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SCADA system for oil refinery control

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ABSTRACT

A Supervisory Control and Data Acquisition (SCADA)/Programmable Logic Control (PLC) system is always used to control small industries like water treatment stations; electric power stations and irrigation systems. Oil and gas refineries generally rely on a Distributed Control System (DCS) to provide all process and equipment control functionality. In this paper, a SCADA/PLC system is used to control a whole oil refinery instead of the conventional control through DCS. The design and specific implementation method of a SCADA/PLC real system in an oil refinery process is introduced. It consists of four main units: a crude oil storage unit, a crude oil pretreatment unit, a distillation unit and products storage/dispatch unit. The output products from crude oil refinery process are Liquefied Petroleum Gas (LPG), Naphtha, Gasoline, Kerosene and Diesel that have a great usage in our daily life. The reason for using the Multipoint Interface/Decentralized Peripherals (MPI/DP) connection in main control loop instead of Ethernet connection is that MPI/DP speed is 185 kbps and Ethernet connection speed is 10/100 kbps, which increases the speed of transfer data through the system. Displacer level transmitters and automatic servo level gauging transmitters are used for measuring levels in the crude oil refinery process. Also differential pressure flow transmitters are used for measuring flow rate. Temperature transmitters with thermocouple temperature elements are used for temperature control. Constructing a highly stable and reliable SCADA/PLC system instead of DCS must realize automatic management and control of oil refinery process in order to avoid the waste of manpower, physical resources, and also to increase the safety of workers.

1. Introduction

The oil refinery industries are extremely important because the output products from crude oil refineries as LPG, Naphtha, Gasoline, Kerosene and Diesel have a great usage in our daily life. Many researchers have studied the usage of SCADA/PLC system in the boiler operation, desalination plants and. wastewater treatment plants. SCADA screens which are connected to Programmable Logic Controller (PLC) by means of communication cables are used to monitor the boiler operation focusing on the temperature, the level, the pressure and the flow control [1]. Multi-stage flash Brine Recirculation (BR) desalination plant is controlled by SCADA and the corresponding Human–Machine Interface (HMI). The plant consists of eight main cycles with a large number of inputs and outputs signals connected to the S7-300 PLC Siemens controller and also connect with the SCADA system based on (WINCC) software to monitor the system [2]. Industrial wastewater is crucial to sustain community health, clean and safe environment. Applying the SCADA solutions has a positive impact on the operations, maintenance, process development and saving for the wastewater treatment plants (WWTP). A SCADA software application is implemented on the wastewater treatment plant with the interface to the hardware to create a comprehensive real-time applications management environment for a modern wastewater operation [3]. The proportional, integral and derivative

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(PID) digital controller based on cascade control system and its experimental validation through three different testing scenarios; namely control action through SCADA, control action using PLC and interfacing of PLC with NI-OPC server is introduced. In this study, Micrologix-1200 PLC and RSVIEW-32 SCADA have been used with RSLinx communication Software. The SCADA/PLC control loop has been implemented with the functionalities such as real time data analysis, set point modifications, automatic report generation and integration of data with MS-Excel and MS-Access. The enhancement in project data analysis is effectively done through the integration of PLC with Lab view. The obtained results proved that the conventional control system can be further enhanced with PLC as well as NI-OPC server significantly [4].

The organization of this paper is as follows: Section 2 presents the SCADA/PLC system description; Section 3 presents the associated Graphical User Interface (GUI); Section 4 is devoted to the units operation, and finally Section 5 presents the conclusions.

2. The SCADA/PLC system

In order to automate an oil refinery and minimize human intervention, there is a need to develop a SCADA system that monitors the plant and helps to reduce the errors caused by humans. While the SCADA monitors the system, PLC is used for the internal storage of instructions for implementing functions such as logic, sequencing, timing, counting and arithmetic to control various types of machine processes through digital and analog input/output modules. SCADA refers to the combination of telemetry and data acquisition. It includes collecting information via a Remote Terminal Unit (RTU), PLCs and Intelligent Electronic Devices (IED) and transferring it back to the central site to carry out any necessary analysis and control and then displaying that information on a number of operator screens. Three of the most important parts of a SCADA system are Master Station, remote terminals (RTU, PLC, and IED) and the communication between them [5–8]. In this paper, SIMATIC WinCC flexible 2008 is used for the implementation of crude oil refinery units GUI. SIMATIC S7-200 PLC is used to communicate between input and output instruments. The interface between WinCC flexible and the PLC station is MPI/DP. The HMI device baud rate is 9600 and the network profile is Point to Point Interface (PPI) [9]. The reason for using the MPI/DP connection in main control loop instead of Ethernet connection is that MPI/DP speed is 185 kbps and Ethernet connection speed is 10/100 kbps, which increases the transfer data speed between the system components and the SCADA system.

3. SCADA system GUI

As explained before, an oil refinery process consists of four main units: crude oil storage unit, crude oil pretreatment unit, distillation unit and products storage/dispatch unit. In this paper, three SCADA GUIs are designed to monitor and control oil refinery gas processes.

3.1. Crude oil storage unit/crude oil pretreatment unit GUI

SCADA GUI consists of:

- A feed pump (P-01) with a variable speed slider.
- Differential pressure flow rate transmitters (FT-01 and 02) with the output signal 4–20 mA. Its restriction flow element is an orifice plate with a differential pressure range of 0–2500 mmH_2O. (FT-01 and 02) have a flow rate range from 0 to 460 m^3/h, where 0 m^3/h is the flow rate when the pump is off and 460 m^3/h is the flow rate when the pump is running at maximum speed. It has an output field to show its reading in the percentage flow.
- A motor operated valve (MOV-01) at the inlet of tank (TK-01).
- A crude oil storage tank (TK-01) with a floating roof tank selected to hold evaporation losses to a minimum and to minimize the fire and explosion risk from the stored stock. Its capacity is 39,750 m^3.
- An automatic servo level gauging transmitter (LT-01) used to measure the liquid level in the tanks due to its high accuracy. The area of the storage tank is very large and the very small error in liquid level measurement will lead to a great error in the liquid volume measurement.
- A motor operated valve (MOV-02) at the outlet of tank (TK-01).
- A pump (P-02) that discharges the crude oil from tank (TK-01) and feeds it to the vessel (V-01) with a variable speed slider.
- An oil/water separator vessel (V-01).
- A displacer level transmitter (LT-02) that measures the crude oil level in the vessel (V-01).
- A displacer level transmitter (LDT-03) that measures the water/crude oil interface level in the water settling pot of (V-01).
- Pump (P-03) discharges sour water from the water settling pot of (V-01) and feeds it to the waste water treatment unit.

Fig. 1 shows the crude oil storage unit/the crude oil pretreatment unit GUI when (P-01) is in the run mode. The push button of (P-01) and the green indication show that it is in the run mode, while the push buttons of (P-02 and 03) and their red indication show that they are in the stop mode. The variable speed sliders of (P-01 and 02) are only activated when the pumps are in the run mode. The blue indication of (TK-01) shows that there is a crude oil level in it. The green indication of the line shows that there is a liquid flow, while the red indication shows that there is no flow. The green indication of (MOV-01) shows that it is fully open, while the red indication of (MOV-02) shows that it is fully close. The "Distillation" and "Home page" push buttons are for navigation between screens.

(FT-01) reading shows that the crude oil flow rate to (TK-01) is 58%, while (FT-02) is 0%.

Fig. 2 shows the crude oil storage unit/the crude oil pretreatment unit GUI when (P-01, 02, and 03) are in the run mode and there is a pop-up alarm screen which shows that the crude oil level in (V-01) is high, and the blue indication of (V-01) confirms the alarm.