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Monitoring and Control of an In-House Steam Power Plant: A Support of the Idea of Distributed Power Generation

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Abstract

As the world is getting more and more sensitive towards the use of energy, it is moving their focus towards independent and distributed ways of generation of energy. Distributed Generation (DG) based on Renewable Energy Technologies (solar, wind, hydro and biomass) is becoming a more important energy option in the future generation system. What we are trying to implement is breaking the large central power plant into multiple smaller, non-centralized power plants. In this way, each user can generate the appropriate amount of power they need and subsequently result in an efficient usage. We will be distributing a centralized energy generation point into a network on smaller energy generation points we will call this network as a "grid". We will also be simulating our idea to verify our claim. In the longer-term, a system-wide approach for determining Distributed Generation costs and benefits should be adopted.

Keywords: Distributed energy generation; Steam power plant

Introduction

One of the major and most inevitable forms of energy for the modern human race is Electricity. Its absence is enough to put the existence of several socioeconomic infrastructures to question. It is easy to handle, simple to transport and is very versatile. This trait makes it the most desirable source of energy. There are various ways of generation of Electricity, namely, Thermal, Hydro, Geothermal, Nuclear and many more. Here, we will be discussing about the Steam Power Plants, which can be classified under Thermal.

Steam power plants play a key role in electric power generation. Therefore the Rankine steam power cycle is one of the most important cyclic processes used in industry. The efficiency is up to 45% with recent technological advancements [1-3].

Working Principle of a Steam Power Plant

The working fluid is Water. The advantage of this type of power plant is. It uses the same fluid repeatedly. Firstly, the water is fed into the boiler, where it is heated and eventually turns to vapor phase. This steam produced by the boiler is directed to do work on the turbine to produce mechanical power in the form of rotation.

The steam from the turbine is then flowed into the condenser to be cooled with the cooling water. At this stage, the steam is back to its liquid stage.

The rotation of turbine is used to turn a generator that is coupled directly to the turbine. So, when the turbine rotates, the generator output terminals generate electricity. Though, the working fluid (water) works in a closed cycle, there will be some decrease in its volume.

This is due to leakages, either intentional or unintentional. The efficiency of the plant working on steam is a function of the maximum temperature of the steam generated and is not directly proportional to the fuel used. Thus, the type of fuel used is insignificant as regards to the efficiency of the steam power generation, but plays an important role in the overall system efficiency (Figure 1).

Tools Used

Labview software

For real time data acquisition of various real time parameters during the simulation.

Arduino

For operation control using Servo Motor.

MCC DAQ card

Used for monitoring process parameters.

Using the results obtained from real time simulations, we have concluded that our proposal of distributed power generation is applicable, both from the technological and economical point of view.

Process Measurement and Simulation Details

We will be using the DAQ MCC 1208FS card for monitoring our steam power plant, we provide the required control using an Arduino Board and the software used is NI Lab View.

MCC expands to Measurement Computing Corporation. DAQ expands to Data Acquisition. The mission of Measurement Computing Corporation is to provide our customers with PC-based data acquisition hardware and software that will save time and save money [4].

A steam power plant will have a number of sensors, like, Temperature sensor, Pressure sensor, Flow sensor, Level sensor, RPM sensor, PH sensor, Vibration sensor, Voltage sensor [5].

Temperature monitoring of the boiler

Thermocouple is used to monitor the boiler temperature. The output of the sensor is obtained in milivolts (mV). In our simulation process, the boiler is heated to 100 degrees centigrade, after that the water is allowed to become steam. The positive terminal of the sensor is connected to Channel-0/Ai0 IN, Pin 1 and negative terminal is

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connected to the ground of Pin 3 Single End Mode. The 1208FS will now monitor the temperature. The card is interface with the VI software the computer will now display the temperature and monitor the boiler temperature changes.

Pressure monitoring of the boiler

A resistive pressure sensor is used to measure the boiler pressure, and the output is in 4-20 mA. As the temperature increases, the pressure also increases. The sensor output is connected to the Channel 1-4, Pin 7/Ai4.IN; and the negative terminal is connected to the ground (Pin 9). The analog output is in the form of pulses. The DAQ card will now monitor the pressure. This card is again interfaced with the VI software in the computer. We can now view and monitor the pressure changes in the boiler on the computer (Figure 2).

Temperature monitoring of turbine

We again use the temperature sensor to sense the temperature of the Turbine. We connect the temperature sensor to single end mode of DAQ MCC 1208. The positive terminal is connected to the channel 1, Pin 2/Ai1 IN and the negative terminal is connected to the ground (Pin 3). As in the previous other cases, this is also interfaced into the Computer, for better visualization.

Pressure monitoring of turbine

The turbine pressure is monitored using the same method we used to measure the boiler pressure. We will be using the single end mode of the DAQ card. The sensor terminal is connected to the positive of channel 1-5/Ai5IN, Pin 4, and the other terminal is connected to the ground (Pin 6). Again, this is interfaced with the PC for Visualization.

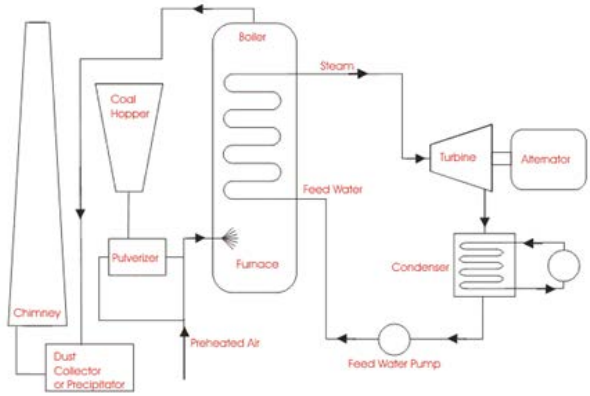

Figure 1: Block diagram of a steam power plant.

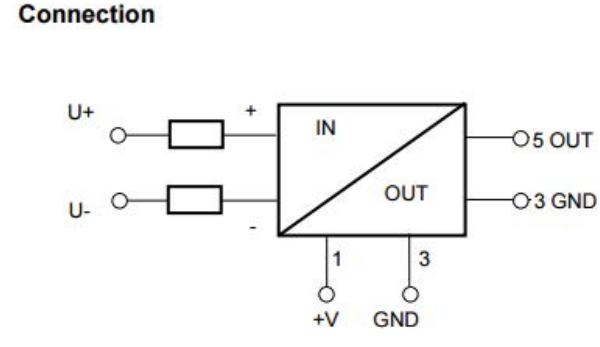

Figure 2: Connection of the cyvs412d01 sensor.

Feed water temperature monitor

The feed water temperature is important parameter. This temperature determines the working of the cooling towers. It is also monitored in a similar way in which we monitored the turbine and boiler temperature. The connections, however, differ. The positive end is connected to Channel 4/Ai2 IN, Pin 4 of the DAQ card. The other end is connected to the Ground, Pin 6. And the negative end is connected to the ground of Pin 6. This card is interfaced with the PC for easy monitoring of the Feed Water Temperature.

RPM monitoring

The turbine shaft and the motor are coupled directly. To monitor the speed of the turbine, or the speed of the motor, we fix a metal at the coupling. We utilize a proximity sensor to sense the metal. Each rotation of the coupling will lead to the proximity sensor to give a high input (5V).

Mathematically, by observing the relationship between the rpm and the corresponding voltage output, we can easily model a mathematical formula to calculate the rotation velocity of the motor or turbine [6].

The sensor output +5V are connected to the USB pin and the negative is connected to the Ground. The third lead is the signal and is connected to the 21st PIN of USB this is a digital input port A. Thus, the speed of the AC generator is monitored in the front panel.

Output voltage monitoring

We need various parameters like Voltage, Current and Speed for monitoring the output voltage of the plant. We set a band of thresholds. The motor is disconnected as soon as the output voltage exceeds its operating output range. The ac motor's phase is connected to the step-down transformer to tune down the voltage. The voltage transducer is connected with the all the phases of the motor. The voltage transducer (Sensor) senses the parameter and its output serves as the input to the DAQ Card, which in turn is connected to the PC. We program a relay in the GUI for the motor to get disconnected as soon as the output goes out of range.

In our simulation and modeling, we will be using the CYVS412D01 AC voltage sensor/transducer works by the principle of electromagnetic induction principle and is designed for applications to measurement and monitoring of single phase AC voltage. The output signal (DC voltage) of this transducer is proportional to the amplitude of input AC voltage. They are suitable for general applications such as fixed frequency voltage supplies etc. The sensor has the advantages of high measuring accuracy, high reliability, low thermal drift, low current consumption, small size, PCB mounting etc. [7].

The AC generator will give AC voltage. The positive terminal of the sensor is connected to DAQ card's Channel 7/ Ai7, Pin 11. And the other terminal of the generator is connected to Ground (Pin No. 12). The output voltage monitored in the front panel.

Temperature monitor and control of burner

We use the same principle and sensor to monitor the Burner temperature that we used to monitor and measure the Boiler temperature. We will use the Thermocouple in the single end mode. For our system, we set a upper threshold of 120 Degree Centigrade. We will be using the Arduino card to control the burner temperature. It is programmed in such a way that the servo motor is turned a complete

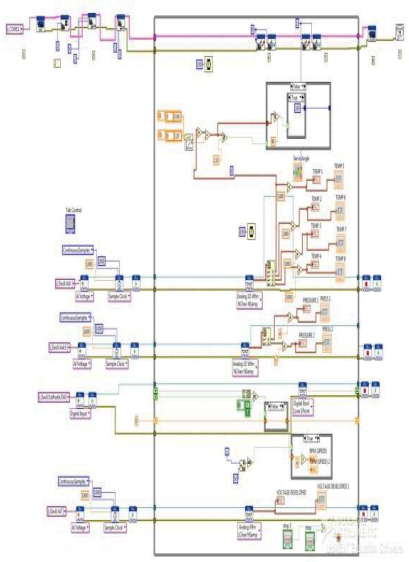

Figure 3: Plant design in lab view software for simulation.

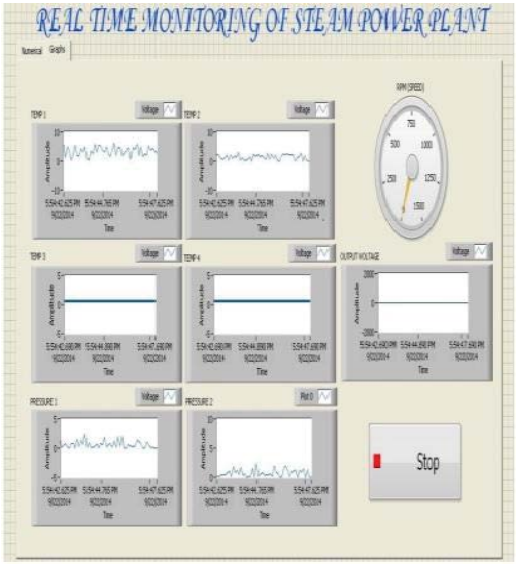

Figure 4: Front panel monitoring data from the MCC DAQ card and the computer.

180 degrees (clockwise) to set it to our process value; if the temperature of the burner droops below 90 degree centigrade, it will turn the servo motor 180 degrees in Anti-clockwise direction.

Simulation Models

Figure 3

Figure 4

Conclusion

It is very clearly evident that an in-house power plant is a realizable concept. Our simulation has shown faithful results and has proved that our idea is practically beneficial. Both electricity deregulation and the more stringent environmental constraints paved the way an increasing share of distributed generation over the past years [8]. Our simulation results also indicate the fact that in case of Distributed Energy Generation, the loses are significantly low due to the relative smaller size of the plant that makes its maintenance easier.

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