## **Improve the Electric Power Generation Issue by Cognitive Thinking**

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*Abstract:* - The enormous increase in power demand due to the prevalent heat wave, the worst power shortage in the last decades, and lack of sufficient fossil fuels like natural gas, coal, oil, etc. has attracted the attention of researchers worldwide. One of the main reasons behind the problem is the mismanagement of proper regulation of the electrical power generation unit. This paper looks at cognitive thinking to address and improve this issue by noting that it is the process of gaining knowledge and understanding through thought, experience, and the senses that have enabled researchers to infer cognitive processes. Highly controlled and rigorous methods of study have always been employed to enable the work. Thermal energy power plants have been taken as the source of power generation and genetic algorithm (GA), fuzzy, and PID (Proportional, Integral, Derivative) controllers are used. All these controllers handle and control sudden changes in load frequency and power. For better and more effective results of the system, combined feedback has been obtained with the help of MATLAB Simulink software. The results obtained from the combined feedback are tabulated, which shows that all the controllers improve the electrical power generation issue by modulating the changes in load frequency and power, but the GA controller produces effective, efficient, and better results by adjusting to the changes in less time. The use of this cognitive thinking of the controller helps in the proper management of power demand which automatically improves and controls the power generation.

*Key-Words:* - Cognitive Thinking, Rampant Rise, Management, Genetic Algorithm, Fuzzy Controller, Power Generation, Thermal Source.

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## **1** Introduction

Amidst the exponential increase in electricity demand worldwide, thermal power generation has a central role to play in the effort to make electricity supply and power generation technology even more efficient. In most countries, these power plants are used as base load power plants. The generated electrical power can be input into the electricity grid for use by society, this electricity must be managed appropriately due to the constant variation of demand by the consumer side. Cognitive thinking is used for this purpose by implementing GA, fuzzy, and PID controllers. Neisser, the father of the cognitive approach, is the process that allows people to focus on a specific stimulus in the environment, pick up new things, synthesize information, and integrate it with prior knowledge, which allows people to take information through their senses. Respond and interact with the world, involving people in decision-making, problem-solving, and higher reasoning. Cognitive science uses

experimental research methods to study mental thinking and related processes such as decisionmaking, amnesia, perception of attention, language, and memory. This indicates that the human brain works similarly to a computer and that the process of acquiring knowledge and understanding through thought, experience, and the senses has enabled researchers to infer cognitive processes, [1], [2], [3], [4], [5], [6], [7].

Thermal power plants, also called combustion power plants, are powered by energy produced by coal, natural gas, heating oil, as well as steam boilers powered by biomass. The steam activates a turbine which in turn drives an alternator to generate electricity. A conceptual diagram of a thermal steam power generation system is shown in Figure 1. This shows the different parts of the steam power generation process like; the steam boiler, electrostatic, combustion turbine. alternator. transformer, condenser, and cooling tower, [8], [9], [10], [11], [12], [13].



③ Steam boiler ③ Electrostatic ③ Combustion turbine
④ Alternator ⑤ Transformer ⑥ Condenser ⑦ Cooling tower

Fig. 1: Conceptual Diagram of Steam Power Generation

## 2 Issue Formulation

The constant fluctuation of load frequency and associated power is the root cause of the electrical power generation problem, this problem can be formulated mathematically.

Equation of a sudden step deviation of power demand  $(\Delta P_D)$ :

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

The Load Power flow equation is;

$$P_{tl} = \frac{|V_1| |V_2|}{x_{tl}} \sin(\delta_1 - \delta_2)$$
(2)

In equation 2,  $|V_1|, |V_2|$  are magnitude of voltage,  $\delta 1$  and  $\delta_2$  are the machine power angle,  $X_{tl}$  is the reactance of line. Incremental changes in power angles ( $\Delta \delta_1$  and  $\Delta \delta^2$ ) when load demands change.

The deviation in incremental power generation can be expressed as here:

$$\Delta P_{tl} = \frac{|V_1| |V_2|}{X_{tl}} \left[ \cos \left(\delta_1 - \delta_2\right) \left(\Delta \delta_1 - \Delta \delta_2\right) \right] MW$$
(3)

$$\Delta \mathbf{P}_{t1} = \mathbf{T}_{12} \left( \delta_1 - \delta_2 \right) \tag{4}$$

Where 
$$T_{12} = \frac{|V_1| |V_2|}{X_{tl} P_1} \cos(\delta_1 - \delta_2) MW/rad$$
 (5)

 $T_{12}$  is the stiffness coefficient or synchronizing coefficient of the line.

The deviation in load power frequency is given here:

$$\Delta F(s)|_{\Delta PC(s)=0} = \left[\frac{\frac{K_{ps}}{1+sT_{ps}}}{1+\frac{K_{ps}}{1+sT_{ps}}\frac{1}{R}}\right] - \frac{\Delta P_D}{s}$$
(6)

$$\Delta F(s)|_{\Delta PC(s)=0} = -\frac{K_{ps} \star_{\Delta P_D}}{T_{ps}} \times \frac{RT_{ps}}{K_{ps+R}} \left[ \frac{1}{s} - \frac{1}{(s + \frac{K_{ps+R}}{RT_{ps}})} \right]$$
(7)

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

$$\Delta f(t) = -\frac{RK_{ps}}{K_{ps+R}} \left[ 1 - e^{\left[ -\frac{t}{T_{ps}} \frac{RT_{ps}}{K_{ps+R}} \right]} \right] \Delta P_D \quad (8)$$

Equation (8) indicates the load frequency deviation  $(\Delta f(t))$  for sudden step load  $(\Delta P_D)$  deviation, [14], [15], [16].

## **3** Solution with Cognitive Thinking

When load frequency and power are continuously changing, PID, fuzzy controllers, and genetic algorithms are employed as cognitive thinking techniques to solve the problem of electrical power generation. Here are the details of the implemented controllers;

#### 3.1 Genetic Algorithm

Natural selection, the mechanism that propels biological evolution, provides the basis for both limited and unconstrained optimization problems, which can be solved using genetic algorithms. GA continuously improves individual solutions for many populations. GA controller flow chart shown in Figure 2.



Fig. 2: Flow Chart of GA for Power Generation Issue

GA parameters for the thermal system are given below in Table 1, [17], [18]:

GA Parameters	Thermal Power System		
Fitness Function	@agma_asd		
Variables	22		
Population Size	32		
Selection	Stochastic Uniform		
Mutation	Constraint Dependent		
Cross Over	Scattered		
Bound Limit	Upper [0] and Lower [-5]		

Table 1. Parameters of GA for System

#### 3.2 Fuzzy Controller

A mathematical framework created to let computers distinguish between data that isn't true or false. Something like the process of human reasoning. The fuzzy controller consists of four main components, the fuzzification interface, the knowledge base, the inference mechanism, and the defuzzification interface. The fuzzy controller's job is to determine the action variable values based on observations of the state variables of the controlled process shown in Figure 3, [19], [20].



Fig. 3: Fuzzy Controller for Power Generation Issue

### 3.3 PID Controller

Proportional, Integral, and Derivative controllers what are known as PID controllers. Its job is essentially to take this error signal and perform three different mathematical operations on it. The controller can be shown mathematically in equation 9. The transfer function of the PID controller is:

$$G(s) = Kp + \frac{ki}{s} + sKd \tag{9}$$

 $K_p$  is proportional gain, Ki is an integral gain and  $K_d$  is derivative gain, PID controller shown in Figure 4, [21], [22], [23].



Fig. 4: PID Controller for Power Generation Issue

## 4 Result

In this paper cognitive thinking based GA, fuzzy and PID controllers have been implemented to improve the power generation issues such as streamlining frequency and power deviations, the result of frequency and power deviation from GA, Fuzzy, and PID controllers is shown in Figure 5, Figure 6, Figure 7 and Figure 8.





Fig. 6: Result of power changes in system 1





Fig. 8: Result of power changes in system 2

The comparative result of settling time of load frequency and power deviation are tabulated in Table 2.

Table 2. Result of Solution of Electricity Problem

Controller	Frequency Changes Settling Time (Sec)		Power Changes Settling Time (Sec)		
	System 1	System 2	System 1	System 2	
GA	13	12	16	18	
Fuzzy	18	22	22	27	
PID	20	27	26	42	

Table 2 demonstrates that, in comparison to other controllers, the GA controller settles the deviation in fewer seconds, providing a better solution to the electrical power generation problem.

## 5 Conclusion

This paper shows improvements in the issue of electrical energy generation using cognitive thinking, which involves the ability to obtain factual information that can be easily separated from the social, emotional, and creative development that underpins human perception, learning, cognition, and experience and is related to it. The senses enable researchers to study cognitive processes and apply rigorous methods to research work. To improve the power generation problem, GA, fuzzy, and PID controllers were applied to the thermal power system and the combined results are tabulated in Table 2. This shows that the GA controller is efficient, effective and gives better results than the other controller by adjusting continuous variation in load frequency and power in less time. Therefore, it can be concluded that using appropriate techniques and management will automatically improve power generation and help to maintain and meet the world's major consumers' demand for electricity.

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#### **Conflict of Interest**

The author has no conflicts of interest to declare.

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