Monitoring and Control Parameters of Fluid Pipeline by Using PLC and IoT System

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Abstract - In recent days the evolution of technology is unbeatable to make things more productive, accuracy, cost effective and high performance. The industrial revolution version 4.0 makes products more reliable, easy to access, time saving and high performance. This work suggests using Programmable Logic Controller and Internet of Things technology to conduct research and construct a fluid pipeline monitoring and control system. This study offers a system that uses PLC and IoT technologies to monitor and control these pipeline characteristics for fluid flow, temperature, and pressure. This IOT module, which has a high-level technical interface, is used to combine the SCADA (Supervisory Control and Data Acquisition) platform with IoT in order to increase supervision performance. We will use PLC and IoT technologies for this industrial automation project because they are popular and easy to use in industrial applications like Industrial 4.0. A PLC, which is connected to every component in our project, is essential. Process visualization and PLC control is achieved using software. Linked sensors, like temperature, pressure, and flow (RTD) sensors, provide data to the PLC.

Keywords: **Fluid monitoring, Programmable Logic Controller (PLC), Supervisory Control and Data Acquisition (SCADA), Internet of Things (IOT)**

I. INTRODUCTION

The need for increased efficiency and dependability in thermal power plants is growing. At regular periods, power plants need to be continuously inspected and monitored. Human workers may make mistakes when taking measurements at different points in time. Automation is required to boost dependability and boost the power plant's overall efficiency. PLC and SCADA are utilized in the development of the automation, which lowers human worker mistake. In this article ladder logic is used for programming. SCADA system is used to oversee a full process. The output of different sensors is sent to the PLC which takes necessary action to manage the parameter [1].Using a variety of tools and technology, PLC and SCADA in the automatic gas pipeline control system keep an eye on the characteristics of gas pipeline transportation. The main objective is to provide the consumer with gas in the most economical and safe manner feasible. Additionally, the automation system may save money, enhance the environment, and lessen the quantity of labor needed [2].The operation condition monitoring module primarily connects the pipeline connects the customer terminal to the network's temperature, pressure, and flow data and performs real-time monitoring and alerts for the status metrics, such as temperature drop, pressure drop, and flow velocity of each pipeline network pipe segment. Among the various elements that make up the system is water hammer monitoring, and operating condition monitoring [3].Because cloud computing offers so many benefits to organizations and enterprises, it is a crucial component in 4.0 Making use of cloud computing services that are available on demand, such networking and storage, servers, software, and intelligence is part of it [4]. Notification leaks, the user will receive a notification by Telegram or SMS. Water flow and water sensors are being used to find these leaks. As interest in Industry 4.0 increases, the study examines PLCs and how they may be connected to the Internet of Things to enable smart manufacturing. It also discusses safety and security issues, including rules for safeguarding PLC-based mechatronics systems. The lecture concludes with a discussion of upcoming advancements in PLC technology, integration with artificial intelligence and machine learning, and possible uses and opportunities [5].

- To use sensors to continually monitor vital pipeline fluid characteristics (such as pressure, flow rate, temperature, and level), giving decision-makers access to real-time data.
- In order to enable operators to make proactive changes and guarantee optimal pipeline performance, SCADA systems are used for remote control of pipeline systems, historical trend analysis, and centralized data display.
- To improve responsiveness and operational efficiency by enabling remote monitoring and control via an Internet of Things network and giving operators and stakeholders access to real-time pipeline data through web or mobile applications.

Here we are going to discuss different sections are: In section II, we will look into the related research works; section III will discuss materials and methods, which are proposed in this work; section IV will present results and discussion; section V will present a conclusion; and at the end of our discussion, in section VI will see reference papers.

II. RELATED WORK

Adedeji et al., (2022) an automated system that effectively controls the disposal of garbage and includes recurring harmful gas filtration from both liquid and solid waste. This system's primary control component, a programmable logic controller, efficiently monitors and controls the liquid level and the presence of hazardous gasses. To guarantee careful monitoring and control of the drainage process, essential parts like gas exhausters, trash pumps, float switches, and pressure sensors are used.

Cormac et al., (2023) this study introduces a novel standalone instrument that measures levels of gas pressure independently on a landfill in operation. This apparatus makes it possible to monitor gas dynamics in real time and aids in the early detection of noteworthy occurrences. The developed gadget makes use of state-of-the-art sensor technologies and wireless communication capabilities to enable Internet access and remote data transmission.

Bartosz Kwapisz et al., (2021 the authors' method for measuring fluid this work provides temperature, pressure, and flow rate. It fits into an already-existing multiphase spraying arrangement on the test stand. Additionally, an application in Python that enables the viewing, storing, and exporting of gathered data was created as part of the research.

Srinivas et al., (2024) the procedure is streamlined and made more efficient by this automation, which spares utilities the money and trouble of making sporadic excursions to physical sites for meter readings. This method helps to cut down on water waste while also speeding up and improving the accuracy of the billing process.

Adu-Manu et al., (2022) in order to automatically collect water measurements and detect pipe leaks, wireless sensor devices were employed in this experiment. Our results demonstrated that an automated water monitoring system can accurately assess water use. The recorded amounts were 500 ml/sec at high pressures, indicating that the water content increases.

Tasmurzayev et al., (2023) this article presents a novel method of managing oil fields that makes use of machine learning and digital twin technologies. Our results demonstrate a significant 10- to 15% increase improve the effectiveness of oil production, emphasizing the ground-breaking potential of integrating DT and ML in the petroleum industry.

Miozzi et al., (2024) an overview of the uses and difficulties associated with radio frequency identification in industrial settings is given in this chapter. attaching tags to items or embedding them inside things during manufacturing. The RFID label and sensors are the fundamental components of the Perception Layer, according to the taxonomy of Industrial Internet of Things designs.

Chandla Ellis et al., (2022) the pertinent chances to improve the efficiency of various SWH subsystems. Control strategies are also developed for the system's overall effective operation. During maintenance, the solar water heater is constantly observed to minimize loss and improve performance. This heater data may be obtained from any place via the Internet of Things.

Mohamed Aglan et al., (2022) to regulate the firefighting system's operational parameters, a programmable logic controller will be integrated with supervisory control and data collection. According to our research, the firefighting system may be enhanced and monitored by creating systems for extensive network connections based on online management and information monitoring tools and technologies.

Escandon-Panchana et al., (2022) analysis of measurement reports is the first step in the study's process. Storage tank administration, control, security, management, and monitoring, physical component condition, and real-time dynamic report production are all covered by the open source SAM program's functional modules. The findings demonstrate that storage tanks can manage temperature, time, maximum and minimum capacity, and precise data recording faster than certain modern computer systems.

III. PROPOSED METHODOLOGY

New technology called "industrial 4.0" aims to implement the IOT in the industrial sector. Anywhere in the world, data logging and monitoring are done through the Internet of Things. We used Adafruit IO as a cloud in our work. In order to obtain the parameter from the fluid pipeline system, the thermocouple, pressure transducer, and flow meter are utilized. Figure 1 displays the suggested work block diagram. The ESP 32 controller is used to calibrate the sensor and trigger the PLC input through the relay circuit. The fluid solenoid coil control through the digix 1 PLC. The ESP32 controller have inbuilt Wi-Fi module. The temperature within the fluid pipeline is measured using a K type thermocouple and a MAX6675 amplifier. The analog output of the 4–20 mA pressure transducers is dependent on the pressure value. The liquid flow is measured with a flow meter to provide a digital pulse output.

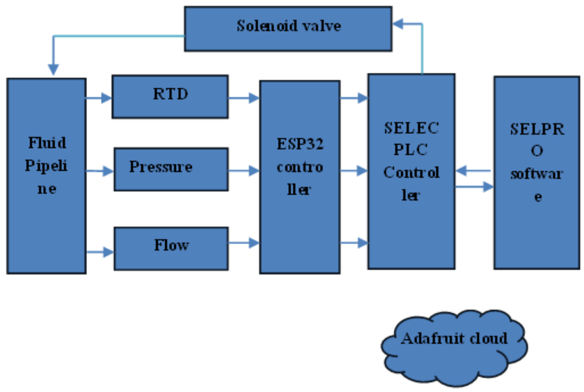

Figure. 1. Proposed work block diagram

A. ESP32 controller

The ESP32 is a family of low-cost, low-power system-on-a-chip microcontrollers that use either a single-core RISC-V CPU, an Xtensa LX7 dual-core microprocessor, or an Xtensa LX6 microprocessor in both dual-core and single-core variants..The ESP32 controller's pin diagram is shown in Figure 2. The ESP32 controller was designed and developed by Shanghai-based Espressif Systems and is manufactured by TSMC using their 40 nm technology.

Figure. 2. Analog pin diagram of ESP32 controller

B. K type thermocouple and MAX 6675 amplifier

A thermocouple amplifier is required in order to get the temperature from the thermocouple. The voltage measured at the reference junction determines the temperature that the thermocouple amplifier will output. The temperature differential between the thermal junction and the reference junction. Thus, the temperature at the reference junction must be known. The k type thermocouple with MAX6675 amplifier is shown in figure 3

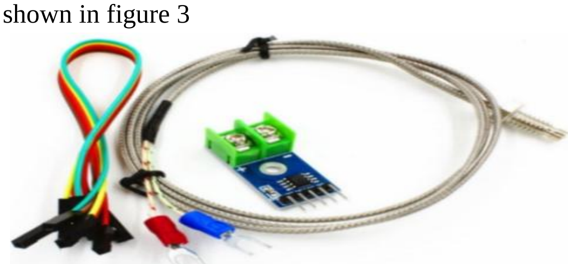

Figure. 3. K Type thermocouple with amplifier MAX6675

C. Pressure transducer

A device called a pressure transducer is used to measure fluid pressure and the force that a fluid exerts on items it encounters. Pressure transducers are used in pump systems, flow, air speed, level, and altitude control and monitoring. A pressure transducer is made up of electronic components that transform the data into an electrical output signal and a pressure-sensitive device that can measure, detect, or track the pressure being applied. The 4-20 mA pressure transducers are shown in Figure 4.

Figure. 4. Pressure transducer

D. Flow meter

Let us now link the ESP32 display with value of YF-S201 Water Flow Sensor with Hall Effect. This water flow rate and total volume that passes through the pipe will be displayed on the cloud using Adafruit IO cloud. If you need data right now, you can switch to the MQTT dash application. In a similar vein, improved wireless communication may be accomplished via the MQTT Protocol. The flow hall effect sensor is interface with ESP32 controller shown in figure 5.

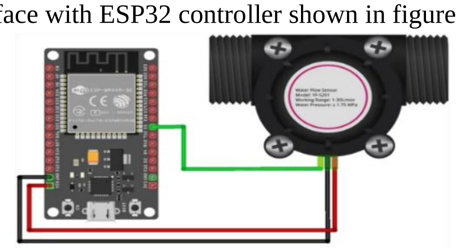

Figure. 5. Flow sensor interface with ESP32

IV. RESULT & DISCUSSION

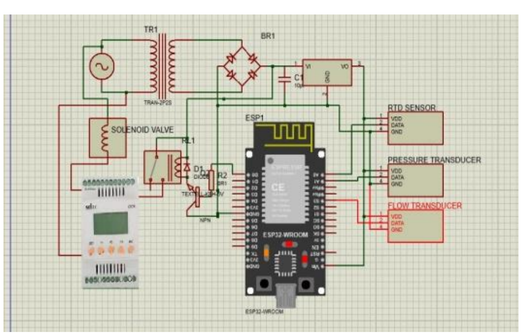

Figure. 6. Overall circuit diagram of proposed concept

The figure 6 shows the overall circuit diagram of proposed work. In our work, the ESP 32 controller and DIGIX -1 PLC is used as brain of our concept. The ESP32 controller consists 12-bit Analog to Digital Converter for acquired calibration of sensor value form temperature, humidity, and flow sensor. The Adafruit IO is used as main cloud platform for visualize the sensor data in the web based dash board. The relay from the ESP322 controller is used as the input of PLC. The PLC consists 2x8 LCD for HMI purpose.

The figure 7 shows the proposed work ladder diagram, developed in SELPRO software tool. The esp32 and relay control circuit is very crucial. Whenever the sensor value reached the threshold. The trigger input given to the PLC input. The figure 7 saves and all the sensor value interface with esp32 controller.

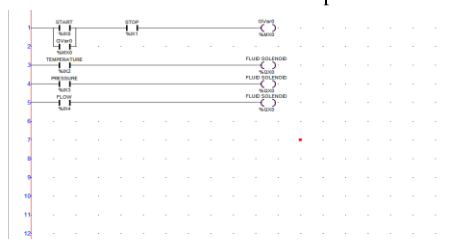

Figure. 7. Proposed work ladder diagram

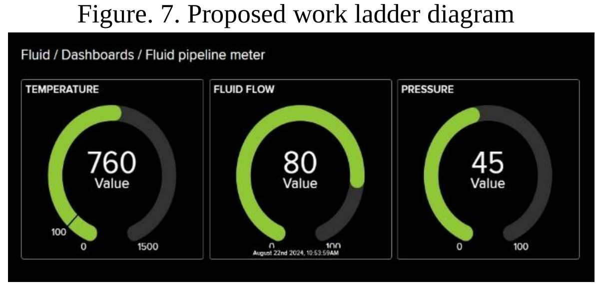

Figure. 8. Adafruit IO dashboard for parameter monitoring

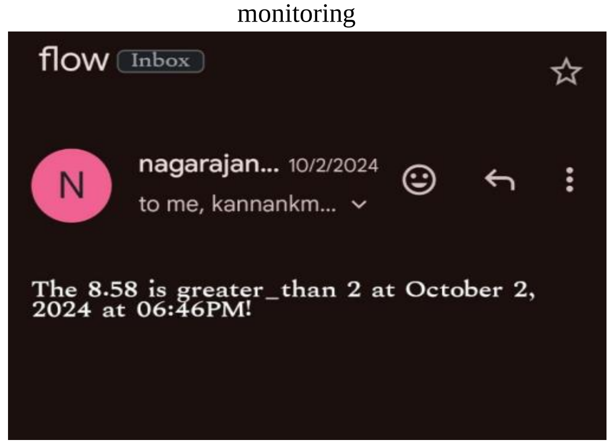

Figure. 9. Mail notification of proposed concept

The Adafruit IO cloud is used to create the web-based monitoring and mobile monitoring of the parameter of fluid pipelining. The temperature, pressure and flow are monitoring in Adafruit dashboard through individual feed. The figure 8 depicts the Adafruit dashboard. The figure 9 shows the mail notification of proposed concept, temperature, pressure and flow sensor have threshold value, whenever cross the threshold limits of sensor, the esp32 controller triggers the mail notification. The figure 10 shows the fabrication of proposed concept.

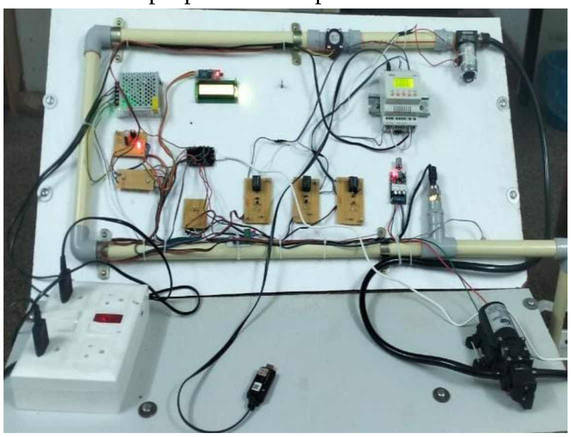

Figure. 10. Fabrication of proposed concept

V. CONCLUSION

The integration of Programmable Logic Controllers and the IoT in fluid pipeline monitoring and control plays a crucial role in enhancing operational efficiency, reliability, and real-time data accessibility. Fluid monitoring is essential for various industries, including water treatment, oil and gas, and chemical processing, where precise control over flow rate, pressure, and leak detection is necessary. By integrating SCADA with PLCs, operators can efficiently monitor pipeline parameters, detect faults, and make data-driven decisions. IoT-enabled sensors transmit real-time data to cloud platforms, enabling predictive maintenance, early fault detection, and enhanced decision-making. Through IoT connectivity, multiple pipeline systems can be monitored from any location, ensuring rapid response to potential issues. Overall, the combination of PLCs, SCADA, and IoT in fluid pipeline monitoring ensures enhanced automation, reduced downtime, improved safety, and cost-effective operations

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