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Design and Simulation of Fully Automated Boiler Control Using PLC and SCADA

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ABSTRACT: This paper features on implementing the governor control automatically in steam turbines in the boilers that can be used in power plants. It mainly focuses on controlling the speed of the turbine by mounting a pulse encoder on the turbine shaft. Thus the boiler parameters in the boiler are constantly monitored and the steam is generated according to the need. The automation can be easily done using PLC (SCADA). The turbine speed can be controlled and monitored. 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 arithmetic, counting, timing, sequencing and logic to control through digital or analog input/output modules various types of machines processes.

KEYWORDS: Programmable Logic Controller, Supervisory Control and Data Acquisition

I. INTRODUCTION

Power plants require continuous monitoring and inspection at regular intervals. There are several ways to measure the errors and various stages involved with human workers and also the lack of few features of microcontrollers [1]. A steam turbine is a device that extracts thermal energy from pressurized steam and uses it to do mechanical work on a shaft which is rotating. The rotary motion generated by the turbine is particularly suited to be used to drive an electrical generator. The governor control of a turbine is essential; as turbines need to be run up slowly to prevent damage and some applications require precise speed control

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 arithmetic, counting, timing, sequencing and logic to control through digital or analog input/output modules various types of machines processes. The automation technique involving the automatic control of all the processes which includes the monitoring and inspection needs provides for a very efficient system. They reduce the increased human resources, reduction in human resources, increased efficiency and importantly cost effective [3]. Over the years the demand for automated machines, greater efficiency and high quality has increased in the industrial sector of power plants. By which the boilers can be converted from a very conventional method to fully automated ones. The boiler parameters such as temperature, pressure, level and temperature can be automatically controlled using PLC. This reduces manual workload and human errors. In
order to increase the production of electricity we need ample amount of steam to be generated. This can be achieved by controlling the speed of the turbine which in turn controls the steam generation.
The amount of steam generated is used to rotate the turbine and controls its speed. Hence, the electricity can be generated according to the needs. In the industries, centrifugal and fly-ball governors are used to maintain the speed of the turbine, irrespective of the load or fuel supply conditions. Industrial steam turbines represent one of the largest populations of prime movers across the world. They have been used in many industries and used in a variety of applications. In a steam turbine the stored energy of high temperature and high pressure steam is converted into mechanical (rotating) energy, which then is converted into electrical energy in the generator. The original source of heat can be a furnace fired by fossil fuel (coal, gas, or oil) or biomass.

A steam turbine is a device that extracts thermal energy from pressurized steam and uses it to do mechanical work on a rotating output shaft. The rotary motion is generated by a turbine to drive an electrical generator [4]. An ideal steam turbine is considered to be an isentropic process, in which the level of entropy of the steam entering the turbine is equal to the entropy of the steam leaving the turbine.
The proposed system is an automation technique involving the automatic control of all the processes which includes the monitoring and inspection needs provides for a very efficient steam turbine in boiler system. The rest of this paper is organized as follows. In Section II, we survey several controlling techniques in existence. In Section III, we present the

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proposed algorithm and illustrate its functioning. In Section IV we show the experimental results. Finally, in Section V, we draw conclusions and point to possible directions for future research.

II.RELATED WORK

A. CONTROL OF BOILER OPERATION USING PLC – SCADA (K. GOWRI SHANKAR)
The Air pre heater and Economizer are used in this process. This paper mainly focuses on pressure, level and flow control at the different stages of the boiler plant [3]. Thus the temperature in the boiler is constantly monitored and brought to a constant temperature as required by the process in power plant. The automation is further extended by constant monitoring using SCADA screen which is connected to the PLC by means of cable used for communication. The tag values set to different variables in SCADA the entire process is controlled as required.

B.SIMULATION OF BOILER CONTROL USING PLC & SCADA (SHITAL S. CHOPADE, PRADHUMAN VERMA, PRASHANT VERMA):
This system monitors boiler`s temperature and pressure and volume via different sensors which provide input to PLC [8]. The output of PLC controls the boiler temperature and pressure and gives out the user desired volume of steam. All temperature and pressure variations are shown on SCADA screen and are controlled through SCADA. Various kinds of automated check valves are used to release pressure and to inform the concerned authority through alarm in case of an emergency.

C.ADAPTATION OF PID CONTROLLER USING AI TECHNIQUES FOR SPEED CONTROL OF ISOLATED STEAM TURBINE (MOHAMED .M. ISMAIL):
It is known that PID controller is employed in every facet of industrial automation. The use of PID controller ranges from small industry to larger technology industry. Tuning a PID controller is very important in PID control. Ziegler and Nichols proposed the well-known process curve method to tune the coefficients of a PID controller. This method of tuning is very simple, but unable guarantee to be always efficient. Because of this reason, this paper investigates the design of self -tuning for a PID controller [7].

D.STEAM TURBINE GOVERNOR DESIGN BASED ON POLE PLACEMENT TECHNIQUE (FIRAS M. TUAIMAH NIHAD, M. AL-RAWI WALEED, A. MAHMOUD):
A computational methodology to design a steam turbine governor based on pole placement technique is introduced to control the turbine speed. The effectiveness of the proposed control action is demonstrated through some computer simulations on a Single-Machine Infinite- Bus (SMIB) power system [6]. To accommodate stability requirements, a mathematical model for the turbine was derived based on state space formulation. Results obtained shows that adopting such a controller enhanced the steady state and transient stability.

III.ALGORITHM

The proposed system features on implementing the governor control automatically in steam turbines in the boilers that can be used in power plant industries. The technique involving the automatic control of all the processes which includes the monitoring and inspection needs provides for a very efficient system. They reduce the reduction in human resources, amount of errors that occur, increased efficiency, and cost effective.

A. GOVERNING SYSTEM:
The load on a turbine generating unit does not remain constant and can vary as per consumer's requirement. The variation between generation and load results in the frequency (or speed) variation. Variation in the load causes variation in the generation to keep the speed constant. This work is done by the governing system. Speed, the indicator of the generation – load mismatch is used to increase or decrease the generation. Basically the scheme which is governing system controls the steam flow to the turbine in response to the control signals like errors in speed and power. It can also be used to respond to error due to variation in pressure. In this closed loop control system the control action goes on till the power mismatch is reduced to zero.

The inlet steam flow is controlled by the control valve. This valve is used for regulation. The end valve (SV) shown in the figure 1 ahead of control valve is used for protecting the system. It is either open or closed. In case of emergency the steam flow is stopped by closing this valve by the protective devices.

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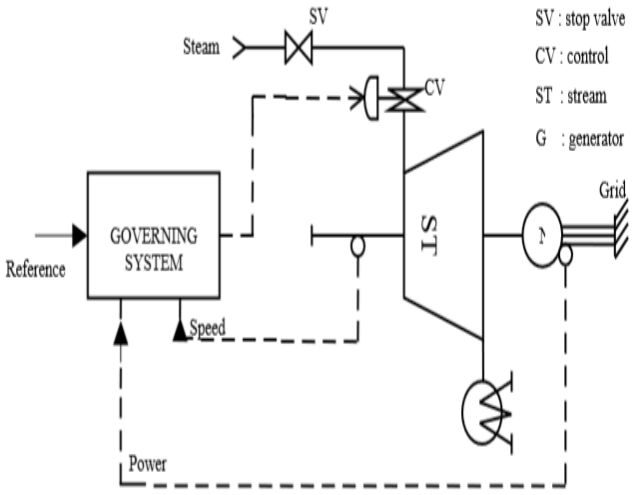

Fig 1: Governing system functional block diagram

B. *ROTARY PULSE ENCODER*:

The digital governor controller uses a pulse encoder that is placed on the shaft of a turbine. As the turbine rotates the speed is calculated using the pulse encoder. This is given to the flow control actuator which indicates to produce more steam when necessary and to reduce the production of steam when it is in excess. This whole process is automated by means of PLC. Rotary encoders are electromechanical devices used for sensing in myriad applications — on motors paired with drives and automated machinery for everything from elevators, consumer point electronics and speed of conveyer monitoring to position control on robotics and automated industrial machines. They monitor the turning of motor to generate digital position and rotational information. Whether absolute or incremental, optical or magnetic, encoders monitor motor shaft rotation to generate digital position and movement information. Their use is effective in industrial and commercial designs. Rotary encoders (figure 2) track motor shaft movement for myriad pieces of industrial equipment and commercial designs. For industrial applications, the encoders (used when only position is needed, or a cost issue) are typically used with ac induction motors.

Fig 2: Pulse Encoder Used In Industry

IV. RESULTS AND DISCUSSION

In this section, the result obtained in the project is discussed in details. SCADA systems are used to monitor and control a plant or equipment in industries such as oil and gas refining and transportation, telecommunications, water waste control, energy is shown in the figure 3.

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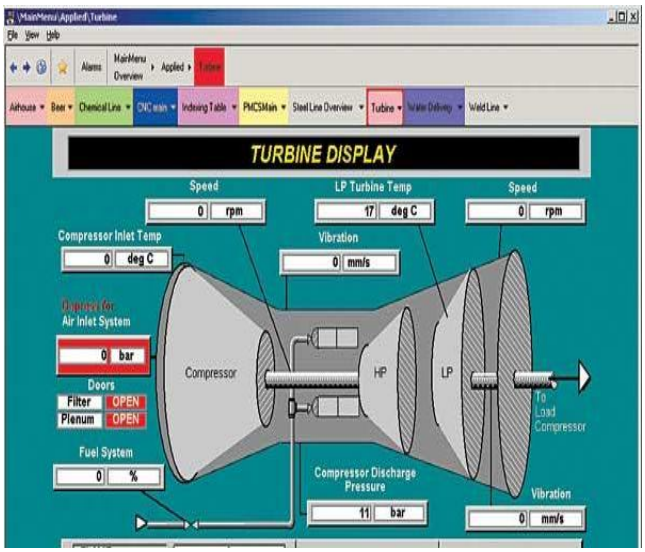

Fig 3: SCADA overview of steam boiler

In PLCs the input and output modules are extendable. The most commonly used input switch is the push button switch. It is the one that needs the least description because it is widely used in automotive and electronic equipment applications.

Outputs from PLCs are mostly relays, but they can also be solid state devices such as transistors for DC outputs or TRIAC's for AC output. Continuous desired outputs require special output cards with digital to analog converters.

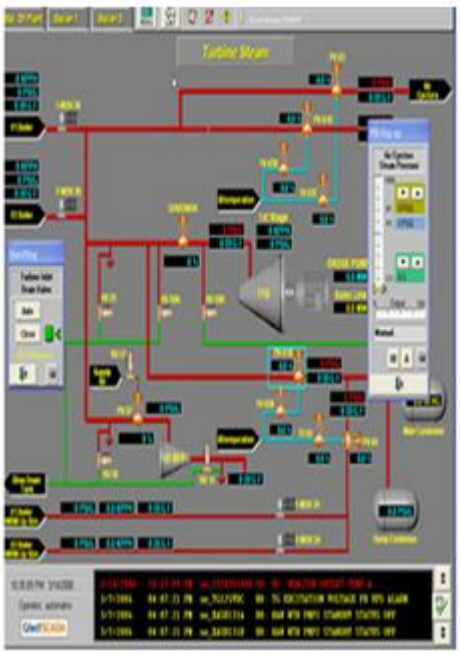

Fig 4: Steam Turbine SCADA

Solenoid Valves, Lights, Motor Starters and Servo Motors are some of the output devices used in PLC. The hardware implementation of the proposed system is shown in the figure5.

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Fig 5- Hardware Implementation

The comparator is constructed by the operational amplifier LM 741. The comparator compares with reference water level and delivered the error voltage at the output terminal. Then the error value of voltage is feed to next stage of gain amplifier which is constructed by another operational amplifier. In gain amplifier the resistor is connected in the feedback path, by adjusting the variable resistor we can get the desired value of gain.

V.CONCLUSION

The most important aspect of any power plant is the boiler control. Several techniques can be used to control the boiler in power plant. The method that has to be used depends on variable objectives like high profit, increased efficiency, superior quality and other such points depending upon the purpose of the company. To the prime objective of catering to these facilities and the needs of the industries, necessity has been given to automation. This work presented here has, the changes that are continuously taking place in the contemporary scenario of the industrial sector. Importance has been given to the automation process that is now rapidly taking its place in all the power plants across the globe. It has furnished itself to study the integral parts of the entire process made, their implementation and the queries that may show up have also been given their due importance. The work deals with controlling the parameters of the boilers and mainly controlling the speed of the turbine automatically using PLC.

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