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Robust Surveillance and Controlling of Pressure and Flow in Oil Pipeline Transport System Using PLC and SCADA

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ABSTRACT*:* In this paper, a new PLC based PID controller is designed. By implementing PLC and SCADA, the automatic controlling and monitoring plays an important role for the continuous operation of the system.It automatically regulates the flow rate of the petroleum products at destination by controlling the flow and pressure signals range in the long transmitting pipeline system. PLC based controller is developed and their closed loop response is identified, and the simulation is carried out to ensure the performance of the controller. The real time data of pressure and flow are monitored through SCADA screen used to provide instantaneous trends using data logging. From the real time experimental results, the PID controller provides most superior performance with minimum time delay PID controller on upholding flow at specified range by implanting multiple pressures as manipulated parameters.

KEYWORDS*:*PLC, SCADA, PID Controller.

I.INTRODUCTION

In this paper, the parameters such as pressure and flow are maintained constantly by implementing control valves depending on the different pressure and flow rate of the transmitting pipe. PLC (Programmable Logical Controller) is used to automatically regulate the flow and pressure during petroleum product transportation by controlling the percentage of opening of the control valves respectively. The required set point for pressure and flow rate are obtained by implementing a suitable controller that regulates in a long transmitting pipeline system. For this, a PLC based PID controller is developed and its closed loop responses are identified.

The control valve assembly typically consists of the valve body, the internal trim parts, an actuator to provide the motive power to operate the valve, and a variety of additional valve accessories, which can include transducers,supply pressure regulators, manual operators, Snubber or limit switches. In our project we are going to use the control valve of globe type to control the flow as a final control element. The project deals with the flow parameter which is to be control with given set point, and the controller action by PID controller. The flow transmitter sends the signal information of flow to PID controller. This is to be passing to control valve acting as final control element. Currently, there is a special linear structure deployed with sensors on pipelines to monitor and regulate flow and pressure.They demonstrated a multilayer communication schemes that ensure the effective routing of data among the sensors but there is no consideration of control valve among the sensor based remote communication networks which involves manual operation to achieve desired performance of pipeline transportation.

II.LITERATURE SURVEY

The Internet of Things (IoT) is a natural extension and evolution of Supervisory Control and Data Acquisition (SCADA). Early SCADA systems were deployed to monitor specific production processes, and separate systems were employed to manage assets, coordinate maintenance operations, optimize supply chains and other business operations.

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Today's enterprises are frequently composed of a patchwork of these legacy information systems. One of the concepts central to the IoT is Machine to Machine (M2M) communication. It is one of the advances that made the Programmable Logic Controllers (PLC) such a revolutionary invention. By giving machines the ability to make decisions and perform actions based on nothing more than information provided to them by other machines, SCADA technology completely redefined the processes involved in industries like manufacturing, water treatment, oil and gas, and much more. Task automation driven by mechanically autonomous devices has improved the speed, efficiency, and quality of industrial processes [1]. In accordance with the actual demands of monitoring system for oil and gas pipeline, for instance, long transportation distance and many distributed stations, a kind of monitoring system based on the S7-400 series PLC and PROFIBUS field bus was designed and realized in this article. It has the characteristics of the following: supporting multi-master station, excellent real time, high reliability, high transmission rate and long transmission distance. This monitoring system adopts the modes of centralized monitoring and distributed control and has been applied in CNPC West Pipeline, and the result proves this system can realize the above functions and run stably [2]. The oil and gas industrial sector is nowadays inclined towards utilizing smart field technologies for optimizing various operations of upstream, midstream and downstream sectors. The recent advances in Internet of things (IoTs) have promising benefits and advantages over manual wired/wireless systems. Oil and gas wells form an important element of upstream sector. After identifying potential viable fields and drilling of exploratory oil and gas wells, wellhead monitoring is another essential and crucial activity not only for safe operation and productivity but also for extending the production life of these wells. In this paper we propose an intelligent IoT based monitoring system which involves smart objects for reliable and efficient monitoring of oil and gas wells. The smart IoT objects are capable of sensing important parameters like pressure temperature, vibration etc. and reliably, efficiently and timely deliver the sensed data to the control center. The proposed system proactively reports about the anomalous events for predictive maintenance of the well equipment. The detection and reporting catastrophic failures and destructive events on time will increase production downtime and oil theft can be easily prevented [3].

III.METHODOLOGY

With the application of SCADA screen the real time monitoring of the entire real time system indulging of 3 pressure sensors, one flow sensor and the final control element i.e., the control valve. The data logging is done using the latest trend of using IOT and HART communication. This is done to know the various status of the field devices and remote terminal units. This process should be fully secure with anticipatory control system since it involves inflammable fuel. To enhance the working of the system in a safe zone we use recent technology of HART communication and IOT. This will reduce the failures and disasters in a smart way.

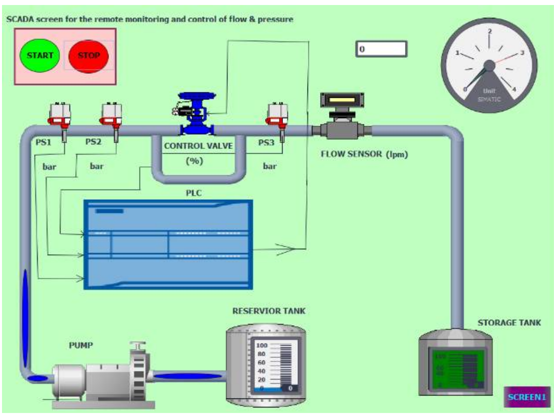

Fig. 1 SCADA screen for monitoring and controlling of flow and pressure

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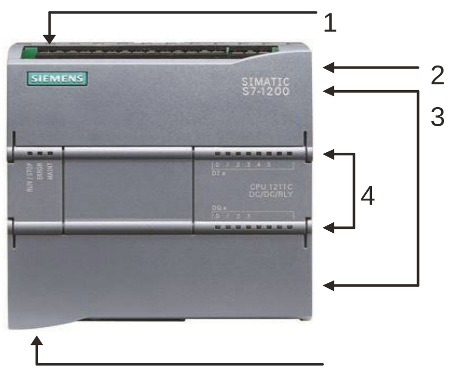
IV. PROGRAMMABLE LOGIC CONTROLLER

The Siemens S7-1200 controller provides the flexibility and power to control a wide variety of devices in support of your automation needs. The compact design, flexible configuration, and powerful instruction set combine to make the Siemens S7-1200 a perfect solution for controlling a wide variety of applications. The CPU combines a microprocessor, an integrated power supply, input and output circuits, built-in PROFINET, high-speed motion control I/O, and on-board analog inputs in a compact housing to create a powerful controller. After you download your program, the CPU contains the logic required to monitor and control the devices in your application. The CPU monitors the inputs and changes the outputs according to the logic of your user program, which can include Boolean logic, counting, timing, complex math operations, and communications with other intelligent devices.



1. Power connector
2. Memory card slot
3. Removable user
4. Status LEDs

Fig. 2 The Siemens S7-1200 controller

The CPU provides a PROFINET port for communication over a PROFINET network. Additional modules are available for communicating over PROFIBUS, GPRS, RS485 or RS232 networks.

V. PRESSURE SENSOR

The Rosemount 3051C coplanar design is offered for Differential Pressure (DP), Gage Pressure (GP) and Absolute Pressure (AP) measurements. The Rosemount 3051C utilizes Rosemount Inc. capacitance sensor technology for DP and GP measurements. Piezo resistive sensor technology is utilized in the Rosemount 3051T and 3051C AP measurements. The major components of the Rosemount 3051 are the sensor module and the electronics housing. The sensor module contains the oil filled sensor system (isolating diaphragms, oil fill system, and sensor) and the sensor electronics.

Fig. 3 Rosemount 3051C pressure sensor

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VI.FLOW SENSOR

The Rosemount 8732E flow transmitter offers best in class performance coupled with advanced diagnostics to provide unparalleled process management capabilities. With multiple diagnostic suites available, the Rosemount 8732E provides users the tools required for highly accurate signal processing for fluids that are traveling between 0.04 and 39 ft/s (0.01 to 12 m/s) for both forward and reverse flow in all flow tube sensor sizes.

Fig. 4 Rosemount 8732E flow

VII. CONTROL VALVE

Basically, a globe type of control valve consists of two parts as follows:

- Main (globe) valve body
- Diaphragm type of pneumatic actuator

This two-valve’s part is coupled by a special coupling, when the air pressure coming into the diaphragm pneumatic actuator the rubber diaphragm inside the actuator will push or pull the main (globe) valve stem/shaft downward or upward. The main design of this control valve is globe type, a valve with a linear up-down type of movement to open/close the fluid flow & the body shape is globular with a plug disc as the main part inside it. The travelling linear up-down distances of the valve is called valve’s stroke. Since the main valve will always open with a certain % of opening. It will create a differential pressure (Δ P = Delta P = P1 – P2) between the inlet & outlet of the valve.

Fig. 5 Control valve

VIII. STORAGE TANK

Floating roof oil tanks have a cylindrical steel shell. As the name of the tank suggests, this cylindrical steel shell has a floating roof, meaning that it floats on top of the liquid that is in the tank. When the crude oil levels are low, then the position of the roof will be low as well. When there is more crude oil being stored in the tank, then the level of the roof rises to match the level of the oil.Floating roof tanks are more ideal for the storage of large quantities of crude oil. Crude oil emits extremely volatile natural gas as well as some air pollutants. The gases collect in the space that is between the roof and the crude oil. The rim seal on the floating roof tank keeps these emissions of highly combustible vapours being released into the environment. These vapours could cause fires and explosions, and so it is good for them to be contained. Depending on the preferences of the owner, it is possible to install mechanisms to capture this vapour

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so that it is not lost and can be either used at the plant where the crude oil is stored or it can be packaged for sale to interested parties.

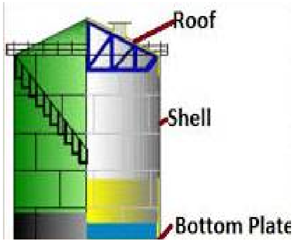

Fig. 6 Floating roof tank

IX. PIPELINES

The processing, transportation and storage of oil is highly complex with high pressure and corrosion. Crude oil from the underground contains substances such as sulphur and hydrogen sulphide that can oxidize the pipeline. This is a key problem during the oil transportation. Therefore, the material chosen must meet these needs. Steel is the most used material applied in the oil transporting and storage. Some technique has been invented to increase its strength and its corrosion resistance.Steel pipes are long, hollow tubes. According to statistics, there are millions of tons of black steel pipe being produced each year, they are so versatile and therefore widely used in many industries. It's not difficult to find that steel pipes are used in a many place. Since they are tough and hard, they are used for transporting oil, gas, water throughout cities and towns. They can be lightweight although they are hard. Black pipe, a form of black steel pipe, was widely used in homes built before the 1960s.But since black pipes are durable, they are still used for applications like gas and oil line. The black appearance is formed by a black oxide scale when forging the steel pipe.

Fig. 7 Steel pipe

X. PUMP

The pumps are made of duplex stainless steel and each one has a flow rate of 2,000 cubic metres per hour. The head is around 80 metres. During testing, both pump and motor exceeded the quoted efficiencies. The oil will be pumped to the surface by three special-designed submersible borehole pumps. All three pumps are equipped with a 700-kW motor and are operated at a voltage of 6,600 V. Centrifugal pumps are extensively used in the oil and gas industries and the pumpperformance drops with higher viscosity and higher surface roughness of the pump impeller, and the impeller design parameters have significant effect on the pump performance. The impeller is the rotating part of the pump and the casing is the airtight passage which surrounds the impeller. In a centrifugal pump, fluidentersthe casing, falls on the impeller blades at the eye of the impeller, and is whirled tangentially and radially outward until it leaves the impeller into the diffuser part of the casing. While passing through the impeller, the fluid is gaining both velocity and pressure. Centrifugal Pumps are useful since they can generally handle large quantity of fluids, provide very high flow rates andcan adjust their flow rates over a wide range.

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Fig. 8 Centrifugal pump

XI. SOFTWARESIMULATION

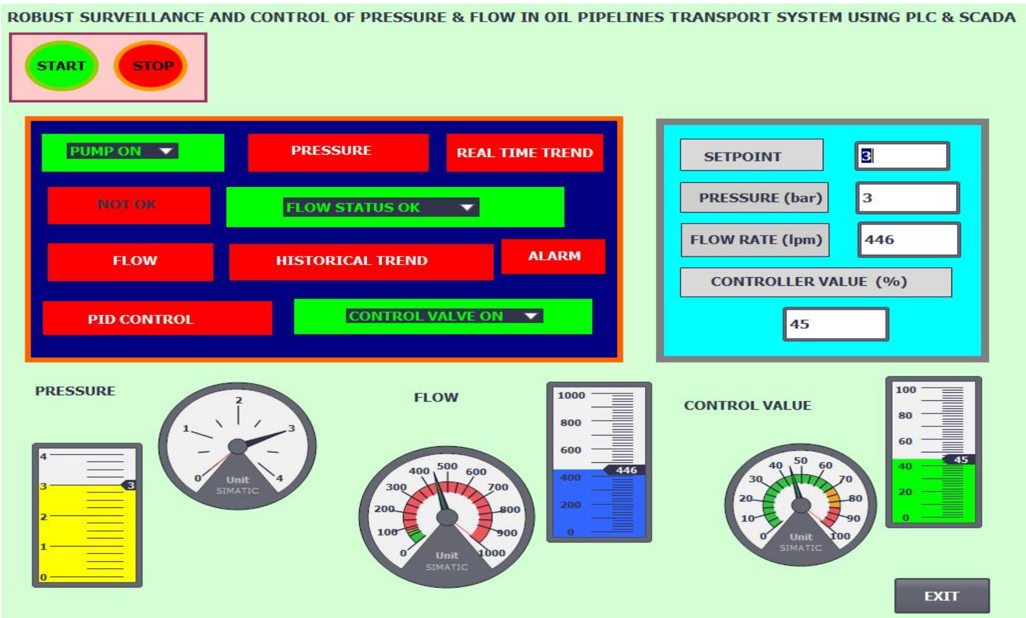

Fig. 9 SCADA Simulation Screen

Software used are,SCADA WinCC Rt Advanced (figure 9). In large industrial establishments many process occur simultaneously and each needs to be monitored, which is a complex task. The SCADA systems are used to monitor and control the equipment's in the industrial processes which include water distribution, oil distribution and power distribution. The main aim of this project is to process the real time data and control the large scale remote industrial environment. In the real time scenario, a temperature logging system for a remote plant operation is taken.

XII. EXPERIMENTAL RESULTSAND DISCUSSION

The elaboration of the control logic in the Programmable Logic Controller (PLC), the data base and the operational screens of the supervisory system. When a control valve is installed in a pipeline, it is necessary to find the reaction it causes in the flow rate and pressure. For each pipeline, these reactions are different, even if similar valves are used. Thus, it was necessary to simulate the insertion of this valve in the system, as well as to perform field tests to confirm the results of the simulation and to find out the control parameters of the valve, which are used for programming the PLC.

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The tests have three main objectives:

- To check if the valves respond correctly to the commands given in the supervisory system.
- To check which valve opening percentage corresponds to which pressure value and to determine the process stabilization time.
- These data feed the controller, which use a method based on the mathematical algorithm PID (Proportional, Integral and Derivative).

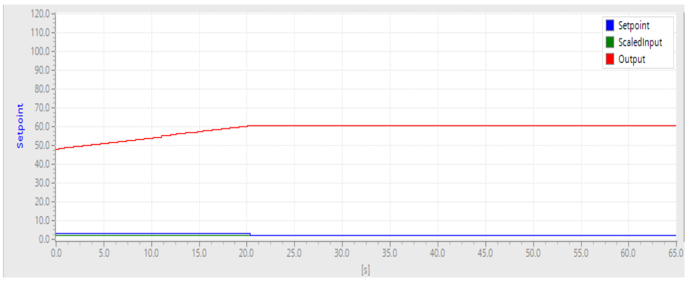

Fig. 10 PID closed loop Response for Control valve output for 50% Set Point

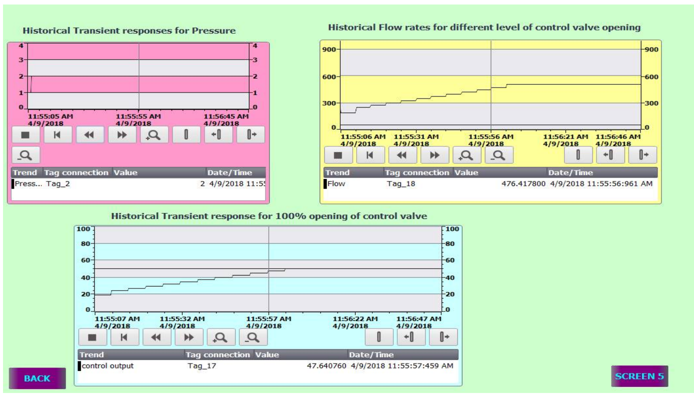

Fig.11 SCADA monitor showing the system running performance

Figure 10 shows the PID closed loop response for control valve output for 50% setpoint. The figure 11 shows the corresponding SCADA monitor showing the system running performance which the details of pressure, flow and percentage of opening of control valve.

After the implementation of this project, the pipeline is centrally controlled by PID. It is now ready for implementing the control of pressure and flow in oil pipelines transport system. The response in the line to any pressure or flow alteration is immediate and is monitored by the measurement system.

XIII. CONCLUSION

The implementation of the project presented was a challenge for the team that was responsible for it, since the whole operating philosophy needed to be changed. These changes consisted in the adaptation of the equipment's, with the introduction of the pumps automation and the insertion of control valves in the destination. Furthermore, PID controller technique was elaborated to qualify them to the new operational needs and to the necessary behaviour change.The operational safety is enhanced by the full pipeline operation, since any disturbance in the process is promptly perceived

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by the supervisory system (SCADA). SCADA is used for wide areas, long pipelines, integrated telecoms, accounting of product flows, and exchange among end users.

XIV. FUTURE ENHANCEMENT

Electrical integration with a Distributed Control System (DCS) is best applied for future gas-gathering points in the oil and gas fields and the pipeline end terminal. Variable Speed Drive (VSD) technology applies well to gas-gathering points, transportation pipeline, and end terminals.An integrated system will also provide centralized control. Plant operators can monitor the health of instrumentation, rotating equipment, IT assets, electrical equipment, and energy consumption to determine overall terminal station status. For example, operators will have immediate visibility of the process control events such as temperature-transmitter failure or calibration-required alert.
The status of critical IT assets be well, alerting operators to potential system problems. For example, with DCS ABB's System 800xA, the information will be provided via alarm and events lists as well as e-mail and text-messaging notifications.
Using Distributed Control System (DCS) in Future will used for saving money and increasing uptime throughout the plant.

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