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Conference Paper · October 2017

DOI: 10.1109/ICITACEE.2017.8257700

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Design of Integrated SCADA Systems in Piston Production Manufacturing Case Study on the Conveyor, the Coolant, the Hydraulic, and the Alarm Systems using PLC CJ1M and CJ1W-ETN21

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Abstract— **This research was conducted at the company in Indonesia which is engaged in the production of piston. Piston is an important part of a vehicle. This research is based on the condition of the manufacturing plant, where there is an abnormality on all production lines, the invisibility of the motor coolant conditions, the conveyors, the hydraulic, and the alarm line. In addition, there are no scheduling program that led to the inefficient use of power from the motor coolant, the conveyor and the hydraulic. This is because when the hours of rest, the condition of the electric motor are still active. Undetected condition of the motor coolant, the conveyors, the hydraulic, and the alarm line, can cause unknowledgeable the condition of the production line that is currently in producing or being stopped. The duration of treatment by the maintenance operator can cause more lost time in the production process. While the duration of treatment by maintenance operators, one of them is caused by the distance between the control panel and monitoring for all conveyor motors, the coolant, the hydraulic, and the alarm line with maintenance space. This makes the maintenance so difficult to check the condition of the panel. We made a scheduling program and wiring the integrated monitoring with SCADA (Supervisory Control and Data Acquisition) systems that can automatically control and monitor the power usage of conveyor motors, the coolant, the hydraulic and also can monitor the alarms in the line. This integrated SCADA system using PLC (Programmable Logic Controller) CJ1M and CJW-ETN21 is based on Visual Basic. Based on the experiments conducted, the system can be more efficient energy output, amounting to 20,430 Watt per day. In addition, the overall state of the production line can be monitored in real-time.**

Keywords-PLC CJ1M; CJW-ETN21; Visual Basic; SCADA Systems;

I. INTRODUCTION

This research was conducted at the manufacturing company in Indonesia which is engaged in production of engine parts i.e. piston. Piston is a vehicle component which serves to accept pressure or expansion pressure of combustion then pass to the crankshaft via a connecting rod.

The initial process of manufacturing the piston starts from a foundry processes i.e. melting processes, materials treatment, gravity casting, sprue cutting, heat treatment, and finishing). The second stage is the machining i.e. guide bore finish, rough turning, rough pin hole, drill oil hole, pin hole finish, outsider diameter finish, engraver). The third stage is a surface treatment, the next step is a visual inspection, and the last stage is the final inspection.

We found an abnormality on all production lines, which are unmonitored condition of the motor coolant, conveyors, hydraulic, and alarm line, as well as the absence of a scheduling program. This resulted in inefficient power use of the coolant motor, the conveyor, and the hydraulic; because when the breaks time the electric motor power remains active. Unmonitored conditions of the coolant motors, the conveyors, the hydraulic, and the alarm line, can cause unknowledgeable condition of the line whether it is productive or not. The duration of treatment by the maintenance operator can cause more lost time in the production process. The duration of the maintenance operator handling by one due to the distance between the control panel and monitoring for all the conveyor motors, the coolant, the hydraulic, and the alarm line with maintenance room. This makes it difficult to check the panel condition.

In this paper, we design the SCADA system to control automatically and monitor the power usage of the motor conveyor, the coolant, and the hydraulic by applying scheduling and also can monitor the alarm systems in each the line using PLC CJ1M and CJ1W-ETN21 based on The Visual Basic inside a personal computer (PC). So that the condition of the motor coolant, the conveyor, the hydraulic, and the alarm in each the line can be monitored in real-time, and use the power more efficiently; this expenses can be reduced [1, 2, 3, 4, 5, 6, 7, 8, 9, and 10].

II. METHODOLOGY

SCADA Systems

SCADA (Supervisory Control and Data Acquisition) system was referred to the combination of telemetry and

data acquisition. The systems consist of a collection of information, transfer it back to the control centre, perform the necessary analyses and controls, and display this data on the number of operators display. SCADA systems are used to monitor and control plant or equipment. Control may be automatic or can be initiated by an operator command. Fig. 1 shows the instrument field of SCADA systems.

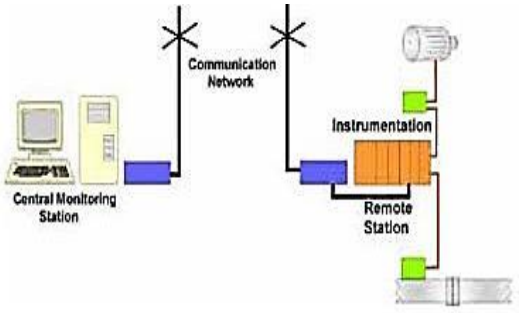

Fig. 1.Field Instrument

The control panel is a panel that serves to automatically control the use of the motor coolant, conveyor, and lights. The layout of the control panel is near to the line 28.

The workings of this panel is to send commands via the HMI screen as input PLC or by scheduling automated contained in the PLC program itself. The order was processed by the PLC as output to turn off the motor coolant, conveyor and light through a junction box that is in line 28.

The Line 28

The line 28 is located in building A and the line that produces piston of type motorcycle. The process of making the piston in the line 28 starts from Guide Bore Roughing (GBR), Rough Turning (RT), Pin Hole Roughing (PHR), Drill Oil Hole (DOH), Pin Hole Finish (PHF), Ring Groove (RG) and last is Automation (CBC, Engraving, and Washing).

Behind the machining process is so complex, there is a driving force that works to assist the machining process, namely: motor coolant that helps the cooling process the workpiece on the machine PHF, DOH, RG, PHR, RT, and the scrap conveyor motor which helps to transport the machining on the RG machine, RT machine, and PHR machine.

Problems in Control Panel

- Problems with the control panel are a panel controller can only be used to control the use of HMI and cannot be to monitor. Therefore, the maintenance cannot know whether the motor coolant, which is in control of the conveyor, is in an active state or not.
- In addition to monitor problems, other problems are found in the control panel with the panel that the distance is 48 m from the maintenance room, thus the operator maintenance is difficult to control or check the panel.

Problems on the Line 28

Scheduling system that has been there previously be proven excellent in reducing the cost of power consumption, but the scheduling system is also a problem. As a result, the absence of a rolling system is generated by the production the line 28 decreases. Therefore, the maintenance dismisses scheduling system and is replaced with EMG button to control the motor coolant, scrap conveyor motors, and the lights manually; consequently the production line back up.

After the removal of this scheduling system using EMG button, then the production line 28 back rises compared with the previous ones. On the other hand, the use of power coolant and conveyor motor back to inefficient, due to the frequent occurrence of human error. That is, when a break time, the operator neglected to press the EMG button, so the use of the motor coolant, the conveyor motors back to inefficient.

A further problem is the absence of a wiring circuit breaker for electric motors that are useful to drive the hydraulic pump. Specifications hydraulic electric motor, namely: 4 pole, 3HP, 50 Hz.

Analysis of the Solutions

Based on the problems that occur, we provide some solutions:

- Design the PLC program, in which the PLC program, there are programs for manual control and scheduling of the use of the motor coolant, the conveyor and the hydraulic. The PLC program there is a program for monitoring the use of the motor coolant, the scrap conveyor, the hydraulic, and the alarm line. The PLC program also has a program for communication with the Visual Basic (VB).
- Add a control to a hydraulic motor.
- Make a wiring for input coolant motors, the conveyors, the hydraulic, and the alarm line to the PLC.
- Make a wiring for the rolling button.
- Design a VB program that serves as SCADA systems for control of scheduling, the motors, and can monitor the line with a personal computer in the maintenance room. This is in order to facilitate maintenance operator in knowing the error in the line 28.

Control System Design

The function of this system is reducing the power usage of the motor coolant, the hydraulic, the conveyor scarp, and if the break time, the operator can still make rolling if needed. Fig. 2 shows the control systems flowchart.

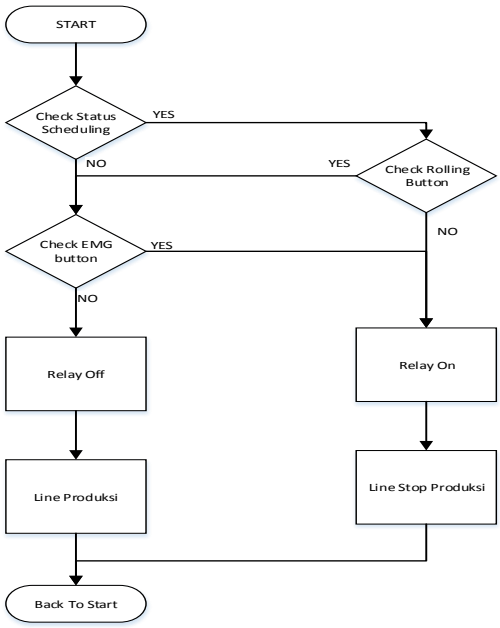

Fig. 2. Control Systems Flowchart

SCADA System Design

We designed a system that can control and monitor the use of coolant motors, the conveyor, the hydraulic, the alarm line, and store the data into a database in a computer in the maintenance room. Fig. 3 shows the SCADA systems schematic.

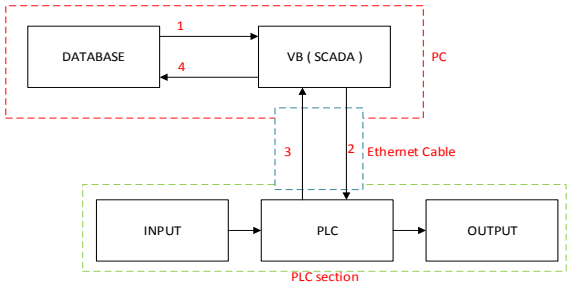

Fig. 3. SCADA Systems Schematic

SCADA process is started from:

- Take some of the data that is required in the database.
- Next SCADA will send commands such as monitoring and controlling to the PLC via a network cable.
- The next command will be executed by the PLC, if the commands are executed in the form of monitoring, the PLC will send the data to a PC.
- If the data which is sent by the PLC has no alarms, the SCADA will start counting alarm and save the alarm data into the database.

III. DESIGN

A. *Design*

Wiring Control System

Systematics is the electrical wiring between the main panel, support panel, junction box, and to the machinery that is in line 28. Wiring is started from the main panel, where the main panel is issued the output voltage coming from the PLC to the supporting panel, and the panel also support to send a 24 volt voltage which is derived from the junction box to the main panel to enter the PLC input.

After that, the panel will issue 16 pieces supporting the cable to the junction box consisting of the output voltage, 220 volts, the input voltage, and others. At the junction box, then the cables will enter into the machines to be controlled and monitored [11].

Wiring the Input Device

Wiring the input device is performed by connecting the input devices that relay, push button, EMG button with PLC as the main controller device. This is done so that the PLC can determine the condition that occurs in the line 28 through a given signal the input device. The following is explanations of some of wiring the input are used, namely:

- Relay. Relay in this system serves as an input to the PLC to determine the condition of electric motors for conveyor or coolant or hydraulic.
- Push Button. Push button in this system serves as an input to the mark if the operator wants to do a rolling line at intermission
- EMG (Emergency). EMG button in this system serves to activate the relay breaker on all machines, so that the electric motor for the conveyor, coolant and hydraulic inactive or ignite. Unlike the scheduling where scheduling can only turn the breaker relay in accordance with the set time EMG button while this could break the tension anytime.

Wiring the Output Device

Wiring device is done by connecting the output device with PLC as the main controller device. It is done; accordingly, the PLC can control the output device in a control system to make the process of scheduling.

Wiring the Ethernet Network

SCADA system requires a device as a media liaison or communication with the master. In this case, the master is the personal computer and the slave is the PLC.

Design for Program SCADA Systems

In accordance with the flowchart, the scheduling system will work if the button is not pressed rolling, and when it is pressed, the line will remain in production.

In the SCADA system there are 2 pieces of programming, namely programming for monitoring the state of the PLC which is connected to the line, and programming to control the PLC, where VB can directly control the output PLC and schedule can also enter the data into the PLC.

IV. TESTING AND ANALYSIS

A. Testing

Testing the VB Monitoring

Testing the VB monitoring is aimed to determine whether the program that has been made has been corrected and can monitor the data in the PLC. Testing is done by visually to see the PLC condition with the VB. Monitoring line with the view parts: lighting, conveyors, coolant, hydraulic, alarm, and rolling line. While monitoring the PLC, it checks: date, time, and time scheduling.

Testing the VB Controlling

The VB Controlling testing is aimed to determine whether the programs are made to control the PLC can be used properly. Testing is done by visually see the PLC condition with the VB.

Scheduling Testing

Testing otherwise is good when scheduling an active schedule, active breaker relay and contactor disconnect voltage electric motor engine. When scheduling an active operator can perform a rolling production line. Testing is expressed not good (NG) if the above statement cannot be executed. The description of test scheduling i.e.:

- Scheduling an active schedule: electric motors for conveyor line 28 off; electric motors for coolant in line 28 off; electric motors for the hydraulic line 28 off; the line 28 lights off.
- Pushbutton for the rolling: all electric motors in the line 28 and the lights came back on.

C. Evaluation Results

The use of SCADA system on the line 28 is a positive impact on the line 28 and the maintenance department. After manufacture the SCADA system, then there is a decrease of power consumption on the line 28. Fig. 4 & Fig. 5 are the display of VB control and VB monitoring.

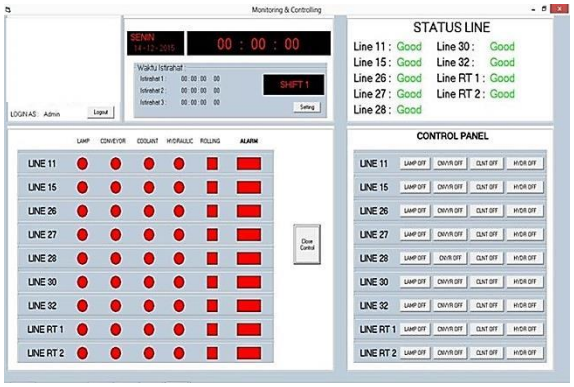

Fig. 4. View of VB Control

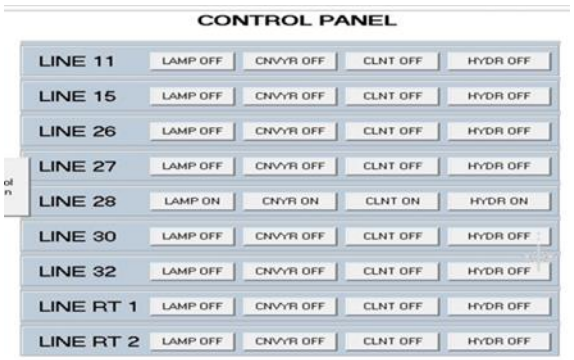

Fig. 5. View of VB Monitoring

Decreasing the Power Usage

Table I shows the electric power comparison between condition before the improvement scheduling system with additional time and after the use of power from the electric motor to the hydraulic system.

Table I. Electric Power Comparison

	Used Power (Watt)	**Work Hour (hours)**	**Watt Hours (WH)**
before	6,810	24	163,440
after	6,810	21	143,010

From Table I, we can see the comparison of the time before any improvement occurs when that is 24 hours and after the repair, to 21 hours. Thus, power consumption can be reduced by 20,430 WH. Fig. 6 shows production data when a new scheduling system is run. This data is taken when the system has been running.

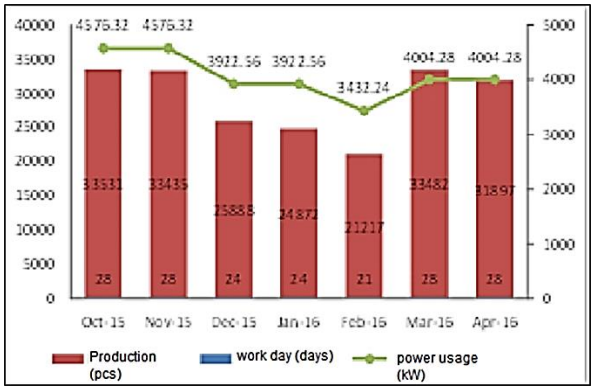

Fig. 6. Production and Power Electric Consumption Graphic

V. CONCLUSIONS

In this paper, we have discussed about the design of integrated SCADA systems on the conveyors, the coolant, the hydraulic, and the alarm systems and using PLC CJ1M and CJ1W-ETN21. The SCADA system is in compliance with the desired design. Overall, the SCADA system can monitor the line conditions in real-time and can control the use of motor power manually or scheduling maintenance indoors. The new scheduling system contained in the PLC system can be controlled via the VB monitoring system. In addition, the use of the power is utilized for the electric motor coolant, the conveyor, and the hydraulic can be more efficient.

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