Design and Implementation of Supervisory Control and Data Acquisition system for Paint shop

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ABSTRACT *To fulfill the needs of automotive industries, an automatic control system is designed, based on PLC and SCADA. Automation can be precise as the technology where the human intervention is minimized. In this paper we are proposing a reasonable method to improve the availability of the system and increased production with reduced cost. Maintenance of historical data manually is very tedious process where the data loss occurs and also it consumes more time. The main aim of the work is to provide a Excel based reporting system which renders the historical data regarding the different elements like quality, process, maintenance and management (parameters) of a vehicle (paint shop) plant, Therefore, the vehicle processing in industries are controlled and monitored by SCADA(Supervisory Control and Data Acquisition System) interface to improve the speed, production cost and faster fault identification, with accurate and consistent information. – Siemens WinCC V7.0 SP1 in this case.*

Keywords: *Automation, Programmable logic controller, SCADA, Vehicle processing*

I. INTRODUCTION

The System that is designed and explained here allows the Supervisory control of the process in a vehicle manufacturing industry. A programmable logic controller is mainly Used in order to control the vehicle process by using Supervisory control and data acquisition system which is Termed as SCADA and the Programmable logic controller Is termed as PLC. Once the vehicle body is welded in the BIW shop body is sent to the paint shop, the paint shop is a fully automated workshop where all the painting work is done automatically by preprogramed robots. After the body is being painted the final finishing, defect analysis and inspections is done by manual labor. The vehicle manufacturing includes number of stages, the work which is carried out is mainly focused on painting the vehicle and the number process which are included in painting. It includes two stages of process lines, Acquience conversion coating as ACC, the BIW body are coated with a corrosion resistance material by loading the bodies at one end, after which the body is painted.

A. Supervisory control and data acquisition system

Supervisory control and data acquisition (SCADA) is centralized system based on distributed input/output. SCADA is referred with respect to the system that gathers the information from various sensors from industry or plant, also in remote places The data which is gathered is sent to a central computer which manages and controls the data, SCADA systems are not only used in industries but also in steel making, nuclear and conventional type of power generation, It is also used in the field of chemistry in the facility such as nuclear fusion. SCADA systems are rapidly entering the class of plants with many number of input output channels. SCADA is used in the control center that is in both plant and load. It is mainly used to collect the information such as,voltage current, power, frequency, circuit breaker status, by knowing these information the online status canbe performed.

B. Programmable logic controller (PLC)

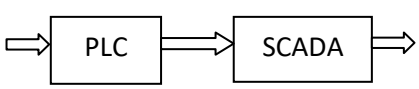
PLC'S are referred as a programmable controller, which are in the computer family. These are used in industrial and commercial applications. PLC'S analyses the inputs and based on the programs it makes the decision, and it controls the outputs to automate the process. PLC comprises of input modules, output modules and a central processing unit. A programmable logic controller (PLC) is used to control process and machines. It mainly uses programmable memory for the storage of some specific functions and instructions and these can include on or off control, sequencing, data handling and timing. PLC is used due to these reasons, it is very feasible with faster response time, and it has simple wiring, its design is modular which is easy to repair, it can handle the complicated systems, the instruction cycle in the PLC are less complicated, easy for trouble shooting and it is less expensive.

II. RELATED WORK

The related work gives the brief description of how various methods are adopted using SCADA and the improvements done in the different fields of automation. Haider Ali, Ahmed Ali, Riaz U Hassnain, Syed Ajmal Khan, Ihsanullah Khan, implemented SCADA for Industrial Temperature
Automation, they developed ladder logic in Micrologix software and it is verified in Allen Bradley PLC. A ladder logic program of a particular application mainly results in software that is difficult in configuration as well as in maintenence. The difficulty can be solved with the real-time control software that is by ladder logic. This makes the initial configuration of the software extremely difficult and labour-intensive, but also makes reconfiguration risky.However the system creates a fast, real-time decision making environment. This paper focuses on an innovative and intelligent monitoring system of process using SCADA [1] K. Gowri Shankar studied the various stages of operation involved in the adaptation of a manually operated boiler towards a totally automated boiler.The work is mainly focused on passing the inputs to the boiler at a required temperature, so as to constantly maintain a particular temperature in the boiler. It is also focused on pressure, level and flow control at the various intermediate stages of the boiler plant. Thus the temperature in the boiler is constantly monitored and brought to a constant temperature as required by the power plant. The automation is further improved by constant monitoring using SCADA screen which is connected to the PLC by means of Ethernet cable. By creating tag values set to various parameters in SCADA the entire process is controlled. [2] Sayatan Dutta, Anushree sarkar introduced an experimental study which helps in maintaining the characteristics on/off of the control valve. The graphical user interface has been developed using SCADA ,and PLC for programming the entire system. In this work it is known that they analysed the factors responsible for the variations in the valve characteristics. The system gives a clear idea about the opening and closing of the valve which are present. The input valves are supplied to the industry as required. Since the system is cost effective, high efficient and accurate, it required a PLC with one interfaced digital system to control many number of valves.[3]. Fahad Durami and Muhamad riaz designed a prototype of electro pneumatic control system using PLC-300 the explosive materials used in the industries. In order to avoid the electric signals instead of electric signals that fully automated test bench is created which consists pneumatic and small electrical signals for cutting the industrial materials[4]. Rajesh kumar, Syed Akif karnal discovered the central controlling and monitoring system it not only ease the managing of the system, but it also provides the accuratre data at very low cost. The main aim is to design a SCADA for monitoring system ogf looms in a textile industry, the system which includes the complete analysis of the problem. The master station types avialble are VAX, LINUX, or UNIX based computer system with the programmable logic controller [4].

III. PROPSED METHODOLOGY

The following figure 1 shows the block diagram of the work carried out.



INPUT OUTPUT
ETHERNET
(Sensors & Actuators) (Digital Report Generation)

Figure1:Block diagram of the Proposed system

The inputs from sensors and actuators are applied to programmable logic controller through Simatic Manager by creating ladder diagrams, the data obtained from PLC is fed to SCADA through Ethernet cable, the SCADA management is done through Simatic Wincc by creating tags and alarm management systems ,on the output side the excel based digital reports are generated. Line status monitoring of ACC line and PCC process lines. The complete system is broadly divided into two parts based on the type of coding, location of coding and application independency characteristics. Those two parts are as below:

1. Data transfer from PLC to WinCC (SCADA).
2. Data fetching from WinCC (SCADA) to SQL Server and Representation in Excel sheets as per approved prototype.

Once the abstract level design is ready, a feasibility test of technology options was carried out. The main task in this phase was finalizing a way to establish a connection from WinCC to SQL server and SQL to Visual Basic to EXCEL for command and data transfer between them. PLC being a micro controller based programmable device, which controls the production line. In this plant we have used Siemens PLC i.e. CPU315-2PN and 13 remote Input/output modules. CPU and remote IOs communicate through profinet

network. Inputs like Sensors pull chord switches, limit switches, nut runner, pokayoke signals and outputs like motors, actuators are connected to remote IO modules. PLC is connected to SCADA (WinCC) through profinet protocol and it gives real time data to SCADA system. PLC coding has been written in Simatic Manager, which is a application tool for coding. We had used three languages namely

A. GRAPHIC DESIGNER

The ACC and PCC lines are designed using simatic wincc graphic designer using various tools. The main screen is designed such a way that whole process is visible to the operator.

The ACC screen contains the animated design of Electro monorail transport system, processing tanks ,carts, oven and conveyors along with sensors. The below figure 2 shows the design of Acquience coversion coating(ACC) line. After designing the process line, particular tag with data values are created under tag management and assigned to the respective components. The movement of the vehicles in the design can be done

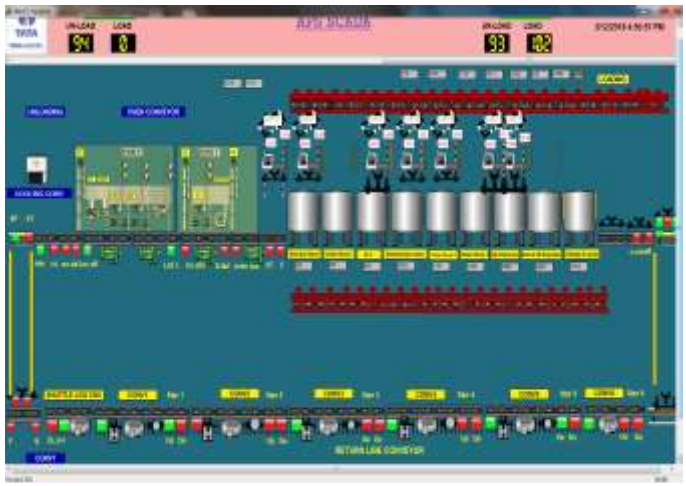


Figure2: Accquience conversion coating line

The below figure 3. Shows the powder conversion coating line The powdered conversion coating line is also designed in a similar manner using the graphic designer tool the major difference is here there are stations instead of tanks since this is a powder conversion coating line. The PCC line consists of thirteen number of stations with the touch up booth , sealent filling and waxbooth, There is a presence of scissor lift 2 followed by disengage conveyor by which the vehicle body is lifted out of the line.

Figure 3: Powdered conversion coating line

B. Human Machine Interface

Human machine interface (HMI) is a user interface machine which helps to connect the user with the controller.

Figure 4: HMI screen of Electromonorail system

The figure shown above shows the HMI Screen of the vehicle positions. The HMI screens are designed for the vehicle up , down ,forward speed , reverse speed and vehicle traverse positions. In the screen it also possible to view the vehicle loading and unloading count of both ACC and PCC process lines with respective date and time.

IV. RESEARCH METHODOLGY

The flow chart of the project is shown in the figure shown below. The methodology includes the hardware and software design also the communication of PLC and SCADA. The complete system flow chart is depicted here. In order to study this project these steps are followed. This section also includes the hardware design, software design and communication of PLC with SCADA. This one is worked out at abstract level. As evident from Abstract level design, the part of the system integrated in WinCC will be fetching all the parameter values which are stored in WinCC Tags and inserting them into SQL Database through time base and event base triggers which are standard features of WinCC. The SQL server resides the complete Database,It will be acting as Data Destination to WinCC SCADA and as Data Source to Visual Basic.

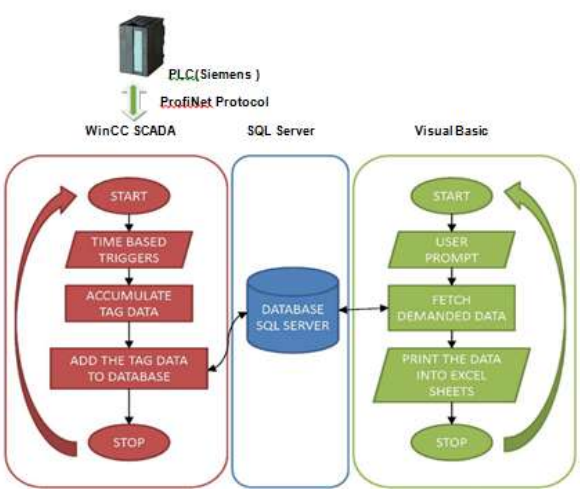


Figure5: Flow chart of reporting system

The part of system residing in Visual Basic prompts the user for inputting the Report Date, and fetch the data from SQL Server for given dates and represent them in approved Excel templates.

A. Hardware configuration

The figure 6 depicted below shows the hardware configuration of the Accquience conversion coating line.The hardware configuration consists of SIMATIC S7-300 CPU 317- 2 DP with 24V power supply. Where the system follows the master slave system which control many number of slaves with a single master.

Figure 6: Hardware configuration of Accquience conversion coating line

The transfer rate of data is of 187.5kbps and the trolley numbers are user defined. There will be a remote input output connections to each trolley with the separate input output modules. The figure 6 shows the hardware configuration of the powdered conversion coating line. The system also connects the entry blower, exit blower, touch up booth , wax booth ,air separation units along with the CPU and power modules. Each blower module is assigned with respective IP address. The hardware configuration of both ACC and PCC lines differ in the i/o configuration only. The CPU configuration remains same for both the lines.

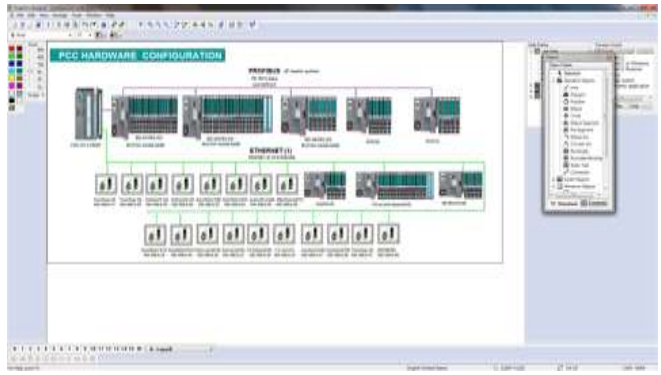


Figure 6: Hardware configuration of powdered conversion coating line

The figure 7 depicted below shows the PLC configuration for eight number of carts, at a time the electro-monorail system is made to transfer eight vehicle body along with the carts.

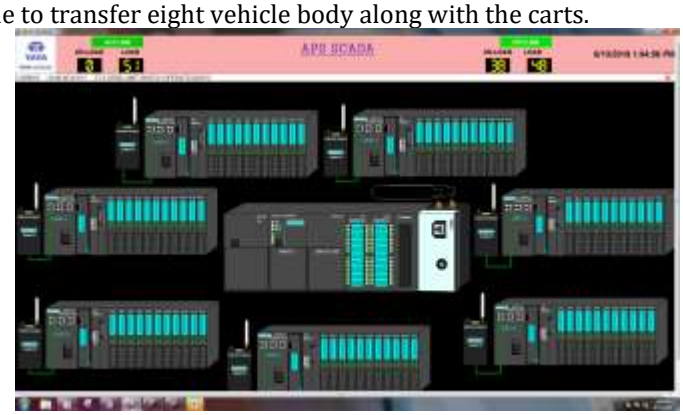
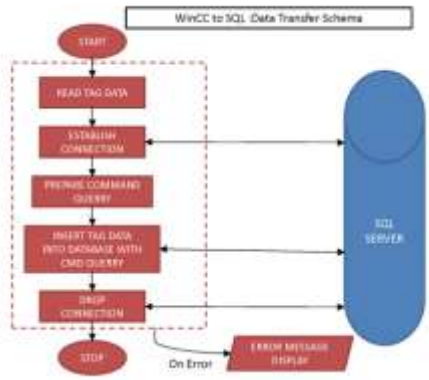


Figure 7: Input Output module configuration

B. Software configuration

The key part of the reporting system is Visual Basic representation. This is final product that is of interest to customer/user. Once the event is triggered, the execution is carried out according to the system flow chart below.



. ***Figure 8: Data transfer flowchart***

To start with the Command Duration is read from the Date Time Picker control. Then an ADODB connection is established with database in SQL Server. The command query is formed based the duration selected and type of the report. This command query is passed to SQL server and the resultant set of records is received into an ADODB record set.

C. PLC programming

PLC has connected to SCADA (WinCC) through profinet protocol and it gives real time data to SCADA system.

Figure 8: Ladder logic for the proposed system

PLC coding has been written in Simatic Manager, which is a application tool for coding, three languages are used namely

1. Ladder Logic
2. STL (Statement Language)
3. FBD(Function Block Diagram)

V. RESULTS AND DISCUSSIONS

The complete system was designed as per the system flow charts and testing of the same was done with some trial data. Once the testing was error free and performance was satisfactory in terms of speed of report generation and accuracy of report generated, the complete system was integrated into actual PC at the site. The system was put on live and was under observation by the user. Finally after sufficient period of error free and accurate operation the project was approved by the customer.

A. Repot format in Excel sheet

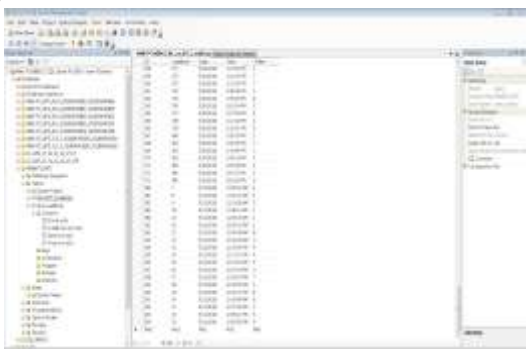


Figure 9: Report generation in Excel sheet

The execution is iterated through each and individual record of the record set, meanwhile the field data of these records are printed onto report sheet at specific cells depending on the Date, Time, and vehicle ID and trolley number. After the execution is iterated through complete record set, the Connection with SQL Server will be dropped.

Figure 10: Alarm generation of ACC, PCC and EMS line

During this complete process if some error occurs, the description of the error will be printed onto the screen. The same procedure will be carried out for each and individual report sheet of the workbook.As discussed earlier the complete reporting package is broadly divided into five broad categories under Records category.

1. LogON/OFF
2. EMS screen
3. ACC and PCC screens
4. Blower screens
5. Alarm generation
6. Report Summary
7. Exit

Figure 11: Report generation screen

The figure 11 shows the final generation of the work carried out. Report has to be saved in specified location before end of the line. This function has given in records screen. Summary of report will generate automatically at the end of line in Microsoft EXCEL format. Once the testing was error free and performance was satisfactory in terms of speed of report generation and accuracy of report generated, the complete system was integrated into actual PC at the site. The system was put on live and was under observation by the user. Finally after sufficient period of error free and accurate operation it was successfully proved SCADA plays an important role in industry.

CONCLUSION

A Complete Reporting System, which reads the line stoppages and process parameters automatically and adds the record of them onto a Database. It also provides with an interface to generate the reports for any required Month/Date/Year in an informative Manner. The system helps in maintaining the information, which is required for Analysis of performance of Paint shop , and to efficiently run the plant. Hence, an efficient Reporting System was developed according to the requirement of the customer with complete utilization of the resources available.

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