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Generator Auto Load Power Control in Power Generating Station

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Abstract

In Thermal power plant, Automatic Generation Control (AGC) is a system for adjusting the output power of multiple generators at different power plants, in response to load changes. Since a power grid requires load generation and closely balancing load moment by moment, frequent adjustments to the output of generators are mandatory. The balance can be predicted by measuring the system frequency; if it is rises, more power is being generated than used, which causes all the machines in the system to rise and accelerate. If the frequency of the system is decreasing, more supply of load is on the system than the instantaneous generation can provide, which causes all generators to slow down Load following power plants run during the day hours and early evening. They either shut down or greatly minimize the output during the night and early morning, when the demand for electricity is the lowest. The exact hours of operation depend on various factors. One of the most necessary factors for a particular plant is how efficiently it can convert fuel into electricity. The most efficient plants, which are almost invariably the less cost to run per kilowatt-hour produced, are brought online first. As demand increases, the next most efficient plants are brought on line and so on. The status of the electrical power grid in that particular region, especially how much is the capacity of base load generation. It has, and the variation in demand is also very crucial. An additional factor for operational variability is that excess demand does not deviate just between night and day. There are also significant variations in the time of year and day of the week. A region that has large variations in demand will require a huge load following or peaking power plant capacity because base load power plants can only cover the capacity equal to that needed during times of lowest demand.

Keywords: Blocking Control, Fuzzy Logic and Steam Governor, Smart Controller

1. Introduction

Thermal power generating plant or thermal power station is the most available source of electric power. Thermal power plant is also referred as coal thermal power plant and steam turbine power plant. A thermal power station is a power plant in which heat energy is converted to electric power. In most of the places in the world the turbine is steam-driven. Water is made to heat; steam is formed and spins steam governor which drives an electrical generator. After it passes through the turbine, the steam is condensed in a condenser and recycled to where it was heated; this process known as a Rankin cycle. The greatest variation in the design of thermal power stations is due to the different heat sources, fossil fuel dominates here, although nuclear heat energy of nuclear and heat energy of solar are also used. Some prefer to use the term *energy center* because such facilities convert forms of heat energy into electrical energy. Certain thermal power plants also are designed to extract heat energy for industrial purposes of district heating, or desalination of water,

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in addition to generating electrical power. The theory of thermal power station or working of thermal power station is very simple. A power generation plant mainly consists of alternator runs with help of steam turbine. The steam is obtained from pressure boilers which is high. Generally in India, bituminous coal, brown coal and peat are used as fuel of boiler. The bituminous coal is used as boiler fuel has volatile matter from 8 to 33 % and ash content 5 to 16 %. As the thermal efficiency increase, the coal is used in the boiler in powder form. In coal thermal power plant, the steam is produced in high pressure in the steam boiler due to fuel burning (pulverized coal) in boiler furnaces. This steam is further supper heated in a super heater. This supper heated steam then enters into the turbine and turbine blades rotate. The turbine is mechanically so coupled with alternator that its rotor will rotate with the turbine blades rotation. After entering in turbine the steam pressure suddenly falls and corresponding volume of the steam rises. After feeding energy to the turbine rotor the steam passes out of the turbine blades into the condenser. In the condenser the cold water is circulated with the help of pump which condenses the wet steam of low pressure. This water which is condensed is further supplied to low pressure water heater where the low pressure steam increases the temperature of this feed water, it is again heated in high pressure. The working fluid is water and steam. This is called feed water and steam cycle. The ideal Thermodynamic Cycle to which the operation of a Thermal Power Station is similar to the RANKINE CYCLE (Figure 1). In steam boiler the water is heated up by burning the fuel in air in the furnace and the function of the boiler is to give dry super-heated steam at required temperature. The steam obtained is used to drive the steam Turbines. This turbine is coupled to synchronous generator (usually three phase synchronous alternator), which produces electrical energy. The exhaust steam from the turbine is made to condense into water in steam condenser of turbine, which creates suction at very low pressure and allows the expansion of the steam turbine to a very low pressure. The principle advantages of condensing operation are the increased amount of energy extracted per kg of steam and thereby efficiency increases and the condensate which is fed into the boiler again lowers the amount of fresh feed water.

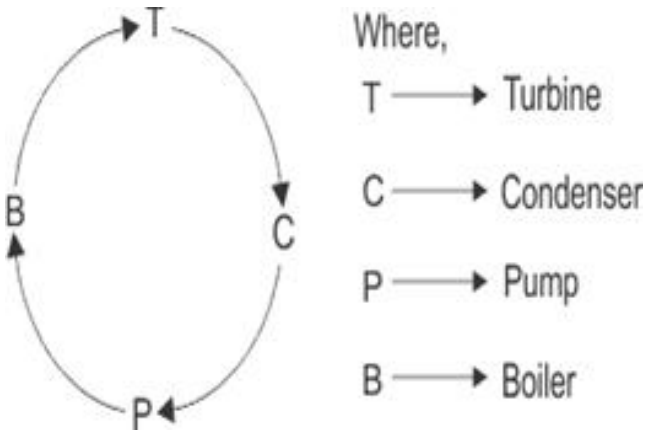

Figure 1. Rankine Cycle.

2. Literature Review

RV Subramanian, "Automatic control of alternator parameters in a power station using PLC" 2015 proposed a PLC to control alternator parameters automatically. PLC are connected to sensors to keep track the value of hydrogen pressure, hydrogen purity and hydrogen temperature in thermal power plant.

Kamaldeep Kaur "Energy Management System using PLC and SCADA" 2014 proposed managing energy without wastage with the help of PLC and SCADA The overall automation of the industry is controlled by SCADA software. SCADA define as a centralized system that control and monitor the whole sites. SCADA is used for collecting the data from various sensors or machines and then monitor the proper functioning of the machines.

Jasna Dragosavac, "PLC-Based Model of Reactive Power Flow in Steam Power Plant for Pre-Commissioning Validation Testing of Coordinated Q-V Controller"2011 proposed a reactive power flow (QFM) in a steam power plant using a programmable logic controller (PLC). PLC-based simulator of the steam power plant is therefore a very good test bed for tunings and adjustments of a coordinated Q-V controller prior to implementation in real power plant.

Asma Aziz "Automatic Generation Control of Multigeneration Power System"2014 Load frequency Control (LFC) is used as part of automatic generation control (agc) in power system. in a mixed power system, it is usual to find an area regulatedby hydro generation interconnected to another area regulated by thermal generation or in combination of both. Control performance analysis of three area interconnected systems is simulated through Matlab Simulink software. Integral square error

and integral time absolute error has been considered as performance indices. Controller designed here minimizes the change in frequency in all the three area.

3. Existing Method

The load control logic maintains in plant generation by adjusting load governor manually in plant generator. When the plant is connected to the tie-line set point at the predetermined level and allocates the balance power to most efficient generator. The load control logic is run every second to determine the megawatt set point in the combustion and steam turbine generator. The turbine controller can be placed in auto or manual mode. When in manual mode operator entered set point are used. When the controller in auto mode, set point is calculated by the load control software. Appropriate graphics in form of single line diagram of process steam and power generating system are provided for the operator to observe any system interaction due to change in generation amount on gas and steam turbine. In this system of Manual Load control (MLC), power output is manually controlled using push button. When the output raises beyond the threshold value then the operator controls the load to the desired set point. Due to the external disturbances the desired process output is not obtained. Thus the power Output of manual mode is sluggish Human intervention is mandatory

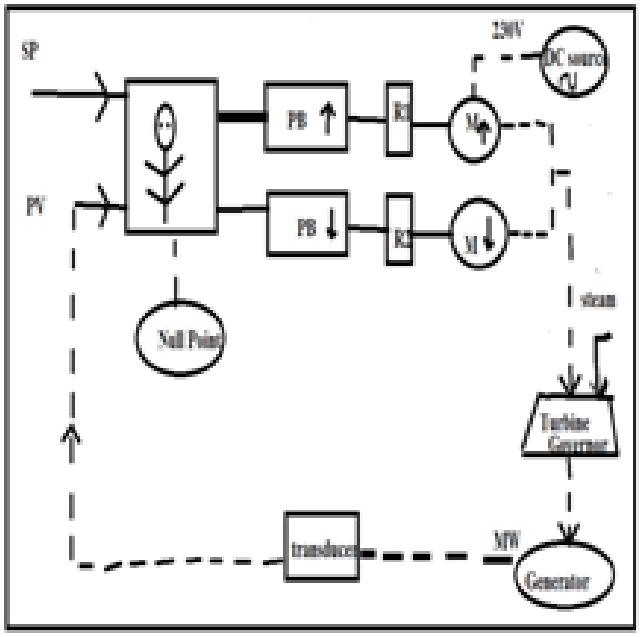

Figure 2. Existing method of load control in power generating station.

In this mode of manual method, where input is fed inside with the setpoint is the load initialized in the beginning and the operator has to check and compare set point and the process variable. If the compared value is positive and increases the push button by the operator is operated manually with the relay button 1 and drives the motor in the clockwise direction or in the forwarded direction which is then fed to the steam turbine or the turbine governor with the steam obtained from the boiler and the turbine rotates the blades and drives the generator to produce electrical energy or electricity and tranducer convert from one form of energy to another and closed loop continues to discharge current. If the set point and process variable value compared is less or negative, then push button is operated manually by operator with the relay button forces the motor to rotate in anti-clockwise direction or in the reverse direction and fed to the turbine or steam governor to produce electricity with the help of generator. Then the cycle continues. In this method the operator has to manually have a check on the closed loop cycle if the value raises or lowers or within the threshold value the operator has to manually perform the operation of increasing or decreasing the push button. The tolerance level of maximum is bearable to +or – 5%. The factors affecting the process is steam flow, steam pressure, grid controller which may increases or decrease which is the major factor for affecting the flow of the process. In this process of manual method, we use only 1:1 ration where it can measure only one input at a time which is the major drawback in this process. The maximum load is 110mw. The deviation control can be 0.5MW. We also will have the annunciator system where the auto response is not okay and output response parameter is affected. The process variable and set point value can be up to 5MW. The Motor we use here is the servo motor which increases or decreases which makes the speed gear increase or decrease which can also make oil pressure increase or decrease, hydraulic valve may also increase or decrease based on the input in forward or reverse direction which in turn drives the steam turbine to turbine increase or decrease the generator output load parameter may increase or decrease based on the demand of electrical energy. During the peak hours or peak season, the demand for electricity is drastically high for consumers then load is increased or during other days the load is normal supply of is electricity is generated. There is also a null point in the system where no response takes place or the process may be in null state (Figure 2).

4. Consequence of Manual Mode

Manual mode (Figure 3) will not increase the speed of response. It can be expected since PI controller does not have means to predict what will happen with the error in near future. It can be used with following constraints

- Fast response of the system is not required Large disturbances and noise are present during operation.
- There are large transport delays in the system.
- Overshoot and undershoot are maximum
- Damage in sequence with increasing severity to seals, bearings, impellers, shaft.
- Increased seal clearances and leakage.
- efficiency.
- Reduced Motor life.
- Unstable flow and pressure

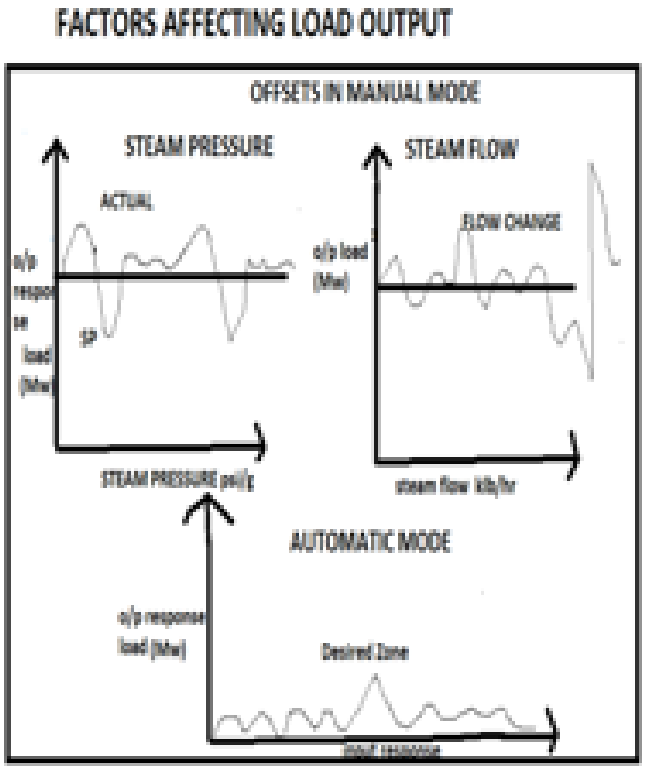

Figure 3. Graph of manual mode of operation in power plant.

5. Proposed System

In this Project, Automatic Load Control (ALC), keeps the value of output at desired or reference value using combined Controller when the disturbance known as load or process load changes in an unpredictable manner. The load fed to comparator checks and compares actual load and the target value. Based on the polarity, it may be increased or lowered and fed to the blocking controller or suppresser or the arrester if it is increased the motor rotates clockwise or if lowered it rotates in anticlockwise. The controller checks whether the boiler is in LFO or in HFO state if LFO state the value is <300 if in HFO state the value is in >300. Required to the input the steam temperature and pressure varies accordingly. When the motor increases speed, gear increases, oil pressure increases which in turn increase the hydraulic valve and steam flow to turbine increases and generator output (Load) is fed to the grid (Figure 4).

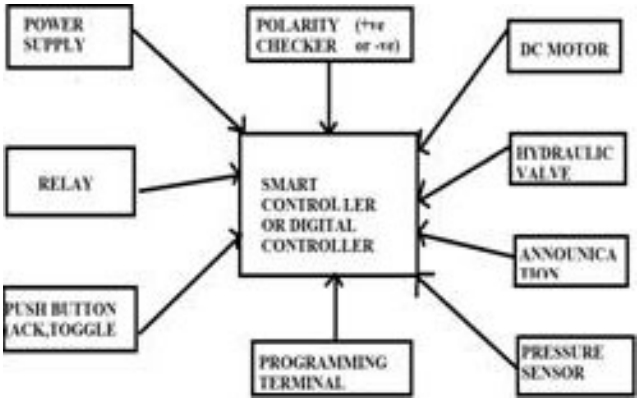

Figure 4. Blocks of automatic mode of controller in power plant.

In this system of Automatic Mode (Figure 5), the load is controlled automatically by using Smart controller with fuzzy logic. The set point is decided by the operator depending upon the need and usage of supply. For example during peak hours like summer there is a huge requirement of electricity but during rainy season the supply is reduced. The Maximum load the system can withstand is the 110MW. The set point of 100MW is fed to the comparator and input to the plant is steam which is obtained from boiler. The set point and the process variable is compared by the comparator, if the result is positive then the motor rotates automatically in forward direction with the help of smart controller using Fuzzy Logic, the polarity is positive and the steam is fed to the generator to electricity. If the result is negative, then polarity will be negative and with the help of relay the Motor rotates in Anticlockwise direction with the help of smart controllers automatically. The blocking controller suppresses the high voltage and the turbine rotates and generates electricity. In Case the result is Null, that

is if the compared value between the set point and process variable is zero the controllers signal as Null and no working of motor and other process takes place. The factors affecting the output is steam temperature, Steam pressure and steam flow which also causes trouble to grid voltage is maximized by using Automatic Mode in Power Plant

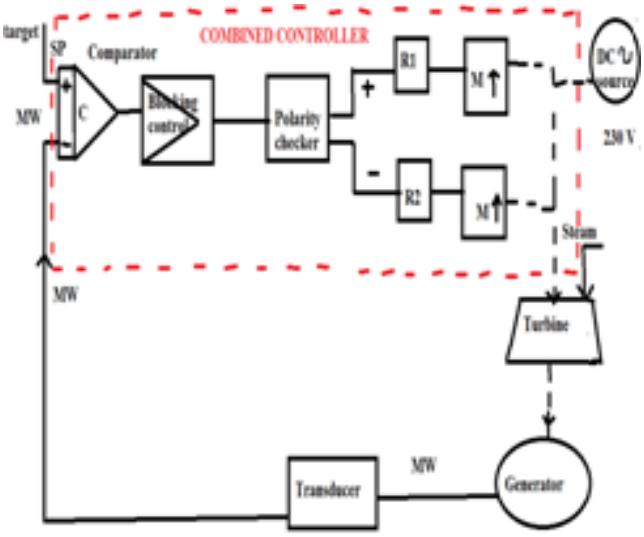

Figure 4. Blocks of automatic mode of controller in power plant.

Smart controller: it is used as a Controller to control the load automatically using Fuzzy Logic. Smart Controllers is also known as combined controllers or digital controllers. It can control more than one input which means it can control steam temperature and steam pressure at the same time. And it works on 2:1 ratio where 2 inputs are constantly controlled at the same pace. Thus if increases in load or decrease in load is controlled and the signal is given with the help of Smart controller. All the other components are linked to the smart controllers. Only with the help of Smart controller all other components function. **Polarity Checker:** It is used in Plant to check the polarity of the load whether the set point and process variable is positive or negative. **Power supply:** The power supply to the plant is 230v Dc power supply. **Blocking Control:** it is the device to protect the electrical component from over voltage caused by external or internal events. It also suppresses the excess voltage and protects the controllers from heavy damage. It is also called Arrester or Suppresser. **Relay:** it acts as a electromagnetic switch operated by small electric current that can turn on and off a much current. **Annunciator:** if the auto response is not okay then the system goes to audible alarm zone. And it indicates that there is some fault in the mode of operation.

DC Motor: A DC motor is a rotary electrical machine that converts direct current electrical power into mechanical power. The most common types depend on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic; to periodically change the direction of current flow in part of the motor it acts a drive which converts electrical energy to mechanical energy

Turbine: A turbine is a rotary mechanical device that extracts energy from a fluid flow and converts it into useful work. The work carried out turbine can be used for generating electrical power when combined with a generator or producing thrust, as in the case of Thermal Power Plant A turbine is a turbo machine with at least one moving part called a rotor assembly, which is a shaft or drum with blades attached. Moving fluid acts on the blades so that they move and impart rotational energy to the rotor.

Fuzzy controller and its tuning

Software based Fuzzy control logic is developed which to fine tune of controls and perfect the control output. Fuzzy constants to be declared in the software are manipulated manually to get fine control system. The software used is Turbo C++. Fuzzy logic software definitely will provide better monitoring, control and protection.

Turbo C is a good choice. Even though DOS has its own limitations, it is having a large number of useful functions and is easy to program. To implement algorithms in terms of graphics, to give display of graphical statistics, to view signals from any source, we can use C graphics.

C graphics using graphics.h functions can be used to design different shapes, display text in various fonts, change colors and many more. The boiler model is drawn using the various functions available in C and the various level actuators are fixed. Coding is done using simple C language. The programming used in this is Turbo C++ (Figure 6).

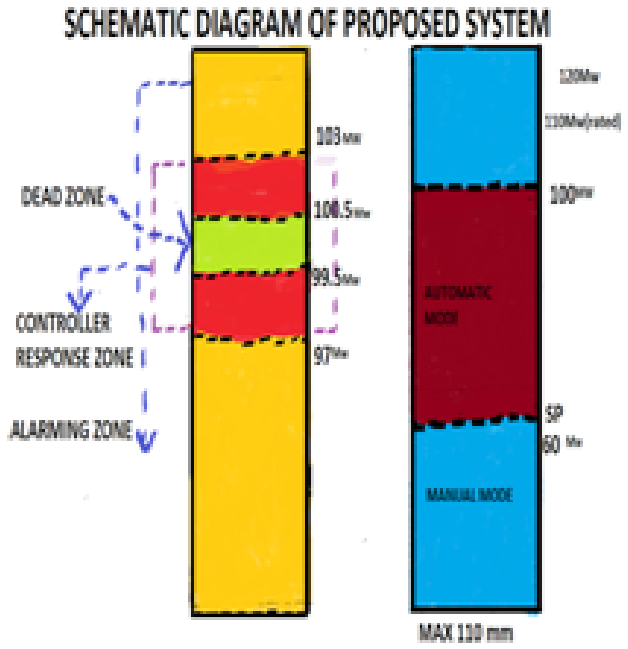

Figure 6. Schematic diagram of proposed system.

6. Modes of Operation

There are two modes of operation taking place in automatic Mode. The target mode and the control mode. Initially it will be constant and as load increases time increases and minimum time is 0.5sec and maximum time is 105 secs to reach the desired set point and it will be in synchronization with the controller. There will be grates in load and spikes in load of control mode. The maximum capacity the plant can withstand is 110MW. And the tolerance level can be in the range of 0.5.

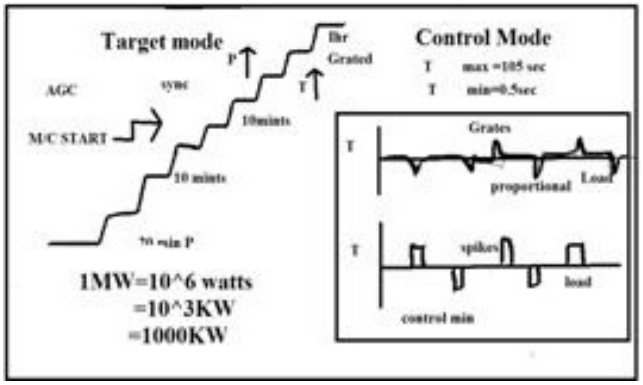

Figure 7. Operation in automatic control.

7. Flowchart

In the Figure 7 shows the initial parts of operation where the fuel flow is fed to the boiler the steam temperature and steam pressure starts to rise, if the boiler is in LFO state <300 then the steam temperature and steam pressure gradually starts to rise and once it reaches the HFO state the speed of the steam temperature and steam pressure increases and again this process continues and CV2 opens once it is filled CV3 opens and Motor rotates in clockwise or Anticlockwise based on the input. And then the motor gives signal stating it is ready for synchronization. And finally the CV4 is only partially opened. As the speed increases load also increases and reaches the desired set point value. In this proposed mode the motor speed is varied with respect to load changes. This flowchart is the pictorial representation of Automatic mode where the load exceeds the permissible threshold of 110MW the load is controlled automatically. The maximum deviation in the load control is +0.5 tolerance. As the load increases the speed also increases at certain point it remains constant. Thus the overshoot, offset, oscillation and error are drastically reduced and output is obtained. When the motor increases the speed gear increases which in turn open the oil pressure and the hydraulic valve opens and steam flow to turbine is increased and generator output load is obtained with the help of steam Governor and thus electrical energy is produced. The loss is less and efficiency is increased with smart controller using fuzzy logic.

Figure 8. Flowchart of Load control.

8. Advantages

- Energy savings
- Improved product quality
- Maintenance savings
- Emissions Reductions
- Local display
- Audible alarms
- Manual acknowledge operation
- Reset push button

9. Output

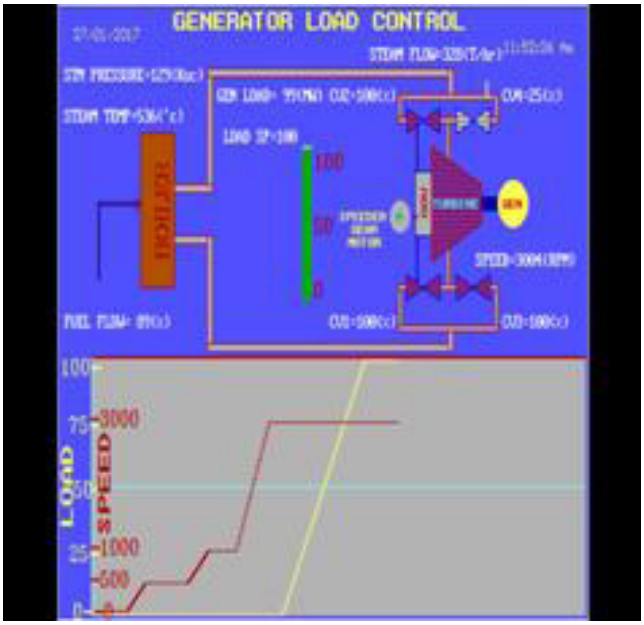

Figure 9. Output of automatic mode of operation.

10.Conclusion

The Fuzzy Logic Controller is an excellent tool to control instruments and equipment. Using fuzzy logic we can quickly lead to more efficient, precise and accurate controls. The Pros of fuzzy logic controllers are simple; they are supposed to be more accurate and more precise than their PI counterparts.

It can be seen from the simulation results that fuzzy logic has many advantages than the conventional PI control.

- Fuzzy uses adaptive logic control.
- Overshoot and undershoot is reduced.
- Accurate level control is maintained.
- Steady state is reached in short span.
- Process speed is very high.

Thus Load is controlled automatically within the threshold limit of 110 MW by using AGC with the PLC Controllers Thus AGC helps to maintain Zero steady state error and therefore the number of oscillations, offset and settling time is reduced. Thus the imbalance between the power generation and load consumptions due to load variation is nullified. During severe disturbance such as load rejections, the boiler variables for example water level and steam pressure will undergo major fluctuations. Such fluctuations are difficult to be eliminated using conventional PI control method. Our project presents a new method to overcome this disadvantage by using fuzzy logic technique to get better system performance

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