PLC BASED CONTROL OF FUEL OIL PUMP HOUSES IN THERMAL POWER STATION

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Abstract— *This paper proposes an idea of PLC Based Control of Fuel Oil Pump Houses (FOPH) in Neyveli Thermal Power Station. In boiler furnace, Due to low calorific value of lignite, direct ignition is not possible as it requires enormous heating for efficient burning. Hence, before admitting lignite into the Boiler Furnace for combustion, Fuel oil is used as ignition agent. From Boiler light-up time to 40MW power generation, only fuel oil is used in the furnace. This is only because to maintain flame stability. Only after ensuring required hot condition inside the furnace, lignite is pumped into the furnace and in parallel oil flow is reduced in steps. Oil flow will be totally stopped at 80% of power generation. Also, oil injection to the furnace will be immediately restored under critical conditions (lignite flow disturbance) to maintain power generation. Hence, keeping fuel oil availability at certain pressure up to the injection point is very essential. In Fuel Oil Pump House (FOPH), each unit has two fuel oil pressurizing pumps, of these two pumps, one (main) will be in service and the other (reserve) will be in stand-by mode. Power supply to the main pump is obtained from Unit Control Board (UCB), whereas reserve pump gets supply from FOPH Motor Control Centre (MCC). This FOPH MCC gets 0.4KV supply from two different sources to increase reliability. In case of main pump failure (due to mechanical or supply problem), existing hard-wired logics initiate starting command to reserve pump. Additional interlocking arrangements are available to change over reserve pump source in case normal source failed in FOPH MCC. This hard-wired logic uses electro-mechanical relays, timers and physical wirings to establish all interlocking requirements. Instead of the existing EMR logic used for interlocking in the FOPH drive system we are replacing it with PLC technology and user friendly Ladder logic.*

Index Terms— **Thermal Power Station, Fuel Oil Pump House, PLC, Automation**

I. INTRODUCTION

THE Second Thermal Power Station (Figure 1) consists of 7 numbers of 210 MW Units and hence having an installed capacity of 1470 MW. Units 1, 2 and 3 were constructed in the First Stage followed by the Second Stage Units 4, 5, 6 and 7. Lignite for the station is supplied from Mine-II having an annual capacity of 10.5 Million Tones. Unit 1 was commissioned in March 1986 and commissioning of the 7th unit was carried out in June 1993. Year after year production records are broken by Thermal Power Station –II. The southern states of Tamil Nadu, Kerala, Karnataka and Andhra Pradesh and the Union Territory of Pondicherry are the beneficiaries of the power produced in the power station.

A. Fuel Handling System

In Stage-I Boilers, now a days Furnace Oil is used. There are two separate Fuel Oil Pump Houses (FOPH), one meant for Stage-I and the other for Stage-II. There are two storage tanks of 100 M3 capacity each for LDO. No heating is necessary for LDO. In the oil handling system there are facilities for decanting, heating, filtering, pumping and metering of flow.

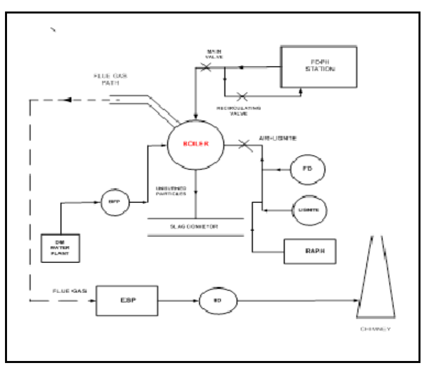

Fig.1. Block Diagram of Thermal Power Plant

B. Necessity of Oil

The Furnace Oil is used to create the initial burning or to create warm-up condition for the furnace. Oil flow is essential at all conditions. The types of Oil that were used in TPS-II are L.S.H.S. oil (Low Sulphur Heavy Stock oil), L.D.O (Light Diesel Oil) and Furnace oil. Owing to the various difficulties faced upon using the above oils, Furnace Oil is being currently used. In TPS-II, Lignite is the main fuel for furnace. Due to the high moisture content of lignite, the required temperature cannot be reached at the instant. Hence in order to create the initial temperature the furnace oil is used.

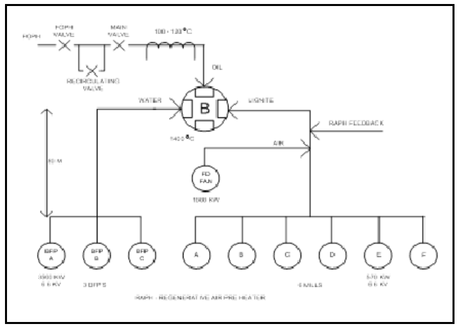

Fig.2. Block diagram of Fuel Flow

C. Importance of FOPH

In Neyveli Thermal Power Station – II / Stage - I steam generators provisions have been made in the furnace for firing furnace oil as well as L.S.H.S. oil (Low Sulphur Heavy Stock oil) as auxiliary fuels for initial lighting up and to stabilize the combustion fluctuating operating conditions with the main fuel i.e. lignite. Operation of the boiler with oil firing system is possible only up to 30% of boiler load.

D. Oil Handling System

Fuel Oil is to be handled carefully not only to achieve efficient utilization but also to ensure safety against fire hazards and all consequent losses. Awareness on fuel characteristics and their significance are hence essential for operation engineers in a Thermal Power Station.

E. Description of Oil Handling System

The activities of the oil handling system take place in the fuel oil pump house which consists of two sections commonly referred to as (1) Decanting pump house (2) Pressurizing pump house. The fuel oil received through railway wagons and Lorries are transferred to the oil storage tanks located outside, by the oil pumps in the Decanting pump house. From the above tank, oil is conveyed to the boiler operating floor of the unit by the pumps in the pressurizing pump house.

F. Decanting Pump House

Both the sections of the fuel oil pump house are in southern side of the boiler house. Railway sidings are provided for transportation of oil up to the Decanting pump hose. A decanting bus (300mm dia) has been erected near the railway line and this had 32 decanting points connected to it. Each decanting line has an isolating valve and a flexible hose, which can be connected to the railway wagon. Oil charged in the decanting bus is taken through a single line (400mm dia) to the suction header, (400mm dia), common for 4 decanting pumps inside the Decanting pump house. The decanting pumps are located at a lower elevation and there is approximately 2.5 meters head difference between the oil wagon or lorry bottom and the decanting pump suction line. This gives a positive suction for the decanting pump, facilitating easy charging of the suction side of the pump. The decanting pump is of 10M3/h capacity and is capable of developing a pressure of 4Kg/Cm3.

G. Fuel Oil tanks

Two fuel oil tanks each of storage capacity 1900M3 are erected inside an earthen bund, the volume of which is equal to the storage capacities of both the tanks put together. The diameter of the tank is 15 meters and the height is 12.5 meters. Each oil tank is having a level indicator and a level switch which gives alarm in case of level increase or level drop. In the bottom of each tank, there are two water drains off points placed diametrically opposite. Apart from them, there points placed diametrically opposite. Apart from them there is also a drain provision. Suction for the fuel oil pressurizing pumps is of the tank and this gives a positive suction of 1.75 meters to the fuel oil pressuring pumps. Taken off from the tank at an elevation of 0.50 from the bottom. Table 1 describes the technical details of drives installed in the power station.

TABLE I
DRIVE DETAILS IN THERMAL POWER STATION

Properties	Name of the Drive
	Decanting Pump
Number of pumps	Four
Type	Double screw
Capacity	110M3/h
Pressure	4 Kg/Cm2
suction lift	5.5 M.L.C
Make	TUSHACO pumps, India
	Drive Motor
Voltage	3 phase; 415 volts
Power	37 KW
Speed	1480 RPM
Current	63.5 AMPS
Make	NGEF, India
	Fuel Oil Pressurizing Pump
Number of pumps	Six Screw pump
Capacity	295-340 litres per minute
Delivery pressure	35 bar
Viscosity	16-850mm2/sec
Speed	1450 RPM
	Motor
Make	Siemens, West Germany
Voltage	3Phase, 415 volts
	35.5 KW
	1470 RPM
	64 AMPS

II. FOPH - BUS SCHEME WITH PROTECTION ELEMENTS FOR STAGE-I

The Figure 3 shows the scheme of supply to the FOP drives of stage-I. It consists of FOP B-series drives and corresponding decanting pumps. The FOP drives are of 35.5KW capacity and the decanting pumps are of 37KW capacity. The drives receive power from 0.4KV FOPH (RESERVE) Drive Bus. This 0.4KV supply comes via two incomer's I/C-1 and I/C-2. The supply to I/C-1 comes from LHS 0.4KV bus-A. Similarly the supply to I/C-2 comes from LHS 0.4KV bus-B. By default I/C-1 remains in closed position and I/C-2 remains in open position. Upon the occurrence of any fault the other incomer gets closed and continues the operation of the drives without any interruption. Just above the incomers, there are under voltage relays (U/V relays). These U/V relays sense the under voltage and trips the corresponding incomer and ensures its safety. The other protection elements available are Over Load Relay (OLR), Electromagnetic Relay (EMR), and Switch Fuse Unit (SFU). These protection elements are provided for every drive in FOP. The OLR gets tripped, if it senses any overloaded drives. Hence these protection elements ensure the full safety of the drives. The below scheme shows how FOP drives and De-canting drives are powered up through FOPH bus. Here for circuit simplicity we show one of the decanting drives also. There are two incomer breakers, only one will feed the FOPH bus at any time.

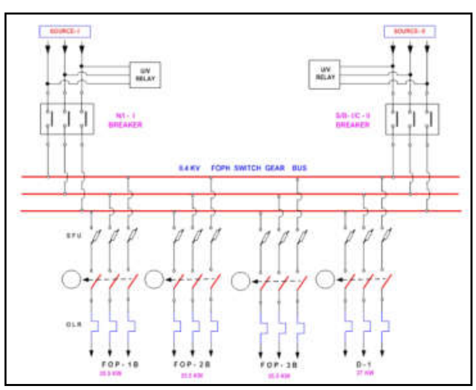

Fig.3. FOPH Bus scheme

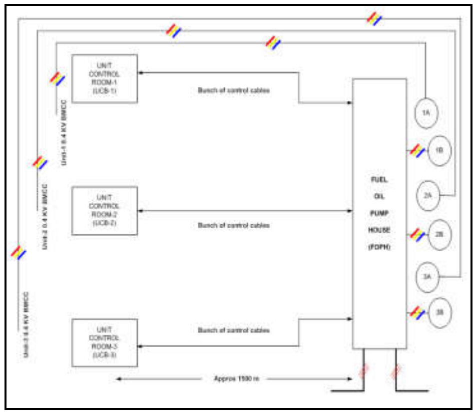

Fig.4. FOPH Drives System

III. FOPH SCHEME

The oil from the tanker is pumped into the furnace oil tank using the decanting pumps. Each pump is of 37 KW capacity. From the furnace oil tank, the oil is pumped into the furnace using FOP drives. During the motion of oil from the furnace oil tank to the furnace, the oil passes through the Flow Monitor (FM). The line consists of Main valve (M/V) and Re-circulating Valve (RC/V). Flow Monitor is to monitor flow of oil with the required parameters. Main valve is the valve that is close to the furnace. The oil can be supplied or stopped by opening or closing the main valve. In order to achieve the continuity of the process, the oil is made to be readily available using re-circulating valves. The firing process in the furnace has the following classification:

A. Oil Firing (up to 25 MW)

Oil firing is the process in which only oil is used for the production of power up to 25MW. It is also done to create the initial warm-up condition.

B. Mixed Firing (25-40MW)

Mixed firing is the process in which both oil and lignite are admitted into the furnace. This is done between 25-40MW.

C. Mixed Firing (25-40MW)

Lignite firing is carried out when the generation reaches 80%. Here only lignite is provided as input to the furnace. Hence, the oil flow to the furnace is completely cut down. After the burning process, the flue gas passes through ESP (Electrostatic Precipitator). Further using ID fans (Induced Draught fans) the flue gas is forced to exhaust through chimney.

IV. ELECTRICAL SYSTEM DESIGN

Here the distance between FOPH and UCB (Unit Control Room) is more than a kilometer. The drives FOP-1A/1B & FOP-2A/2B & FOP-3A/3B controlled from respective unit control room board engineers. In addition to that each and every drive can be started/stopped from pump house itself. It is for maintenance purpose. To enable this operation there is a selection switch at control room addressed as L/R (Local/Remote). If it is in Local the starting/stopping possible from pump house only and if it is in Remote UCB commands only will be processed. There is an Emergency latch for every drive available at pump house – trips the concerned drive in case of any abnormal situation arises in the drive area.

Pressure switch in oil line monitors the pressure of oil- if the pressure is normal it allows the drive which is in service otherwise issues trip command (to the Switch-Gear) to trip the drive and at the same time the control logic enables start command to the another drive (FOP-1A/1B for example) to maintain continuous flow of oil. The information of faulty drive will be now available at concerned UCB- for further maintenance action.

At present the total activities of FOPH system being controlled through Electro-Mechanical Relays based traditional logic. This involves lot of physical wiring work between control ends and hence trouble – shooting will be a tedious one during break-down periods. More over for this application even today there involves bunch of cables laid between UCB and FOPH – for a distance more than a kilometer as said earlier. If we introduce PLC in place of existing Relays logic- 80% of wiring will be avoided. Trouble shooting time greatly reduced – because of the PC friendly PLC technology. Within minutes we may find the faulty element in the process through desk top at UCB. It is a proven technology and hence now discussions going on to automate FOPH in TPS-II.

A. Power Scheme

All the drives are 0.4 KV – The concerned unit 0.4 KV supply availed for drives 1A/2A and 3A, while the 'B' series pumps like 1B/2B and 3B are powered through 0.4 KV bus from the FOPH itself. This bus remains as the Back-up source- because normally FOP drives 1A/2A and 3A will kept in service for oil supply for UNITS 1,2and 3. If at all any problem in unit sources (in switch gear side) with a prefixed time delay the 'B' series will come into service automatically, for UN-interrupted oil supply. Each drive is protected for overload conditions through overload relays. The bus at FOPH end is supplied with 2 sources using breaker feeders- this supply is taken from common Grid (we have to pay for consumed power). It is protected through Numerical relays- which one is the micro-processor based latest technology- capable of monitoring all possible protections –with a single modular pack. An Electrical overview of FOPH DRIVES system shown in Figure 4.

B. Existing Control Scheme

This is the control circuit using EMR logic that is available in UCB instrument panel at present. It consists of Local/Remote selector switch. If the selector is put in local, then the control operation (start/stop) can be done only in the local area.ie. In FOP area itself. The local system is mainly present for maintenance checks. On the other hand, if the selector is in remote the control operation can be carried out in the remote area. i.e. In Unit Control Board (UCB). Each one of these selectors has individual energizing coils namely K1 and K2.

There are individual OLR and Emergency for both local and remote selections. The emergency switch has an important feature. That is if the emergency switch is pressed the drive must go off despite of its operation in local or remote selection. It is used only in unavoidable situations. There are start and stop push buttons for local and remote operation. The starting and stopping of the drive from local/remote depends on the selection switch.

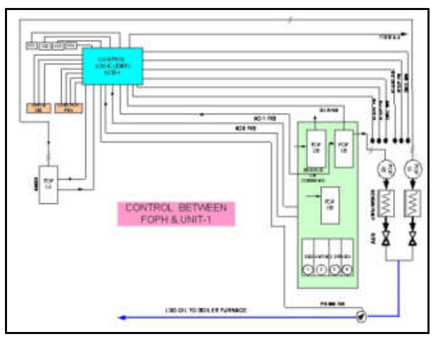

Fig.5. Simplified control cable activity of EMR based existing logic for FOP-1A

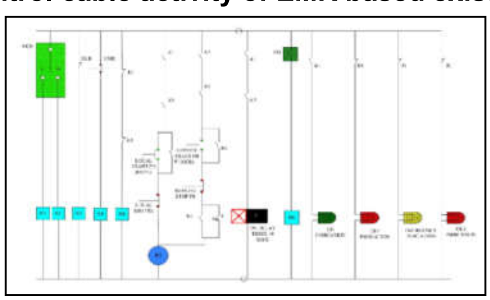

Fig.6. EMR logic control circuit -1A

Now as an example of its operation, consider that the selector switch is in remote. The corresponding K1 gets energized. The control circuit checks the OLR and Emergency status and proceeds further. As the selection is in remote, the K2 contact closes. Thus start/stop is made possible in the UCB. When start PB is pushed, the R1 contact closes. Thus the R1 switchgear operating in 0.4KV unit bus gets energized. Simultaneously the on-delay timer (10 seconds) gets activated. The flow monitor also starts its monitoring. If the required pressure is not developed within 10 seconds the drive gets tripped and the corresponding backup drive starts running.

The status of every component can be viewed through the indications. There are indications provided for FOP1A ON, FOP1A OFF, OLR trip and EME applied in FOP1A. Using these indications, the status of all components can be noticed in the UCB. Next page shows the control cable flow between FOPH and unit control board. The approximate distance between the two will be approximately 1.5 km. In the forthcoming page a simplified circuit using EMR logic is shown in figure for clear understanding. Figure 5 shows simplified control cable activity of EMR based existing logic for FOP-1A and Figure 6 describes EMR logic control circuit.

C. Logics of Control of Drives from UCB

Pump drives A/B selection switch will be available at concerned UCB. The two selection switches are Local selection and Remote selection. The selection switch will be switched to local mode for Maintenance purpose and at this mode control of drives from remote area is not possible. When the selection switch is at remote selection, then control of drive is possible only from the UCB. The control logic includes switches of Start PB (Push Button) Stop PB and the Emergency switch. START command is given to switch ON the drive, STOP command activation switches OFF the drive.

The EMERGENCY switch is a valid protection and if applied drives can't be started from either ends. The control circuit for drives operates at a voltage of 110v ac. Apart from these status indication is also provided to the concerned Unit Control Boards. The UCB also consists of provisions for selecting "A" or "B" pumps for operation. "B" series pump drives (35.5 KW) are supplied by FOPH 0.4KV bus. "A" series pump drives (35.5 KW) are supplied by unit 0.4 KV bus. Any one of the series pump drive will be running at a Time for a unit. When "A" series pumps are in operation, "B" series pumps kept as reserve. When there is any fault such as under-voltage or ground Faults in "A" pump drives, then "B" series pump drives will come into service automatically.

D. Proposed Control of Drives

Existing logic for control of drives Electro-Mechanical relays are used. Electromechanical relays are also called as switching relays or control relays. A relay is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism, but other operating principles are also used. Relays find applications where it is necessary to control a circuit by a low-power signal, or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits, repeating the signal coming in from one circuit and re-transmitting it to another. Relays found extensive use in telephone exchanges and early computers to perform logical operations. A type of relay that can handle the high power required to directly drive an electric motor is called a contactors.

E. PLC Control Scheme

Automation plays a major role in industrial process control applications. Almost all industrial process control applications – for electrical engineering- which involves complicated conditions or interlocks, time delays and fail safe operations- today well supported by Programmable Logic Controllers- shortly called PLC- is a well-known term among all electrical engineers. PLC dominates all other control technologies and proves its talent in electrical process control applications. Though it consumes high initial cost for commissioning, because of its flexibility, user-friendly, easy programming, adaptability and maintenance free, networking facilities – the end users really welcome this newer technology. The Configuration of FOPH with Programmable Logic Controller is shown in Figure 7 and The Figure 8 shows the PLC based control between FOPH and UCR.

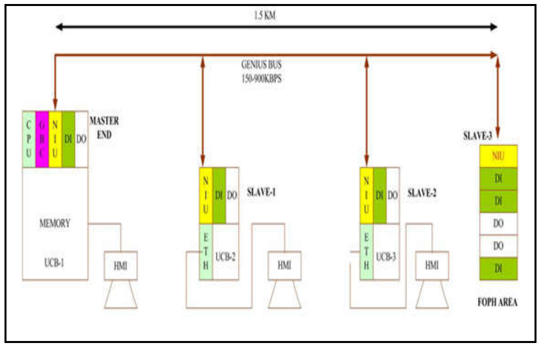

Fig.7. Configuration of FOPH with PLC

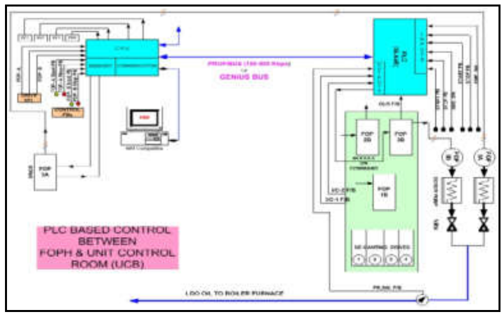

Fig.8. PLC based control between FOPH and Unit Control room

Here usage of PLC is a control platform - to monitor one of a continuous process in Thermal Power Station. The main aim of process is to supply Light Diesel Oil (LDO) to Boiler. This is being carried out through the FOPH system in Thermal Power Stations. LDO oil helps in the start- up of boiler from shutdown periods. The lignite is allowed after making sufficient temperature with in boiler using oil. Even after the entry of lignite, oil usage will be cut in steps and then it is being re-circulated between boiler ends and pump house- to meet out emergency situations. Hence without LDO oil boiler burning is not possible. For this process application, the electrical part provides 6 numbers of 37 KW, 0.4 KV drives called FOP drives. It is a high capacity drive made for continuous service application. The stage-I of TPS-II has 3 units of 210MW generation. Each unit is equipped with 2 numbers of FOP drives. The addressing of drives will be

FOP- 1A FOP- 1B
FOP- 2A FOP- 2B all are L.T (0.4 KV) drives.
FOP- 3A FOP- 3B

In addition to these drives there are four drain pump drives of high capacity to drain oil from tankers and fill the same to a huge oil storage tank. If FOPH system is automated with PLC- it is more advantageous to do with Modular PLC concept. This one is the distributed I/O technology –Master- Slave type and good networking facilities.

V. Conclusion

At present the total activities of FOPH system being controlled through Electro-Mechanical Relays based traditional logic. This involves lot of physical wiring work between control ends and hence trouble – shooting will be a tedious one during break-down periods. More over for this application even today there involves bunch of cables laid between UCB and FOPH – for a distance more than a kilometer as said earlier.

If we introduce PLC in place of existing Relays logic- 80% of wiring will be avoided. Trouble shooting time greatly reduced, because of the PC friendly PLC technology. Within minutes we may find the faulty element in the process through desk top at UCB. It is a proven technology and hence now discussions going on to automate FOPH in TPS-II. Almost, 80% of Industries are swiftly switching over to this latest technology.

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