Simulation of Water Supply Pump System with PLC based Control

Sudirman[a], I Nyoman Gede Baliarta[b], Putu Darmawa[c] and D. G. Agustriputra[d]
Mechanical Department, Bali State Polytechnic, Jl. Kampus Bukit Jimbaran, Badung-Bali, Indonesia

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Abstract: This paper discusses the simulation of the control of a clean water pump system for supply to the building. There are several systems in the field, generally using conventional controls. The system uses a contactor and WLC. The simulation system is made with 3 tanks, namely tower tank, consumption tank and ground tank. This simulation control system using PLC control. The PLC used is the Zelio SR3PACKBD Smart Relay. The inputs are stainless steel rod sensors in the tower tank and ground tank. The outputs are 2 pump motors and a solenoid valve. The PLC program used is Ladder diagram with ZELIO SOFT 2 program. Pumps 1 and 2 will operate from low level to middle level. When middle level to high level only pump 1 operates. Meanwhile, when the hight level there is no pump operating. The test results show satisfactory results according to the program made, and the equipment required is very simple compared to conventional controls.

1 INTRODUCTION

The main objective in designing a water supply system for high-rise buildings is to ensure adequate water supply at all times, both in terms of required pressure and discharge for all outlets, fixtures and equipment. In addition, also to achieve energy saving, efficient and energy saving. (Rodrigues, Fernanda.2011).

Bali as a foreign and domestic tourist destination, must provide adequate accommodation to ensure the comfort of International and Domestic guests, during their stay in Bali. Hotels and villas grow moldy anticipating the arrival of guests. Hotel and Villa building facilities adjust the status of the Hotel and Villa. The basic facilities for hotels and villas are the availability of clean water whenever needed.

Disruption of the clean water supply system in a hotel will also disrupt the comfort of the guests staying and will reduce the credibility of the hotel, which in turn will reduce the hotel occupancy rate. For this reason, a reliable clean water supply system is needed to meet the basic needs of guests, so that the hotel's credibility is maintained.

There are many clean supply pump systems installed in hotels depending on the hotel owner's request. The supply system uses a tower tank and distribution by gravity and the supply system uses a ground tank and distribution uses a pump. Each system has its advantages and disadvantages. (Pears, A., 2002).

Building utilities consist of mechanical and electrical systems. One of the sub-mechanical systems is a clean water supply system. Clean water supply systems installed in hotels mostly use 2 or 3 supply pumps. For hotel or villa locations with flat locations, most pumps supply directly to the end-user by using pressure as the on-off control of the pump. Meanwhile, hotels/villas with high-rise locations use tower tanks for water distribution to end-users. (Vinita Chanan, 2013).

The Clean Water Distribution System in Multi-story Buildings by Wujek, Joseph B. (2012) is divided into several systems, namely:

[a] https://orcid.org/0000-0003-2816-523X
[b] https://orcid.org/0000-0003-3286-2732
[c] https://orcid.org/0000-0001-7621-6420
[d] https://orcid.org/0000-0002-9422-7876

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1.1 Up-feed System

In this system, the distribution pipe directly from the ground tank with the pump is directly connected to the main pipe for providing clean water to the building, in this case using the full capacity of the pump. Due to the limited pressure in the pipe and the limited size of the branch pipe from the main pipe, this system is especially applicable for housing and small low-rise buildings (Alfred, 1984). The manufacture is relatively cheap but the pump breaks quickly.

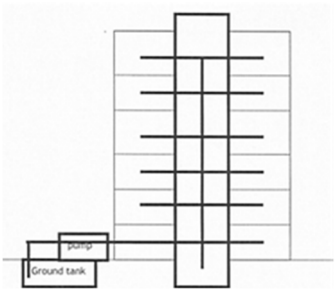

Figure 1: Up Feed System.

The disadvantages of this system are:

a. pump working continuously
b. The height is limited because the strength of the pipe is limited to anticipate the pressure of the water inside.

1.2 Down Feed System

In this system, water is first stored in the ground tank, then pumped to the upper tank which is usually installed on the roof or on the highest floor of the building. From here the water is distributed throughout the building. This roof tank system is quite efficient to implement because:

a. As long as the water is used, the pressure changes that occur in the plumbing tool are insignificant.
b. The pump system that raises water to the top tank works automatically in a very simple way so that difficulties can be suppressed.
c. Tank maintenance is very simple compared to for example a pressure tank.

The advantages of this down feed system are:

a. The pump does not work continuously so it is more efficient and durable.
b. Clean water is always available at all times.
c. No need for automatic pump.

The disadvantages of this system are :

a. Requires additional costs for the procurement of additional tanks.
b. Adding weight to the structure of the building.
c. Increase maintenance costs.

For long-term use, this system is effective and efficient even though it is expensive to manufacture. If the number of floors is very large, the water pressure in the pila is very high, so that the pipe can burst due to high pressure (every seven meters of pressure the pipe receives a pressure of 1 atmosphere), then this down feed system is equipped with: Spillback Tank

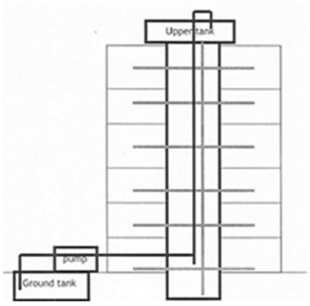

Figure 2: Down Feed System.

1.3 Spillback Tank

In the form of auxiliary tanks that are placed on each particular floor. Each tank is equipped with a pressure control valve. When the water pressure is high, the valve will close. The most important thing in this roof tank system is to determine the location of the tank whether it is installed in the ceiling, on the roof, or installed in a special tower. This determination must be based on the type of plumbing device installed on the highest floor of the building and which determines the highest working pressure.

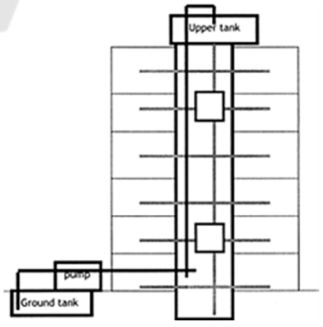

Figure 3: Down Feed System With Spill Back Tank.

The working principle of this system is as follows:

a. Water that has been pumped in a spill back tank that is on several floors so that the air inside is compressed.

b. The water in the tank flows through the building's distribution system. The pump is regulated automatically by a relative that drives the electric motor switch that drives the pump.
c. The pump stops working when the tank pressure has reached the maximum set limit and works again after the tank pressure reaches a predetermined minimum limit as well. This area of pressure fluctuation is usually set between 1.0 -1.5 kg/cm'.

1.4 Presure Reducer Valve (PRV, Katup Reduksi Tekanan)

On a relatively large number of floors, there is a possibility that the pressure in the pipe is very high so it needs to be reduced with a valve. These valves are placed on certain floors.

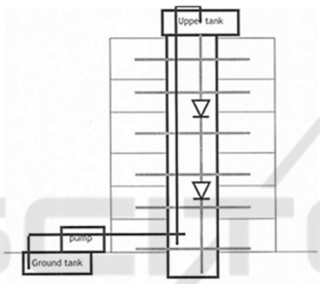

Figure 4: Down Feed System With Pressure Reducer Valve.

1.5 Some Systems Applied in Hotels

Surveys to hotels that have been carried out to find out directly the installation of clean water supply systems in hotels with regard to this research, namely:

1.5.1 Double-Six.Luxury Hotel Seminyak

The installation of a clean supply system at Double-Six.Luxury Hotel Seminyak uses 3 pumps. The three pumps are alternately controlled by the Control Panel. This installation is without tower tank. From the pump, water is distributed directly to the user at a pressure of 3.5 Bar, using a Digital Pressure Transmitter.

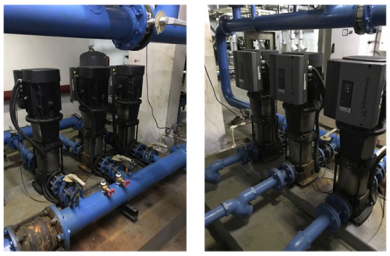

Figure 5: The installation of a clean supply system at Double-Six.Luxury Hotel Seminyak uses 3 pumps.

Figure 6: Control Panel of the clean water supply system at Double-Six Luxury Hotel Seminyak.

1.5.2 Estate Villa Four Seasons Resort Jimbaran

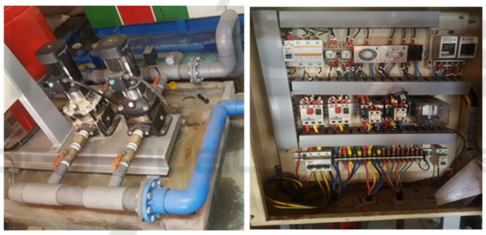

Figure 7: Plumbing installation and control panel of clean water supply system Estate Villa Four Seasons Resort Jimbaran.

The clean water supply system at Estate Villa Four Seasons Resort Jimbaran uses 2 pumps. Switch on duty pump from pump 1 to pump 2 using a switch over relay. Water is distributed directly to the end-user of the pump using a pressure switch for on-off.

1.5.3 Luna 2 Hotel Seminyak

Clean water is pumped from the ground tank to the tower tank, the pump turns on and off based on the flow to the end user by gravity. On and off the supply pump to the tower using WLC based on the water level in the tower tank

Figure 8: Installation of a clean water supply system and tower tank at Luna 2 Hotel Seminyak.

Pump control that has been widely applied now is using PLC, as done by Indra Saputra et al, (2013). They designed the Water Level Control using an Omron Sysmac C200H PLC equipped with Wonderware InTouch 10.5 SCADA Software. Dendin Supriadi, (2015), made a water level control system using an ultrasonic sensor based on PLC (Programmable Logic Controller). For monitoring and control interfaces on this system, the Omron NB7W-TW00B HMI is used, so that all events that occur in the system can be directly controlled and monitored. in real time. This water level control system has two controls, namely automatic control and manual control.

Sri Kusumastuti and Suryono (2015), made a practical teaching aid for water level control in reservoirs and tanks using PLC. With an output in the form of a water pump and a solenoid valve. Gebremaryam Alem and Dr. Krishnanaik Vankdoth (2016), designed a water level control using PLC. With input in the form of electronic sensors in the form of limit switches and outputs in the form of pump motors and solenoid valves, and they create Ladder logic diagram programs using the Softcomfort Logo.

Paper written by Cosmina Illes et al, (2017), about water level control system using PLC and wireless sensors. The aim of the paper is to present the cheapest cost method for water level control using wireless.

For this water level control simulation project, the Schneider Smart Relay Zelio Logic SR3PACKBD PLC is used.

2 METHODOLOGY

The scheme built in the clean water system simulation project with PLC is as shown in Figure 8 below.

This Simulation Scheme consists of 3 tanks, namely;

1. Tower Tank as a water reservoir whose position is the highest, or its position on the roof of the building. The tower tank is equipped with probe A (water level sensor) with 4 sensor rods.
   a. Sensor No. Probe A1 as cummon
   b. Sensor No. Probe A2 as low level sensor
   c. Sensor No. A3 probe as medium level sensor
   d. Sensor No. A4 probe as a hight level sensor
2. Consumption Tank is a tank which is a water storage tank that comes out of the Tower Tank which is associated as a water consumer in a building. The consumption tank is connected to the ground tank by 2 different pipes. The first pipe is equipped with a solenoid valve, the way it works is when the ground tank is in a low level position, the solenoid valve will automatically open. The second pipe is equipped with a gate valve 4, which works manually.

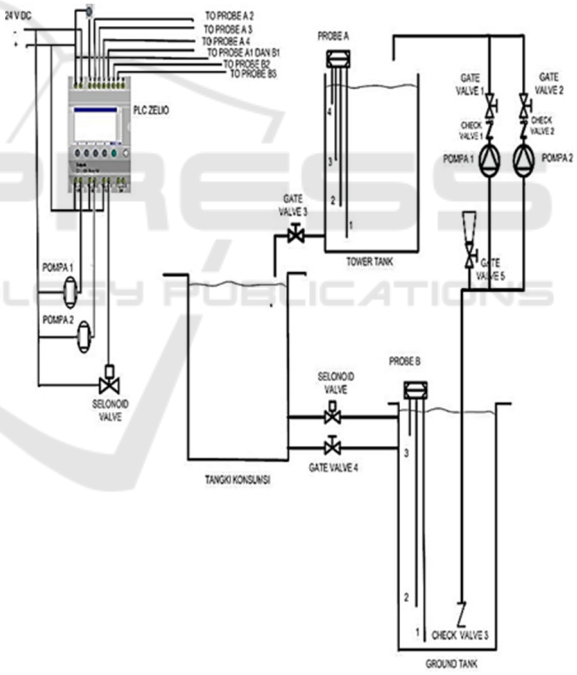

Figure 9: Simulation scheme of clean water pump control using PLC.

3. Ground Tank is a storage tank whose position is at the bottom of a building. Water reservoirs from drinking water companies or underground water reservoirs. The end of the pipe that enters the ground tank is the pump suction pipe, check valve 3 is installed whose function is so that the pump suction pipe always has water. Ground

tank is equipped with probe B. Which consists of 3 sensor rods,

a. Sensor No. Probe B1 is as cummon
b. Sensor No. Probe B2 as Low level sensor
c. Sensor No. Probe B3 as a hight level sensor.

2.1 Description Sistem

This simulation tool uses 2 pumps, which move water from the Ground tank to the Tower tank, when the water is consumed (gate valve 3 is manually opened), the water is accommodated by the consumption tank. The consumption tank collects water from the tower tank and forwards it to the ground tank again. Thus the water cycle in this simulation tool. Sistem kontrol akan bekerja jika kondisi level air pada Ground tank tidak mencapai posisi Low Level (batang Probe B2 tidak menyentuh air) dan kondisi level air di Tower tank tidak hight level (batang Probe A4 tidak menyentuh air).

When the Probe B3 ground tank sensor is submerged in water and Probe A2 is not touched by the water in the tower tank, Pump 1 and Pump 2 will turn on pumping the ground tank water to the tower tank, When the tower tank water level touches the Probe A3 sensor, pump 2 will turn off and only pump 1 is still alive. When the water level reaches/touches probe B4 (hight level), pump 1 will also stop.

When gate valve 3 is opened, water flows to fill the consumption tank. When the water level of the tower tank decreases and the probe rod A3 does not touch the water, pump 2 will automatically start pumping water from the ground tank to fill the tower tank. When the water consumption is too much, the tower tank water level continues to decrease and the water level does not touch the A2 sensor probe, then pump 1 will run and fill the tower tank.

If the pump is running continuously, and the condition of the water level in the ground tank continues to drop until the ground tank water level does not touch the probe rod B2, then the system will not work. Because if it is continued, the pump will work in dry running condition (no water is pumped). This can cause the pump to fail and this system is designed to save the pump from being severely damaged.

In this condition, the solenoid valve will automatically open, filling water from the consumption tank, the water flows by gravity.

2.2 Program PLC (Ladder Diagram Program)

This PLC program is in the form of a Ladder Diagram Program that will be uploaded/transferred to the PLC. PLC used is PLC SMART RELAY ZELIO SR3PACKBD. While the software used is ZELIO SOFT 2. PLC and its software is a product of SCHNEIDER.

For PLC programs there are inputs and outputs. The inputs of the PLC are;

a. Input 1 is the start of the program in the form of a push button
b. Input 2 is the sensor Probe A2 (low level tower tank)
c. Input 3 is sensor probe A3 (medium level tower tank)
d. Input 4 is the sensor probe A4 (hight level tower tank)
e. Input 5 is sensor probe B2 (low level ground tank)
f. Input 6 is sensor probe B3 (high level ground tank).

The output of the PLC is;

a. Output 1 is Pump 1
b. Output 2 is Pump 2
c. Output 3 is the Selenoid Valve.

The Ladder Diagram Program that is made in accordance with the work system as described above is as shown in Figure 10.

3 RESULT

Ladder Diagram program created using Zelio Soft 2 program, then uploaded to the Smart Realy PLC using an SR2USB01 USB cable that is compatible with Windows 7, 8.1 or 10.

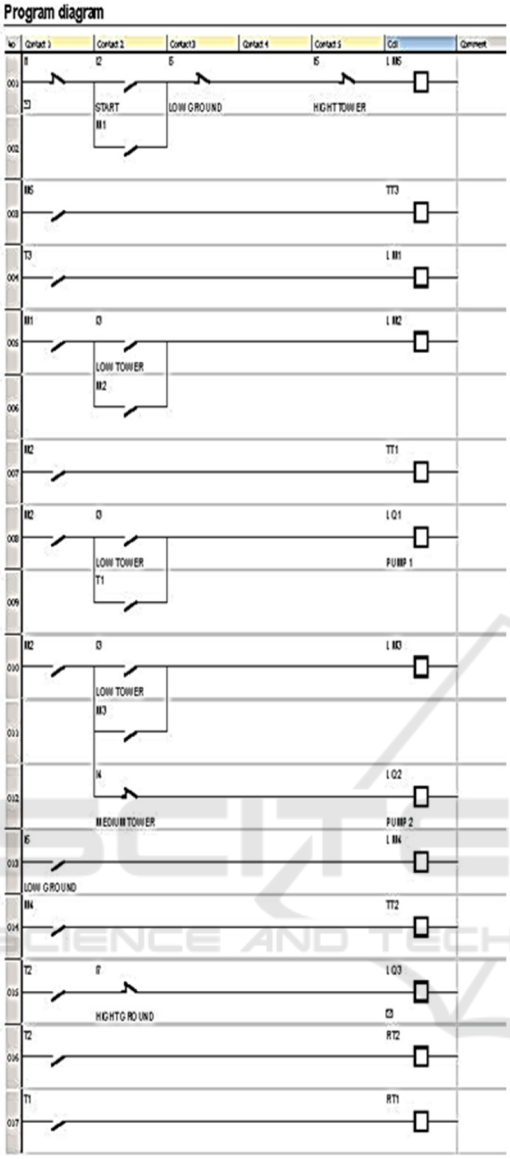

Figure 10: Ladder Diagram Program.

Figure 11: Schneider SR3PACKBD PLC and USB cable SR2USB01.

After the Ladder diagram is uploaded to the PLC, the results of the running test simulation of the water supply control system with the PLC are as follows, which are shown in Table 1.

Table 1: Matrik Kerja *Water Supplay Pump System.*

No	Kondisi Level air	*On Duty*		
		Pompa 1	*Pompa 2*	*Selenoid Valve*
1	*Hight Level Tower Tank*	***OFF***	***OFF***	***OFF***
2	*Medium Level Tower Tank*	***ON***	***OFF***	***OFF***
3	*Low Level Tower Tank*	***ON***	***ON***	***OFF***
4	*Hight Level Ground Tank*	***ON***	***ON***	***OFF***
5	*Low Level Ground Tank*	***OFF***	***OFF***	***ON***

Table 1 is the output condition with several input conditions in the form of the water level in the ground tank and tower tank.

Pump 1 will work when the tower tank is in low, medium level and high level ground conditions.
Pump 2 works when the tower tank is in a low level condition and the ground tank is in a high level condition.

The solenoid valve will work or open if the ground tank is in a low level condition, which will drain water from the consumption tank to the ground tank.

Figure 12: Simulation of Water Supply Pump System.

4 CONCLUSIONS

The PLC-based Water supply control simulation system that was made showed very satisfactory results. The big advantage of PLC based water supply

control is that it has maximum accuracy, also has higher reliability and small space requirements compared to conventional controls.

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