Analyzing Mathematical Approach for Facing the Electricity Problem Using Traditional and AI Technique

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***Abstract:* -** Amid the fierce rise in electricity demand due to the prepotent heatwave and the worst electricity scarcity in past few years due to lack of sufficient coal supply to thermal plants etc., several countries in the world are now experiencing power outages for multiple hours. To fulfill this need to reduce the problem of electricity by applying new technology, which is AI (Artificial Intelligence: Fuzzy) technique, used to potentially viable computers to show human like intelligent activities such as speech recognition, decision-making, controlling of electricity generation, natural language understanding, Output limitation etc. In this paper the AI and Traditional techniques (PI and PID) has been used for better and effectiveness outcome of aoristic system. Analyzing mathematical approach with techniques applied to thermal power plant. The combined results shows that the AI technique gives efficient, good and effective results with respect to the traditional techniques by providing constant supply scientifically hence we conclude that by controlling the changes of frequency and power, demand of electricity can be maintained.

***Keywords:* -** Aoristic System, Rampant Rise, Artificial Intelligence, Fuzzy System, Frequency, Power, Traditional Technique, Mathematical Approach.

1 INTRODUCTION

Electricity demand varies greatly by season and time of day. Because thermal power generation can flexibly adapt to changes in demand, it plays a central role in maintaining the power supply. By combining various power sources, we can provide the quantity of power required to accommodate demand for the season and time of day.

The continuous increase of power system complexity and installation of more and more new equipment in power systems has demanded better methods for power system analysis, planning, and control. At present, analysis of modern power systems is generally based on digital computers. Hence, establishment of a mathematical model, describing the physical processes of a power system, is the foundation for the analysis and investigation of various power system problems. Correct and accurate computation for power system analysis requires a correct and accurate mathematical model of the power system. Transient processes of the power system are very fast. This is why power system operation heavily relies on the applications of automatic control. With the installation of many different automatic control devices, the operation of which largely depends on the application of electronic and computing technology, modern power system operation has reached a very high level of automation. [1], [4], [5], [10], [11], [14], [15], [30].

More than half of the world's energy requirements are met by thermal power plants (or thermal power stations). Through burning some fossil fuel in these power stations, steam is produced, which is then used to operate the steam turbines. Therefore, thermal power plants may also be classified as steam power plants. The steam is then condensed in the steam turbine, and then condensed in the condenser, and then the steam is reheated in the steam turbine. This is the ranking phase. The thermal power plant is a power plant that generates energy by burning fossil fuels, including coal, petroleum, etc. It conducts the chemical energy from the gasoline into mechanical energy and then translates it into electrical energy. This power is transferred to a motor which drives a generator which generates electricity. Thermal power plants are planned for continuous operation, which enables the plant to run for years. The unit used to transform thermal energy into mechanical energy is known as a turbine. In thermal power plants, the fuel is used to convert heat to water. [16], [17], [18], [19], [20], [21], [22], [24], [25], [26], [27], [28], [32].

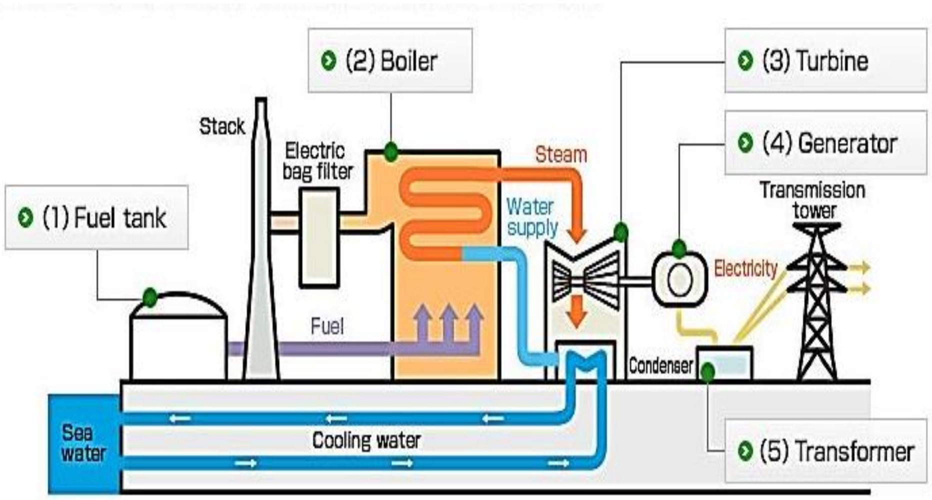

Fig.1 Conceptual Diagram of Steam Power Generation

2 MATHEMATICAL APPROACH

The mathematical approach has been used for solving the electricity problem. The mathematical equations for the frequency and corresponding power flow have been given below;

For a sudden step change of load demand (ΔP_D),

$$\Delta P_G(s) = \frac{\Delta P_D}{s} \quad (1)$$

The change in frequency is given by

$$\Delta F(s)|_{\Delta PC(s)=0} = -\left[\frac{\frac{K_{ps}}{1+sT_{ps}}}{1+\frac{K_{ps}}{1+sT_{ps}}\times\frac{1}{R}}\right]\times\frac{\Delta P_D}{s} \quad (2)$$

$$\Delta F(s)|_{\Delta PC(s)=0} = -\frac{K_{ps}\times\Delta P_D}{T_{ps}}\times\frac{RT_{ps}}{K_{ps+R}}\left[\frac{1}{s}-\frac{1}{(s+\frac{K_{ps+R}}{RT_{ps}})}\right] \quad (3)$$

$$\Delta f(t) = L^{-1}\,\Delta F\,(s)$$

$$\Delta f(t) = -\frac{RK_{ps}}{K_{ps+R}}\left[1-e^{\left[-\frac{t}{T_{ps}}\frac{RT_{ps}}{K_{ps+R}}\right]}\right]\Delta P_D \quad (4)$$

Equation (4) shows the load frequency deviation ($\Delta f(t)$) for step load (ΔP_D) changes.

Governor Transfer function = $\frac{Ksg}{Tsg\,s+1}$ (5) Where K_{sg} is the gain of governor and T_{sg} is the time constant of governor, normally range of T_{sg} is ≤ 100 ms.

Turbine Transfer function = $\frac{Kt}{Tt\,s+1}$ (6)

Where K_t is the gain of turbine and T_t is the time constant, normally range of T_t is 0.2 to 2 sec.

Generator Transfer Function = $\frac{Kps}{Tps\,s+1}$ (7) Where K_{ps} is the gain of generator and T_{ps} is the time constant of generator, normally range of T_{ps} is 20s.

For a practical system,

$T_{sg} < T_t << T_{ps}$,

Typical values are:

T_{sg} = 0.4s

T_t = 0.5s

T_{ps} = 20s

If T_{sg} and T_t are considered negligible compared to $T_{ps,}$ and by adjusting T_{sg} .

Power flow out of control area-1 can be expressed as

$P_{TL1} = \frac{|E_1||E_2|}{X_{TL}} \sin(\delta_1 - \delta_2)$ (8)

Where $|E_1|$ and $|E_2|$ are voltage magnitude of area 1 and area 2, respectively, δ_1 and δ_2 are the power angles of equivalent machines of their respective area, and X_{TL} is the tie line reactance.
If there is change in load demands of two areas, there will be incremental changes in power angles ($\Delta\delta_1$ and $\Delta\delta2$). Then, the change in the tie line power is

$P_{TL1} + \Delta P_{TL1} = \frac{|E_1||E_2|}{X_{TL}} \sin[(\delta_1 - \delta_2) + \sin(\Delta\delta_1 - \Delta\delta_2)]$ (9)

After solving the above equation we get,

$P_{TL1} + \Delta P_{TL1} = \frac{|E_1||E_2|}{X_{TL}} \sin(\delta_1 - \delta_2) + \frac{|E_1||E_2|}{X_{TL}} [\cos(\delta_1 - \delta_2)(\Delta\delta_1 - \Delta\delta_2)]$ (10)

Therefore, change in incremental tie-line power can be expressed as

$\Delta P_{TL1} = \frac{|E_1||E_2|}{X_{TL}} [\cos(\delta_1 - \delta_2)(\Delta\delta_1 - \Delta\delta_2)]$ MW (11)

$\Delta P_{TL1} = T_{12}(\delta_1 - \delta_2)$ (12)

Where $T_{12} = \frac{|E_1||E_2|}{X_{TL} P_1} \cos(\delta_1 - \delta_2)$ MW/rad (13)

T_{12} is known as the synchronizing coefficient or the stiffness coefficient of the tie-line. [29], [30], [31].

3 METHODOLOGY

Traditional and AI techniques used to solve the issue in electricity. The details of the applied techniques given here;

3.1 TRADITIONAL TECHNIQUE

One of the most important Traditional Techniques are PI (Proportional Plus Integral) and PID (Proportional Plus Integral Plus Derivative). These technique using from several decade for solving the issue of electricity by controlling the frequency and corresponding power. The details of Traditional technique are given here;

3.1.1 PI Technique

It is used to mediate some of the flaws of the proportional controller. P controller main flaw was its inability to bring the steady state error to zero. We have this steady state error and we need a controller to somehow act on it in a way that will allow our control signal to accumulate until the desired setpoint is reached. This is easily achieved by taking the integral of the error. Let's add the integral term to our original controller to form a PI controller.

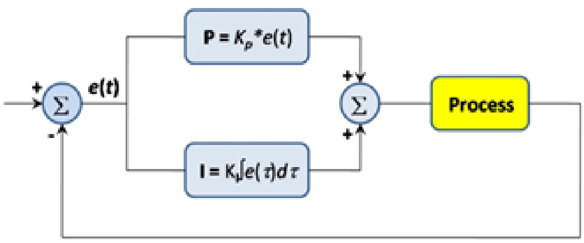

Fig. 2 PI Technique for Solving Electricity Problem

3.1.2 PID TECHNIQUE

The PID controller job is to essentially take this error signal and perform three separate mathematical operations on it. Sum up the results and cleverly produce an output that will drive the system or process to the desired set point. The controller can be mathematically written out as shown where a control signal is a summation of three mathematical operations. The term involves taking the error and multiplying it by a constant Kp. The integral term involves integrating the error over time and the derivative term involves taking the derivative of the error.

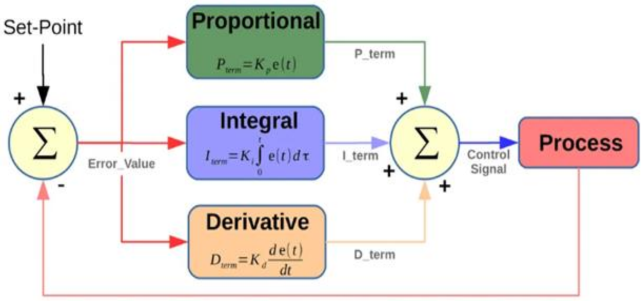

Fig. 3 PID Technique for Solving Electricity Problem

3.2 AI TECHNIQUE

Fuzzy algorithm has been applied to various fields, from control theory to AI. It was designed to allow the computer to determine the distinctions among data which is neither true nor false. Something similar to the process of human reasoning.

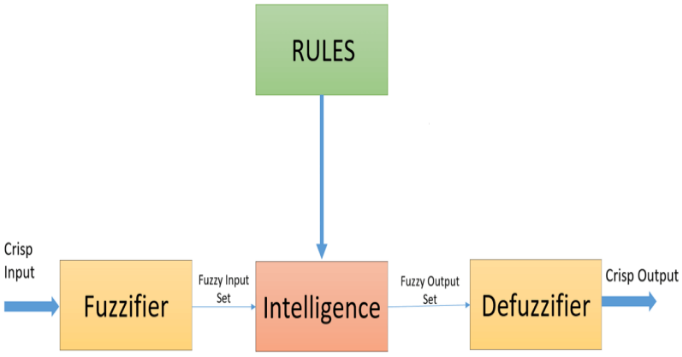

Fig. 4 AI Technique for Electricity Issue

4 RESULT

In this paper Traditional (PI, PID) and AI (Fuzzy) technique has been used to solve the problem of electricity by controlling the frequency and corresponding power. The settling time response of frequency and corresponding power deviation has been obtained by applying these techniques with the help of MATLAB Simulink software. Result has been tabulated in the table 1 and comparative response of the applied techniques is given below in figure 5 between frequency deviation and settling time and in figure 6 power deviation and settling time ;

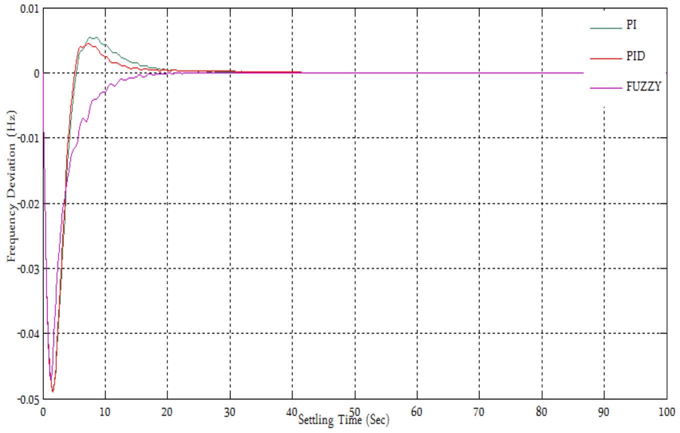

Fig. 5 Combined response of frequency changes system

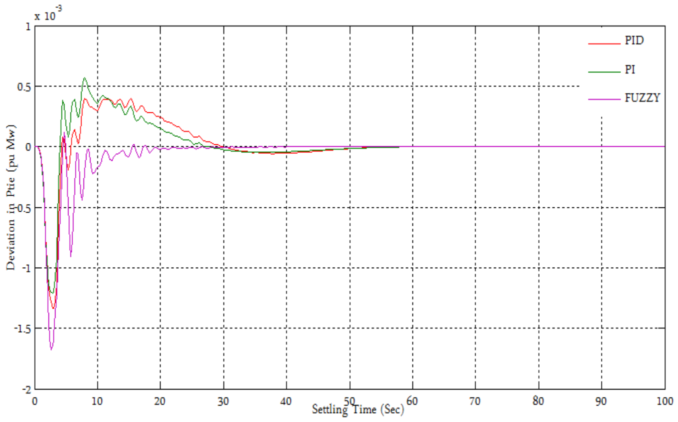

Fig. 6 Combined response of power changes in system

The comparative result of settling time of load frequency and power deviation are tabulated as under;

Table 1 Result of Solution of Electricity Problem

Technique	Frequency Deviation Settling Time (Sec)	Power Deviation Settling Time (Sec)
Traditional (PI)	31	78
Traditional (PID)	30	68
AI (Fuzzy)	20	38

Table 1 shows that the AI technique gives better solution of electricity problem by settle down deviation in less second compare to traditional technique.

5 CONCLUSION

From the several decades we are facing electricity problem due to sudden changes of demand time to time. Various technique already been used to solve such problem but challenges are being still very tough by using traditional techniques. In this paper the traditional and AI technique using for the solution of electricity problem. The result obtained from these techniques have been tabulated in Table 1, which shows that the settling time (Sec) of frequency and power deviation obtained by AI technique improve the better performance of the system settle down the variation and maintain the system constancy. Here it can be concluded that the AI technique help to improve electricity problem by giving better result in a normal and abnormal situation which varies time to time.

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