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Real- Time Implementation of Hydroelectric Power Plant Using PLC and SCADA

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Abstract- This paper emphasize on controlling the process variable parameters such as level and flow with real time implementation of gate control of hydroelectric power plant using Programmable Logic Controller. In this work, a programmable logic controller is used as an industrial computer playing the role of a control device and push buttons, level and flow sensors provide incoming signals to the control unit. The prototype model is provided with five levels in the upper tank and two levels in the lower tank and depending on the level sensor outputs the ladder logic is actuated. This work uses PLC of ALLEN BRADLEY MICROLOGIX 1200 inbuilt with 24 digital inputs and provides 16 potential free outputs to control the miniaturized process depicted in the work.

***Keywords*- Ladder logic, PLC, SCADA, Hydro power plant, Level sensor, Solenoids**

1 INTRODUCTION

The increasing demand of energy has forced us to look at the other options different from conventional means of exploiting energy as conventional sources of energy are exhaustible. The capacity to produce this energy is dependent on both the available flow and height from which it falls. To meet the various disadvantages of conventional type such as Ecosystem damage, siltation, flow shortage, methane emissions etc., automation can be used[1].

Before the existence of automation, qualified personnel operated the equipment manually called as the manual system where the automatic system reads the information on the equipment status operation and then activates commands or controls to optimize the output production. Therefore the need for automation for a small hydroelectric power plant is to improve the efficiency, productivity and the operating management of the system which solves the problem of production needs.

2 BLOCK DIAGRAM AND DESCRIPTION

The heart of the process is PLC, where the input signals are given to the PLC. The input devices can be pushbutton, selector switches, level switches, limit switches, photoelectric sensor, motor stator contactors etc. The PLC[2] is connected to the SCADA (Supervisory Control And Data Acquisition) which monitors the process. The output of the PLC is given to the final control element. The output elements can be valves, motor stator, solenoids, control relays, alarms, light, fans and horn. The final control elements used in this work are the solenoids. They control the opening of the gates. Hence the process is controlled using the solenoid valves and the feedback signal which is the level of the gates (opened/ closed) is given to the input.

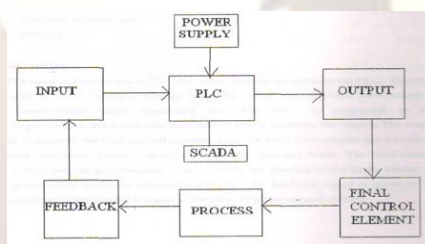

Figure 1Block Diagram

3 PROCESS DESCRIPTIONS AND LAYOUT

The hydropower plants use modern turbine generators to produce electricity and the difference is the fuel. A typical hydro plant is a system which has three main parts:

- Reservoir where water can be stored
- Dam with gates to control water flow
- Power plant where the electricity is produced

A hydro plant uses the force of flowing water to produce electricity. A dam opens the gate at the top to allow water from the reservoir to flow down large tubes called penstocks. At the bottom of the penstocks, the fast- moving water spins the blades of turbines. The turbines are attached to generators to produce electricity, which is transported along the transmission lines to a utility company.

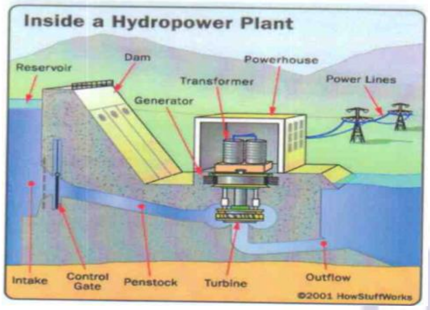

Figure 2 Process layout

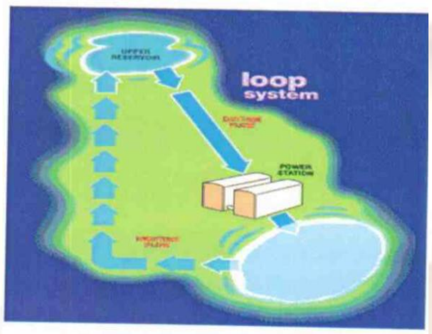

Figure 3 Process Flow

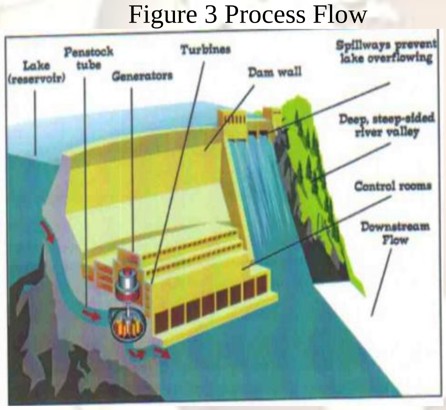

Figure 4 Reservoir

Most hydroelectric power comes from the potential energy of dam water driving a water turbine and generator. To boost the power generation capabilities of a dam, the water may be run through a pipe called a penstock before the turbine. A variant on this simple model uses pumped storage hydroelectricity to produce electricity to match periods of high and low demand, by moving water between reservoirs at different elevations. At times of low electrical demand, excess generation capacity is used to pump water in to higher reservoir. When there is a higher demand, water is released back into the lower reservoir through a turbine. The choice of instrumentation in this work is mostly governed by the nature of process industry and the application involved. With the upcoming of microprocessors and associated peripheral chips, the whole process of control and automation underwent a radical change. The programmable Logic Controllers have in recent years experienced an unprecedented growth as universal element in industrial automation.

4 DESCRIPTION OF THE MODEL

The prototype model basically consists of the following hardware components:

- Programmable Logic Controller
- DC motor
- Generator
- Capacitive level sensor
- Submergible pumps
- Solenoids

PLC which has inbuilt 24 digital inputs with 24v DC and provided with 16 potential free outputs. This is used to control the miniaturized process shown in the project. The model also has a DC motor, generator, capacitive level sensors, submergible pumps and solenoids. The PLC is used for auto operation of small hydroelectric plant where it can be programmed according to the operational requirements and mode of operation like grid connected and isolated, semi automatic and fully automatic control etc. By using PLC, the conventional methods for control are replaced by digital control and are also suited for integrated control and automation system in small hydroelectric power plant. The RS logic 500 of professional addition 8.10 addition version software is used for programming the PLC. The PLC type plant controller combined with PC based SCADA [3] systems are used for plant control and data acquisition. This makes the system economically viable and thus can be suitable for many small hydroelectric power plants [4] for generation, control and automation. The capacitive level sensors excel in sensing the presence of a wide variety of solids, aqueous and organic liquids and slurries.

5 FUNCTIONS OF THE PROCESS

In the prototype model, there are five levels in the upper tank and two levels in the lower tank. The upper five levels are

- Low level
- Average level
- Medium level
- High level
- Danger level

The two levels of the lower tank are

- Low level
- High level

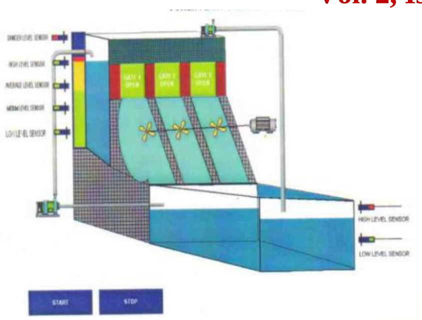

Figure 5 Process Working

When the water in the ground tank is above the low level sensor, then the water from the lower tank is pumped to the upper tank (reservoir). As the water level in upper tank increases, then the level sensor gets actuated. Based on the level sensor outputs the ladder logic is actuated and as per the programmed logic the gates of the dam open at their respective levels. When the water level in the upper reservoir reaches to medium level the first gate of the dam is opened. When the water increases beyond medium level and reaches the average level, then the second gate of the dam is opened. If still the water in the reservoir increases and reaches up to high level then the third gate of the dam opens. If the water increases beyond this level, then the overhead pump located at the upper tank gets actuated and it pumps water into the lower tank. Simultaneously, the upper level sensor in the ground tank is checked. When the water in the lower tank reaches the high level sensor in the lower tank, all the dam gate and the overhead pump is turned off. In this way the water circulates between the two tanks and will protrude out of the gates when they are opened. This water with high pressure falls on the turbines and rotates them. Turbines are connected to the shaft of a generator; hence it also rotates simultaneously with the turbines producing electricity.

6 SOFTWARE DESCRIPTION

The software module of the project consists of PLC programming Language and
Supervisory Control And Data Acquisition.The specifications of the PLC programming software is RS logic 500 professional addition 8.10 version and the SCADA software used is Factory talk view studio. The commonly used language for PLC's is ladder logic. The ladder logic programming language is an adaptation of an electrical relay- wiring diagram. The input to the PLC can be wired as normally open contact or normally closed contact depending on this when the input is actuated the input relay may turn on or off respectively.

SCADA stands for supervisory control and data acquisition [7] which generally refers to industrial control systems: computer system that monitor and control industrial, infrastructure or facility- based processes. The flow chart of the process is given in figure 6.

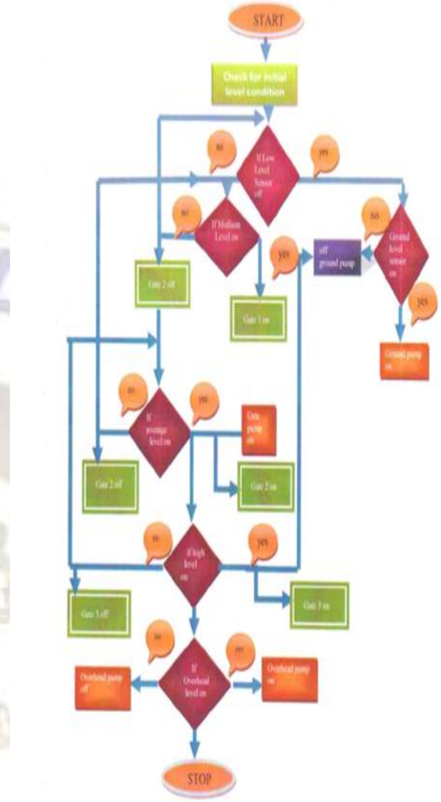

Figure 6 Flow Chart

7 RESULTS AND IMPLEMENTATION

The results of the process [5,6] using PLC is shown using SCADA as in figure 7 to figure 12. The figure 7 shows when there is no level in the tank

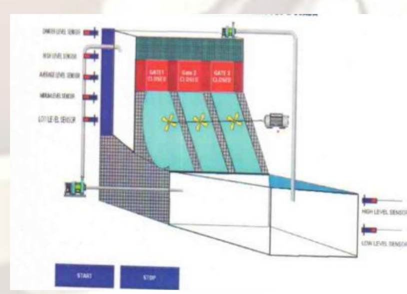

Figure 7 No level in tank

Figure 8 shows the result when the water is at a low level in the upper tank.

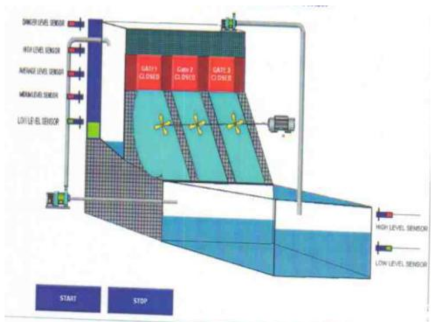

Figure 8 Low level in upper tank

Figure 9 shows the medium level of water in the upper tank

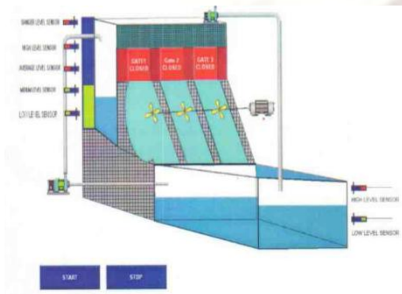

Figure 9 Medium level in upper tank

When the water is above the medium level, then the gate1 opens as shown in figure 10.

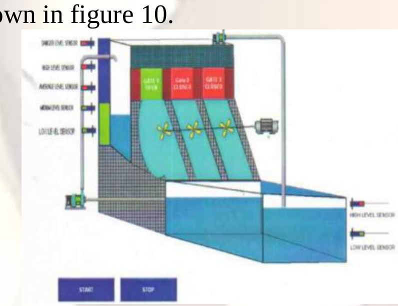

Figure 10 Opening of gate 1 above medium level

When the level of water is at average level, then the gate 2 opens as in figure 11

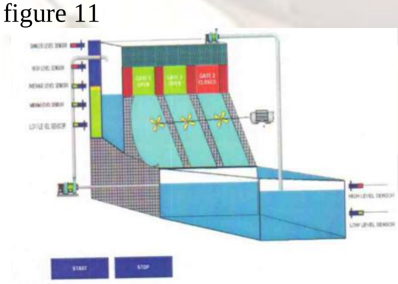

Figure 11 Opening of gate 2 at average level

And finally, when the water level is at a high level , then the gate 3 opens as in figure 12.

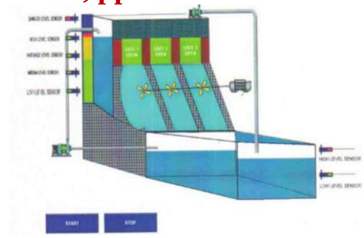

Figure 12 Opening of gate 3 at high level

8 CONCLUSION

In this paper, it represents an automatic/ remote controlling of an hydroelectric power plant using PLC and SCADA. This prototype model of a hydroelectric power plant which is completely automated can control the level of the dam gates using backup of the water. Thus using PLC and SCADA the level of water in the dam is controlled effectively thereby opening the gates of the dam whenever the level deviates.

Therefore the use of PLCs has opened doors for a level of automation of hydropower plants.

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