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Protection and Control of Stator Water Cooling System

S.Gogula Priya[1], C.Subash[2], S.Gokulramesh[3], M.Manokaran[4], N.Sivakumar[5]

[1,2,3,4] UG Scholar, [5] Assistant Prof/EEE

Department of EEE, Sengunthar College of Engineering

Abstract- **Probabilities of heat inducing in the Stator Winding of the Generator are undoubted and hence automatic protection is absolutely necessary to detect and safeguard or to isolate the system from faults. Hence it is very important to provide all possible protection for the Generator's Stator Winding and accordingly Alarming / Trip signals should also to be made ready to handle the situation under odd hours.Our project deals with the cooling of the Stator Winding located in the Generator. Here the Winding part is cooled by using water by maintaining the level of the Conductivity Meter, Flow Meter and Pressure level. Here temperature of water and Stator winding's plays the major role and it has to be controlled within limit.Our Project shows how PLC is introduced in the place of present control logic to maintain the Conductivity, Flow and Pressure of the Water level thereby initiating Alarm and Trip signals for related operation and maintenance convenience. There-by ensuring Stator Winding for its efficient operation. The greatest advantage of PLC technology is Personal Computer (PC) connectivity. Its application is totally written as software and hence usage of physical control relays, timers and its associated wiring are avoided. Incorporation of Human Machine Interface and PC makes end-user to view system activities right through desktop screen.**

I. INTRODUCTION

To monitor and control the cooling activities of 200/210/235MW Generator's using PLC technology. The reasons for monitoring the Generator cooling process is the temperature of water and winding plays the major role and has to be controlled within limit.One of the ways of taking away the losses from the windings is direct cooling using water. The optimum design of large capacity Turbo-Generator, rule envisages water cooling of stator windings. High quality De-Mineralized water through the stator windings made of hollow and solid conductors. The generator delivers its rated load only when the stator-water cooling system is functioning properly, to ensure quick removal of majority of heat we are using the water flow in direct contact with the winding conductor, in additionally the heat are removed by hydrogen from the surface of hot winding insulation.The winding insulation besides having good dielectric strength has excellent thermal conductivity to ensure fast removal of heat. The flexible connection between the high voltage (15.75kV) conductors to water header is through Teflon tube.

II. PROPOSED SYSTEM:

In our proposed system the relays are eliminated and it will be replaced by using PLC. A PLC (i.e. Programmable Logic Controller) is a device that was invented to replace the necessary sequential relay circuits for machine control. By introducing PLC into action the process becomes more flexible, reliable and PC friendly. Trouble shooting experience becomes easier now comparing to the existing technology. With this updated technology, we monitor and control our Stator Winding from Unit Control Board (UCB).

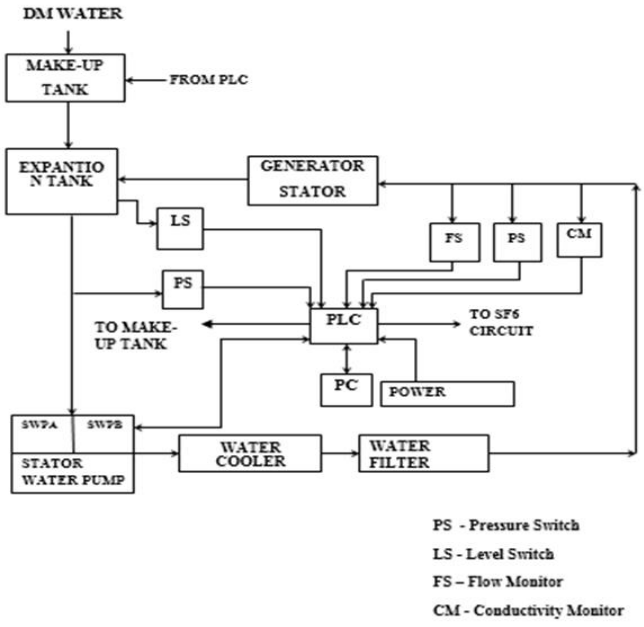

Fig: Block Diagram

This is compatible and reliable.Through using the PLC the wiring circuits are eliminated and Simple in manner. Conitinous operation without any intrupution.

III STATOR WATER COOLING SYSTEM

We know that the current flowing through the generator during full load condition is 9056A. Due to this high current the copper loss i.e., I^2Rloss will be very high in the stator winding. Hence the very high amount of heat will be dissipated from the stator winding.So this heat dissipated from the stator winding must be excavated continuously using

proper cooling system in order to prevent the stator core from severe damage.

Heat energy, H= I^2Rt joules

One of the ways of taking away the losses from the windings of any electrical machines is by direct cooling using water.The 200/210/235 MW Generators employs a closed loop circulation of High quality De-Mineralized water through the stator windings made of hollow and solid conductors. The generator is capable of delivering its rated load only when the StatorWater Cooling System is functioning properly. Therefore it is necessary that highest attention is paid for proper operation and maintenance of all the equipment's in this system.

A. DESCRIPTION

The heat losses arising in the stator windings, main terminal bushings and phase connectors are removed by the DM water coming into direct contact with high voltage windings. The DM water must have an electrical conductivityof less than 2.5 micro mho/cm.The stator water cooling system comprises of following main components: (i) Two 3 phase drive of 9.3 KW for DM water pumping application of100% duty cycle. One in service and other kept as reserve.(ii)Two vacuum pump drives for creating vacuum in Expansion tank. One will be in service and another kept as reserve back-up. (iii) Two DM water cooler (Exchangers) of 100% duty cycle (iv) Polishing Unit (v) Mechanical Filters (vi) Magnetic Filter (vii) DM water for ExchangersOther components employed in the system are Gas trap device, Expansion tank, water jet ejector, valves and associated. The cooling system circuit uses either of the following water supplies, free from Oxygen.(i) Distilled water(ii)Fully De-Mineralized water from WTP Condensate

Fully De-Mineralized water from the Boiler Feed Water Treatment Plant and condensate may only be used if no chemicals, such as Ammonia, Hydrazine, and Phosphate etc. A part of water is bypassed and is treated in mixed bed ion exchanger, connected in Parallel to the Stator Winding (Polishing Unit) and returned into suction side of the water pump- thus maintaining the conductivity of closed loop circulating water within permissible level.The DM water pump drives are of single stage type with spiral casing and overhung impeller. The pump is connected to a three phase ac induction motor. Failure of working pump due to fault or power supply failure results in an automatic starting or changeover to standby pump drive.

The Polishing Unit is provided across the stator winding, to comprises theExchanger Tank , filled with anion and cat ions resins in the form of mixed bed ion exchanger. The mechanical filter eliminates the foreign particles in the DM-Water, which may choke, erode the hollow conductors of stator winding. The difference of pressure at inlet and outlet of stator winding is of the degree of choking. The choked filter may be cleaned after using standby without affecting the system working. The magnetic filter prevents any magnetic particles from entering to the generator. Any accidental leakage of Hydrogen into the DM water stream is detected by Gas Trap device.The DM water from the outlet of stator winding collects in an Overhead Expansion tank, which provides a constant level of water during normal running of the system.

The hot DM water from generator enters into the tank through perforated pipe in the form of spray thus releasing heat and any entrapped gas. A water jet ejector is connected to the expansion tank for creating vacuum for the purpose of removing any traces of Oxygen/Hydrogen which may be present as a result hydrogen leakage into the DM water stream. Level signaling device in the expansion tank monitors the High and Low level of DM water and initiates a tripping command for running Stator water pump at low level in expansion tank.Generally the latter detect levels that are excessively high or low. High level is 90% and low level is 20% if it exceeds the level, then it will give alarm.

Make-up DM water to the system is provided at expansion tank through a float operated level regulator.The quantity of DM water flowing through the windings is measured by a system of orifice plate, flow transducer and flow indicator and recorder. Signaling contacts are available in flow switch/the indicator/recorder, which are set annunciate at low flow through the windings and initiates tripping of the machine at emergency flow on the principles of two out of three.Normally flow monitoring device maintain the low level of 13 meter cube/hr. otherwise it will be tripped and high level 21 meter cube/hr,otherwise it will give an alarm.Conductivity meters are used to continuous monitoring of the conductivity of water, which annunciate alarm at conductivity high set value. At very high conductivity is tripped automatically.Both measuring devices are equipped for indication and alarm. It will give the trip feedback when it exceeds the high level of 21 micro mho/cm and it will give alarm when 13 micro mho/cm. Generally the DM water used here will have electrical conductivity of less than 2.5 micro mho/cm.

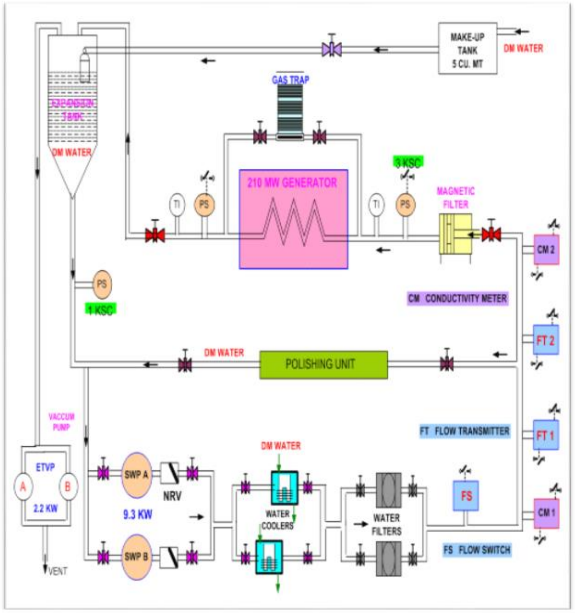

Fig: Stator Water Cooling System

B.POWER CIRCUIT

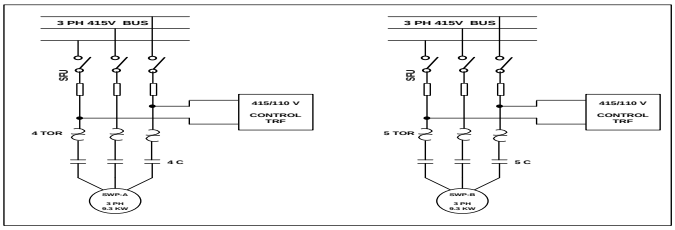

Fig: Power Circuit for SWP-A SWP-B

C. PROGRAMMABLE LOGIC CONTROLLERS

Programmable Logic Controllersaresolid-state members of the computer family, using integrated circuitsinstead of electromechanical devices to implement control functions. They are capable of storing instructions, such as sequencing, timing, counting, arithmetic, data

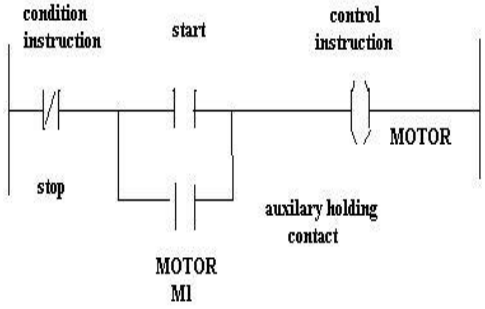

Fig: Ladder logic diagram

manipulation, and communication, to control industrial machines and processes.

In all type of Industries, Electrical process and Instrumentation process are the predominant processes based on which all other functions are being carried out. Systems by which these processes are monitored effectively are called control Technologies.The following are the most widely used control technologies:

1) Electro-Mechanical Relay Logic (hard-wired logic)
2) Electronics based Logic (including Digital Logics)
3) Micro-Processor Logic (µP based control)
4) Micro-Controller Logic (Embedded system)
5) Programmable Logic Controller (PLC)

Of these available control technologies, almost 80% of Industries have switched over to PLC from existing control technology. The control may be automatic or initiated by the Operator. Data acquisition is accomplished firstly by the RTUs (It may also called PLC). This is usually at faster rate. Hence, PLC technology is economical as well as reliable one for most of the industrial process. That is why, PLC is rolling ahead of all other Control Technologies.Hence, it is very essential to understand the functioning of PLC. But, in the market, we can get lot of text books to understand theories of PLC functioning. So, it would be sufficient enough to gain first-hand knowledge about application oriented advantage of PLC device over convention hard wired control circuits.Let us start with one simple electrical circuit.

D. LADDER LOGIC PROGRAMS

A PLC ladder logic program closely resembles an electrical ladder diagram. On an electrical diagram, the symbols represent real world devices and how they are wired. A PLC program uses similar symbols, but they represent ladder logic instructions.

A ladder logic program exists only in PLC software – it is not the actual power bus or the flow of current through circuits. Another difference is that an electrical diagram, devices are described as being open or closed (OFF or ON). In a ladder logic program, instructions are either true or false (however,theterms are often used interchangeably).

E. SWP-A CONTROL LOGIC USING LADDER DIAGRAM

Timer T-1 is the software timer we avail from PLC allotted facility for the above program the selection process is made on through our requirement. Above case is manual selection and starting process is throughremote selection. When we give the command I4 remote start push button it will make the contact with power contactor so that motor comes to the running position (Q1) indicates the on indication.

If any fault occurs OLR relay will trip the circuit and indicate the OLR fault indication through Q 3. Though selection was remote, if we stop the motor through local emergency the motor will be stop. Another starting process is through the local start push button can be start the motor. Any one of the motor will be in running condition another motor either is in auto mode or manual mode.

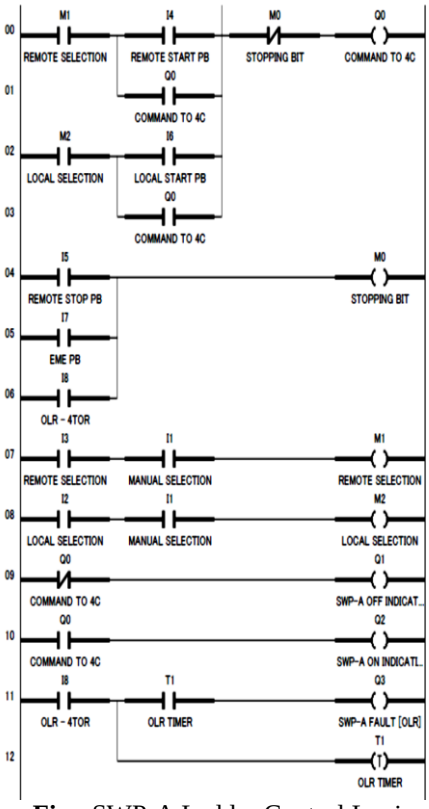

Fig : SWP-A Ladder Control Logic

INPUTS:

I_1 = Auto Selection
I_2 = Manual Mode
I_3 = Local Mode

I_4 = Remote Mode
I_5 = OLR Trip
I_6 =Exp tank pressure switch
I_7 =Exp tank level switch
I_8 = Local start PB
I_9 = Emergency stop PB
I_A = Remote start PB
I_B = Remote stop PB

OUTPUTS:

Q_1=SWP-A (Power contactor - 4C)
Q_2=SWP A Run Indication
Q_3= SWP A OFF Indication
Q_4= SWP A OLR Trip Indication
Q_5=Expansion Tank Low Level Indication
Q_6=Alarm

IV.COMPARATION OF RELAY LOGIC SYSYTEM & PROPOSED SYSTEM (PLC)

Industrial control should ensure first man safety then machine safety. Drive control normally uses Control supply or control voltage for safe and secured operation. The voltage levels might be 24 v /110 v ac or 220 v d.c.

In SWCS the control room and process area are separated at a distance of 250-300m. In general the switch gear area will be separated – from where the power flow is going to concerned drive. Here the control room is at first floor and the switch-gear area (Annex) is at ground floor. The distance from control room and switch-gear is 100m approx. The control logic to control our drives in SWCS application is in control room. At present it is being carried out through Electro-Mechanical relays, timers.In control room Local/Remote selection switch is there to decide the SWP- series sequential starting/maintenance purpose. If the selection is in Local the drives will be controlled through local commands only. For this each and every drive is having its own control post near to the drive itself. In this selection the control logic will not respond for control room commands.

This is for testing purpose.If the selection is in REMOTE, then the stream is started through a single start command- for the drive running there are some pre-defined conditions like local emergency switch should be in normal condition and the protection feed-back should also be in healthy plus the pit level should be sufficient. Due to the drive capacity and pump nature these drives should not run with out slurry.
The control logic receives command from control room in charge and checks for the conditions- finally issues command to the switch-gear module for SWP-A.Pressure interlocks are also there to disturb or continues the stream running. If at all any problem in running drive (SWP-A/SWP-B), automatically the control logic issues command for alternate drive (SWP-B/SWP-A) in the same manner. At present the working logic requires physical wiring between control and monitoring ends. Moreover the interlocking between EMR relays would be a complicated one, when we are in a position to trouble-shoot under break down.Industrial process normally includes, (i) Interlocks for man safety (ii) Interlocks for machine safety (iii) Interlocks for process safety.
Since the process and the control rooms are seprated at distance the condition of the above interlock has to be taken from the concerned elements to the control logic logic (at control room) only through physical cabling. It makes the trouble-shooting to extend in hours. Our aim of project is to update the system control technology using PLC. In simple words at present the EMR logic delivers the command (it may be a breaker or else a ordinary switch gear) to the concerned switch-gear module to make or break the power to drive, if at all PLC is introduced the same command will be issued through PLC- here the control technology is software-ladder-user friendly one.Here we have to say about the software part what we have discussed previously for SWCS (SWP-A, B & INSTRUMENT) SYSTEMS and discuss something regarding its advantages like non-usage of relays & timers and reduction in physical wiring , space will be reduced and the operating time also will be reduced.so we conclude instead of using the timer and relay, PLC is an efficient and user friendly one.

V. CONCLUSION

The aim of our project is to monitor the Stator Water cooling process based on PLC. Since the temperature of Water and winding plays major role in Stator performance and operation,the monitoring plays key role. We got idea about existing control and monitoring with relays and timers. With our project concept we simply eliminate the probles in existing control with the help of Intelligent Programmable Logic Controllers.The control technology is simply converted to software-supports user-friendly Plotform with PC connectivity for any level of complication in process. The control technology is simply converted to the software supports user friendly plotform with PC connectivity for any level of complication in process to inter lock.Trouble shooting experience becomes easier now whwncompred to the existingtechnology.With technology we monitor and control even trouble shoot our Stator Winding from the Unit Control Board (UCB).

We have full confidence and satisfaction of our project, did in a good way by the lots of collected technical informations. The software program of our project is also included in the record, which was loaded and tested with the PLC.The performance of the system was satisfactory. The modular PLC can be easily interfaced with other. This is compactable and reliable.

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