration for the Plant

Sr. No.	**Address**	**Description**
1	B3:0/5	Start Switch
2	B3:0/7	Pump 1
3	B3:0/8	Pump 3
4	B3:0/9	Pump 2
5	B3:0/10	Valve V_{12}
6	B3:0/11	Valve V11
7	B3:0/12	Valve V_{21}
8	B3:0/13	Valve V_{22}
9	B3:0/14	Mixer m1
10	B3:0/15	Mixer m2
11	B3:1/0	Valve V4
12	B3:1/2	Valve V_{13}
13	B3:1/3	Valve V_{23}
14	T4:0	For fill of t1and 50% unfilled of t3
15	T4:1	Used for mixing in t1
16	T4:2	Used for unfill of t1 and fill of t2 and t4 and reaming unfill of t3
17	T4:3	Used for mixing of t2
18	T4:4	Used for unfill of t2 and fill of t4
19	T4:5	Used for unfill of t4

PLCs as Compared To The Other Control Systems

PLCs are well-adapted to a range of automation tasks. These are typically industrial processes in manufacturing where the cost of developing and maintaining the automation system is high relative to the total cost of the automation, and where changes to the system would be expected during its operational life. PLCs contain input and output devices compatible with industrial pilot devices and controls; little electrical design is required, and the design problem centres on expressing the desired sequence of operations in ladder logic (or function chart) notation. PLC applications are typically highly customized systems so the cost of a packaged PLC is low compared to the cost of specific custom-built controller design. On the other hand, in the case of mass-produced goods, customized control systems are economic due to the lower cost of the components, which can be optimally chosen instead of a "generic" solution, and where the non-recurring engineering charges are spread over thousands of places.

For high volume or very simple fixed automation tasks, different techniques are used. For example, a consumer dishwasher would be controlled by an electromechanical cam timer costing only a few dollars in production quantities.

A microcontroller-based design would be appropriate where hundreds or thousands of units will be produced and so the development cost (design of power supplies and input/output hardware) can be spread over many sales, and where the end-user would not need to alter the control. Automotive applications are an example; millions of units are built each year, and very few end-users alter the programming of these controllers. However, some specialty vehicles such as transit buses economically use PLCs instead of custom-designed controls, because the volumes are low and the development cost would be uneconomic. Very complex process control, such as used in the chemical industry, may require algorithms and performance beyond the capability of even high-performance PLCs. Very high-speed or precision controls may also require customized solutions; for example, aircraft flight controls.

PLCs may include logic for single-variable feedback analog control loop, a "proportional, integral, derivative" or "PID controller." A PID loop could be used to control the

the temperature of a manufacturing process, for example. Historically PLCs were usually configured with only a few analog control loops; where processes required hundreds or thousands of loops, a distributed control system (DCS) would instead be used. However, as PLCs have become more powerful, the boundary between DCS and PLC applications has become less clear-cut

3.4 Positive Displacement Pump

A Positive Displacement Pump has an expanding cavity on the suction side and a decreasing cavity on the discharge side. Liquid flows into the pumps as the cavity on the suction side expands and the liquid flows out of the discharge as the cavity collapses. The volume is a constant given each cycle of operation.

A Positive Displacement Pump, unlike a Centrifugal or Roto-dynamic Pump, will produce the same flow at a given speed (RPM) no matter the discharge pressure. A Positive Displacement Pumps is a "constant flow machine" A Positive Displacement Pump must never operate against closed valves on the discharge side of the pump - it has no shut-off head like Centrifugal Pumps. A Positive Displacement Pump operating against closed discharge valves continues to produce flow until the pressure in the discharge line is increased until the line bursts or the pump is severely damaged - or both.

The positive displacement pumps can be divided in two main classes

1. Reciprocating
2. Rotary

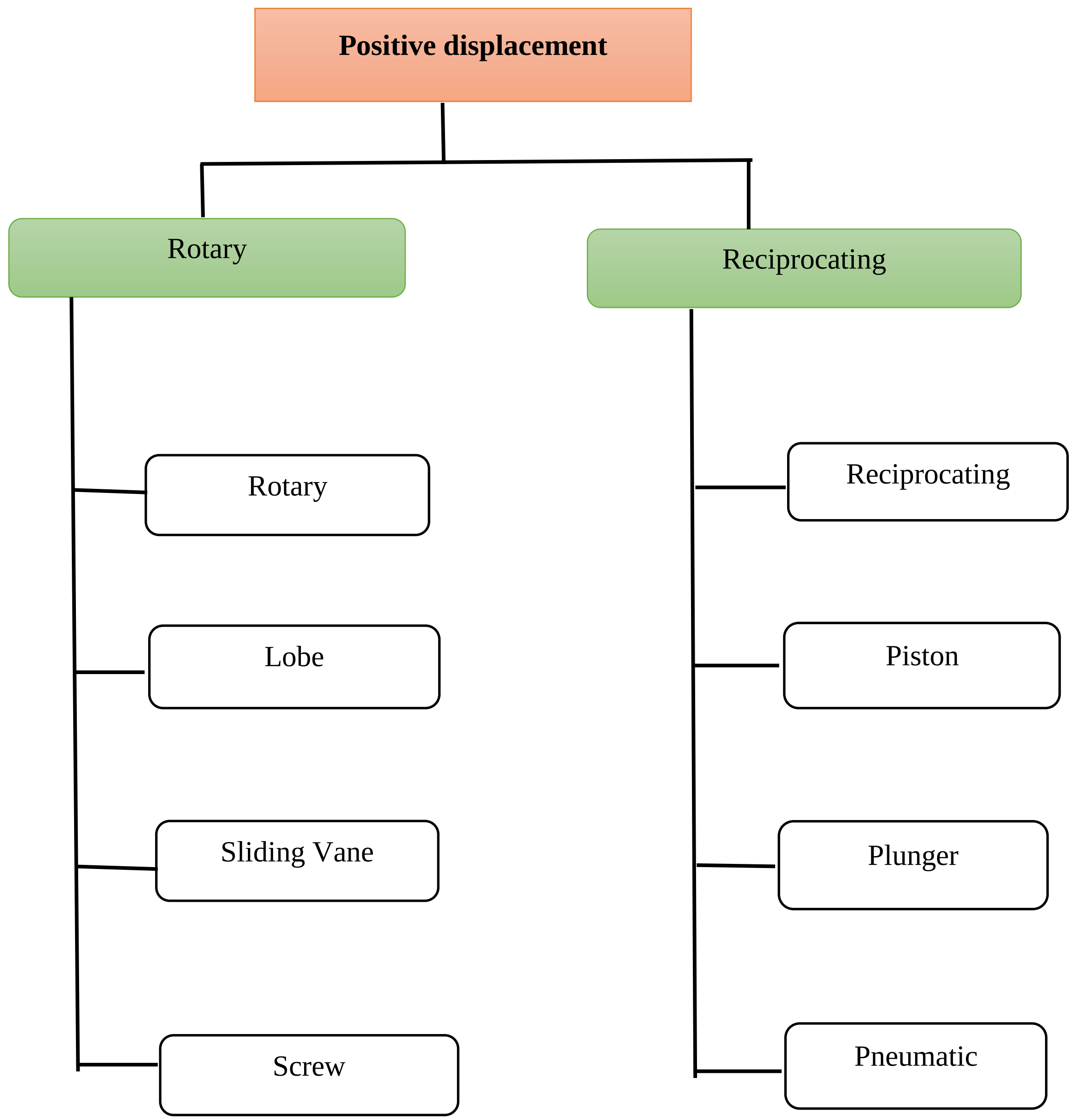
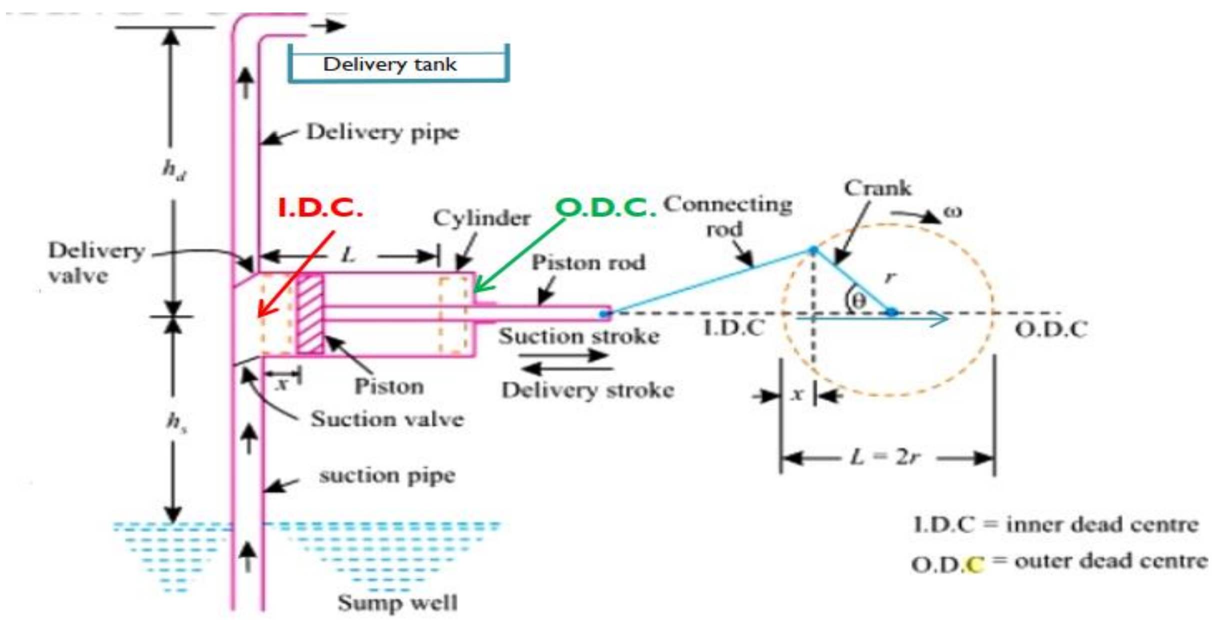


Figure 3 4: Positive Displacement Classification

3.4.1 Reciprocating Pump

Reciprocating pump is a positive displacement pump where a certain volume of liquid is collected in an enclosed volume and is discharged using pressure to the required application. Reciprocating pumps are more suitable for low volumes of flow at high pressures.

- single acting pump



https://theconstructor.org/practical-guide/reciprocating-pump

Figure 3 5: single acting pump

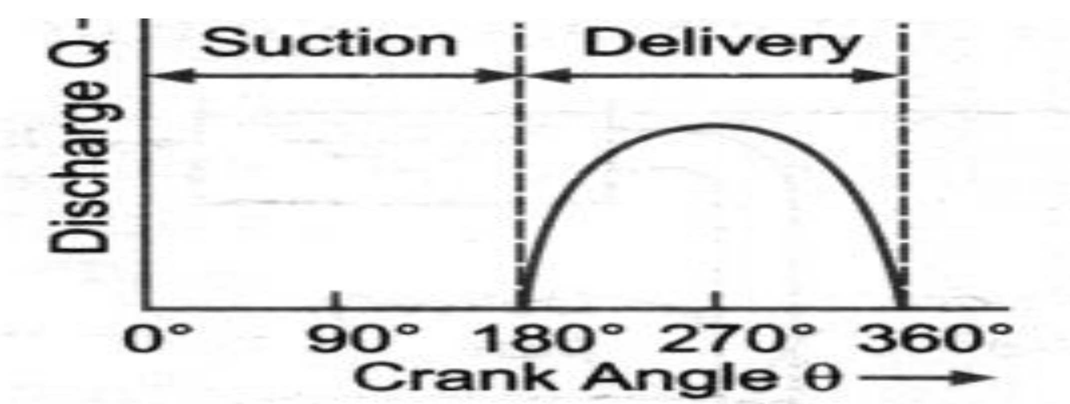


Figure 3 6: Discharge variation

L- Length of stroke (=2r)

D-diameter of the cylinder

d- Diameter of the piston rod

r- Crank radius

A – Cylinder or piston area

A_{pr} - Area of the piston rod

N - Revolution per minute

h_s - Height of the center of the cylinder above the liquid surface

ha_d - Height to which the liquid is raised above center of the cylinder

w- Specific weight of the liquid Volume of liquid sucked in during suction stroke = A× L

Discharge of the pump per second

$$Q = A \times L \times N/60$$

Weight of water delivered per second

$$W = w \times Q = wALN/60$$

Work was done per second = (weight of water lifted per second) × (total height through which liquid is lifted)

$$= w(hs + hd) = \frac{nWALN}{60}(hs + hd)$$

- Double acting pump

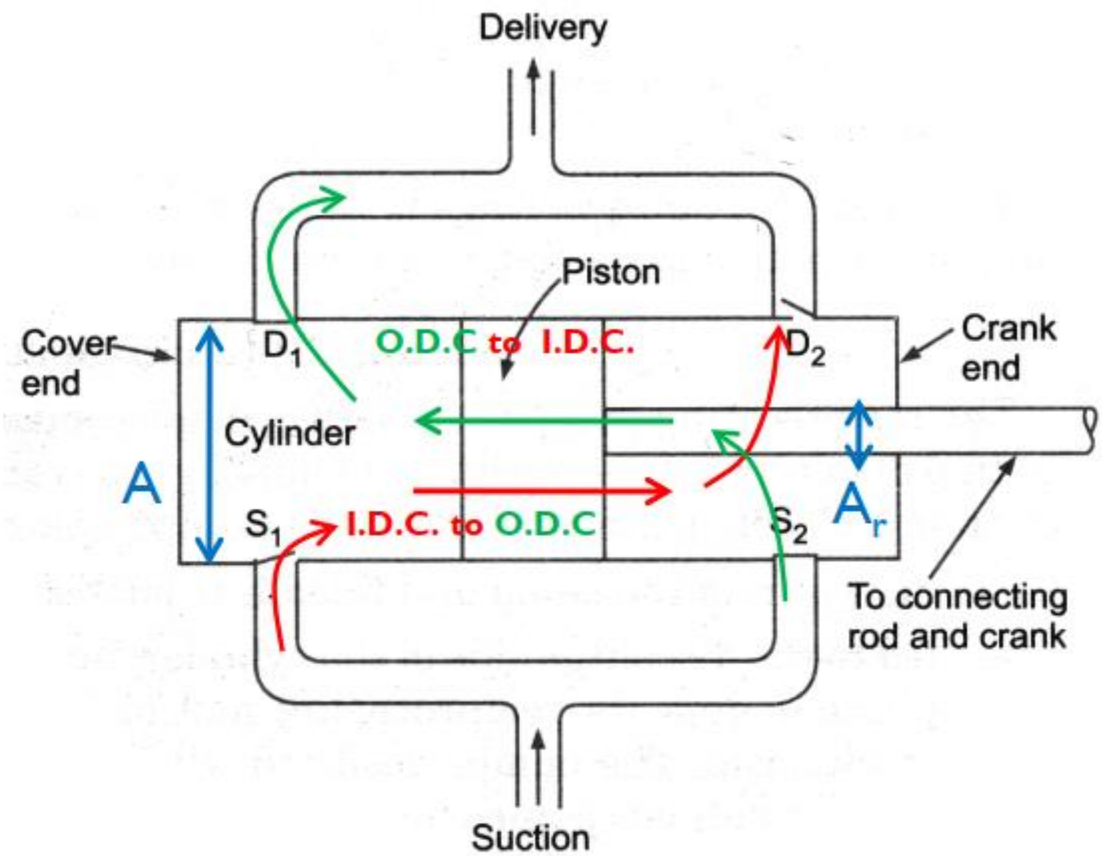


Figure 3 7: Double Acting Pump

Figure 3 8: Double Acting Discharge Variation

Discharge, work is done and power required to drive a double acting reciprocating pump

Area on one side of the piston $A = \frac{\pi}{4} D^2$

Area on the other side of the piston where piston rod is connected

$$A = \frac{\pi}{4} D^2 + \frac{\pi}{4} d^2$$

Volume of water delivered in one revolution of the crank

$$= \mathrm{AL} + \mathrm{AL} = \left[\frac{\pi}{4} D^2 + \frac{\pi}{4} (D^2 - d^2)\right] * L$$

Discharge of the pump per sec = volume of water delivered in one rev* No. of revolution per sec.

$$= [\tfrac{\pi}{4} D^2 + \tfrac{\pi}{4} (D^2 - d^2)] L * \tfrac{N}{60}$$

Compared to the piston area, the piston rod area is very small and neglecting this will

$$Q = [\frac{\pi}{4} D^2 + \frac{\pi}{4} (D^2 \quad)] L * \frac{N}{60} = \frac{2ALN}{60}$$

Work was done per second = (weight of water lifted per second) × (total height through which liquid is lifted)

$$w(hs + hd) = \frac{2WALN}{60} (hs + hd)$$

Slip:

There can be leakage along with the valves, piston rings, gland and packing which will reduce the discharge to some extent. The difference between the theoretical discharge and actual discharge is known as slip. The actual discharge is always less than theoretical discharge due to leakage.

$$\text{Slip} = Q_{th} - Q_{ac}$$

Negative Slip:

It has been found in some cases that $Q_{ac} > Q_{th}$, due to operating conditions. In this case, the slip is called a negative slip. When the delivery pipe is short or the delivery head is small and the accelerating head in the suction side is high, the delivery valve is found to open before the end of the suction stroke and the water passes directly into the delivery pipe. Such a situation leads to a negative slip.

Components of Reciprocating Pump

The main components of the reciprocating pump are as follows:

- **Suction Pipe**

The suction pipe connects the source of liquid to the cylinder of the reciprocating pump. The liquid is sucked by this pipe from the source to the cylinder.

- **Suction Valve**

Suction valve is a non-return valve which means only one directional flow is possible in this type of valve. This is placed between the suction pipe inlet and cylinder. During suction of liquid, it is opened and during discharge, it is closed.

- **Delivery Pipe**

The delivery pipe connects the cylinder of the pump to the outlet source. The liquid is delivered to the desired outlet location through this pipe.

- **Delivery Valve**

Delivery valve also non-return valve placed between the cylinder and delivery pipe outlet. It is in the closed position during suction and in opened position during discharging of liquid.

- **Cylinder**

A hollow cylinder made of steel alloy or cast iron. Arrangement of piston and piston rod is inside this cylinder. Suction and release of liquid take place in this so, both suction and delivery pipes along with valves are connected to this cylinder.

- **Piston and Piston Rod**

The piston is a solid type cylinder part which moves backward and forwards inside the hollow cylinder to perform suction and deliverance of liquid. Piston rod helps the piston to its linear motion.

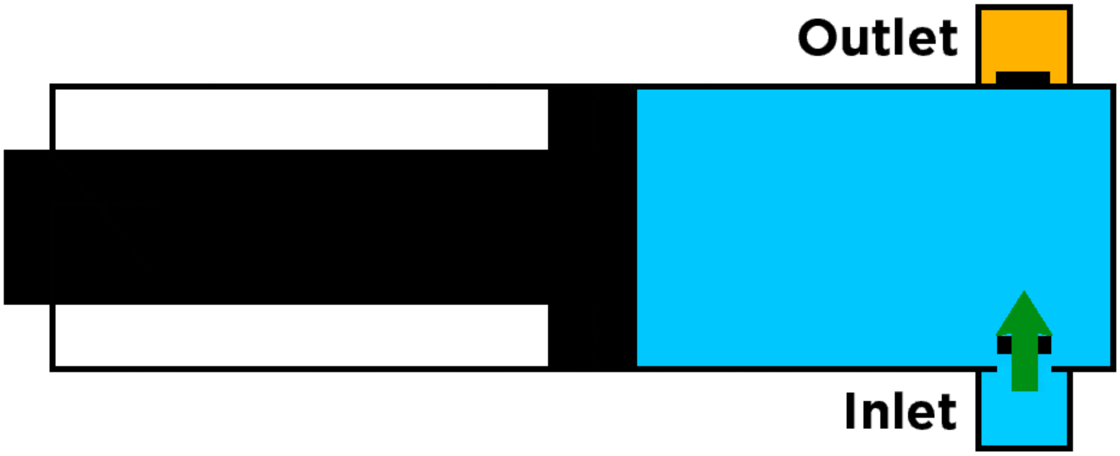
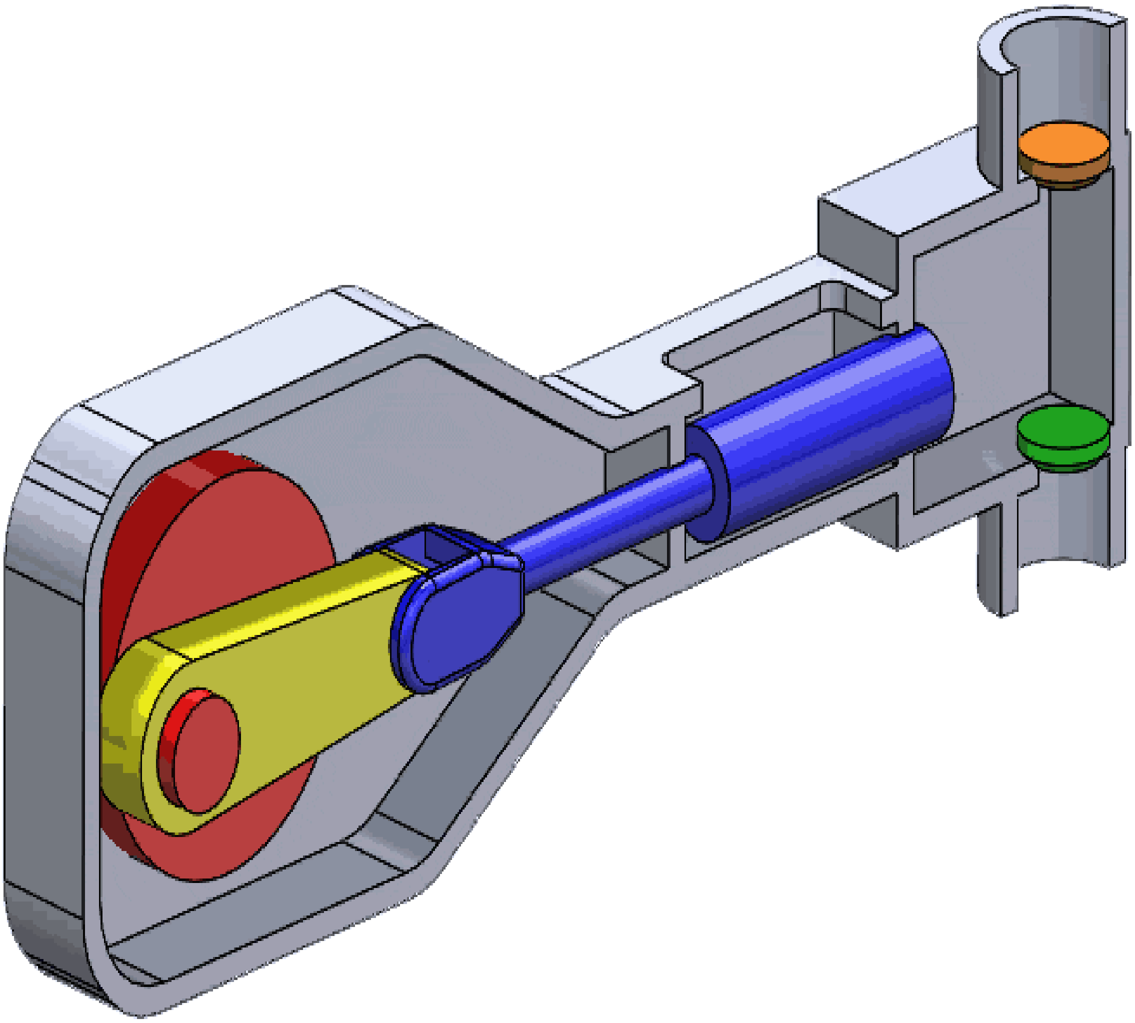


Figure 3 9: Piston During Suction And Discharge

- **Crank and Connecting Rod**

Crank is a solid circular disc which is connected to a power source like motor, engine, etc. for its rotation. Connecting rod connects the crank to the piston, as a result, the rotational motion of crank gets converted into linear motion of the piston.



source: https://theconstructor.org/practical-guide/reciprocating-pump-components

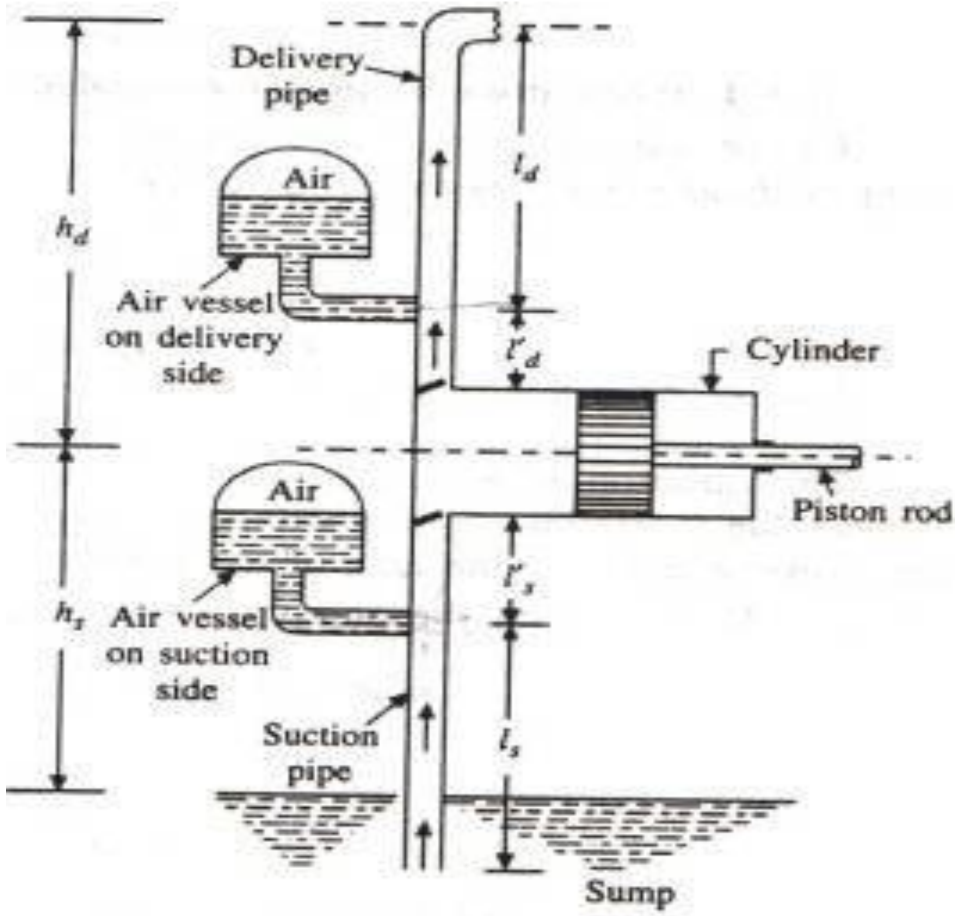
Figure 3 10: Crank Rotation

- **Strainer**

The strainer is provided at the end of the suction pipe to prevent the entrance of solids from the water source into the cylinder.

- **Air Vessel**

Air vessels are connected to both suction and delivery pipes to eliminate the frictional head and to give uniform discharge rate.



https://theconstructor.org/practical-guide/reciprocating-pump

Figure 3 11: Single Acting With Air Vessel

Effectively Control PD Pumps

Positive displacement (PD) pumps aren't as common as centrifugal pumps at most plants. So, engineers typically are less familiar with how to control the flow of these pumps. Yet, many applications of PD pumps may benefit from flow control e.g., direct control to meet process objectives or a cascade from level, temperature or other control loops.+

Flow control on most centrifugal pumps involves varying the discharge pressure to alter the pump flow rate. A control valve supplies the variable pressure drop for the system. As long as the pump has a continuously rising head to zero flow, this system usually works dependably.

In contrast, changing flow resistance on a PD pump doesn't vary the flow rate. In an ideal PD pump with incompressible fluids, the flow rate is independent of both the suction and discharge pressures. Real pumps may vary from the ideal due to internal leakage. A control valve on a PD pump doesn't control the flow rate. A control valve on a PD pump discharge controls the discharge pressure.

Controls for PD pump flow rates must take one of three approaches. First, modify the pump so that each stroke (reciprocating or diaphragm) moves a different amount of flow. Second, alter the speed of the pump. Third, use a recycle stream and change the amount of recycling.

Except for small metering pumps, varying the volume per stroke generally is mechanically complex and expensive. So, flow control in process applications usually involves either altering the pump speed or using recycle. Recycle may be either external or internal or both.

A PD pump normally runs at a slower speed than a standard motor. Therefore, a mechanical connection — such as a hydraulic torque converter, hydro viscous drive or eddy-current coupling — links the motor to the pump. All these can vary the pump speed at constant motor speed. In addition, today's reliable variable frequency drives enable changing motor speed when using belt drives and gearboxes.

Reciprocating Pump Performance

The following data will outline the main terms involved in determining the performance of a reciprocating pump.

Main Terms:

a) **Brake Horsepower (BHP)**: Brake horsepower is the actual power required at the pump input shaft in order to achieve the desired pressure and flow. It is defined as the following formula:

$$BHP = (Q * Pd) / (1714 * Em)\ 102$$

Pumps Reference Guide where:

BHP = brake horsepower

Q = delivered capacity (GPM US)

Pd = developed pressure (psi)

Em = mechanical efficiency (% as a decimal)

b) Capacity (Q): The capacity is the total volume of liquid delivered per unit of time. This liquid includes entrained gases and solids at specified conditions.

c) Mechanical Efficiency (Em): The mechanical efficiency of a power pump at full load pressure and speed is 90 to 95% depending on the size, speed, and construction.

d) Displacement (D): Displacement (gpm) is the calculated capacity of the pump with no slip losses. For single acting plunger or piston pumps, it is defined as the following:

Where:

D = displacement, (gpm US)

A = cross-sectional area of plunger or piston, (in2)

M = number of plungers or pistons = speed of the pump, (rpm)

S = stroke of the pump, (in.) (half the linear distance the plunger or piston moves linearly in one revolution)

e) Slip(s) Slip is the capacity loss as a fraction or percentage of the suction capacity. It consists of stuffing box loss BL plus valve loss VL. However, stuffing box loss is usually considered.

3.5 Induction Motor

An induction motor (IM) is a type of asynchronous AC motor where power is supplied to the rotating device by means of electromagnetic induction.

The induction motor with a wrapped rotor was invented by Nikola Tesla Nikola Tesla in 1882 in France but the initial patent was issued in 1888 after Tesla had moved to the United States. In his scientific work, Tesla laid the foundations for understanding the way the motor operates. The induction motor with a cage was invented by Mikhail Dolivo-Dobrovolsky about a year later in Europe. Technological development in the field has improved to where a 100 hp (74.6 kW) motor from 1976 takes the same volume as a 7.5 hp (5.5 kW) motor did in 1897. Currently, the most common induction motor is the cage rotor motor.

An electric motor converts electrical power to mechanical power in its rotor (rotating part). There are several ways to supply power to the rotor. In a DC motor, this power is supplied to the armature directly from a DC source, while in an induction motor this power is induced in the rotating device. An induction motor is sometimes called a rotating transformer because the stator (stationary part) is essentially the primary side of the transformer and the rotor (rotating part) is the secondary side. Induction motors are widely used, especially polyphase induction motors, which are frequently used in industrial drives.

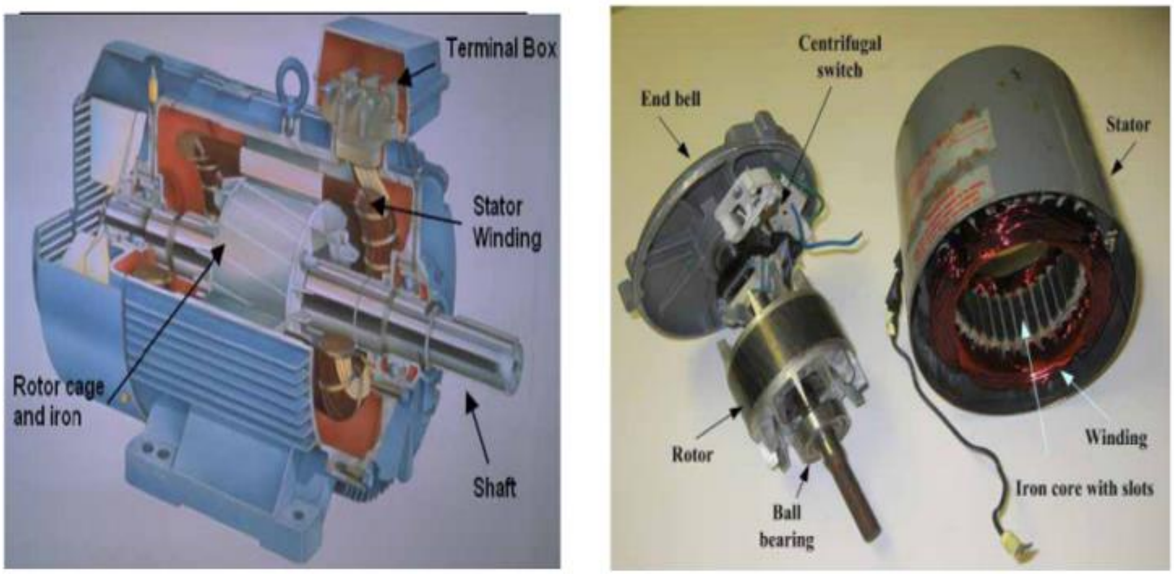
Induction motors are now the preferred choice for industrial motors due to their rugged construction, absence of brushes (which are required in most DC motors) and the ability to control the speed of the motor.

Construction

A typical motor consists of two parts namely stator and rotor like another type of motors.

i) An outside stationary stator having coils supplied with AC current to produce a rotating magnetic field,

ii) An inside rotor attached to the output shaft that is given a torque by the rotating field.



Source: *https://www.testandmeasurementtips.com/test-motors-oscilloscope/*

Figure 3 12: Induction Motor Components

There are two main types of induction motors exists. They are

i) Squirrel cage induction motor

ii) Slip ring induction motor

Squirrel Cage Induction Motor

In simple words, the induction motor which uses a squirrel cage rotor is called a squirrel cage induction motor. The reason behind the name "squirrel cage" is because of the type of rotor used in these motors. In these type of motors, the rotor is simplest and most rugged in construction. These motors have much higher efficiency than slip ring induction motors. Most of the industries prefer these type of motor due to less maintenance cost, higher efficiency, and their lightweight construction. Let see the construction of a squirrel cage induction motor.

Type of rotors

i) Squirrel cage rotor ii) Wound rotor

Squirrel-Cage Rotor In the squirrel-cage rotor, the rotor winding consists of single copper or aluminum bars placed in the slots and short-circuited by end-rings on both sides of the rotor. Most of single phase induction motors have Squirrel-Cage rotor. One or 2 fans are attached to the shaft in the sides of the rotor to cool the circuit.

3.6 Advantages and Disadvantages of Reciprocating Pump

Advantages of Reciprocating Pump

- High efficiency
- No priming needed
- Can deliver water at high pressure
- Can work in the wide pressure range

Disadvantages of Reciprocating Pump

- More parts mean high initial cost
- High maintenance cost
- No uniform torque
- Low discharging capacity

3.7 System Modelling

In this section, we will discuss the system modelling of the chlorination tank system, so by using tanks and valves, we will model the system. The model that we plan to construct have basically three tanks which is chlorine tank, underground tank, overhead tank and also it have three valves, since the chlorine tank is initially full so we not consider the input for the first tank and the underground tank receives untreated water outside source and chlorine from chlorine tank then with the help of valve two the treated water goes to overhead tank and finally we will observe the level of a liquid in each tank with respect to time.

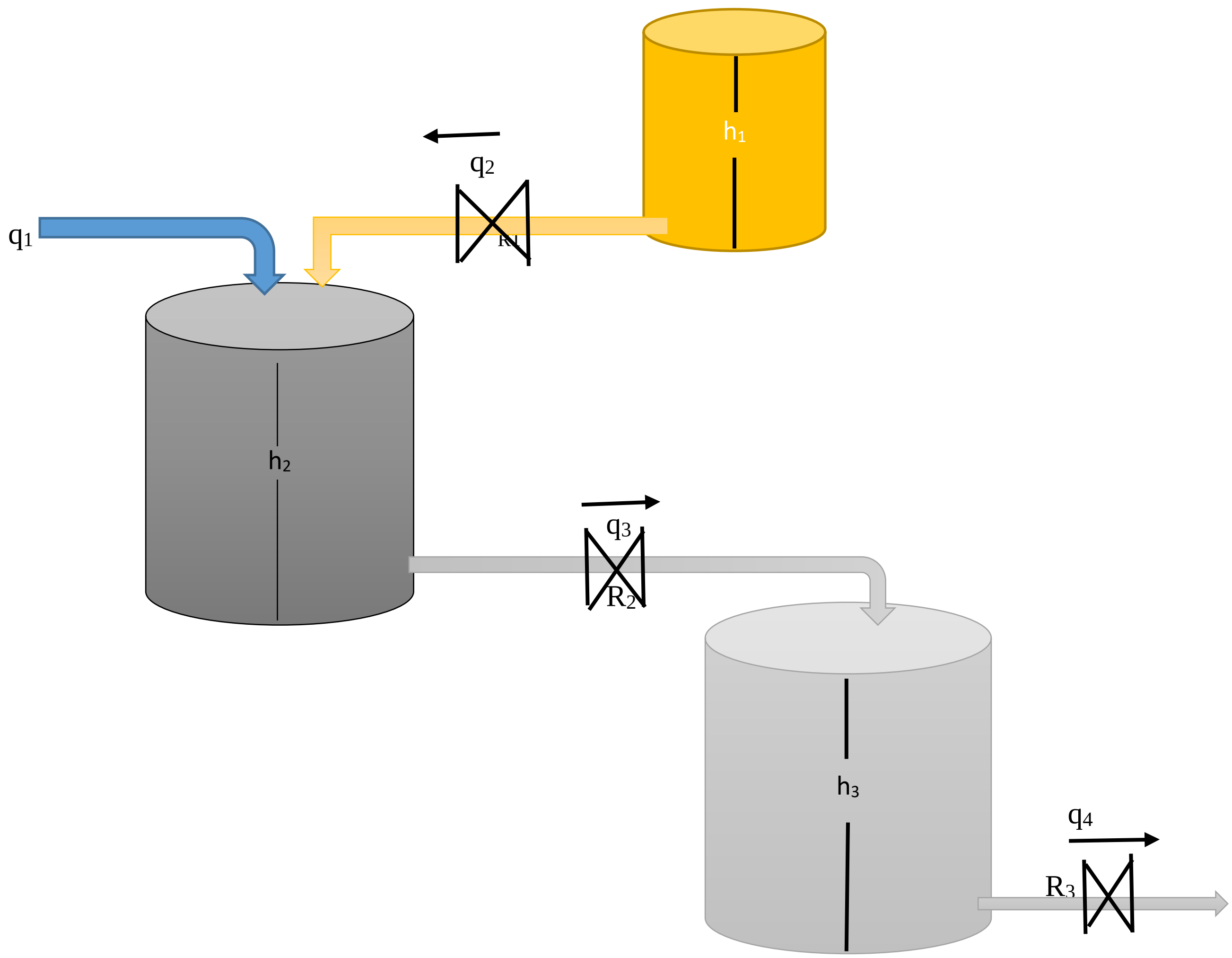


Figure 3 13: Schematic Diagram of Tank Filling System

- q_{in} = Inflow of the water and chlorine tank, which is assumed to be constant [m^3/s]
- q_{out} = Outflow of the chlorinated water tank [m^3/s] change in head, m
- h= Small deviation of head from its steady-state value,[m]
- A: Cross area of the water tank [m^2]
- R = Valve of linear resistance which is $R = \frac{\text{Change in level difference [m]}}{\text{change in flow rate } [\frac{m3}{sec}]}$
- C = Capacitance of a tank which is $C = \frac{\text{change in liquid stored,m3}}{\text{change in head,m}}$

Cdh = (q_{in} - q_{out})dt, but we do not consider q_{in} for tank 1

$$C1\frac{dh1}{dt} = q1 - q2$$

$$C1\frac{dh1}{dt} = -\frac{h1 - h2}{R1}$$

$$\frac{dh1}{dt} = 1(\frac{h2-h1}{C1R1}) \text{..........................} \quad (3.1)$$

$$C2\frac{dh2}{dt} = q1 + q2 - q3$$

$$\frac{dh2}{dt} = 1/C2\left(q1 + \frac{h1-h2}{R1} - \frac{h2-h3}{R2}\right) \text{...............................} \quad (3.2)$$

$$C3\frac{dh3}{dt} = q3 - q4$$

$$\frac{dh3}{dt} = 1/C3(\frac{h2-h3}{R2} - \frac{h3}{R3}) \text{..................................} \quad (3.3)$$

Based on the assumption that the system is either linear or linearized, the differential equation of this system can be obtained as shown above: Since the inflow minus outflow during the small time interval *dt* is equal to the additional amount stored in the tank or based on the law of conservation of mass, the actual height is equal to the total inflow mass subtracts the total outflow mass.

CHAPTER 4

DESIGN AND SIMULATION OF THE SYSTEM

4.1 Software Description

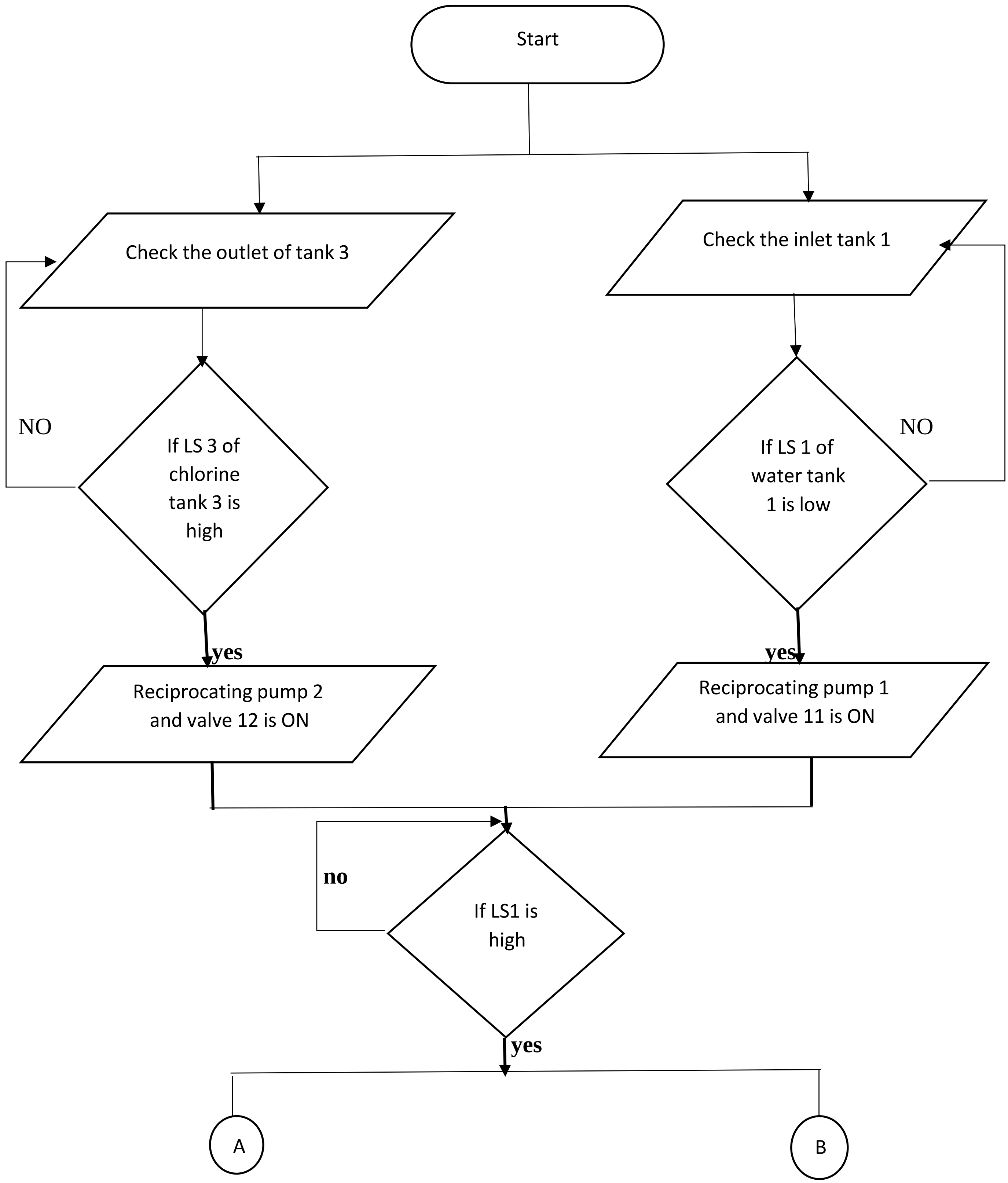
This chapter discusses the automated chlorinating tank filling and draining controlled system design for the effective management and control of tank filling and emptying processes at the Delhi Technological university compound. The simulation of the design has also been discussed together with its performance.

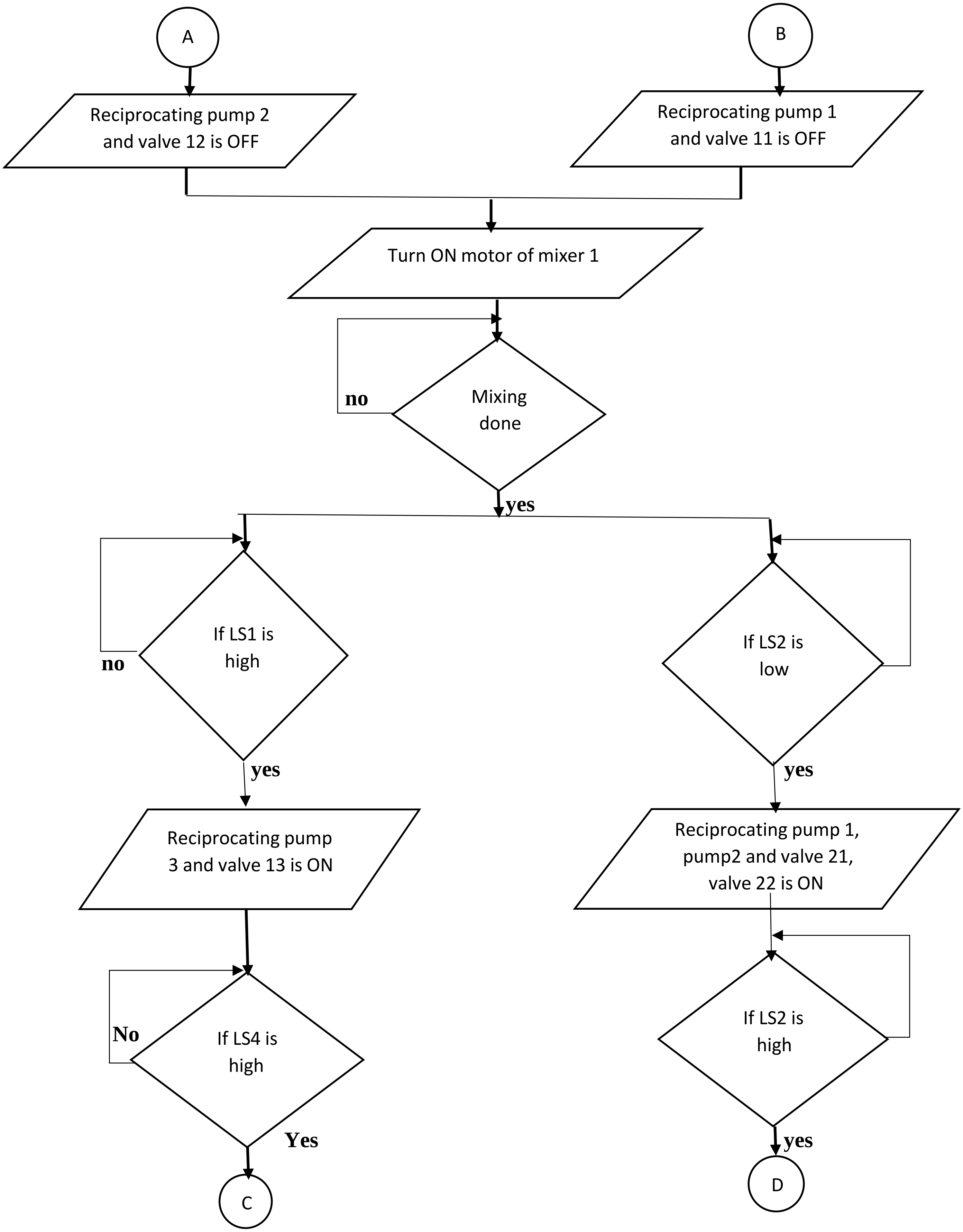
4.1.1 SCADA

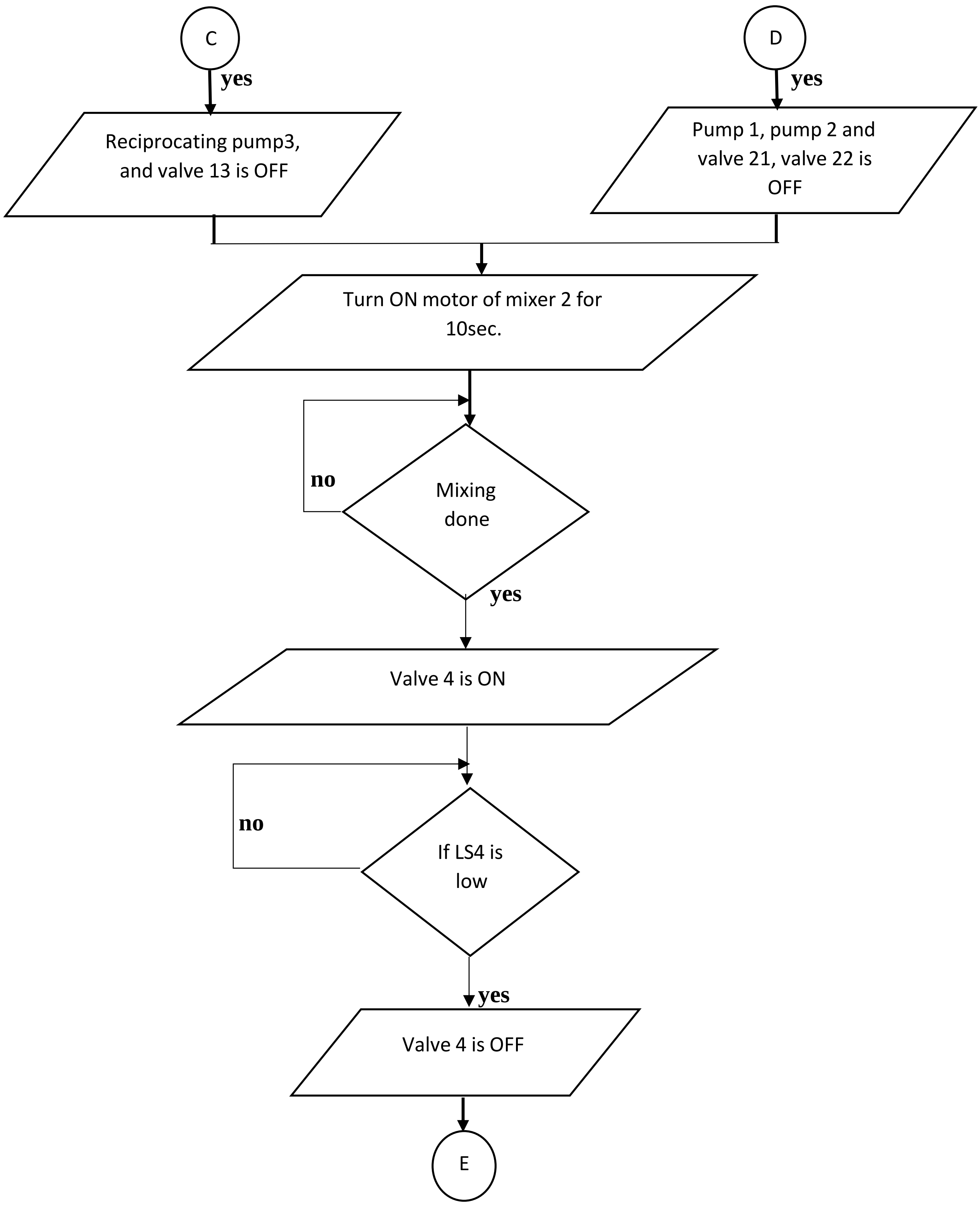
SCADA stands for "Supervisory Control and Data Acquisition. As the name indicates, it is not a full control system, but rather focuses on the supervisory level. As such, it is a pure software package that is positioned on top of hardware to which it is interfaced, in general via Programmable Logic Controllers (PLCs), or other commercial hardware modules. Previously without SCADA an industrial process was entirely controlled by PID & microcontrollers program PLC, CNC (Computer Numerical control) which it is a type of application used to control a multi-axis machine tool for example milling machine and is in the execution of the program, in addition with that PLC is sequential but CNC is conditional. These programs were either written in assembly language or relay logic without any monitoring. Using SCADA we can visualize the graphical view of the entire process and also control from the remote place or control room. SCADA is a software through which we can create a visualization of any industrial process.

4.2 Flowchart

The flow chart in Figure below explains the process steps for the automated mixing of chlorination and tank filling system using Programmable logic control


Start
Check the outlet of tank 3
Check the inlet tank 1
NO
If LS 3 of chlorine tank 3 is high
If LS 1 of water tank 1 is low
NO
yes
yes
Reciprocating pump 2 and valve 12 is ON
Reciprocating pump 1 and valve 11 is ON
no
If LS1 is high
yes
A
B


A
B
Reciprocating pump 2 and valve 12 is OFF
Reciprocating pump 1 and valve 11 is OFF
Turn ON motor of mixer 1
Mixing done
no
yes
If LS1 is high
no
yes
If LS2 is low
yes
Reciprocating pump 3 and valve 13 is ON
Reciprocating pump 1, pump2 and valve 21, valve 22 is ON
If LS4 is high
No
Yes
If LS2 is high
yes
C
D


C
yes
Reciprocating pump3, and valve 13 is OFF
D
yes
Pump 1, pump 2 and valve 21, valve 22 is OFF
Turn ON motor of mixer 2 for 10sec.
no
Mixing done
yes
Valve 4 is ON
no
If LS4 is low
yes
Valve 4 is OFF
E

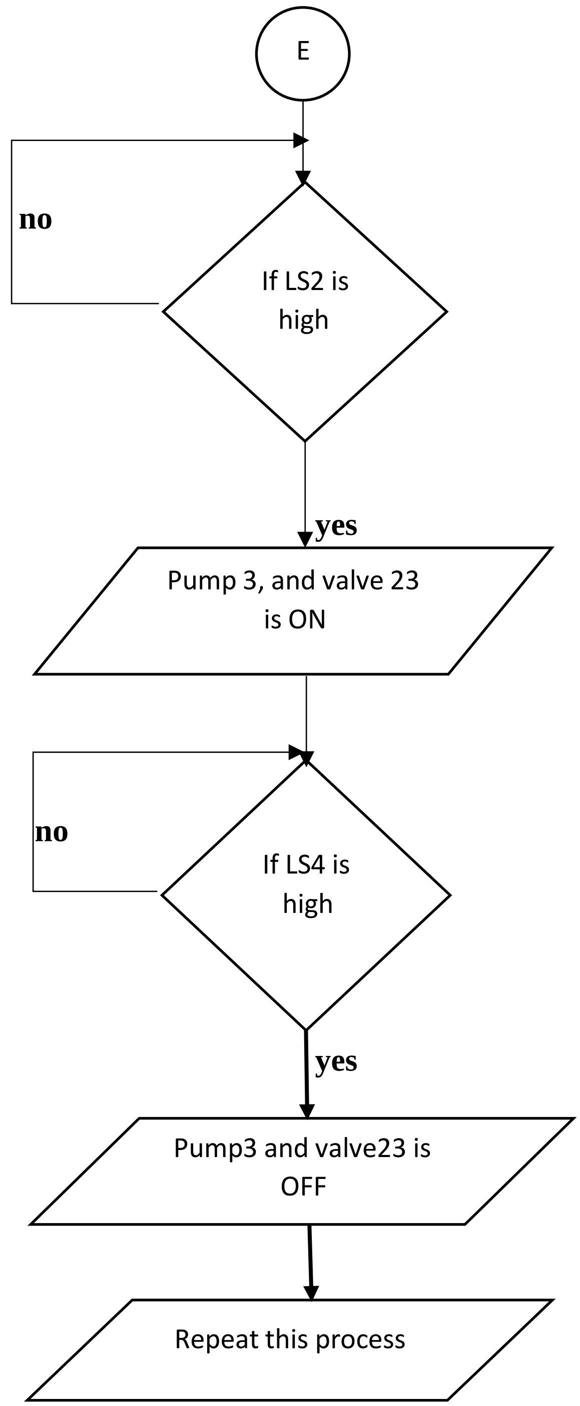


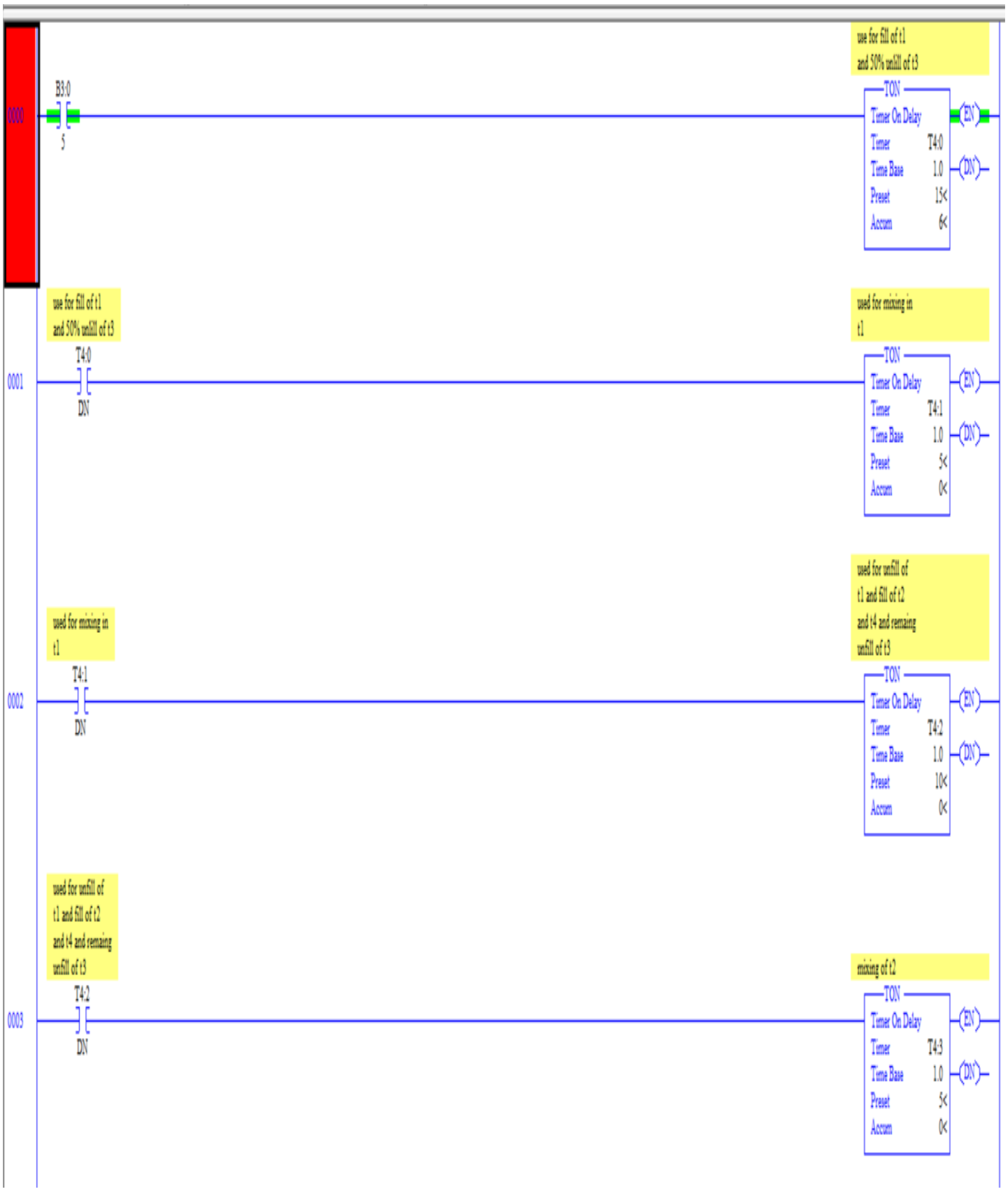
Figure 4 1: Flowchart of Main Program

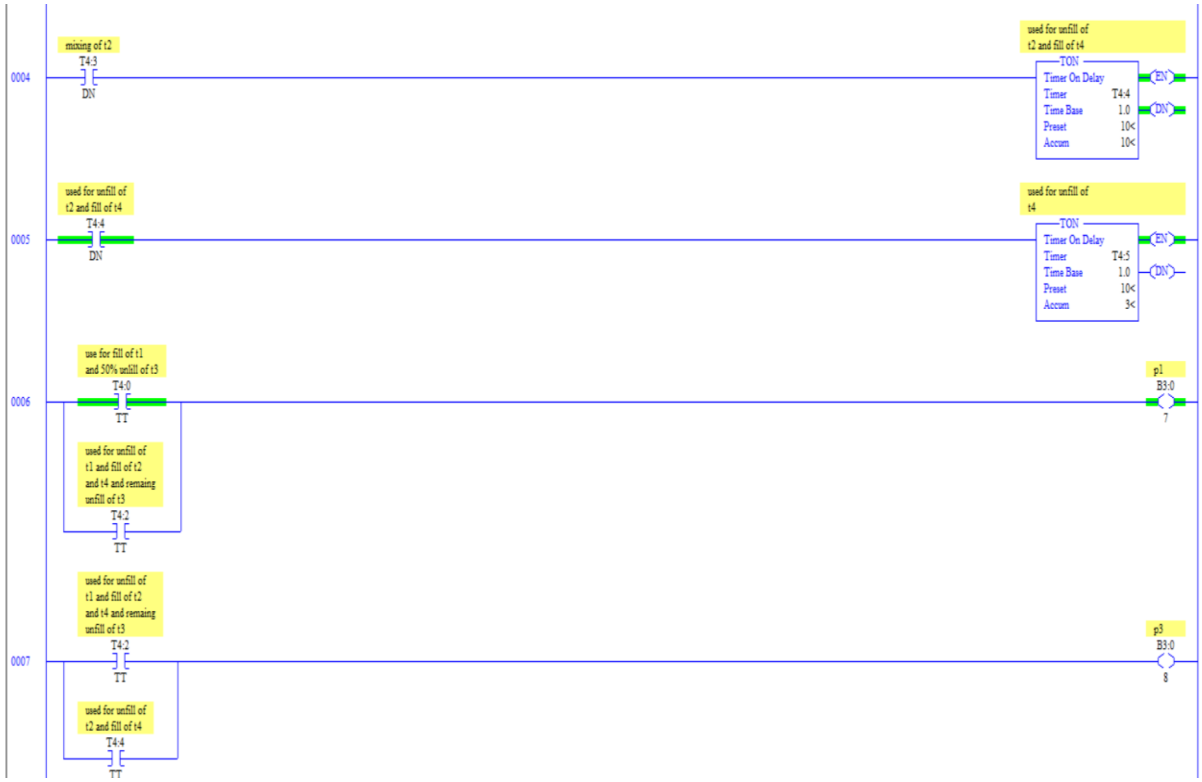
4.3 Algorithm of The Process

1. Start
2. Checking the inlet of tank 1 and outlet of tank 3
3. If *LS 1* is low and *LS 3* is high then pump 1, pump 2 and valve 12, valve 11 is ON else go step 2.
4. If LS 1 high then pumps 1, pump 2 and valve 12, valve 11 is OFF. Else go step 3.
5. If the water and chlorine in tank 1 then turn ON mixer 1 for 30sec. else repeat this step.
6. If LS 1 high and LS 22 is low then pump 1, pump 2, pump 2 and valve 13, valve 21, valve 22 is ON. Else go step 5.
7. If LS 4 and LS 2 high then pump 1, pump 2, pump 3 and valve 13, valve 21, valve 22 is OFF. Else go step 6.
8. If the water and chlorine in tank 2 then turn ON mixer 2 for a 30sec.else repeat this step
9. If the mixing process is done the valve 4 is ON
10. IF LS 4 is low then valve 4 is OFF.
11. If LS 2 is high then pump 3 and valve 23 is ON.
12. If LS 4 is high then pump 3 and valve 23 is OFF.
13. Repeat the process.

4.4 Ladder Diagram

The Ladder logic in the PLC is actually a computer Program that the user can enter and change. The ladder diagram language is basically a symbolic set of instructions used to create the controller program. These symbols are arranged to obtain the desired control logic that is to be entered into the memory of the PLC. A ladder diagram consists of individual rungs just like a real ladder. A line showing an input or several inputs and an output is known as a rung. Ladder logic programing is a graphical representation of the program designed to look like relay logic. Ladder diagrams are specialized schematics commonly used to document industrial control logic systems. They are called “ladder” diagrams because they resemble a ladder, with two vertical rails (supply power) and as many “rungs” as there are control circuits to represent. Ladder logic is widely used to program PLCs, where sequential control of a processor manufacturing operation is required. Ladder logic is useful for simple but critical control systems.


0000
B3:0
5
use for fill of t1
and 50% unfill of t3
TON
Timer On Delay
Timer T4:0
Time Base 1.0
Preset 15<
Accum 6<
EN
DN
0001
use for fill of t1
and 50% unfill of t3
T4:0
DN
used for mixing in
t1
TON
Timer On Delay
Timer T4:1
Time Base 1.0
Preset 5<
Accum 0<
EN
DN
0002
used for mixing in
t1
T4:1
DN
used for unfill of
t1 and fill of t2
and t4 and remaing
unfill of t3
TON
Timer On Delay
Timer T4:2
Time Base 1.0
Preset 10<
Accum 0<
EN
DN
0003
used for unfill of
t1 and fill of t2
and t4 and remaing
unfill of t3
T4:2
DN
mixing of t2
TON
Timer On Delay
Timer T4:3
Time Base 1.0
Preset 5<
Accum 0<
EN
DN



0004
mixing of t2
T4:3
DN
used for unfill of t2 and fill of t4
TON
Timer On Delay
Timer T4:4
Time Base 1.0
Preset 10<
Accum 10<
EN
DN
0005
used for unfill of t2 and fill of t4
T4:4
DN
used for unfill of t4
TON
Timer On Delay
Timer T4:5
Time Base 1.0
Preset 10<
Accum 3<
EN
DN
0006
use for fill of t1 and 50% unlill of t3
T4:0
TT
used for unfill of t1 and fill of t2 and t4 and remaing unfill of t3
T4:2
TT
p1
B3:0
7
0007
used for unfill of t1 and fill of t2 and t4 and remaing unfill of t3
T4:2
TT
used for unfill of t2 and fill of t4
T4:4
p3
B3:0
8

0008
used for unfill of t1 and fill of t2 and t4 and remaing unfill of t3
T4:2
TT
v13
B3:1
2
0009
used for unfill of t2 and fill of t4
T4:4
TT
v23
B3:1
3
0010
use for fill of t1 and 50% unlill of t3
T4:0
TT
used for unfill of t1 and fill of t2 and t4 and remaing unfill of t3
T4:2
TT
p2
B3:0
9
0011
use for fill of t1 and 50% unlill of t3
T4:0
TT
v11
B3:0
10
0012
use for fill of t1 and 50% unlill of t3
T4:0
TT
v12
B3:0
11
0013
used for unfill of t1 and fill of t2 and t4 and remaing unfill of t3
T4:2
TT
v21
B3:0
12

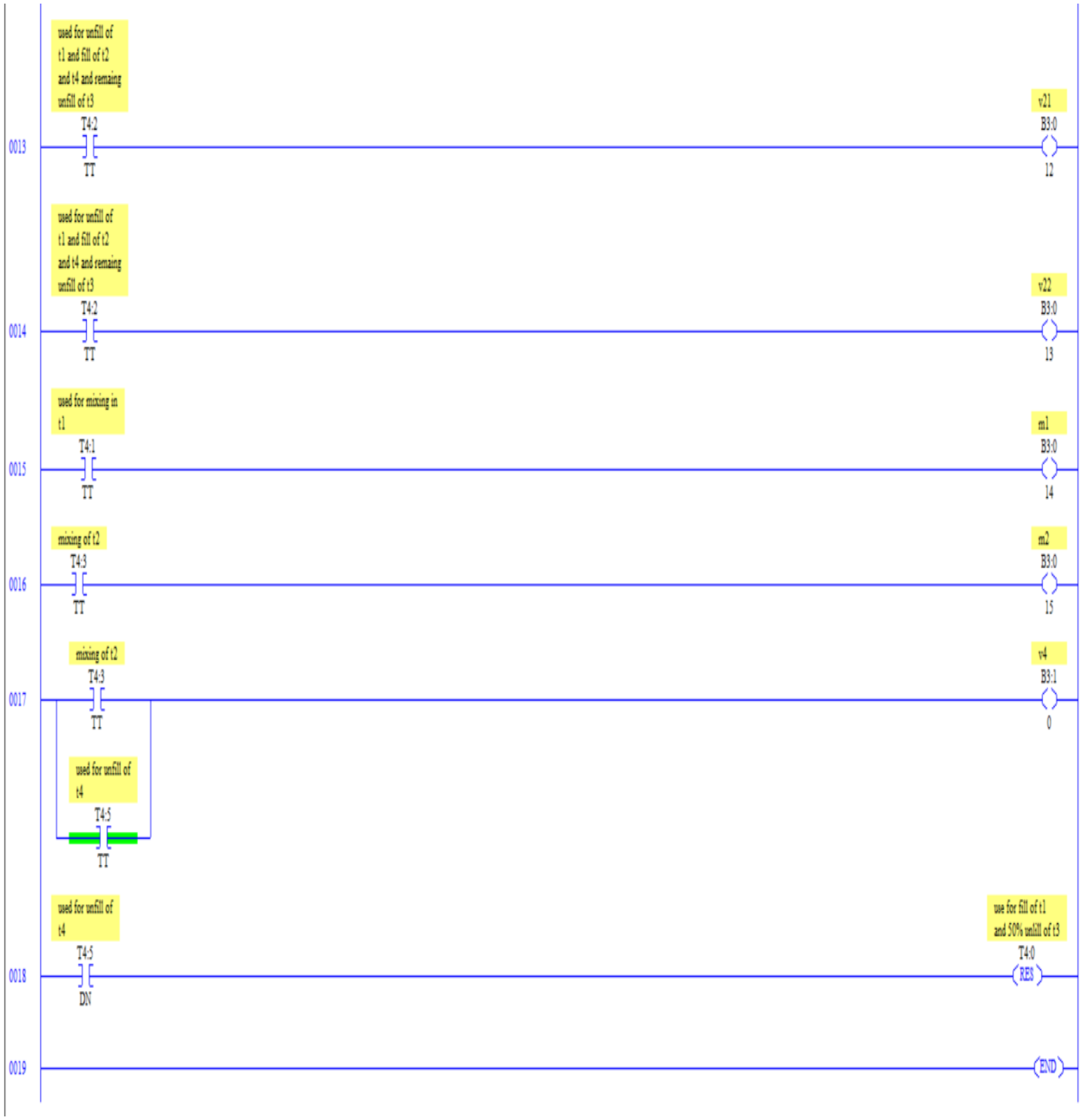


Figure 4 2: Ladder Diagram In RSlogix 500

4.5 Simulation of The Water And Chlorine Tank Filling System

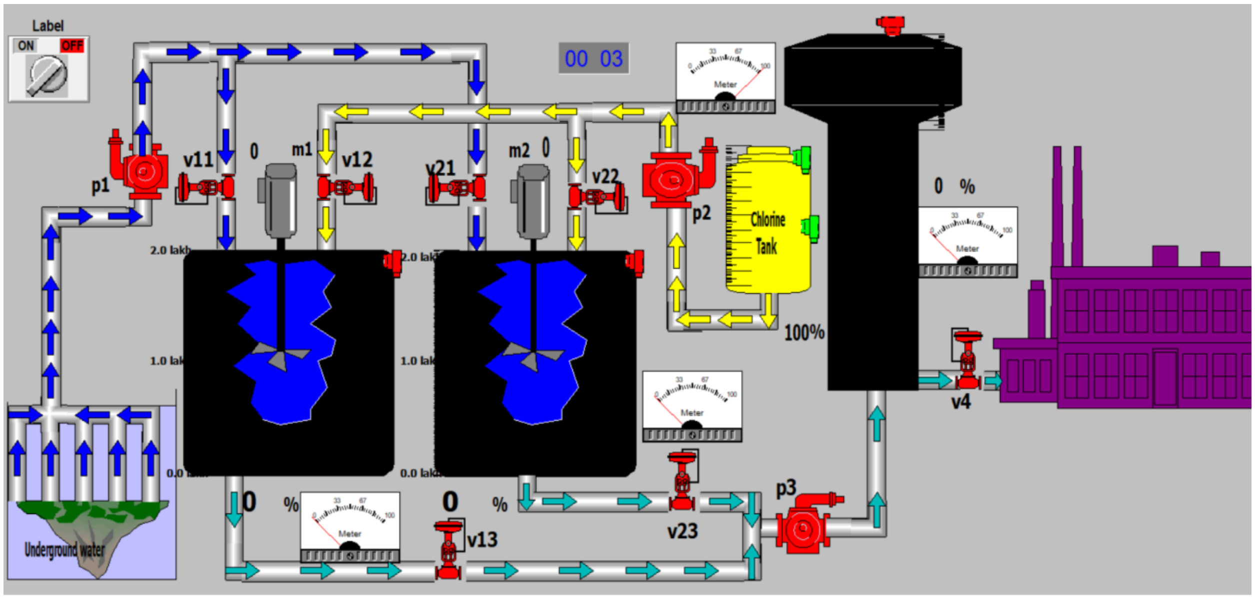


Figure 4 3: Simulation Display before Switch is ON

When the switch is turned ON ones then pump 1, pump 2 and also the two valves which allows water and chlorine inlet into underground tank t1 will be open Since some amount of chlorine is already transferred into the first tank, this means the chlorine tank is drained until it reaches 50% and untreated water from underground water pumping station fill the first underground tank, this process is continued until the level sensor of t_1 is high. Figure4.4: is a SCADA representation for the start of the automation in the filling process of the first tank.

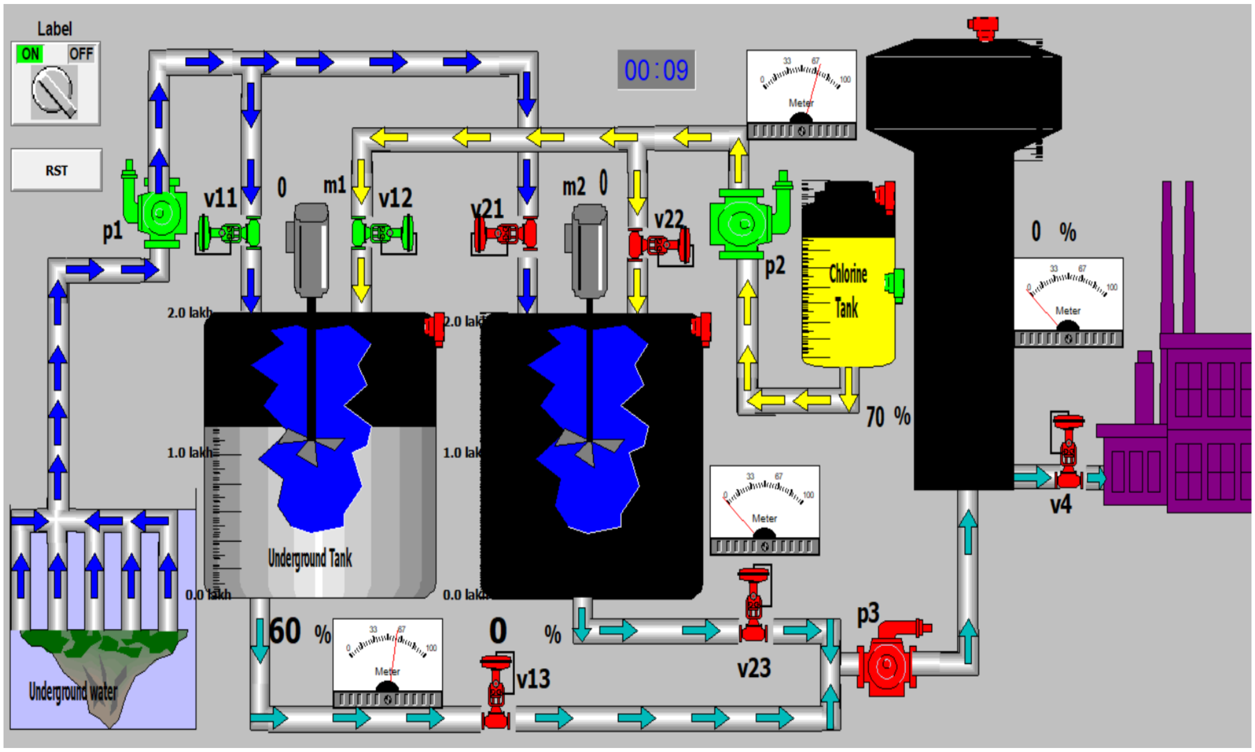


Figure 4 4: Simulation Result of Inflow to Tank One

When the level sensor output of tank 1 is getting high then the two pumps (P_1, P_2) and the two valves V_{12} and V_{11} will be closed. Based on the sensor on the first tank, the mixer 1 is active for the given specific time in that time all valve and pump is in off state. The first mixer motor will start running at the same time all valves and pumps are in OFF state. And this shown in Figure below.

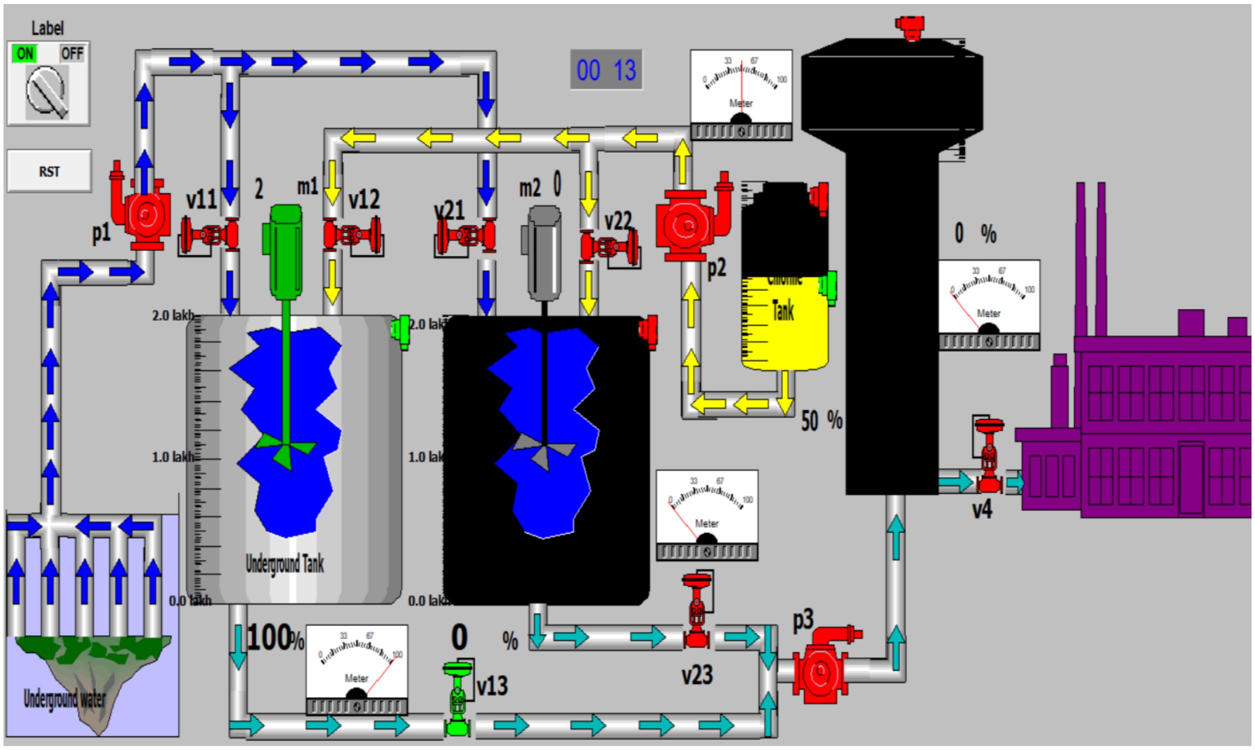


Figure 4 5: Contact of LS1 and Mixer One is ON

After completion of mixing chlorine with water then former untreated water changed into treated water, then this water goes to the overhead tank (t_3) for this process valve (V_{13}) and pump three (P_3) must be in ON condition. Simultaneously the remaining chlorine in tank three is transferred to tank two. In addition with that untreated water is also inter into tank two and tank four is filled until level sensor output of tank four is going high.

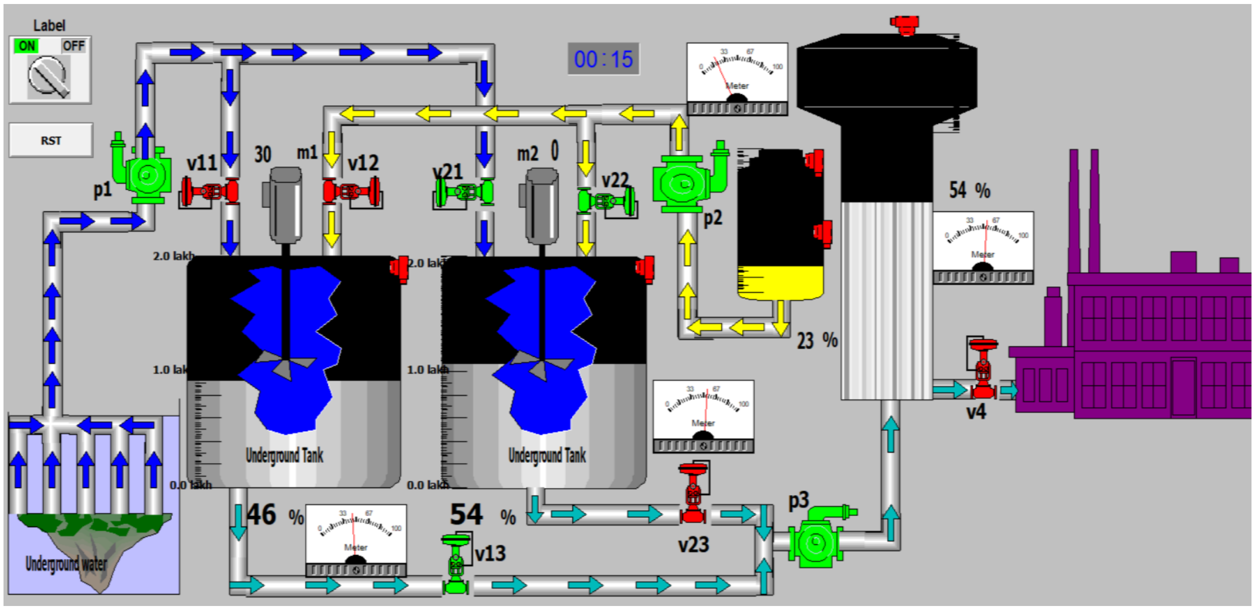


Figure 4 6: Tank One Outlet Valve Open and Pump Three ON

The above process is continued until tank four is full, this means level sensor output in tank four is going to be high, at the same time to fill tank two pumps 1, pump 2 and the two inlet valves V_{21} and V_{22} for tank two must be open until level sensor output of tank two is going high, when the level sensor output of tank four and tank two is high then all inlet valve for each tank and all three pumps come to OFF state.

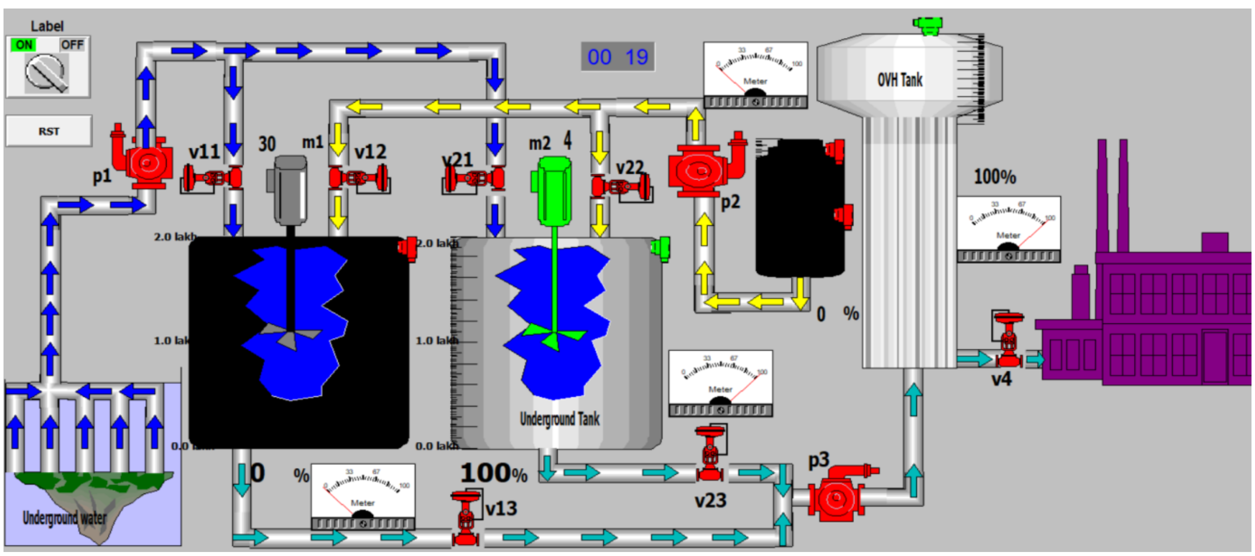


Figure 4 7: Contact of LS2 and Mixer Two is ON

When the level sensor output of tank two is high, then motor of mixer 2 starts running for the purpose of mixing chlorine with water. Then the water which is treated and stored in the overhead tank is distributed to consumers inside the compound of a college. Then it's mandatory to fill the overhead tank again by treated water from tanker two since tank 2 is full and it supply's the water to tank four. The process is proceed when pump 3 (P_3) and the valve (V_{23}) must be in ON state then tank 4 will be filled again. The tank is filled until the level sensor output of tank four is goes high. Immediately after the sensor output is going to high. Then again the process is continued and repeat itself.

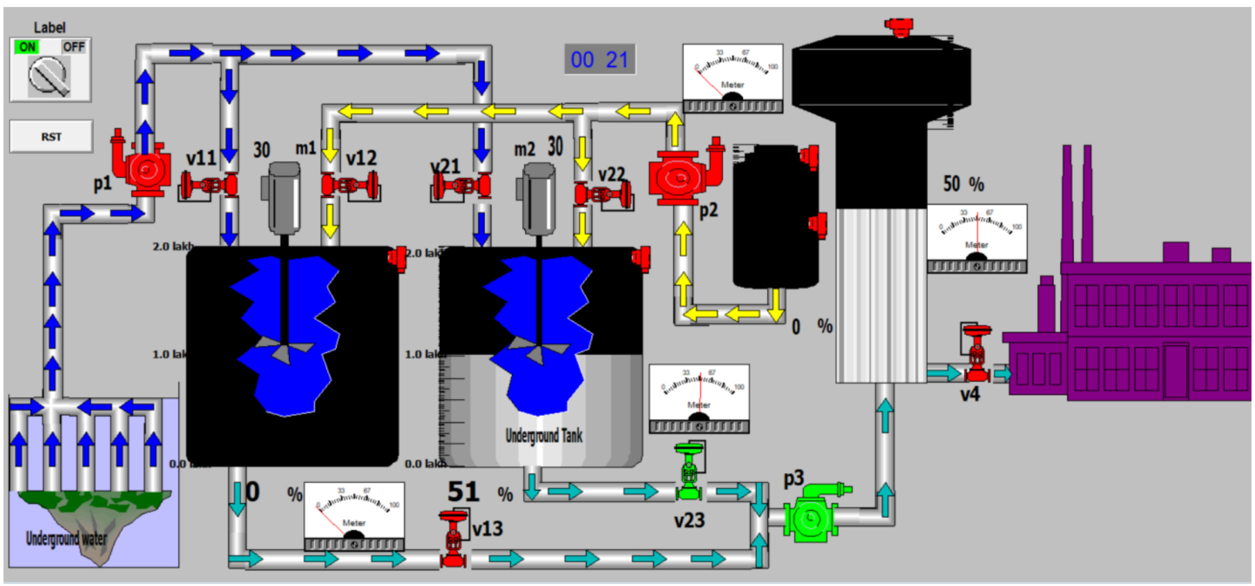


Figure 4 8: Tank Two Outlet Valve Open and Pump Three ON

The two underground tanks each have a capacity to hold 200,000L. Then to fill those tanks it takes 4hrs, this means in each second 13.9L of water is accumulated in each tank. And the same amount of treated water is accumulated in the overhead tank. And the all process repeated itself.

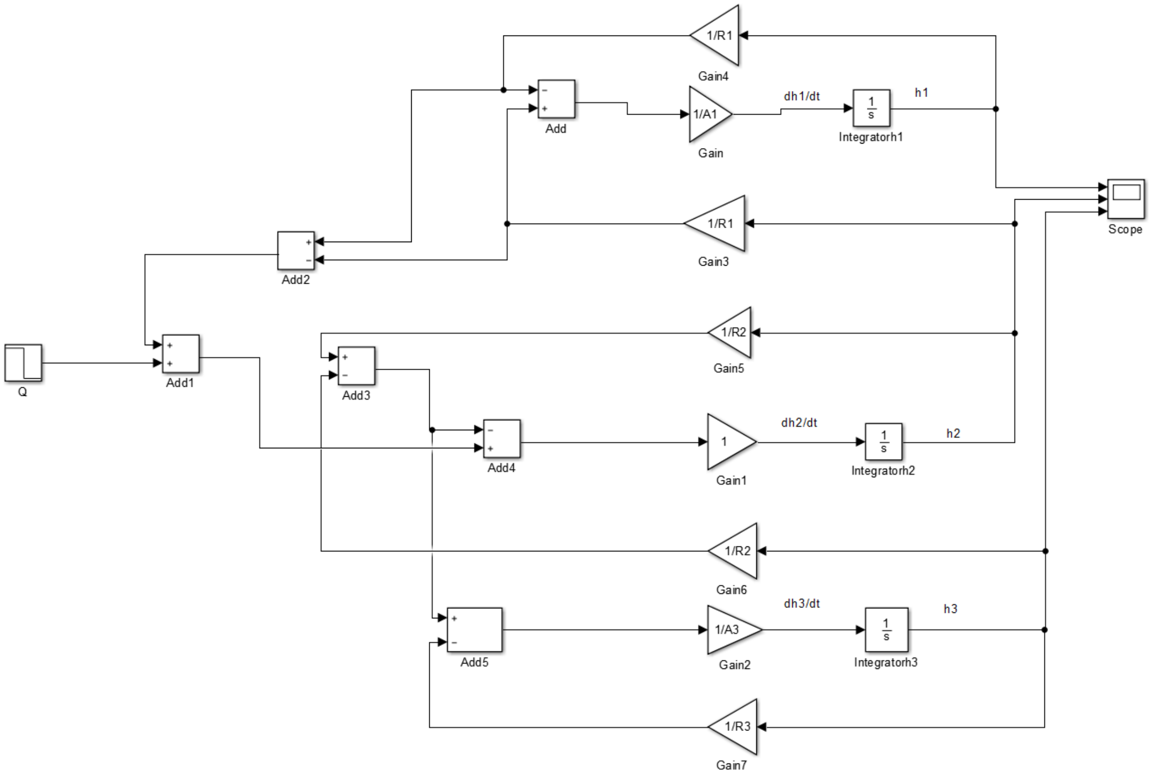
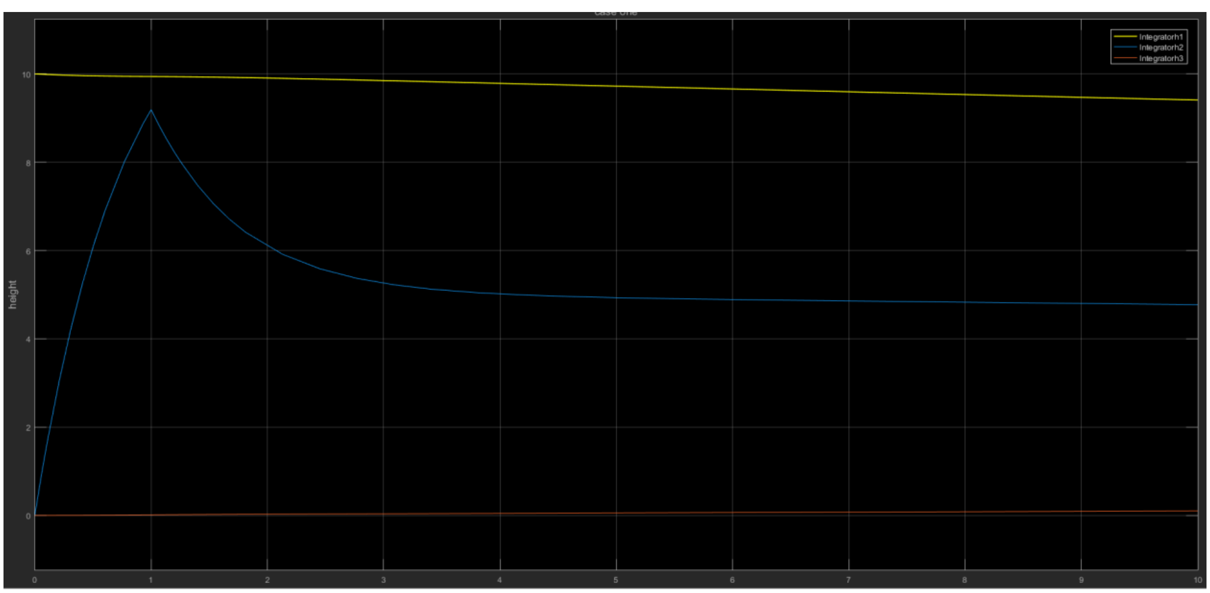


Figure 4 9: Simulink Model of The Chlorination Process



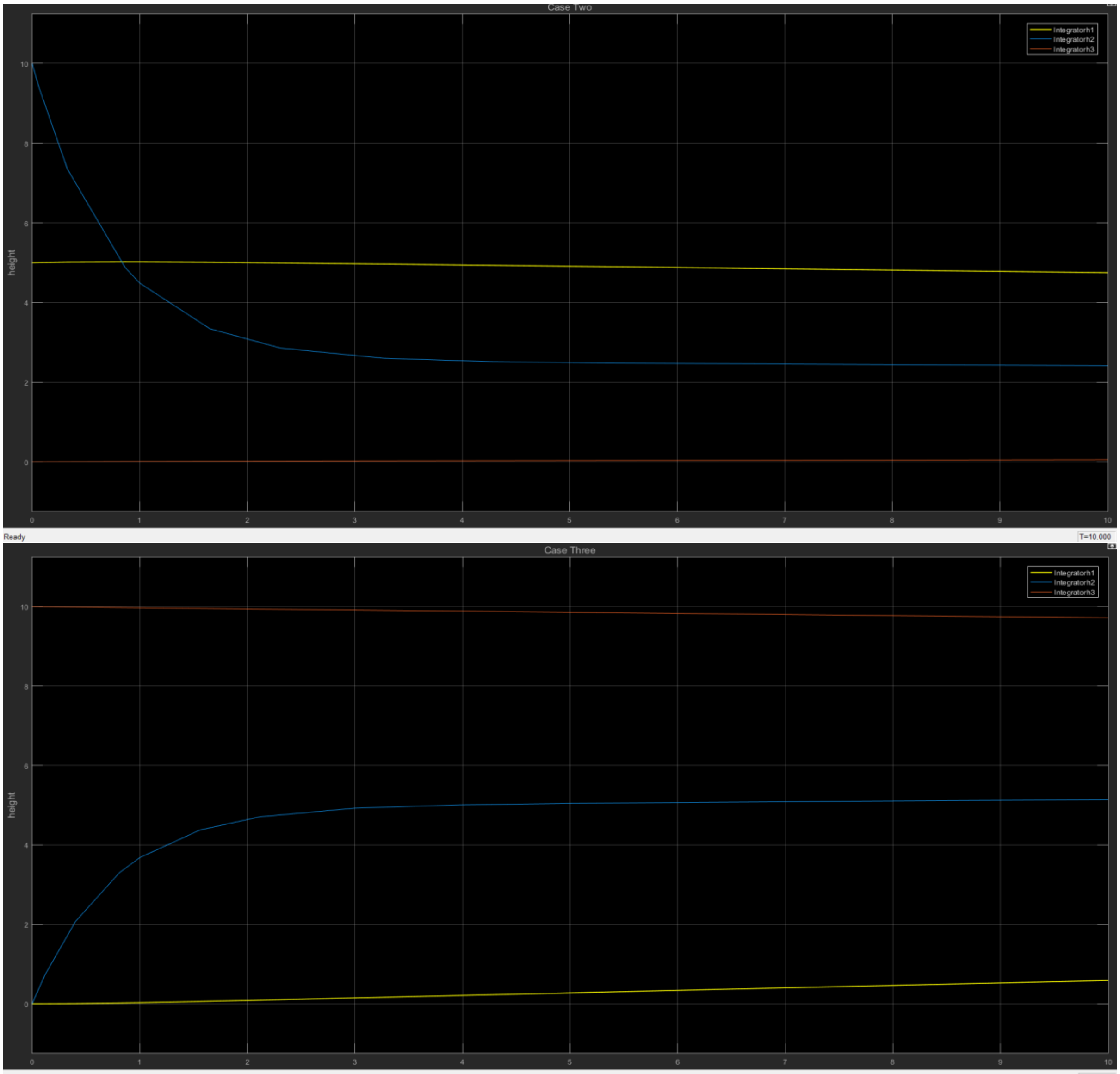


Figure 4 10: The Simulink Output of Height V_s Time

Based on different input initial values, there are three outputs which are represented the three different colour line in a result display. The yellow one represents the chlorine level inside tank one, blue line represent chlorine and the underground water level inside tank two and the brown represents the treated water level inside the overhead tank or tank three. So based on the input and initial value of the integrator in Simulink we will get different outputs results. In the first action the chlorine tank height is start decreasing and tank two or the tank which have chlorine and untreated water liquid level come to high because the tank gets the water directly from underground source, in the next process the chlorine level stays in half of its original height at that time the tank level which has the treated water will deteriorate, then the third tank water level increased up to its maximum, then one's reach in this level then out valve of tank three is open and the water level inside tank three decreases. In the same time, the second tank gets water again and the process continued and repeat itself.

CHAPTER 5

CONCLUSION AND FUTURE WORKS

5.1 Conclusion

This report investigates a designing process of PLC based chlorination control system. Manualization of some parts of water purification processes exposes the process to some shortcomings. Manually operated systems require frequent human contact with the system so tend to put pressure on persons working with it to be precise in all details of their work and at all times. However, it must be noted that human's aren't consistent with what they do with their hands and minds. The effective and efficient running of such manual systems is heavily dependent on individuals and therefore management shoulder the responsibility to run training continuously for staff to keep them motivated and to ensure they are following the correct procedures with a correct amount.

Since there is no proper level indicator in all tanks so monitoring of all plant is difficult. To give a solution for such cases so An automated system of chlorination and tank filling at a water processing unit using a PLC system has been designed and implemented through simulation. The simulation clearly shows that the automation of chlorination and water tank filling will prevent or minimize the following:

- The incidence of tank overflow since water tank filling is automatically controlled
- The incidence of pump overheating since the pump will not run dry.
- The stress associated with manual operation and the human dependant of the system.
- This system is applicable to food and beverage and chemical producing factories
- To maintain the proper amount of chlorine which is added to water with a specified time.

5.2 Future Works

In this project, the PLC-based control system is used to maintain the chlorination of water at a constant level. The simulation and experimental results show that the PLC and SCADA contributes as good and stable performance. However, the weak point is that I only focus on the final result but ignore the system disturbance and efficiency, such as responding time, air consumption, and power consumption and so on. As a result, further study on improving system efficiency is required.

Next, due to some equipment shortage and other limitation, this project only discusses a simple simulation control problem. However, in real industries, a control problem is more complicated. Therefore, a couple of practical chlorination tank interacting system design and control should be studied in the future.

APPENDIX :

Window Script

Script on Show:

```
aa=1;
sw1=0;
p0=0;
p1=0;
p2=0;
p3=0;
v11=0;
v12=0;
v13=0;
v21=0;
v22=0;
v23=0;
v3=0;
v4=0;
t1=0;
t2=0;
t3=100;
t4=0;
m1=0;
m2=0;
tmr1=0;
tmr2=0;
ab=0;
ac=0;
rst=0;
s1=0;
s2=0;
s3=0;

s32=0;
s4=0;
```

Script while showing, every 100 msec:

```
IF sw1 == 1 AND aa ==1 THEN

  p1 = 1;

  v11 = 1;
```

```
  v12 = 1;
  p2 = 1;
ENDIF;
 IF sw1 == 1 AND p1 == 1 AND p2 == 1 AND v11 == 1 AND v12 ==1 AND t1 < 100 AND t3
> 50 THEN
    t1 = t1 + 2;
    t3 = t3 - 1;
 ENDIF;
 IF t1 == 100 THEN
    p1 = 0;
    v11 = 0;
    v12 = 0;
    p2 = 0;
    m1 = 1;
    s1=1;
 ELSE
    s1=0;
        ENDIF;

IF t3==100 THEN
    s3=1;
 ELSE
    s3=0;
 ENDIF;
 IF t3 >= 50 THEN
    s32=1;
 ELSE
```

```
    s32=0;
   ENDIF;
IF m1==1 AND tmr1<30 THEN
    tmr1=tmr1+1;
 ENDIF;
IF sw1==1 AND tmr1 == 30 THEN
         p1 = 1;
         p2 = 1;
         v21 =1;
         v22 = 1;
         aa =0;

     ENDIF;
     IF sw1==1 AND aa ==0 AND t3>0 AND t1>0 AND t2<100 AND t4<100 THEN
     t1 = t1 - 2;
     t2 = t2 +2;
     t3 = t3 -1;
     t4 =t4 +2;
      p3 = 1;
      v13=1;
 ENDIF;
 IF sw1==1 AND t2 == 100 THEN
         p1 = 0;
         p2 = 0;
         v21 =0;
         v22 = 0;
         m2 = 1;
```

```
        p3 = 0;
        s2=1;
        v13=0;
      ELSE
        s2=0;
    ENDIF;
IF t4 == 100 THEN
      s4=1;
    ELSE
      s4=0;
      ENDIF;

 IF sw1==1 AND m2==1 AND tmr2<30 THEN
   tmr2=tmr2+1;
 ENDIF;

 IF sw1==1 AND tmr2 == 30 AND t4> 0 THEN
 t4 = t4 - 1;
 v4= 1;
ENDIF;

IF sw1==1 AND t4 ==0 THEN
v4 = 0;
ENDIF;
```

```
IF sw1==1 AND tmr2==30 AND t4==0 THEN
Ab =1;
ENDIF;
IF sw1==1 AND ac==1 AND tmr2==30 AND t4>0 THEN
 t4 = t4 - 1;
 v4= 1;
ENDIF;

IF ab==1 THEN
t2= t2 - 1;
t4=t4+2;
p1 =0;
p2=0;
v21=0;
v22=0;
p3= 1;
 v4= 0;
v23=1;
ENDIF;

IF sw1==1 AND tmr2 ==30 AND t2==0 THEN
aa=1;
p0=0;
p1=0;
p3=0;
p2=0;
v23=0;
```

```
v11=0;
v12=0;
v21=0;
v22=0;
v3=0;
v4=0;
t1=0;
t2=0;
t3=100;
t4=0;
m1=0;
m2=0;
tmr1=0;
tmr2=0;
ab=0;
ENDIF;
IF rst==1 THEN
    sw1=0;
    aa=1;
p0=0;
p1=0;
p3=0;
p2=0;
v23=0;
v11=0;
v12=0;
v21=0;
```

```
v22=0;
v3=0;
v4=0;
t1=0;
t2=0;
t3=100;
t4=0;
m1=0;
m2=0;
tmr1=0;
tmr2=0;
ab=0;
 ENDIF;
```

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