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Reliable Protection and Fast Changeover Method for Boiler Feed Pump By Using Computerized Control

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***Abstract*—This paper is a description of the project aims for protecting the boiler feed pump from damages and using a method for fast changeover through monitoring and controlling feed pump operations by means of computerized process. In the existing system, Boiler Feed Pump Protection is achieved with the aid of protective devices which are connected to the hardware based input and output modules and dedicated Erasable Programmable Read Only Memory (EPROM) based processor module. Processor module consists of EPROM, which contains hex coded instructions to carry out Boiler Feed Pump Protections. Because of this more complicated hardware and many relays are employed, expensive input and output modules of hardware versions are used. Processor EPROM consists of hex coded instructions and same can be altered only by the supplier. Therefore the changeover of one Feed Pump to another standby Feed Pump takes more delay and which causes emergency in the present system. To avoid this problem, the proposed system uses computerized process for boiler feed pump protection and fast changeover method. In this project it is proposed to connect the sensing devices such as pressure sensor, temperature sensor etc to the Analog to Digital Converter (ADC) after modifying the above signals to the acceptable form by the ADC. The digital signals from the ADC are given to PC through printer port. Computer display graphically all the parameter of Boiler Feed Pumps and sends trip signal to trip the Feed Pump through specially designed fast acting drive circuits when abnormal occurs in any one parameter of Boiler Feed Pump. Therefore, this project initiates system security and increases system reliability.**

***Keywords*—Erasable Programmable Read Only Memory (EPROM) Processor, Boiler feed pump, Changeover method, Analog to Digital Converter (ADC), Printer port, Pressure sensor, Temperature sensor, Drive circuits.**

I. INTRODUCTION

Thermal power plant is a generating station which converts heat energy of coal combustion into electrical energy. Boiler is the major component for power generation in all the power plants [1]. In thermal power plant the boiler uses the coal as a fuel for producing heat energy which in turn is converted as a mechanical energy by the turbine and the generator generates the electrical energy by converting the mechanical energy [1-3], [6]. The water is the working fluid, which is used to produce steam for power generation. The water is supplied to the boiler from the tank through the pumps which are commonly known as boiler feed pumps. In all the thermal power plants each boiler consists of several feed pumps running and keeping one feed pump standby. They are horizontal barrel type installed at '0' meter turbine hall. One pump is required for full load while the other pump is 100% stand by. The feed pump is driven by an electric motor through step up gearbox of 2:3 ratio and hydraulic couplings [1-2]. Feed water pumps range in size up to many horsepower and the electric motor is usually separated from the pump body by some form of mechanical coupling. Large industrial condensate pumps may also serve as the feed water pump [2]. The hydraulic coupling is used for varying the speed of the pump for varying the quantity of feed water delivered to the boiler as per requirement by varying the discharge pressure. The speed control is done with the help of scoop tube setting which consequently alters the oil quantity maintained in the hydraulic coupling between driving shaft and pump shaft. The lubricating oil is supplied by Pre lube oil pump (PLOP) initially and once the feed pump is taken in to service the oil for lubrication and hydraulic coupling will be supplied by the main oil pump inside the Voith coupling [2], [6]. After the main oil pump develops enough oil pressure the PLOP will trip on auto. There are two nos. pressure switches provided in the oil system.

II. FUNCTIONS IN EXISTING SCHEME

In the existing system, Boiler Feed Pump protection is achieved with the aid of protective devices [4], which are connected to the hardware based input and output modules and dedicated EPROM based processor module. Processor module consists of EPROM, which contains hex coded instructions to carry out Boiler Feed Pump protections. Block diagram of existing scheme shown in Fig 1. Existing scheme employs more relays, analog and binary modules make the circuit much more complex. Meanwhile, these input modules will send signal to the processor with some delay around 2 minutes to 30 seconds. The processor receives signals and checks it up with set values, if there is any deviation the processor will fetches control command to furnace trip relay. And the control commands from EPROM Processor are hex-coded instructions. Hence the consumer needs to find help from the supplier. It also turns to be a drawback for the existing system. The following drawbacks are:

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- The cost of installation and maintenance of the above hardware modules involve large investments and it is time consuming.
- The interconnections between the hardware modules and the relay are very complicated.
- The causes relating to the fault tripping and any logical component failure cannot be visually analyzed.
- It requires the presence of highly trained professionals, which involves high cost of training.

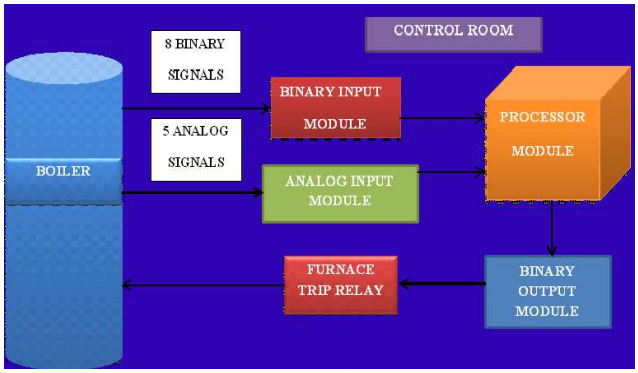

Fig. 1. Block Diagram of Existing Scheme

III. FUNCTIONS IN PROPOSED SCHEME

In this project it is proposed to connect the sensing devices such as pressure sensor, temperature sensor etc., to the analog to digital converter after modifying the above signals to the acceptable form by the ADC. The digital signals from the ADC are given to PC through printer port [8]. Computer display graphically all the parameter of Boiler Feed Pumps and sends trip signal to trip the Feed Pump through specially designed fast acting drive circuits when abnormal occurs in any one parameter of Boiler Feed Pump. The abnormal occurs such as lowering of suction pressure, rising of temperature [4] etc., by this proposed scheme; the computer will start the standby pump very fast around 20 seconds to 10 seconds. And helps the system to retain in normal state. With this the software used is graphic aided turbo C, which is an improvised replacement of hex coded instructions. The graphic aided turbo C software finds a reliable solution for the problems raised in existing system. Block diagram of proposed scheme shown in Fig.2

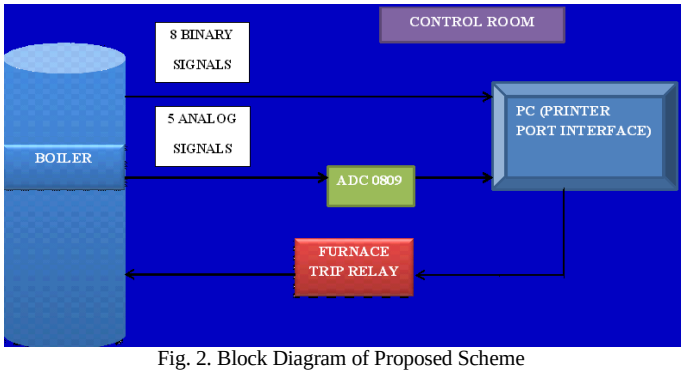

Fig. 2. Block Diagram of Proposed Scheme

The proposed project in which the existing hardware relay logics are replaced by the PC controlled one by which the unwanted delays can be avoided. The binary signals that coming from the boiler (field device) is the start or stop signal for the pump. Analog signals such as suction water pressure and temperature, delivery water pressure and temperature, along with that motor winding temperature and lubrication oil temperature are the signals to be measured [3-4].The processor module of the original system is replaced by the personal computer. The analog input signals are analyzed after conversion to digital signals by ADC0809. The analog and digital signals are interfaced to the computer via the parallel port interface. The parallel port communication is preferred for its speed of operation. The various input signals of the boiler furnace and its drum level are monitored through the computer with the means of printer port interface by DB-25 Female and Male connectors.

A. HARDWARE DIAGRAM FOR PROPOSED SCHEME

Fig. 3. Represents the hardware diagram for the proposed scheme. In our proposed method the boiler pump indications are graphically viewed and are adjusted using the analog and binary simulation board. The digital signal coming out from the PC after processed by the software installed, which drives the required pump and protects the boiler from shut down. This changeover scheme is useful for the uninterrupted power generation.

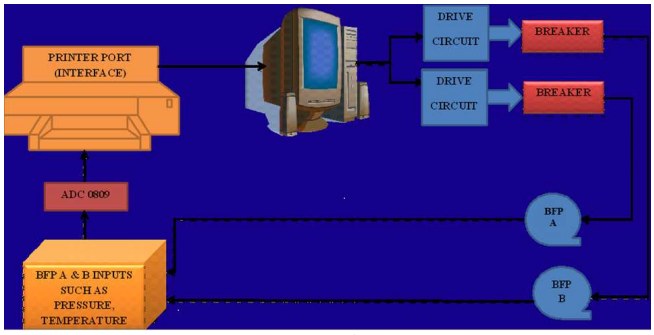

Fig. 3. Hardware diagram for Proposed Scheme

B. ADVANTAGES OVER THE EXISTING SYSTEM

- It is easier to install and commission.
- It needs only operators with basic computer knowledge.
- The system can be setup in the short span of time.
- It is of relatively lower cost when compared to the cost one relay module.
- The causes of faulty tripping can be easily sorted out.
- It enhances plant management and maintenance techniques.
- Any new hardware can be added by just configuring the software program.
- It has no complicated connections as in the relay modules.

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- It provides visual aid to analyze the cause of the problem.
- In case of any parameter change, it can be rectified by just changing the variables in the software program.

C.COMPARSION BETWEEN EXISTING SCHEME AND PROPOSED SCHEME

Table 1. represents the components used in the proposed scheme is represented by comparing this proposed scheme with real time system.

Table 1. Comparison between existing and proposed scheme

INPUT	PARAMTERS	REAL TIME	PROPOSED PROJECT
PUMP	DELIVERY PRESSURE	PRESSURE GUAGE	SIMULATOR POTENTIOMETER
	SUCTION PRESSURE	PRESSURE GUAGE	SIMULATOR POTENTIOMETER
COUPLING	LUBRICATING OIL PRESSURE	PRESSURE GUAGE	SIMULATOR POTENTIOMETER
	LUBRICATING OIL TEMPERATURE	RTD / THERMOMETER	THERMISTOR
MOTOR	MOTOR VOLTAGE	UNDER VOLTAGE RELAY	VOLTAGE TRANSDUCER AND TRANSFORMER
	MOTOR CURRENT	OVER CURRENT RELAY	CURRENT TRANSDUCER AND TRANSFORMER
	MOTOR WINDING TEMPERATURE	THERMISTOR	THERMISTOR

D. OVERALL CIRCUIT DIAGRAM

Fig. 4. Shows the circuit diagram for the proposed scheme. The Overall Circuit consists of power supply circuit, analog simulation circuit board, boiler feed pump indication circuit, ADC circuit, and drive circuit etc., the power supply circuit supplies 5V and 12V d.c. power to the hardware components. It comprises of transformer to step down the 230V a.c. voltage to 15V a.c. voltage, a bridge rectifier, and fixed voltage regulator IC's 7805 and 7812 to convert the 15V a.c. voltage to 5V and 12V voltage respectively [8]. Heat sinks are provided to protect the IC in case of any overload currents. A 100µF capacitor is connected is employed to reduce the a.c. ripples. An LED at the output terminal indicates the ON-state of the circuit. The bridge rectifier finds application not only for power circuits, but also as a rectifying system in the rectifier a.c. meters for use over a fairly wide range of frequencies. The analog simulation circuit board consists of voltage transducer and transformer, current transducer and transformer, frequency transducer. Here the clamp meter current reading is employed. The boiler feed pump indication circuit consists of suction and delivery pressure indications, motor winding temperature indication etc., ADC circuit consists of interfacing buffer IC 74HC244, inverting buffer IC 74HC240, and non-inverting buffer IC 74HC245. Drive circuit consists of relays and connectors for pumps.

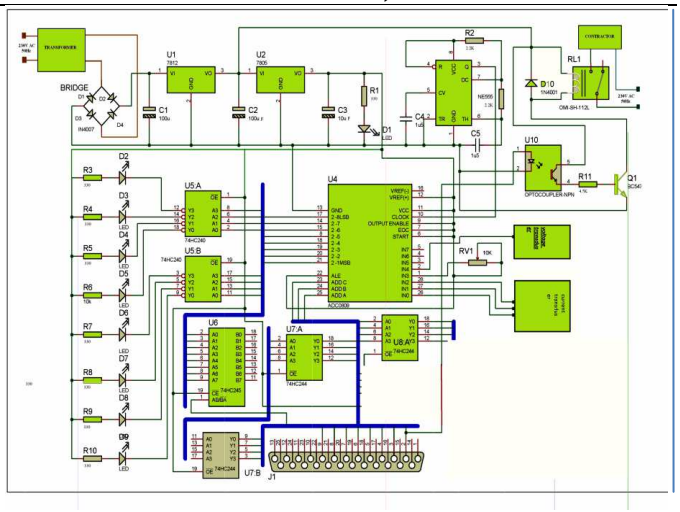

Fig. 4. Circuit diagram

E. INPUT PARAMETERS RANGE IN SYSTEM

The operating point for the input parameters used in the scheme , their range, and the threshold limit used in the proposed scheme are shown in Table 2 .

Table 2. Parameters Specification

INPUT	PARAMETERS	RANGE	OPERATING POINT	THRESHOLD LIMIT
PUMP	DELIVERY PRESSURE	(0-200) Kgm/s²	160 Ksc	< 80 Ksc
	SUCTION PRESSURE	(0-10) Ksc	5.6 Ksc	< 1.5 Ksc
COUPLING	LUBRICATING OIL PRESSURE	(0-4) Ksc	1.5 Ksc	< 0.8 Ksc
	LUBRICATING OIL TEMPERATURE	(0-150)°C	(50-60)°C	> 80°C
MOTOR	MOTOR VOLTAGE	6.6 kV	-	-
	MOTOR CURRENT	606.06 A	-	-
	MOTOR WINDING TEMPERATURE	(0-150)°C	80°C	100°C

IV. EXPERIMENTAL RESULTS

The proposed scheme is to provide reliable protection for boiler feed pump has been simulated by using MATLAB. The Protection of boiler feed pump is achieved by updating the working parameters condition using PC for continuous power generation. Changeover of one Feed Pump to another stand by Feed Pump using this proposed model takes less delay and helps the system in the Emergency period and avoids the boiler to shut down and provides continuous power generation. If any parameter goes to alarming state it is detected very fast and graphically displayed to view easily and also audible alarm is generated to alert the operator. If a parameter goes abnormal such as lowering in suction pressure, rise in temperature [5], [7]. PC sends trip signal to the Boiler Feed Pump through suitable drive hardware which trips and protects the Feed Pump. Computer also starts the standby Feed Pump very fast and helps the system to change from emergency to normal state.

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Fig. 5 shows the simulation model for the proposed scheme, in which two voltage sources have been taken instead of pumps in the model. And they have been connected in parallel, for input parameters such as temperature, pressure values are confined. These parameters connected embedded mat lab function, and for overload protection two series RLC load is connected. Tap is provided by the means of switch. During the overload condition, the proposed scheme is provided to switch on both the running as well as stand by pumps through the relay co-ordination.

Fig. 6 represents the simulation result for the proposed scheme; it shows the relay signal for the pumps. In the simulation for ease of access two pumps have been simulated. One of the pump parameters is matching the set values, and other pump parameters are not matching the set values. The simulation result showing the pump 1 in running condition and pump 2 in stand by condition.

Fig. 7 represents the prototype hardware for the proposed scheme, the hardware comprises of simple circuit which initially reduces the complexity and simple operations carried out. With the continuous monitoring computer displays the entire system graphically.

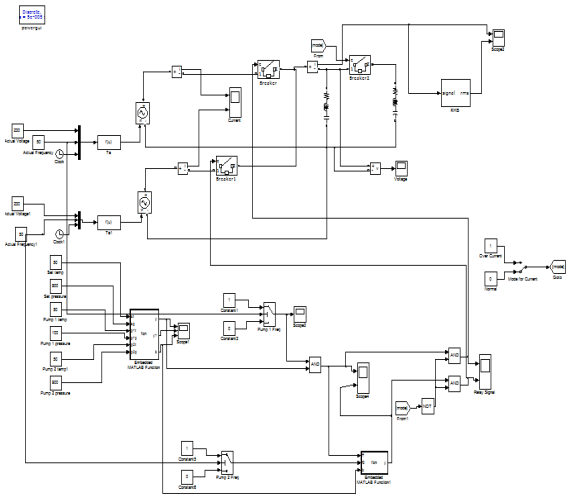

Fig. 5. Simulation for Proposed Scheme

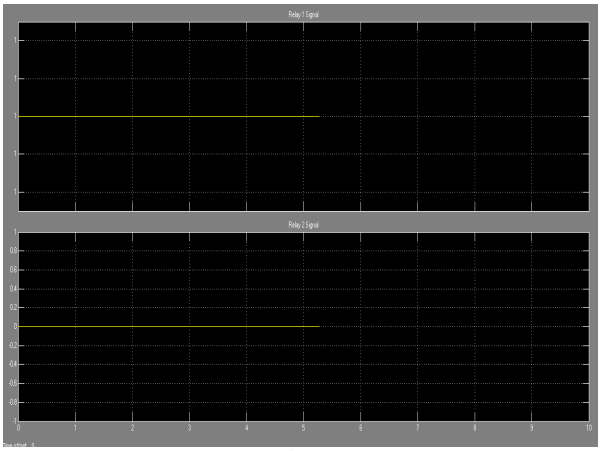

Fig. 6. Simulation Result for pump changeover scheme

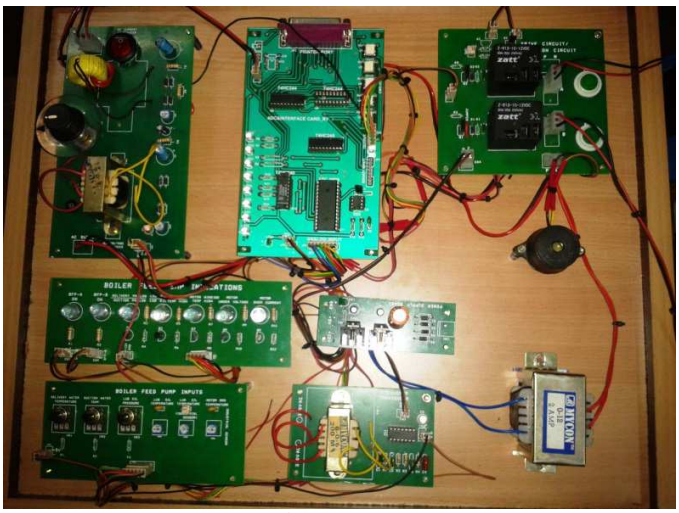

Fig. 7. Prototype of the designed proposed scheme

V. CONCLUSION

This proposed scheme provides reliable protection of Boiler Feed Pump. Very fast Changeover can be achieved with the help of this project to help the system to change from emergency to normal state. Along with these features software used here is graphic aided turbo C, which is improvised replacement of EPROM Processor for monitoring and controlling the boiler feed pump operations. Since boiler feed pump has highest capacity motor, when comparing all other components in thermal power station. Current practice is to use only induction type of motors for direct on-line start. Proposed scheme finds reliable solution to this problem. If over current condition prevails existing scheme switch off one pump and turn on another one using changeover method. But in this proposed scheme instead of switching off one pump, it is possible to turn on both the pumps to meet the overload condition. This can be achieved by relay co-ordination. In prototype hardware it has been functioned by programming. . By introducing the PC based protection the chances of false tripping may be avoided. Also fault tracing is made easy by the soft-based logics as it uses the concept of '0' or '1'. Hard timers have their own limited range of operations whereas through PC based protection any range of time delay can be achieved. All the logical operations are achieved through programming which is easy to understand and modify as and when required. The concept of introducing PC based control is to identify and to have continuous monitoring of signal status by introducing graphics. Visualization gives the faulty signal status for identification much faster.

VI. SCOPE OF PROJECT

The scope of the project is to replace graphic aided turbo C software by SCADA software. That the proposed technique used for the protection of the boiler in the power plant can be evolved to protect the entire power plant as a whole. This may include the main assets of the power plant such as the turbine, generator etc. This advancement can be achieved if separate signals are sensed from each part of the power plant and are

accordingly checked and the power plant is safeguarded from the damages automatically. This proposed scheme not only for protecting feed pump in power plant, it can also be used for the commercial purpose. And it is even possible to reduce the hardware with the means of replacing ADC, printer port interface, and computer by single chip computer in which LINUX OS is in-built.

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