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Remote Pressure Water Valve Control System Based on PLC

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***Abstract*— Currently, valve operations use manual processes to safeguard water pressure and distribution to the Regional Water Company. Conventional systems are still used upon operations in opening and closing the valve. This method requires operators to rotate the valve by hand to maintain the distribution and water pressure's stability to the Regional Water Company. It would be more efficient if operators can maintain the distribution and water pressure stability without going to the location where the valve is located. A PLC and Android-based distribution valve remote control system design is planned to be produced from this research. Control commands are done via HMI display on Android to the PLC via PC and server to control the gearbox motor located on the valve. The pressure analysis shows that there are differences before the control system is installed. The pressure tends to be under 4 bar and is less stable. However, after the control system is installed, it tends to be more stable, between 4 bar and 4.5 bar. The data flow results show a difference in the flow before the control system is installed. The distributed flow tends to be below the number 180 l / s and is less stable. After installing the control system, the flow is more stable and increased from originally at an average of 144.4 l/s to 171.2 l/s, a difference of 26.8 l/s.**

***Keywords*— Water pressure valve; PLC control; flow; stable.**

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I. INTRODUCTION

High water demands within the society are increasing sharply, especially when it is in line with population growth and development of the tourism industry. This condition strongly refers to Bali, specifically in Bali's southern region, as it is one of the world's tourism destinations. Recognizing that water is one of the basic needs (primary), it is appropriate for the community to obtain optimal water services with high-quality water, fulfilling healthy and clean water requirements [1]. The government provides *Perusahaan Daerah Air Minum (PDAM)* or the regional water company to ensure sufficient water availability for the whole community. However, some Bali regions, such as Badung regency and Denpasar city, are not provided sufficient water supply and distribution.

To overcome the deficit and improve the quality of water supply in the southern Bali region, the central government agreed to cooperate with the provincial government of Bali, the Badung Regency government, and the Denpasar city government in developing the quality of "Sistem Pasokan Air Minum" (SPAM Penet) or clean water supply system. A valve is required as one of the supporting tools [2]. Currently, conventional systems are still used upon operations in opening and closing the valve. This working method requires workers or operators to rotate (open / close) the valve by hand to maintain the distribution and water pressure's stability to the Regional Water Company. Due to this conventional method, operators will require much time to finish as the locations between the operators with the valves are far apart. Also, the number of operators on duty is around two people, where they occasionally check the pressure in the distribution network pipeline. If the pressure increases or decreases into the pipe, operators need to regulate the main valve's rotation in the Buduk reservoir. This process usually takes a long duration of time. Therefore, due to those conditions, it is fair to conclude insufficient water quality and supply services for each PDAM.

On the other hand, to reduce water leakage, pressure management is required [3] and [4]. A gasket is essential to prevent pipe leakage. Pressure management must be done because water itself is classified into peak time use, non-peak time use and transition time. During peak time use, the pressure will drop dramatically because simultaneous use of water is used at the same time. This incident occurs in the morning before noon and in the evening. Whereas the transition time occurs is in the evening. The pressure which occurs on the pipe will gradually rise or fall depending on the usage.

Moreover, during non-peak time use, the distribution pipe's pressure will increase dramatically at night before dawn. The pipe's maximum pressure is also limited to no more than 4.5 bar, and the minimum pressure is 4 bar. Pressure limits are the standard reference for distributions that each PDAM specifically requests. Currently, energy use must be sought efficiently without reducing energy use. The method used in the effort to save energy is to promote energy efficiency in the industry. One reason for wasteful energy is leakage in factories, so it is necessary to design an appropriate energy optimization program [5].

It would be more efficient if operators can maintain the distribution and water pressure stability without going to the location where the valve is located. By referring to the idea above, it is supported by the rapid development of the world's current technology, such as remote control systems that use the internet, wireless, Bluetooth, Android, and many more [6]. Currently, the use of android signals is widely used in research, especially in communication systems. The pulse formation technique program, REC, and ISP pulse have been introduced. OFDM has applied REC techniques and ISP pulses that have been compared to the ICI suppression effect. So, in general, OFDM performance is better because pulse formation can reduce the power of the side lobes of subcarriers and potentially cause ICI. Therefore, by using pulse formation, the side lobe subcarrier will not interfere with other subcarriers [7], [8].

In this research, the author wants to make a remote control designed to facilitate the operator when opening and closing the main valve in the Buduk reservoir without having to go to the valve's location. Thus, this research method is related to long-distance control of the 3 phase motor induction connected to the main valve and is operated using a Programmable Logic Control (PLC) [9]. The computer server through Android is expected to set the motor induction to move forward and backwards when the operator is not in a specific location. This control system is expected to provide distribution stability to maximise clean water production and supply [10].

II. Material and Method

A. Description of Research

In this research, an automatic valve design that is controlled remotely will be carried out by using direct measurements in the field to determine the position and shape of the motor seat, handle valve, worm gear speed reducer, gearbox, and panel placement to establish an optimal function [11]. The following draft research concepts have displayed in Fig. 1. The material which has a strong character is suitable to choose for the handle valve. The handle valve is created from ductile materials [12], [13].

This design uses a 3-phase motor with an output speed of 1,500 rpm and a Worm Gear Speed Reducer type WPA 50 with a ratio of 1:60; thus, the output speed is reduced to 25 rpm. The valve used in measuring the drive shaft is 1 meter long and 1 inch in diameter. The number of Pinion teeth on a cone gear is 12. The number of teeth on the cone gear that is moved is 30 units. The gear selection plan is chosen because it can produce a 10-rpm rotation on the gear valve rotation. In Figure 2, the size of the valve, which will be used, is a valve with a diameter of 710 mm with a horizontal valve installation position.

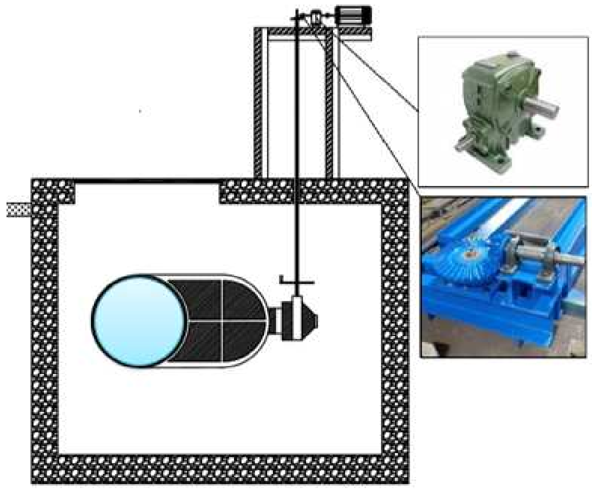

Fig. 1 Valve design dimensions and design

In Fig. 2, there is a 3-phase motor connection cooperating as a valve and a worm gear. As a result, when the motor is operating, the worm gear will rotate forward to the valve, and the valve closes or opens the gear in the direction of the motor rotation. On the panel, the box will be installed with a PLC, CPU server, and the 3-phase electric motor installations (star-delta circuits), which will be controlled via Android. Also, CCTV is used to monitor the increase or decrease flow caused by valve rotation.

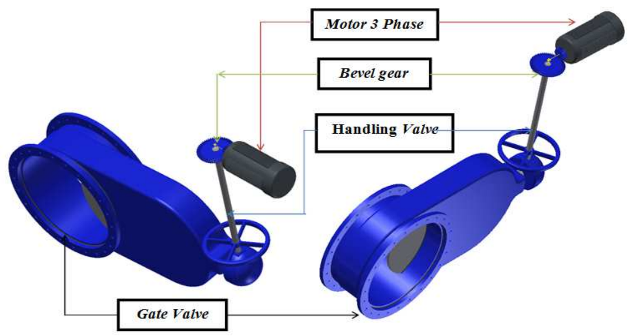

Fig. 2 Designing of automatic rotation valve

Fig. 3 shows the workflow of the remote-control system using Android. Firstly, monitoring the pressure on bridge 1 on the "Jaringan Distribusi Utama" (JDU) pipeline via Android using the intelligent video monitoring system (IVMS) 4500 application is required. As a result, it shows the numbers on the manometer. If the pressure is between 4 - 4.5 bar, the pressure is stable (not necessary to do operations/orders). If the pressure is below 4 bars or above 4.5 bars, Android operations/commands must be performed to close or open the valve. This operation is carried out by monitoring the CCTV located in the main network meter in the Buduk reservoir by reopening the IVMS 4500 application to determine the flow value when the pressure is below 4 bar or above 4.5 bar. After recognizing the flow, the valve operation command is performed via Android by opening the viewer team application connected to the CPU Server. This procedure is done to instruct the PLC to open or close the valve following the pressure conditions monitored on the CCTV. During this condition, adjustments are made to the flow rate with a reduction of -20 lt / s when the pressure is above 4.5 bar and an increase of +20 lt / s when the pressure is less than 4 bar. After increasing or reducing the flow, monitoring is done again through the IVMS 4500 application on the CCTV bridge 1 + 30 minutes after the order is placed. If the pressure is still less than 4 bars or more than 4.5 bars, thus the same command is done until the pressure condition is between 4 - 4.5 bar (stable).

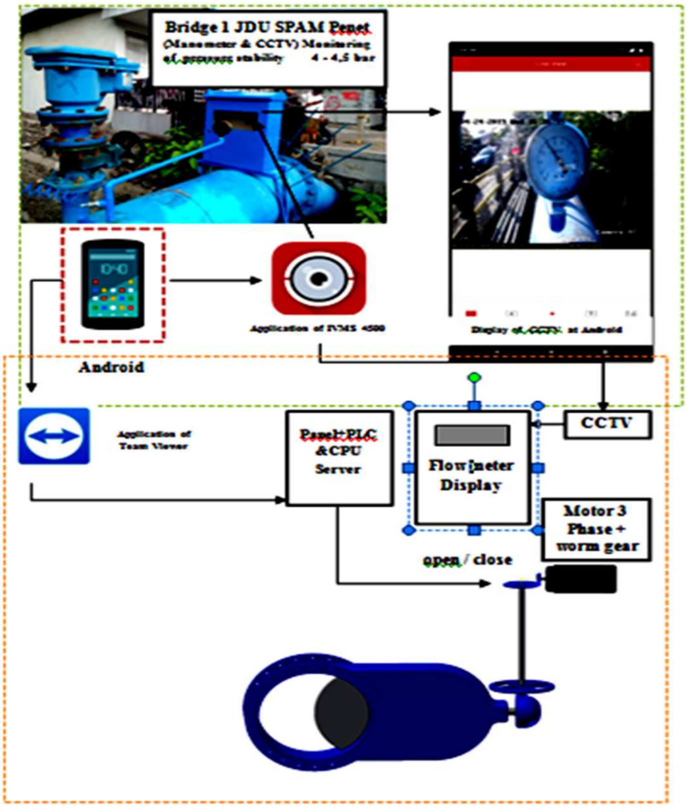

Fig. 3 Process flow of automatic valve design

B. Design of Water Distribution Valve Remote Control System

From this research, a PLC and Valve-based Remote Control Distribution System Design is produced based on Android. This type of control is done by pressing a button from the interface display (via Anydesk application) on Android to the controller (PLC) through the PC media and server to control the gearbox motor installed on the distribution valve. The design built consisted of several control circuit modules, including the gearbox motor module as a valve drive and a panel module consisting of PLC, MCB, magnetic contactor, thermal load, power supply, buttons, a PC as an interface display, and a router (modem). Push buttons are provided for control / manual operation when the operator is at the distribution valve's location or when there is a problem with the tool. Fig.4 shows a realisation image, a PLC wiring diagram, and the Android-based remote control valve distribution system. PID Control is suitable to control the motion of open and closed valve [14], [15].

Fig. 4 Realization of the panel and motor gearbox installation on the valve

C. PLC Module

In this design, PLC programming is an essential part of the gearbox motor control system's performance process to the distribution valve. This is because all hardware devices which have been installed and connected will not function properly if the PLC control program is not initialized to the PLC system hardware via computer equipment. PLC functions in controlling the factory process control system and gearbox motor following the desired control system work description, while the Human Machine Interface (HMI) system functions to control and monitor the motor gearbox's work process. In this case, the system is initialized as an instrument to control the gearbox motor system. The PLC program has a connection with the HMI system in controlling and testing the gearbox motor system, shown in Fig.5 [16].

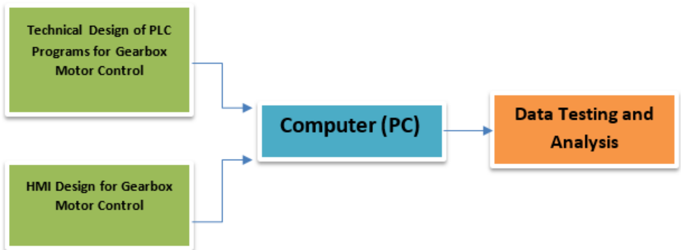

Fig. 5 Technical Control and Testing Diagram of a Gearbox Motor Block

D. Ladder Diagrams on PLC

Proportional, Integral, and Derivative (PID) control are subject to regulate the system's pressure and flow water distribution [17]. Fig. 6 shows the block diagram above, and it is making a PLC control system ladder diagram which will be used for the operating system control process. Firstly, determining the I / O (Input / Output) used on the PLC is required. As a result, it will be more efficient and easier to make a ladder diagram that will be installed/programmed into the PLC memory.

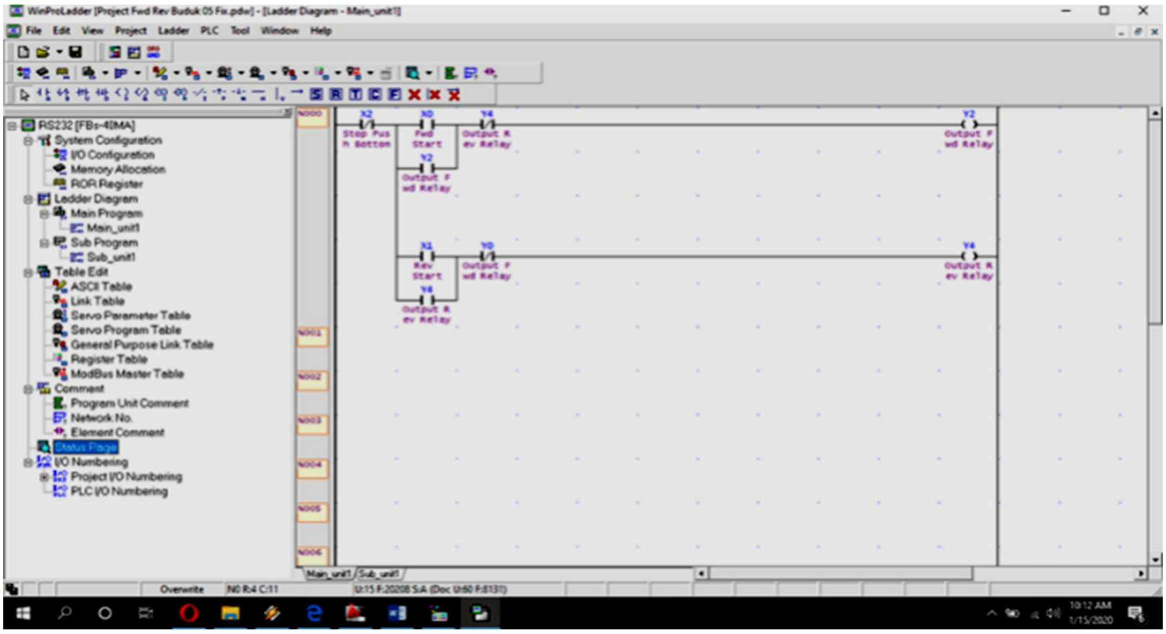

Fig. 6 Display application for making ladder diagrams and programming PLC

E. The Design of the Display HMI

The HMI system is designed to control and monitor the gearbox motor, initializing the I / O system, controls the gearbox motor of the process associated with the PLC I / O system, and relays process, which is programmed in one PLC control circuit program. As a result, it is marked by the interaction between the PLC control program process and initializing the gearbox motor control system in the HMI system. From the technical process, the design of the monitoring display system and the technical control of the plant process and gearbox motor with the HMI system can be made in the display design based on the working description of the plant process and gearbox motor as Fig. 7.

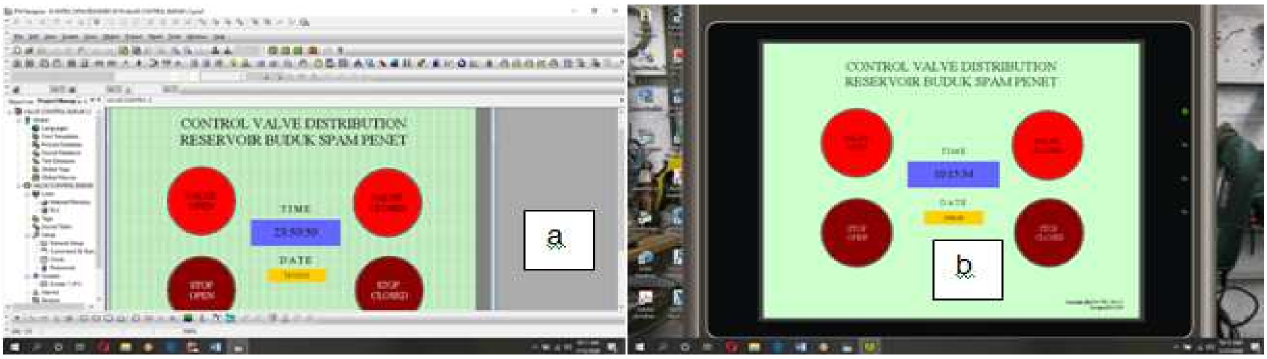

Fig. 7 Display Application for Making Ladder Diagrams (a) and Display Human Machine Interface (HMI) when running (b)

The purpose of the designed HMI display: There are four button designs used for control operations. The "Valve Open" button is used to open the valve and vice versa. The "Valve Closed" button is used to close the valve. The "Stop" button located under the Open and Closed button is used to stop each Open or Close Button operation. There is a timer on the HMI screen used to measure the duration of the valve operation and the date for real-time valve operation [18].

F. Communication between PLC and PC

The buttons on the HMI display have worked according to the desired commands after the PLC and PC are connected. The block diagram connects a PLC to a PC using a USB to RS485 Converter Adapter and FBs-CB5 devices that can be directly mounted on the PLC module. Furthermore, the wiring is carried out following the poles in both devices. When the two devices are connected, they can be simulated in online or offline mode on the HMI display that has been created. To be simulated online, first determine the number (Serial Port) (USB to RS485 Converter Adapter connected to the PC) read on the PC through the Device Manager. After knowing the Serial Port number (COM7) on the PC that COM input in the port selection in the Sim Panel in the HMI Application, then clicking Run will display as shown in Fig. 8. This method is used explicitly during simulation or running HMI in online mode, and offline mode is not required.

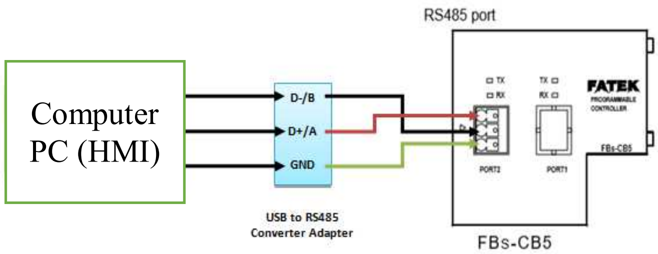

Fig. 8 Block diagram of PLC data communication to PC

III. Results and Discussion

Testing the performance of gearbox and HMI (PLC) motor distribution is done using Android (mobile phone) for each operator on duty every day. Recording and data collection is done within 24 hours non-stop for 30 days and the time specified for data sampling is at 1:00, 3:00, 5:00 a.m., 7:00 p.m., 9:00 p.m., 1:00 p.m., 3 p.m., 5 p.m., 7 p.m., 9 p.m., and 11 p.m. Fig. 9 and 10 show the results of the recorded data before, and after the Remote Distribution Valve Control System is installed, the comparison table can be as follows:

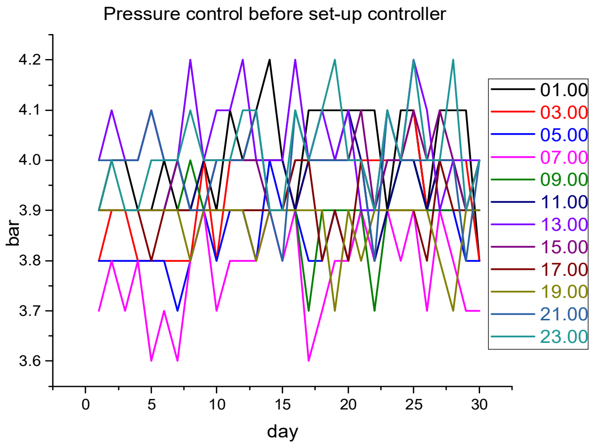

Fig. 9 Pressure comparison graph before installing the control system

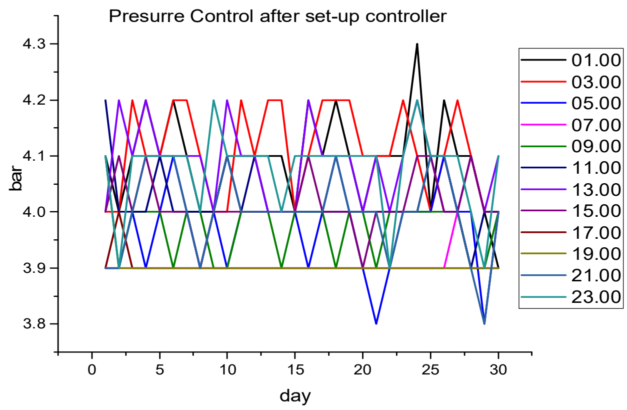

Fig. 10 Pressure comparison graph after installing the control system

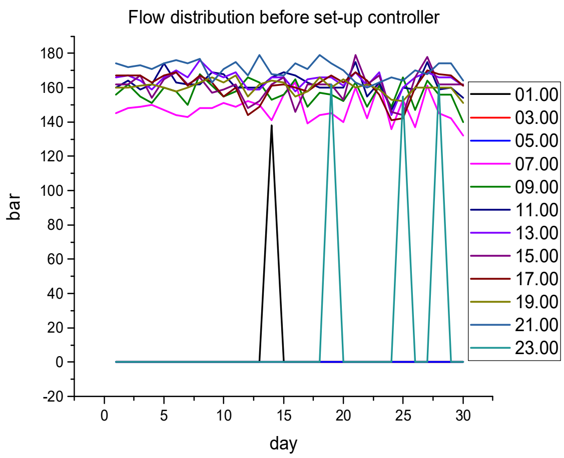

Fig. 11 Flow comparison chart before control system installation

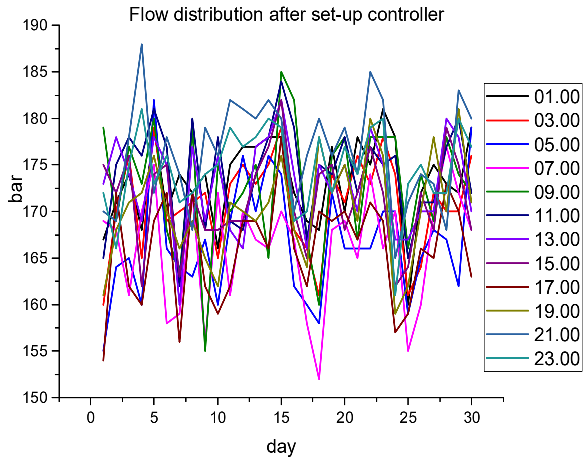

Fig. 12 Flow comparison chart after control system installation

Fig. 11 and 12 show the data collection and pressure comparison graph results above that there are differences before installing the pressure control system. Before the pressure control system is installed, it tends to be under 4 bar pressure and less stable. However, after the control system is installed, it tends to be stable and is between 4 bar or more even though there was pressure below 4 bar as it is caused by the peak time use, causing the pressure to drop dramatically. The peak use time tends to occur at 05.00, 07.00 and 09.00 in the morning and 17.00, 19.00 and 21.00 at night.

The data collection results and the flow graph above show differences in the flow before the control system is installed. Before the control system is installed, the distributed flow tends to be below the number 180 *l/s* and is less stable. The data result that reads 0 *l/s* is caused by night shift operators who deliberately did not check the location and only focused on serving at the Yeh Penet Water Treatment installation. Also, the flow is intentionally reduced at 21:00 to reduce any increase in excess pressure as it is a standard for securing the pipe when non-peak time use occurs from 23:00 to 05.00. However, at certain times the pressure monitored exceeds 4.2 bar, the operator will come to the valve location to reduce flow or close the valve until the pressure is below 4.2 bar. On the graph, after the flow control system is installed, it is more stable, and there is an increase in the flow, which initially averaged 144.4 *l/s* to 171.2 *l/s*. The difference was 26.8 *l/s* after the remote-control system was installed. The flow is monitored via CCTV, where the flow increases after 21:00.

Testing the remote response systems using mobile phones is carried out to determine how effective and efficient the system can save time and cost after the system is installed. Testing the remote control and remote response system using Android resulted from how the installed system can receive fast responses up to 10 kilometers. In comparison, the operator carries out the reality of controlling the system with a distance of 8.4 kilometers from the IPA Yeh Penet. The server signal dramatically influences the response speed of the system. If the signal indicator is strong, the response speed will be fast, but conversely, it will interfere with the control system's response speed if there is interference with the signal.

IV. Conclusion

This section concludes the performance of remote-control distribution/design of valve control systems based on PLC / Android. The remote-control valve distribution system's working condition using PLC can be controlled remotely using Android by the operator. Using the HMI system on the PLC makes it more efficient and easier for the operators to monitor and control valve position. The PLC remote control and Android system design are very effective and efficient, making it easier for operators to maintain pressure stability on the distribution network for each PDAM without having to go to the location where the valve is located. The distribution of clean water flow is more stable, and there is an increase in the flow of 26.8 *l/s*, which initially averaged 144.4 *l/s* to 171.2 *l/s*. The distance control system reaches a distance of 10 kilometers with an average time of 1.2 seconds.

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