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Optimization of Energy for Industrial Heater Using PLC and SCADA

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***Abstract*—This research project mainly focus on proper coordination of heater and supporting components in order to reduce its energy consumption and optimize power for specific input parameters. Control algorithm measures critical parameters and adjust variable outputs to optimize power by turning ON/OFF the heater with improved performance. Temperature stability is a one of the basic requirement of this system. Implemented PLC base controller is compatible to handle any type of high and medium capacity heater system. It has online data system connected to the PLC frontend and the System can be controlled dynamically by varying the thresholds of input/control parameters. This controller eliminates the need of constantly turning ON the heater. Further electricity cost further reduces by around 5%. PLC and SCADA is used to model and realize the complete system and perform the experiment for result analysis. Automation is further enhanced by constant monitoring using SCADA screen which is connected to the PLC by means of communication cable. By means of tag values set to various variable in SCADA the entire process is controlled as required.**

***Index Terms*—Heater, PLC, SCADA, Dynamic Control, Automation.**

I. INTRODUCTION

Over the years the demand for high quality, greater efficiency and automated machines has increased in the industrial sector of power plants. Power plants require continuous monitoring and inspection at frequent intervals. There are possibilities of errors at measuring and various stages involved with human workers and also the lack of few features of microcontrollers. Thus this paper takes a sincere attempt to explain the advantages the companies will face by implementing automation into them. In order to automate a power plant and minimize human intervention, there is a need to develop a SCADA (Supervisory Control and Data Acquisition) system that monitors the plant and helps reduce the errors caused by humans. While the SCADA is used to monitor the system, PLC (Programmable Logic Controller) is also used for the internal storage of instruction for the implementing function such as logic, sequencing, timing, counting and arithmetic to control through digital or analog input/ output modules various types of machines processes.

Systems are used to monitor and control a plant or equipment in industries such as telecommunications, water and waste control, energy, oil and gas refining and transportation.

Energy conservation is using a fuel with its intrinsic energy value, much more efficiently by saving or using less of something, so that the work done or output is many times more than what is achieved presently. This results in economic saving similar to additional use of the fuel and substitutes as a source of input of energy without depleting fuel reserves or creating pollution. Several studies of conservation as a source of energy have concluded that it represents by far the cheapest and most reliable method of producing new energy. However, it must be realised the even though conservation is one of our most potential energy sources, it will not come easily or cheaply considering the cost of technology, energy efficient equipment and power saving devices and availability of expertise etc.

Although, compelling reasons for conservation includes preservation of scarce resources, reduction of pollution. Elegance of design and research developments of alternative, non-conventional [8] renewable resources, the principal incentive for industrial conservation is profit. The principal goal of energy resources conservation is reduction in the consumption of the energy resources. In order to meet t his goal, it is necessary to pursue three objectives simultaneously.

(i) To describe society's demand for good services requiring the expenditure of energy resources and

(ii) To supply this (decreased) demand at maximum efficiency i.e., at the expense of the least amount of energy resources (iii) development of new, cheap 8 renewable resources of energy. To meet the second objective it is essential to develop new and better technology 8 equipments [3,4,9]. The demand for power and energy is steadily increasing over the years without the corresponding increase in supply, as the result of industrial growth in view of liberal policy of industrial development of the Government. In particularly small and also medium and large scale industries corporations. The supply of power and energy has not kept pace with the demand leading to gap in the demand and supply and even improper control/maintenance insufficient management of power generation.

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The quality and efficiency of power generating and supply systems fuel calorific value has drastically one down compared to developed countries standards. Power sector has added 16,384 MW capacities during the first four years of seventh plan thus resulting in total power generation of 221 billion units in 1988-89. The highest contribution has come from thermal power generation which was of the order of 157 billion units followed by 57 billion units from hydro plants and the remaining seven billion units contributed by nuclear and gas based projects. Natural gas based power generation is likely to play a major role in future with 10.000 to 15,000 MW capacity additions envisaged. Electricity demand is projected to register highest growth with increased industrialization and urbanization. The demand is projected to increase from estimated 295 trillion watt hours (Twh) in 1989-90 to 400 Twh in 1994-95 and 818 Twh by the year 2004-05 according to Planning Commission report (1987). Good performance in the power sector is critical to India's development, as it provides a key input and absorbs 20-25 percent of the National Plan outlay. However, India has witnessed perpetual power deficit for the last twenty years and it continues. It is estimated by World flank that the current total electricity deficit is 10 percent with peak shortages, unplanned power cuts and planned rationing are common features.

Companies, organisations have been doing commendable work in developing technology, equipment. Engineering know how, expertise, information database and infrastructure facility for transmission of this knowledge.

For conducting the study and research survey, a detailed, structured questionnaire was prepared. It was made comprehensive and included various questions on engineering practices. This questionnaire after pretesting as to the usefulness and readability was personally given to the industry's engineering/ manageria1 personnel while holding detailed discussion and interview and was also mailed to number of industries. The data was collected on this questionnaire information was obtained by holding detailed interview and plant visits [2].

The discussion and the interview were held with the people responsible for work engineering management and energy (Electricals, utility services) department. The format of the responses in the questionnaire divided under different heads from organisation, product profile, energy use details and role of financial institution .Outside consultant and government agencies. The results of the study and observations reveal the dimension of variability in the success achieved. We find the various factors are responsible for good results which depend as we see on the effective energy management practices.

Results show that audit practices, if diligently applied, bring in lot of benefits. Though only approx. half of the sample industries have taken up audit or does it on the regular basis, the rest of the industries have also realized the importance of the economic benefits of the audit. But the results have also shown that the audit practice has not been taken seriously by some of the industries. The incentive system and education and training have to go deeper i n t o the culture and the management has to show greater commitment, involvement and belonging to the cause of energy conservation. The need for energy manager and separate cell have to be worked out, keeping in view the economic priorities of the organisation. Success is mostly linked to the day to day basis calculation/computation o f cost and very important. Along with this, the causality and cost conscious companies have been able to rope in consultants/expertise which was a possible constraint with many respondents. Plant engineering system and practices of maintenance are also responsible in energy conservation. The results and analysis show that role of financial institutions/banks and dependability of the consultants are matters of further discussion and deliberations.The paper is organized as follows: in section 2, critical parameters and system details are considered. Next automation is discussed in general and then the concept of PLC and its use is highlighted. Section 4 discusses SCADA and its use in heater control.

In section 5, some results are provided to demonstrate the effectiveness of the proposed method and also present the conclusion of the research.

II. Critical Control Parameters In Heater And System Design Platform

A. Pressure Control

Force draft pressure, Induced draft pressure, Steam drum pressure, de-aerator pressure, Turbine inlet steam pressure, balanced draft pressure

B. Flow Control

Air flow, Steam flow, Water flow

C. Temperature Control

De-aerator temperature, Steam drum temperature, Under-bed boiler temperature, Turbine inlet steam temperature, Flue gas temperature.

Wide area controlling and monitoring systems are essentially based on the SCADA system. In contrast to conventional control systems, where e.g. Programmable Logic Controller (PLC) system [4] is used for acquisition of data, Remote Terminal Units (RTU) [5,11] acquire digital and analog current, voltage and frequency measurements for SCADA system.

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RTUs are installed at selected locations of different grid stations to acquire complete analog and digital data of the station and are time-synchronized via Global Positioning System (GPS) [6] receivers with an accuracy of one microsecond. These RTUs are getting digital data from field instruments connected with relays to show and operate live status of Circuit breakers or isolators, however for analog data, transducers are connected with CT and PT. For power electric system, generating stations are producing electricity and distribute it on the network. Some electricity imported from other electric resources e.g. Independent Power Plants and electric companies etc.

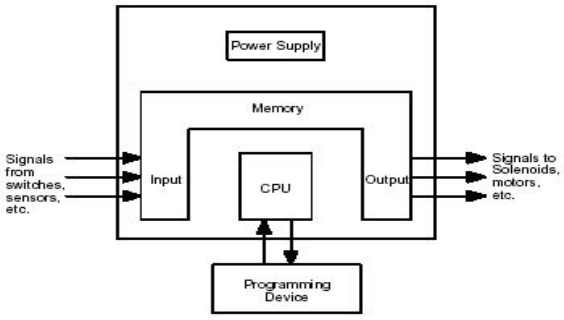

Figure 1: Block Diagram of PLC

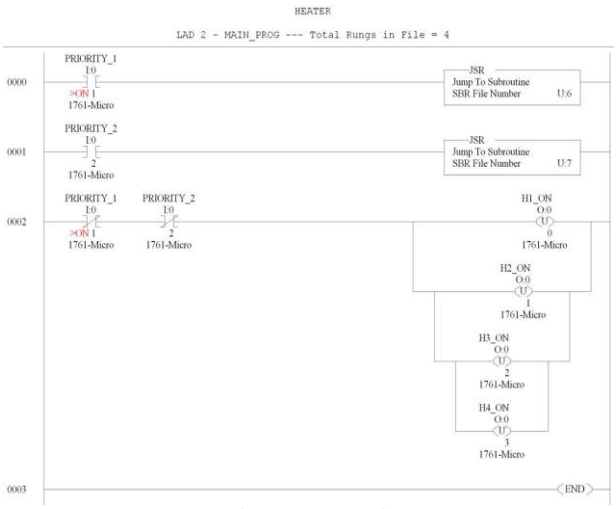

Figure 1: A part of Ladder Logic for heater control.

III. AUTOMATION AND PLC

Delegation of Human Control to technical Equipment aimed towards achieving.

Advantages

Higher productivity, Superior quality of end product, efficient usage of raw materials and energy, improved safety in working condition.

A. History of Control and Automation PLC
ELECTRICAL CONTROL WITH LOGIC GATES
WITH LOGIC GATES
MANUAL CONTROL

In this, the Control and Automation are done by Manual Operations [9, 12, and 13].

Drawbacks:

Human Errors subsequently affect quality of end product.

Hard Wired Logic Control

In this, Contractor and relays together with timers and counters were used in achieving desired level of automation.

Bulky and complex wiring, Involves lot of rework to implement changes in control logic, the work can be started only when the takes is fully defined and this leads to longer project time.

Electronics Control with Logic Gates

In this, Contactor and Relays together with timers and counters were replaced with logic gates and electronic timers in the control circuits.

Advantages

Reduced space requirements, energy saving, less maintenance and hence greater reliability.

The Major Drawbacks

Implementation of changes in the control logic as well as reducing the project lead- time was not possible.

Programmable Logic Controller

In this, instead of achieving desired control and automation through physical wiring of control devices, it is achieving through program say software.

Advantages

Reduced Space, Energy saving, Modular Replacement, Easy trouble shooting, Error diagnostics programmer, Economical, Greater life and reliability, The Compatibilities of PLC'S, Logic Control, PID control, Operator control, Signaling and listing, Coordination and communication.

B. How PLC works

Basics of a PLC function are continual scanning of a program. The scanning process involves three basic steps.

Step 1: Testing input status

First the PLC checks each of its input with intention to see which one has status on or off. In other words it checks whether a switch or a sensor etc., is activated or not. The information that the processor thus obtains through this step is stored in memory in order to be used in the following steps.

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Step 2: Programming execution

Here a PLC executes a program instruction by instruction based on the program and based on the status of the input has obtained in the preceding step, and appropriate action is taken. The action might be activation of certain outputs and the results can be put off and stored in memory to be retrieved later in the following steps.

Step 3: Checking and Correction of output status

Finally, a PLC checks up output signals and adjust it has needed. Changes are performed based on the input status that had been read during the first step and based on the result of the program execution in step two – following execution of step three PLC returns a beginning of the cycle and continually repeats these steps.

Scanning time = Time for performing step 1+ Time for performing step 2+ Time for performing step 3[4].

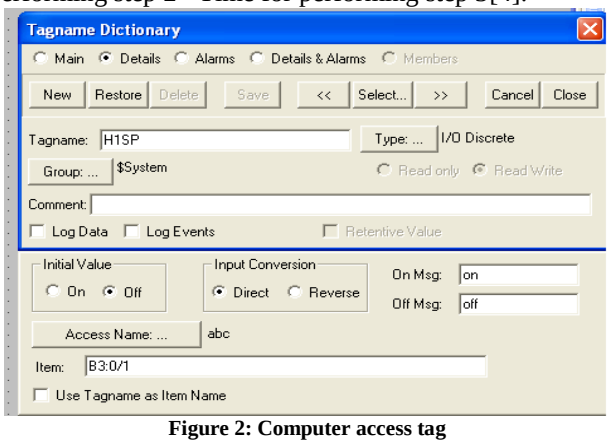

Figure 2: Computer access tag

IV. SCADA

SCADA stands for Supervisory Control and Data Acquisition. As the name indicates, it is not a full control system, but rather focuses on the supervisory level [12].

It is used to monitor and control plant or equipment. The control may be automatic or initiated by operator commands. The data acquisition is accomplished firstly by the RTU's scanning the field inputs connected to the RTU (it may be also called a PLC – programmable logic controller.). This is usually at a fast rate. The central host will scan the PTU's (usually at a slower rate). The data is processed to detect alarm conditions, and if an alarm is present, it will be displayed on special alarm lists [10].

A. Basics

A SCADA system consists of a number of components [7]. The RTU's. Remote telemetry or terminal units. The central SCADA master system.

Field Instrumentation

The SCADA RTU is a (hopefully) small ruggedized computer, which provides intelligence in the field, and allows the central SCADA master to communicate with the field instruments. It is a stand-alone data acquisition and control unit. Its function is to control process equipment at the remote site, acquire data from the equipment, and transfer the data back to the central SCADA system [14].

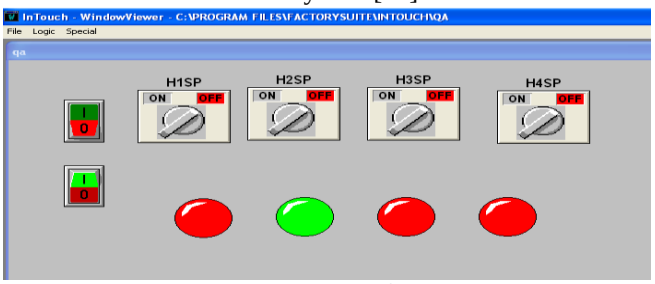

Figure 3: SCADA diagram for the system.

INTOUCH software enables you to configure a system environment that provides: [3]

Supervisory control, batch processing, data acquisition, continuous control, and statistical process control for industrial applications. Interfacing of PLC to PC and to SCADA is as follows:

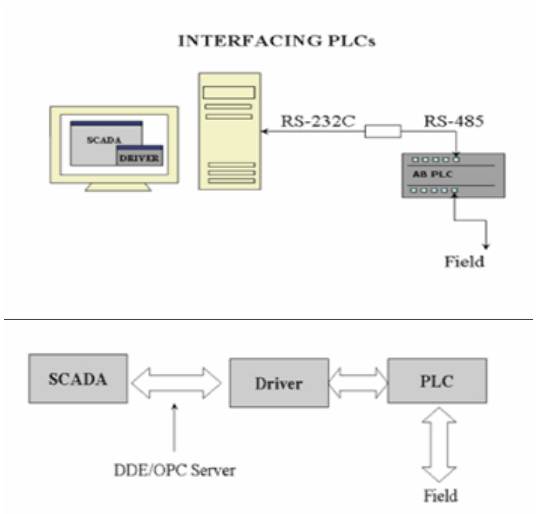

Figure 4: Interface diagram of PC to PLC and to SCADA.

V. CONCLUSIONS

The most important aspect of any power plant is the heater control. Several techniques can be implemented to control the heater in power plant. The method that has to be used relies on varied objectives like superior quality, increased efficiency, high profit and other such points depending upon the purpose of the company that implies it.

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With the prime objective of catering to these necessities and the needs of the industrial sector, significance has been given here to automation.

This paper presented here has kept in mind, the ceaseless changes that are relentlessly taking place in the contemporary scenario of the industrial segment. Emphasis has been given to the automation process that is now rapidly taking its place in all the power plants across the globe. The Paper has furnished itself to study the integral parts of the entire process involved, their implementation and the problems that may show up have also been given their due importance.

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