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Data Acquisition and Controlling in Thermal Power Plants using a Wireless Sensor Network and LabVIEW

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Abstract- **Monitoring and controlling of parameters such as temperature, humidity and pressure is an essential process in critically controlled environments of industries including the Thermal Power Plants. For the working of Thermal Power Plants, storage of different chemicals to the process of cracking and combustion, controlling these parameters are essential. In this paper various data acquisition process in a Naphtha based thermal power plant was investigated and a virtual system has been designed to monitor and control, using 16F877A microcontroller and LabVIEW based platform. This provides a cost effective and energy efficient monitoring and control system. With very little modifications this platform can be utilized for various industrial needs.**

Key words- Data Acquisition, SCADA, Thermal Power Plants, wireless networks, LabVIEW.

I. INTRODUCTION

The development of science has led to the improvement of technical requirements and recession. Hence the number and function of the original electronic measuring instruments cannot meet the actual needs. Updating the instrument leads to increase in production funds and is difficult to achieve in a short term. Alternative to these traditional mechanisms, virtual instruments are more effective in the way. The virtual instrument to be dependent mainly on computer technology can provide the concept of software instrument. This helps user-self-definition and designing. Furthermore, it can reach one or even multiple functions of traditional instruments in an integrated environment and are easily upgraded and expanded, and is cost-effective.

With the development of network and communication technology, the inconvenience of wiring is solved with Wireless Sensor Network. It has wide perspective and practicability in the area of remote sensing, industrial automation control, and domestic appliance [4]. WSN works with good functions of data collection, transmission, and processing. It has many advantages compared to the traditional wired network. In order to satisfy the demand of low power dissipation and low speed among wireless communication devices, a new type of wireless net technology Zigbee is to be used [8,11].

LabVIEW is a graphical programming tool based on powerful test system, which is a well-connected, open, and has dedicated services. Hence the test system development cycle is short, low cost, and yield high quality [2, 10]. LabVIEW virtual signal generator is easy to operate, which can be utilized in a wide range of applications including scientific research, production and other related fields. The systems consist of both hardware and software platform. The core of the hardware platform includes a PIC microcontroller and a Wireless transceiver. The hardware platform acquires the critical parameters with the help of various sensors which are interfaced with a microcontroller 16F877A [3]. The controller gathers the data and processes it. Software part constituted by LabVIEW receives the data through the serial port and Virtual Instrument System Architecture (VISA). The data can be stored in a defined file of PC by LabVIEW platform while carrying out the data acquisition [10].

A. Process of power generation

In the electric power generation, a combined cycle is utilized, which is an assembly of heat engines that work in tandem from the same source of heat, converting it into mechanical energy, which intern drives the electrical generators. The principal is that the exhaust of one heat engine is used as the heat source for another, thus as the heat, increasing the system´s overall efficiency.

Naphtha is stored in large containers at a temperature of 40 to 60°C. These can be driven to the combustion chamber using pipe lines. Naphtha boils at 160 to 220°C and vapor pressure is less than 666Pa. It is incompatible with strong oxidizers [9].

Air is sucked from the atmosphere into the compressor at a temperature ≈ 525°C, to the combustion chamber where naphtha is sprayed and combustion takes place at 1300°C. The steam produced here is directed to the Gas Turbine. The rotating turbines are connected to the motors via a shaft, which in turn rotate to produce electricity [7]. The gas exhaust after the generation of a combined cycle operation is let out to atmosphere upon condensation through boilers. Data acquisition is done using sensors with respect to parameters such as temperature, humidity, volume of fuel and the circulating water, and pressure [5].

II. LabVIEW DATA ACQUISITION SYSTEM

Continuous Monitoring Systems evaluate the working of the various systems in power generation. It acquires the physical variations and produce corresponding digital signals which were send to the central control unit. The control unit processes these signals and analyzes the parameters. With respect to these changes, control signals are generated which can maintain the sensitive parameter values for the proper working of the machines and enhance power generation. The Fig. 1 shows the overall block diagram for the data acquisition system.

III. DESIGN OF WIRELESS SENSOR NETWORK

The design and simulation of the wireless sensor network is implemented using the simulation software Proteus. The software provides different functions and allows selection of various electronic components for the circuit. Proteus enables the user to select the desired controller with the required specifications. Here the microcontroller used is PIC16F877A [14]. The required oscillator clock frequency and the ADC pins are configured. Various sensors are used to acquire critical parameters such as Temperature, Pressure, Humidity etc. and these signals are processed by the built in ADC and they are given to ZigBee through the built in USART facility of the controller 16F877A. The sampling frequency of the ADC is selected as 1 MHz To program 16F877A, PIC C compiler is used**.** The Fig. 2 shows the circuit diagram for the Wireless Sensor Network. Here three sensors are used for collecting parameter values such as temperature, pressure and fuel level respectively.

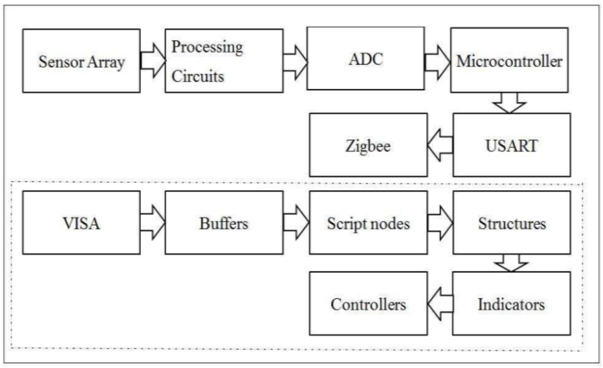

Fig.1. Schematic block diagram of the proposed system

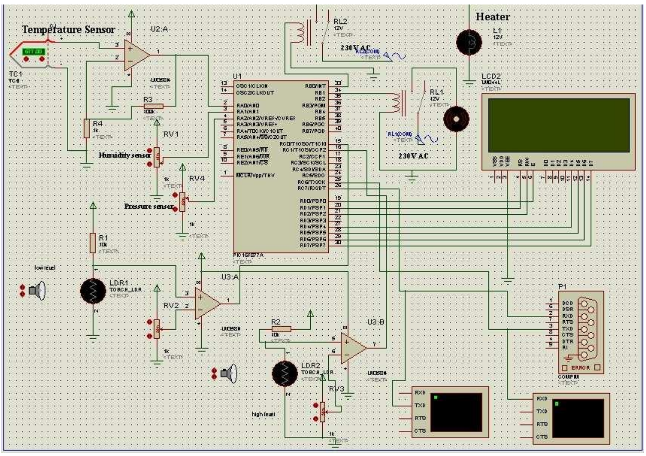

Fig.2.Circuit diagram of the Wireless Sensor Network

The data obtained from the sensors are processed by PIC16F877A and generate corresponding control signals. Thus it provides continuous monitoring in the power plant [7]. The control signals are generated by the LabVIEW and these signals were fed back to the control system which operates the heater, water sprayer and pressure piston at the combustion chamber. The front panel, which is designed using LabVIEW, shows the status of every sensor, value of parameters, status of control valves etc. The data acquired using the sensors are directed towards the control unit i.e. the LabVIEW control panel via a USART communication port, also known as COMPORT.

Simulation of the integration between hardware and software part is done with the help of VSPE (Virtual Serial Ports Emulator) package. With VSPE users are able to share physical serial port data for several applications, expose serial port to local network (via TCP protocol), create virtual serial port device. It is a simple tool for developers working with serial ports. Setting up devices is both quick and seamless. PIC C Compiler provides a complete integrated tool suite for developing and debugging program. Use of this compiler maximizes code reuse by easily porting from one MCU to another. C is a general purpose language which is very easy and user friendly. The digital signals from ADC are processed in the microcontroller. Microcontrollers also generate the necessary control signals for the sensors. The signals from the microprocessor are transmitted to the control unit with the help of USART.

A. Circuit Operation

The temperature sensor used here is type K thermocouple, which provides -200 to 1330°C. The analog output from the sensor is given to any of the ADC pins of the PIC16F877A microcontroller.

For the monitoring and control of the temperature in the combustion chamber, system tries to maintain the temperature around 1300°C, as per the industrial requirement. When the temperature value is less than or graeter than this range, control signal will be sent by the LabView to the controller, to switch ON the heater. And if the temperature is maintained at the normal level or if it goes much higher, then the heater is turned OFF. A water sprayer pipe is utilized to reduce the temperature and also in adjusting the humidity content in the combustion chamber. Humidity in the chamber should be maintained at 39% to 42%. Similarly, pressure at the compressor and the combustion chamber is controlled with the help of a piston (gas piston). The fuel (naphtha) is burnt at a vapour pressure of 600psi (pressure per square inch).These variations in parameters will be displayed in the control palette at the control unit which is installed with the help of LabVIEW. The fuel level is detected with the help of LDRs and checked with PIC16F877A Analog Comparator module. To fill the fuel tank, control signals are send, to open the inlet valve. When the fuel level rises beyond the maximum range then the outlet valve is open, which directs the excess fuel from the fuel tank to separate tank.

IV. DESIGN OF LabVIEW DATA ACQUISITION SYSTEM FUNCTION MODULE

Data from controller is received by the ZigBee and it's given to the computer system in which LabView is installed. Interfacing between the systems is done through the serial port of the system.

Data porting between System serial port and LabView is established by Virtual Instrument Software Architecture (VISA).Necessary serial port configurations can be done by using VISA node. These data is stored in an array. Figure 3 shows input stage of the designed system using LabView.

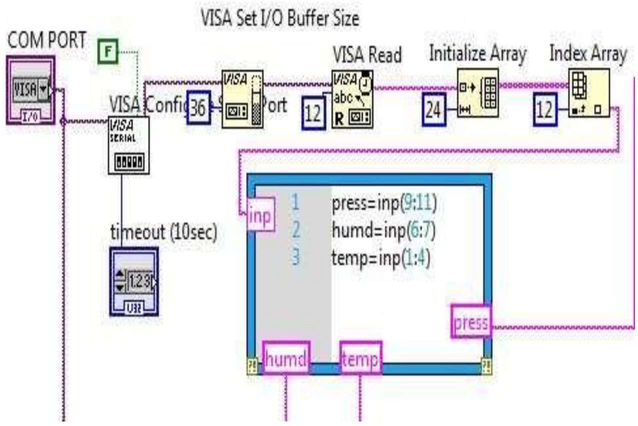

Fig. 3. VISA configuration function

Controllers are used as a platform to convert the data and process them to a format .They are evaluated by the monitoring system, i.e., LabView. Depending on the set-up of the physical (or non-physical) system, adjusting the system's input variable will affect the operating parameter, otherwise known as the controlled output variable. Upon receiving the error signal that marks the disparity between the desired value (set point) and the actual output value, the controller will then attempt to regulate controlled output behavior.

The design of the instrument process is based on the function required. Here the sub-VI provided by virtual instrument development platform is used to serve the purpose. In the block diagram, as shown in Fig. 4, a serial port configuration function, a byte serial port function, serial read function, waveform charts, file write function, the file read functions, conditions structure, sequence structure, loops and LEDs are used.

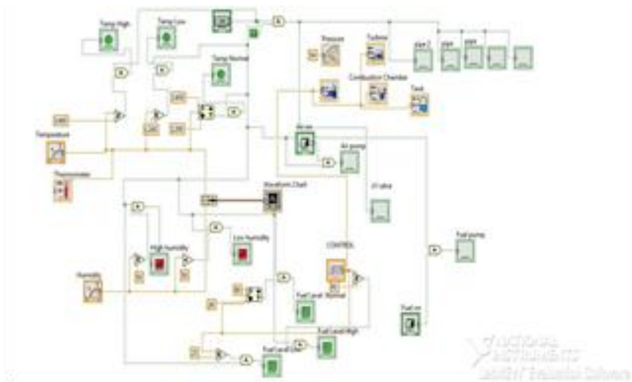

Fig. 4. Continuous monitoring system block diagram in LabVIEW

Fig. 5. Front Panel of Continuous monitoring system

The Front panel of the Continuous monitoring and Data Acquisition which appears in the control panel in the centralized control unit of the Thermal Power Plant, shown in Fig. 5. The LEDs were designed to light up Red, Yellow and Blue colours with the corresponding High level, Low level and Normal level of temperature, humidity and fuel tank level respectively. The variations can be observed through the Thermometer, Hygrometer, pressure gauge and the waveform chart. In the Thermal Power generation, the humidity level should not exceed 42% of the total dry air in the chamber. This is regulated by heaters and by spraying water droplets into the chamber. The amount of vapor content also has a vital role in maintaining the temperature suitable for fuel combustion. The system also checks the amount of fuel in the tank, for the process of power generation to take place continuously. Any interruption or slowdown in the process may not give out the maximum output. One cycle of power generation is capable of producing 115MW (Mega Watt) of electricity. This is increased with the implementation of the combined cycle operation in the Power Plant. The pipe lines, pumps and vessels are obtained from the DSC module of the Control palette in LabVIEW.

As the process is switched on, the tank is filled and the levels are indicated in the control panel. When the level reaches the maximum value, the outlet valve opens and the fuel is taken out at a constant rate. Here, at this point of operation, the inlet of fuel to the tank is closed for a small time period, till the fuel level reaches normal range. If the fuel level is below the minimum requirement, the pump starts again and tank is refilled.

V. CONCLUSION

This system provides an efficient continuous monitoring and data acquisition system. It reduces the complexity in cable installation and maintenance costs. The secure data transfer and reliable data acquisition is obtained in the critically controlled environments of Thermal Power Plants. The system well suits integrating with the existing wired systems and enterprises. Data acquired using the different sensors deployed with respect to the necessary parameters in the industry processed by LabVIEW functionalities. The necessary control signals were generated and send back to the sensors. The front panel obtained is installed in the centralized control unit of the Power Plant. The continuous monitoring systems for temperature, humidity, fuel tank level and pressure have been integrated to a single control panel which enables easy access to the operator. Control panel evaluates the parameter variations and system performance effectively, that provides faster error detection. Failures are readily identified and control signals were send immediately without interrupting the processes involved in power generation. The results obtained on simulating the front panel designed in the professional platform of LabVIEW presents an excellent picture of the variations of industrial parameters. The LabVIEW graphical language is an instinctive way for users to develop their measurement and control applications. It is also easy to learn, the language delivers the required performance with advanced applications.

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