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Automation of a 7 MW Turbo Generator using PLC

Sherin Thomas[1], Silpa Tom[2] and B. Priestly Shan[3]

[1,2,3] **Department of Electronics and Communication Engineering**
St Jospehs College of Engineering and Technology
Palai, Kottayam, Kerala, India

Abstract

Control engineering has evolved over time. In the past, humans were the main methods for controlling systems. The development of low cost computer has brought the most recent revolution in control engineering, the Programmable Logic Controller (PLC). PLC has become the most common choice for manufacturing control. This paper focuses on the automation of controlling a 7MW turbo generator using PLC. Ladder Logic is the main programming method used which mimics the relay logic. The tripping and resetting conditions are studied and the turbine is programmed in such a way that turbine is automatically tripped if any tripping conditions occur and finally reset if all the resetting conditions are met.

Keywords: *PLC, Controlling schemes, Turbine tripping, Turbine restart.*

1. Introduction

A turbo generator is the combination of a turbine directly connected to an electric generator for the generation of electric power. Turbo generator machines powered by steam generate most of the world's power. A furnace is used for most conventional turbo generators and it heats water under high pressure so that it turns into steam vapour. Since there is only one exit point within the device, the vapour exits at a high velocity and drives a turbine to produce electricity. A turbo-generator consists of a turbine, generator and other auxiliaries like condenser, pipelines carrying superheated steam etc. Turbo-generator falls under high speed rotary type machines and its capacity varies from 2 MW to 2000MW. The block diagram of a turbo generator can be shown in figure 1.

The exciter generates electric current by the principle of induction. It consists of the primary winding which produces the desired effect. This is then supplied to the generator. Here the generator is rotating at a speed of 3000rpm after suitable reduction.

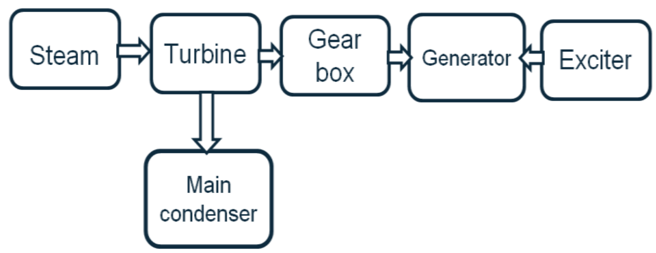

Figure. 1 Block diagram of Turbo Generator

A speed of about 9000rpm is possible due to the gear box used. The generator is supplied with steam at the rate of 60kg/cm2. The steam temperature is maintained at 450 degree Celsius.

2. Controlling schemes

The three main schemes to be controlled in a turbo generator are:

2.1 Lube oil scheme

Turbine lube-oil systems have many missions. Among the most important: cooling bearings, flushing contaminants away from rotating parts, preventing inleakage of gases, providing hydrostatic lift for shafts, actuating valves in the hydraulic circuit, and protecting lube-system internals. Oil stored in main oil tank, is pumped to various parts such as bearings or gear box using Main Oil Pumps, MOP1 or MOP2 at 10 kg/cm2.
In case of emergency, an Auxiliary Oil Pump AOP supplies the oil at 8 kg/cm2. This oil passes through oil cooler and filters and then goes to lube oil header, finally reaches the main oil tank. If in any case, none of these pumps is running, the turbine will be tripped. The oil is then supplied by low pressure ACEOP(AC Emergency Oil Pump), and if no ac supply DCEOP(DC Emergency Oil

Pump) will turn on and provide the necessary lube oil supply. In order to minimize chances for bearing damage, the turbine would be tripped. And the pump would maintain adequate bearing lubrication and cooling to allow safe shutdown.

2.2 Condensate flow scheme

The condensate system condenses the steam from the turbine exhaust and other reclaimable steam. The condensate are collected in the hotwell and are pumped via the condensate pumps to the feedwater preheater for each heat recovery steam generator train. The condenser removes non-condensable gasses during operation and de-aerates the cycle make-up water. Condensate is also supplied to the steam turbine seal steam de-superheater, auxiliary steam de-superheater, steam turbine exhaust hood spray, and the condenser spray curtain.

The condensed steam is temporarily stored in hot well. The condenser hotwells are incorporated in the bottom of each condenser shell and serve as collection points for all condensate. The hotwell for each shell is integral with, and a continuation of, the condenser shell side plates.

The hotwells are tied together with 24 inch equalizing lines to ensure equal level in both hotwells. The water is pumped from hot well to de-aerator using Condensate Extraction Pump1(CEP1). If this pump gets tripped, CEP2 turns on. Cooling water utilized is circulated between the condenser and cooling tower. It absorbs heat from the steam that reaches the condenser so that the steam is condensed into water. In the cooling tower, the hot cooling water is sprayed from top to cool it. It also uses huge fans to cool it. After cooling, it is pumped back to condenser.

2.3 Steam flow governing scheme

Steam flow governing is the procedure of controlling the flow rate of steam into a steam turbine so as to maintain its speed of rotation as constant. The variation in load during the operation of a steam turbine can have a significant impact on its performance. In a practical situation the load frequently varies from the designed or economic load and thus there always exists a considerable deviation from the desired performance of the turbine. The primary objective in the steam turbine operation is to maintain a constant speed of rotation irrespective of the varying load. This can be achieved by means of governing in a steam turbine.

Steam from boilers is collected in the 60 kg/cm2 header. From the header, it passes to the turbine. The Governing Valve determines the amount of steam entering into the turbine. The steam loses its pressure and temperature as it advances the condenser. Finally, partially condensed steam is sucked away by the condenser.

3. Programmable Logic Controller

PLCs have been gaining popularity on the factory floor and will probably remain predominant for some time to come. The advantages are:

- Cost effective
- Flexible
- Allow more sophisticated control
- Trouble shooting aids make programming easier and reduce downtime
- Reliable components

As a control device, the PLC performs several functions. The PLC monitors input signals generated by sensory input field devices. Based on the input signals, the PLC makes logic decisions. As a result, the PLC takes control action by sending signals to the actuators of the output field devices. The input field devices provide status information to the PLC. The information is either the open or closed state of the field device or its voltage or current magnitude. The PLC reads the status information and stores a corresponding logic status value in the memory section of the CPU. Based on this value stored in the memory, the PLC solves the user control program which is designed to regulate the process.

After solving the user control program, the PLC takes control action by turning the actuators of the output field devices to either ON or OFF state. The PLC regulates the output field devices that control a process based on status information provided by the input field devices.

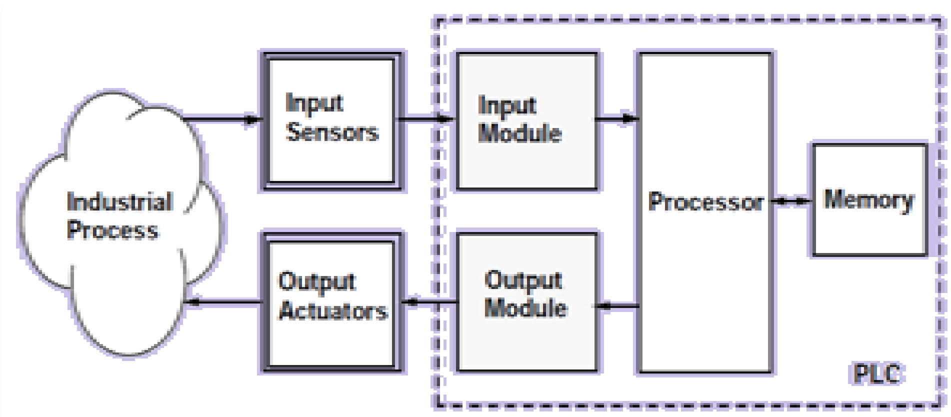

Figure 2 PLC Block diagram

In order to create or change a program, the following items are needed:

- PLC
- Programming device
- Programming software
- Connector cable

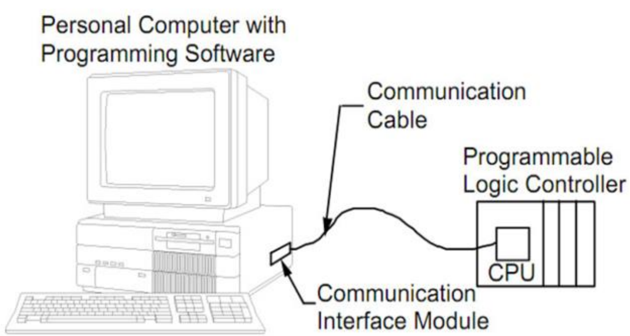

Figure 3 Programming terminal

In the proposed project, GE-FANUC 90-30 series PLC is used. The software used is Versa Pro with Ladder Logic programming.

4. Proposed work

The turbo generator has to be programmed such that if any one condition of the tripping has occurred, the turbine must be tripped at the moment. And when all the reset conditions are satisfied, it has to be restarted. The turbine tripping conditions and the conditions for resetting are explained as below:

4.1 Turbine Trip Devices

Whenever the turbine is to be tripped, the governing oil pressure trip oil line is drained by the tripping device . Thus the pressure in front of the stop valve and secondary oil pressure falls resulting in the closure of stop valve and control valves. The tripping device is operated on the occurrence of any one of the following:

1. Emergency trip from Human Machine Interface
2. Emergency trip from Turbine Control Panel
3. Emergency trip from WOODWARD
4. Governing oil pressure low
5. Lube oil pressure low
6. Trip from generator control panel
7. Vibration high
8. Hot Well level low

4.2 Turbine Reset Conditions

Once the turbine has tripped, it has to be restarted again. This is done only when all the necessary reset conditions are satisfied. Those conditions can be listed as:

1. Overhead tank level not low
2. Turbine reset from HMI
3. Emergency Stop Valve (ESV) closed
4. Turbine healthy

The flowchart for this proposed work can be shown as below:

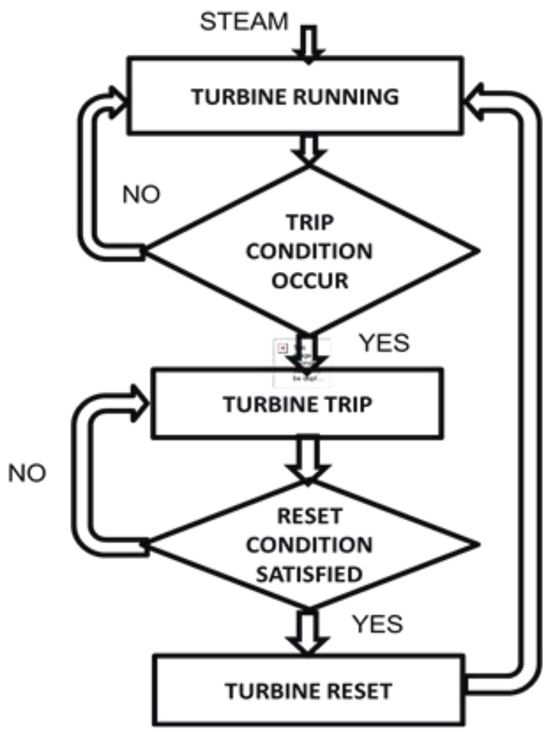

Figure 4 flowchart

For programming the PLC, Ladder diagram is drawn using special symbols. This is done using various tools provided in the Versa Pro. This program is then simulated in Versa Pro software and downloaded into the PLC using Ethernet cable. Then it is implemented and connected to the control panel and HMI.

5. Conclusion

The automation of turbo generator was implemented successfully using Ladder Logic language in PLC. The turbine was thus automatically tripped when any one of the tripping condition occurred and finally reset with all the resetting conditions satisfied. With the present PLCs it is possible to incorporate the complete control system to be incorporated in one PLC.

References

[1] Finch, "Developments in turbogenerator control and modeling", UKACC International Conference, Volume 1, 1996, pp. 569-574.

[2] Venayagamoorthy, G.K. , "A continually online trained neurocontroller for excitation and turbine control of a turbogenerator", Volume 16, Issue 3, September 2001, pp. 261-169.

[3] Lixin Ren , Irwin, G.W. , Flynn, "Nonlinear identification and control of a turbogenerator-an on-line scheduled multiple model/controller approach", IEEE Transactions on Energy Conversion, Volume 20, Issue 1, 2005, pp.237-245.

[4]Flynn, Swidenbank, Hogg, B.W., "Real-time expert control for turbogenerator systems", International Conference on Control, Volume 2, 1994, pp-1495-1500.