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Automatic Generation Control Of Multi Area Power Plants In Coordination With Non-Conventional Energy Source With The Help Of Smart Controllers

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Abstract: The automatic generation control is amalgamation of wind, hydro and thermal power plant that has concocted with progressive controllers. Efficiency of automatic generation control (AGC) system can be enhanced by using few techniques like gradient descent and particle swarm optimization. Particle swarm optimization is way better than gradient descent. Above style used to get the better performance and to optimize the speed governance parameter (Ri), integral gain (K_i), proportional gain (K_p) and frequency bias (B_i) parameter distinctive area. There are lots of modern approach for AGC for conventional mainly established with integral squared error(ISE) to get best choice of controller parameters. Method represented here is just a trial version but it consumes time to calculate for several parameters. The computer based technique like Particle Swarm Optimization is highly productive and reliable in calculations of dissimilar gains in load frequency control. Moreover, PSO recital is much better than Gradient Descent (GD) to get the best optimized result for discrete parameter and controller which enhanced vital performance for three area network which includes hydro, thermal and Wind power plants. MATLAB in which SIMULINK library is used to depict the replica of the Automation Generation Control (AGC).

Keywords: Automatic Generation Control, Non- Conventional Energy Sources, Particle Swarm Optimization.

1 Introduction

Demand of continual energy sources, Wind, hydro, solar are increased day by day with increasing technology. There are main merits of the conventional energy sources that are summarized as:

- Fossil resources are dependent, decreasing with time.
- Environmental protection and green-house gas emissions are reduced.
- Energy production cost reduced.

Therefore, Load Frequency Control problems needs to be considered as important in power plants. The huge availability of the wind power in the nature, the LFC problems are difficult with

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incorporating in wind power plant. This issue can be sort out with the investigation of prediction of wind direction and speed to get the idea with the available wind power. The conventional energy sources are not fixed and not easily available in the nature, the independent energy sources with overestimation and underestimation must be available in wind power plant as a function of cost. Particle Swarm Optimization approach is tested on Economic Dispatch obstacle with complicate amount operations.

Here new ideology of Load Frequency-Control problems including wind power plant with the help of Particle Swarm with Optimization method. Wind, hydro, thermal power plant mainly depends on natural resources. Furthermore, wind energy plays an indispensable role in the wind power plant which also depends on tariff of the power plant. So, overall expenditure can be determined with the help of wind power at the particular instant of time. Therefore, mathematical problems cannot tell about the real optimum economic dispatch. Particle swarm optimization method is made to corporate with wind power plants economic. Combination of the power plants depicts the total cost differently simulated scheme with or without the production of power.

Operating frequency, load flow and voltage conditions must maintain constant throughout electrical power transfer in electrical power plant. With the help of the above parameter, electrical power can be preserved constant during the operating hour. There must be a perfect balance in power requirement and power generation to grant the full capacity power to the customers with affordable, finest electric power. Genetic algorithm is one approach used to optimize controller gains. Artificial neural network, Genetic Algorithm, Particle Swarm technique and Fuzzy Logic[1]. The variation in the tractable sources in system, generation of actual and imaginary power can be controlled properly. The smallest variation in the load side change in operating output of the power system. The variation in power interest mainly affects frequency of power system and power flows in tie-line in control area. In power system, reliability criteria depends consistently on generation and power demand[2].

Main aim is to keep the frequency constant all the time by varying generator units with the help of area control error (ACE), it can be controlled to zero by making the continual alteration of operating power[3]. Area control error is amalgamation of the frequency and frequency time aberration and power networking error that can be used in an input of load frequency controller, this method used to regulate area to control error and variation in linkage frequency.

Load frequency control methods are used in industry where proportional-integral (PI) type and online base approach is used in which trial and error is the main objective to know about the problems[4]. The optimized control in different parameters there are various optimization techniques that are probing in real time simulation not for a single but for whole electrical power system. Two non-identical power plants with two interconnected area power system is regarded for research. The hydro and nuclear power plant can be considered as field-1 and field-2 respectively. With the help of the control strategies mentioned above, testing the controller in

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non-real time situation and it can be converted into real time controller, which can be used to get the real time results. Real time simulation gives the ideology of producing a prototype into real function for industrial processes and devices that can be managed with a intertwined control system[5]. Day by day load frequency controllers are made with the less tendency. The controller is having the advanced technology of strong control strategy known as particle swarm optimization to get the best possible result with expected output. Gradient descent is also one of the methods is to get tune with various parameters. The best way to select governor speed supervision criterion is to calculate zero steady state error present in frequency. The variation in the speed governor also helps to get the best optimized result in AGC. In particle swarm optimization, firstly, the designed controller works according to the Fuzzy Logic rules such that it works fundamentally strong. Secondly, earlier Fuzzy Logic Controller (FLC) was optimized with PSO so as to get the best possible result with adjustment of membership functions[6].

1.1 NUTSHELL OF AGC PLOT

The flywheel governor is the main part of the synchronous machine that makes it possible to achieve the desired power. This concept was not as sufficient as one can rely on. So, that governor needs to be controlled with a second method which is proportional to the variation in frequency in integral. There are lots of articles presented on AGC which helps to find out the main idea and it created a development in this area to control the transmission and distribution[7].

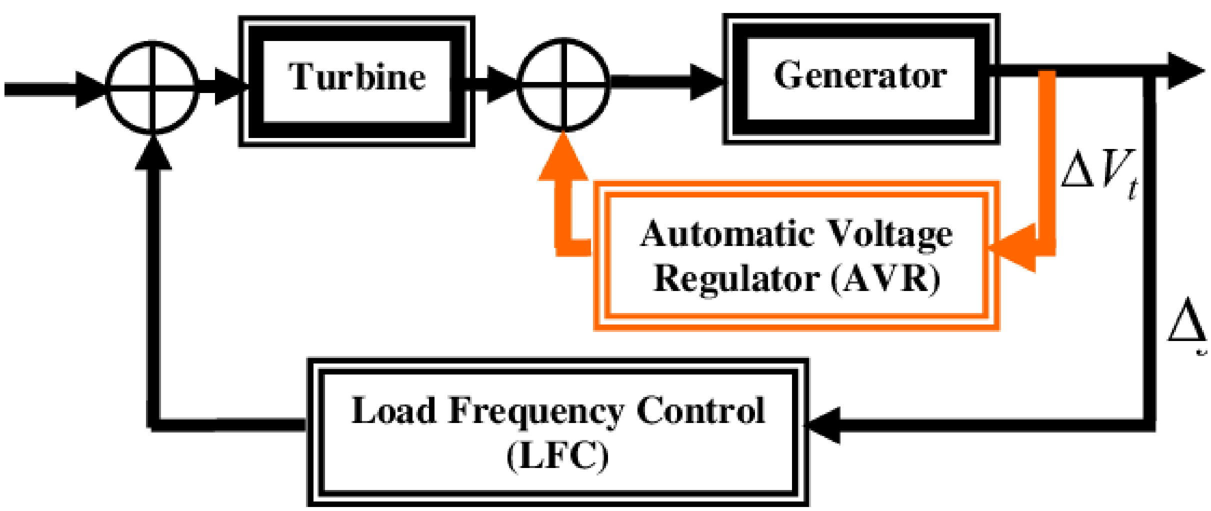

Fig1 Automatic generation control

The area control errors (ACE) can be controlled with the help of making a secondary AGC schemes. There are many aspects that can be seen in the article regarding about the power system control models, AGC infrastructure and few numbers of controlling approaches which are

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devised in the AGC schemes. The linear, non-linear models of power system which can be considered as centralized, decentralized and to get the optimized algorithms.

The research also includes the minute features, quality of load and excitation control in AGC. AGC uses lots of methods to overcome a problem, like phase shifters, HVDC transmission links, reactive compensator and static volt-ampere are used in power control system to get the optimized results. The tiny signal is very important to get the solution for the system response. With the help of tiny signals, system can be prevented from hazardous situation. However, it is very crucial to make a counterbalance for system non-linearity when operating over a wide margin of operating frequency. In AGC, linearized models do not provide the desired performance which they meant to be when implemented with non-linear system having in condition with the large disturbances.

Due to lots of profits in technology, many researchers made it possible with the help of computational qualities and their fast performance for power systems. Fuzzy Logic, Genetic Algorithm and Neural Network are the best way and optimized methods to dodge the arduous linked with the AGC. AGC regulators do not have sufficient knowledge to handle the problems linked with the system required to get the exact modelling. After having lots of research in AGC, there are many changes in decades, such that power industries deregulation and uses of SMES, PV cells and wind powered turbine and there are other material for electrical energy[8].

Deregulated markets of electricity have grown up so far, having lots of multiple providers and generation and distribution, drastic and huge changes happen at the load demand. At present, a multivariable control infrastructure is devised and a well build design is also concocted for thermal power plant. A system with model predictive control (MPC) approach handles like a classical regulator does. When it comes to the multivariable, it corrects limitations of classical regulators. When MPC controller is not active then SISO comes in contact and make the operation go smoothly with no disconnection[9].

Multivariable solutions are best to get the aesthetic performance, the plant model is the idea to give the best possible solution for the control action. The classical model needs an operator to operate when it necessary, manually acting on the single part of the model. Multivariable control system is not only used for optimal performance but also for maximum malleability. Discrete time non-linear model is used for the production of an AGC regulators in thermal units.

The periodic changes occur when there a drastic change in load to maintain frequency and faults in tie-lines. It crucially important to maintain power line transfer as well as the performance of the operating frequency at both the sides. Th can be achieved by managing the tie-line and frequency and the power variation in system to get net difference by shrinking unstable of different areas[10].

There are two controlling methods one is soft computing and another conventional control.

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1.2. Conventional control techniques

(A). Integral controlling technique

(B). Proportional integral derivative (PID)

(C). Proportional integral (PI) controlling technique

(D). Linear-quadratic governor based supervising technique

Conventional control approach:

(A) Integral controlling technique: With the help of the frequency variation, changing of speed can be maintained by naturally. After modification of the controller then the rate of the steady state error can minimized to zero[10].

(B) Proportional with integral derivative (PID): This is the combination of the integral as well as the derivative. The value changes feedback into present faults, integral modifies the feedback of new damage and then derivative makes whole process easy to solve by varying the faults[10].

(C) Proportional integral (PI) controlling technique: This controlling method is generally used universally foe LFC designed systems. The major role for the PI controller to completely remove the stationary state error to zero with giving unknown damage occurring in its previous stage[10].

(D) Linear quadratic governor based supervising: Control system which basically linked in running system with low probability cost. The condition can be shown with the help of the linear equations and the cost also can be determined by the help of the quadratic equation[10].

1.3. Soft computing based techniques

(A). Artificial intelligence with Neural Network

(B). Fuzzy with Logic

(C). Genetic using Algorithm

(D). Particle swarm with Optimization

Soft computing based techniques:

(A) Artificial neural network: By adjusting the values of which are proportional to the derivative and integral terms through PID controller to get optimal solution[10].

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(B) Fuzzy logic: Fuzzy logic controller system mainly concocted to remove incompatibility of productivity. With the help of the reference value, all the parameters are adjusted automatically without any operator and there is no need of regular checking[10].

(C) Genetic algorithm: Genetic algorithm is the best way to get the precise outputs and this process is basically dependent on the genetics and it draws a data network that tell about the best fit position[10].

(D) Particle swarm optimization: Particle swarm with optimization method invented by Kennedy and Eberhart in 1995, best method to get optimized results. There are lots of papers out there on the study and the performance using the non-linear functions[11]. Particle swarm optimization is just like genetic algorithm in which it moves in a path with some velocity according to their previous data to get the best possible solution. This search void can be any integer. Following Kennedy, Eberhart's naming convocation, D is dimension of search space. i^{th} particle can be shown as $X_i = (x_{i1}, x_{i2}, x_{i3}....,x_{iD})$, previous data $P_i = (p_{i1}, p_{i2},...p_{iD})$. Whole group is g and the position change is shown as $\Delta X_i = (\Delta x_{i1}, \Delta x_{i2}, \Delta x_{i3}....,\Delta x_{iD})$. Every particle has latest update regarding its position and two eqautions:

$$\Delta x_{id} = \Delta x_{id} + c_1 rand1()(p_{id} - x_{id})+c_2 rand2()(p_{gd} - x_{id}) \qquad ......(1.1)$$

$$X_{id} = x_{id} + \Delta x_{id} \qquad .....(1.2)$$

Few researchers have found that c_1 and c_2 gives the best performance when it set to 2.

Originally PSO was invented to describe only one problem at a time. However, many practical engineering problems found out that this is used for combination optimization[11].

Particle swarm optimization technique is just an alternative to Genetic algorithm (GA). This method is just like social animal behaviour like fish in terms of schooling, bird with flapping wings and swarm theory. In PSO the particle contains memory so there is better chance of getting a good and optimized results but in case of GA, there is no such memory existed in GA, the previous knowledge destroyed when population changes[12].

The generation is the main aspect in the electrical power system. If the system collapses then the generation leads to the hazardous issues. It can lead to the failure of electrical power system. Transmission and distribution, most important and toughest part of the electrical power system. The technology increased and rate of the electricity. It is mandatory to use all the sources in power generation and distribution to get the full capacity of the electrical power system[13].

The steady state frequency error should be zero to neglect the further problems in automatic generation control. Steady state tie flow in the line through load change must be zero. There should be a tough controllers so that there would be no wear and tear of the instruments[14].

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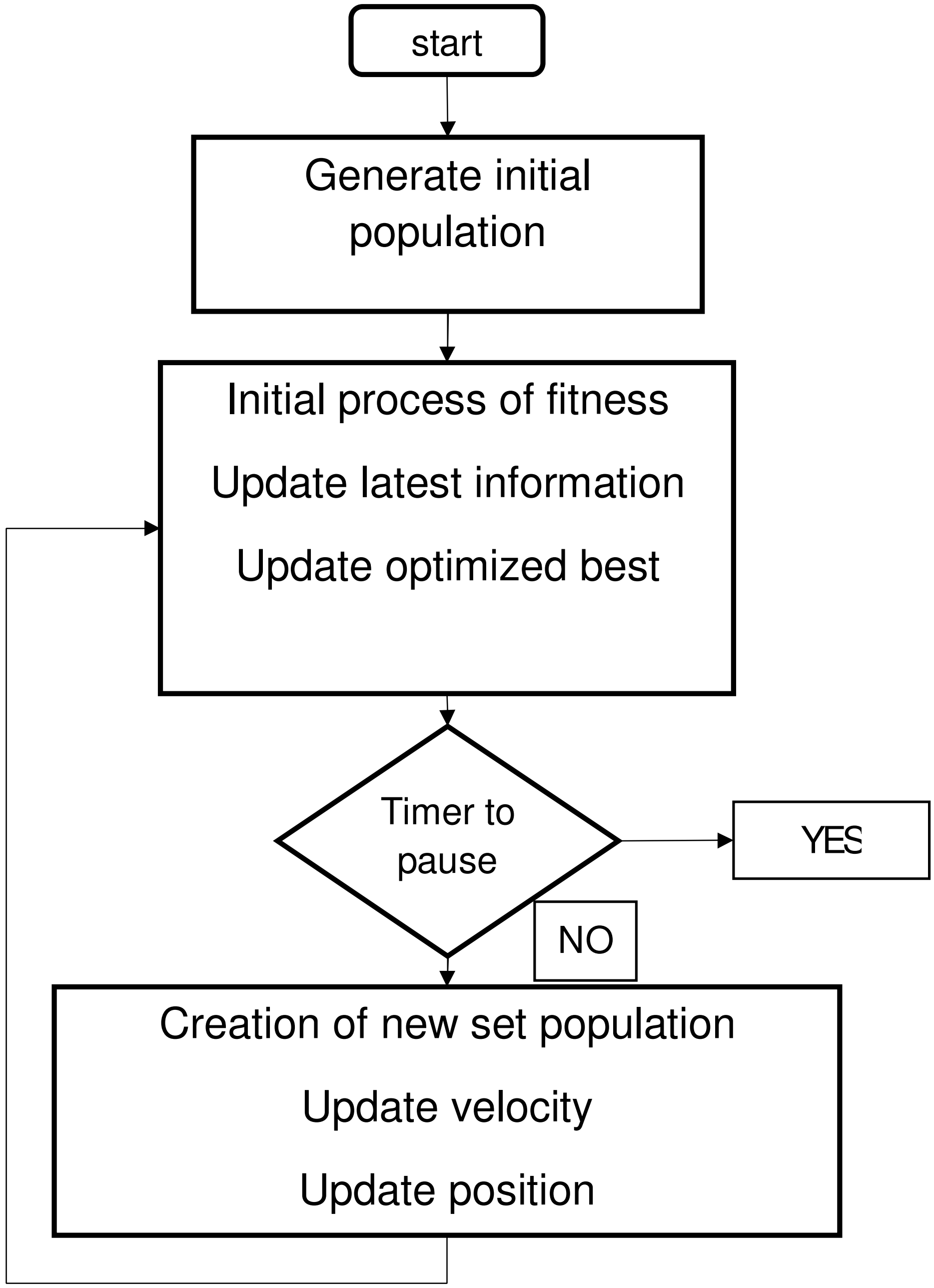

Fig 2. Flow chart of particle swarm optimization.

Particle swarm optimization flow chart can be explained with a simple flow chart. At the initial position, it generates initially a set of population. It initializes the process with fitness and update latest information into data set, it optimizes with best solution with latest update. When

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population data set does not match with preferred values then it creates a new set of population with having its velocity along with its position.

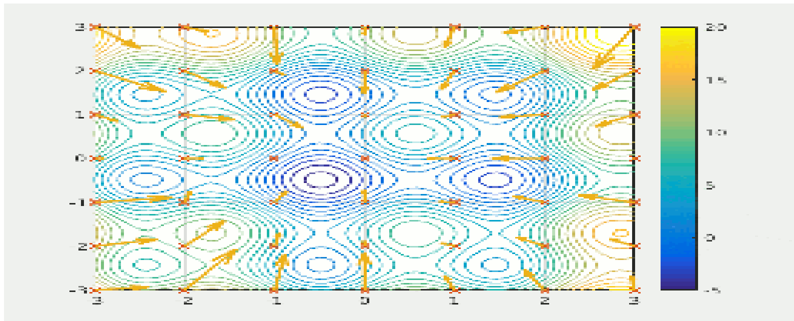

Fig3 Particle Swarm Optimization

2. Simulation Model:

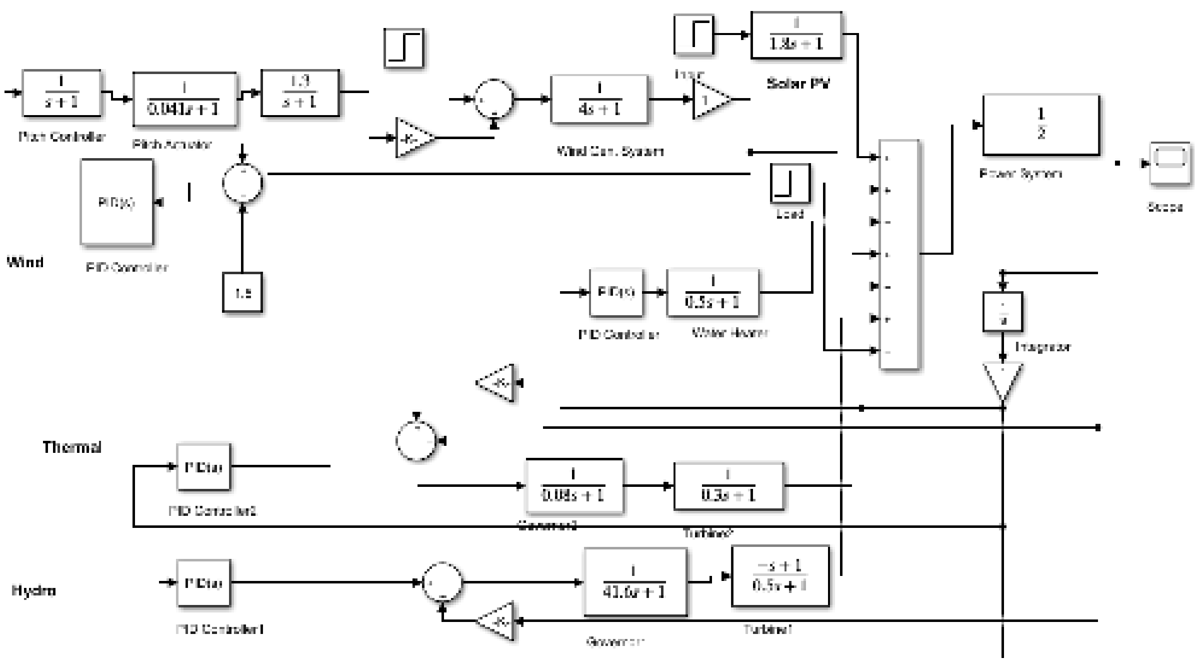

Fig 4 Simulation model of Automatic Generation Control In MATLAB/SIMULINK.

This AGC model represent the rough idea of generation control in electrical power system. Pitch controller is used to control the angle and speed of the propeller of the turbine.

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Pitch actuator: It is just a subsystem of the wind turbine which is used to control the pitch of the control system.

Integrator: It is used to measure the signal which is time integral of the signal.

PID Controller: It is used to vary the temperature, pressure, speed and other process variables.

Turbine-governor: It is used store huge amount of energy to their huge mass.

Solar PV: Solar photovoltaic cell is used as an input here to provide the continuous power to the system.

The future work shall be done on this model to get the best idea about the Automatic Generation Control (AGC).

3. Results and discussion:

To justify investigation part of expected algorithm, multi-modal gauge functions F1, F2, F3, F4, F5 and F6 are considered as these functions have several native optima with quantity rising aggressively w.r.t magnitude. Table-1 (a) presents explanation of multi-modal gauge function with BMFO1 algorithm and Table-1 (b) presents the explanation of multi-modal gauge function with BMFO2 algorithm.

Table-1 (a): Results of BMFO1 Algorithm for Multi modal Gauge Function

Benchmark Functions	Parameters				
	Mean Value	SD	Worst Value	Best Value	Wilcoxon
F1	-3140.2851	290.75126	-2641.0282	-4071.3905	1.73E-06
F2	1.6250998	0.9594445	2.9848772	0	6.87E-06
F3	0.038505	0.2109003	1.1551485	8.88E-16	1.01E-07
F4	0	0	0	0	1
F5	4.86E-32	1.64E-33	5.58E-32	4.71E-32	1.60E-06
F6	0.0010987	0.0033526	0.0109874	1.35E-32	1.20E-06

Table-1 (b) : Outcomes of Hybrid BMFO-SIG Algorithm for Multi modal Gauge Function

Benchmark Functions	Parameters				
	Mean Value	SD	Worst Value	Best Value	Wilcoxon
F1	-3361.17	287.3247	-2879.42	-4071.39	1.73E-06

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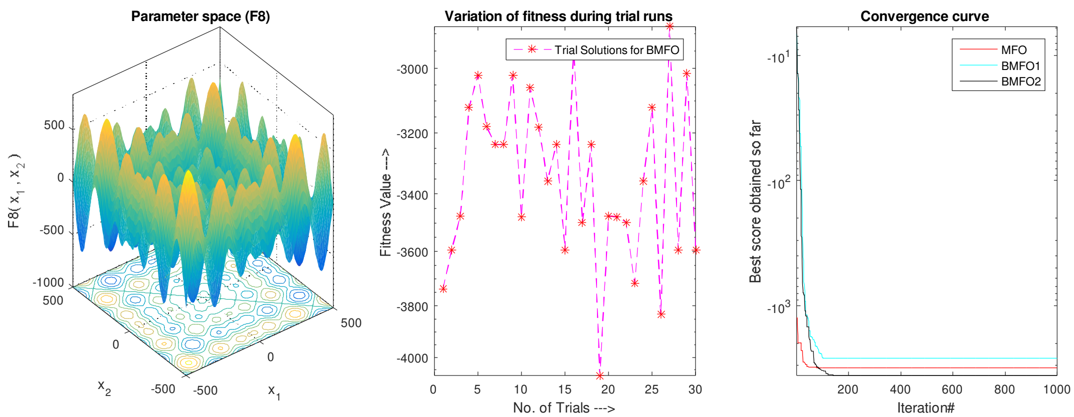
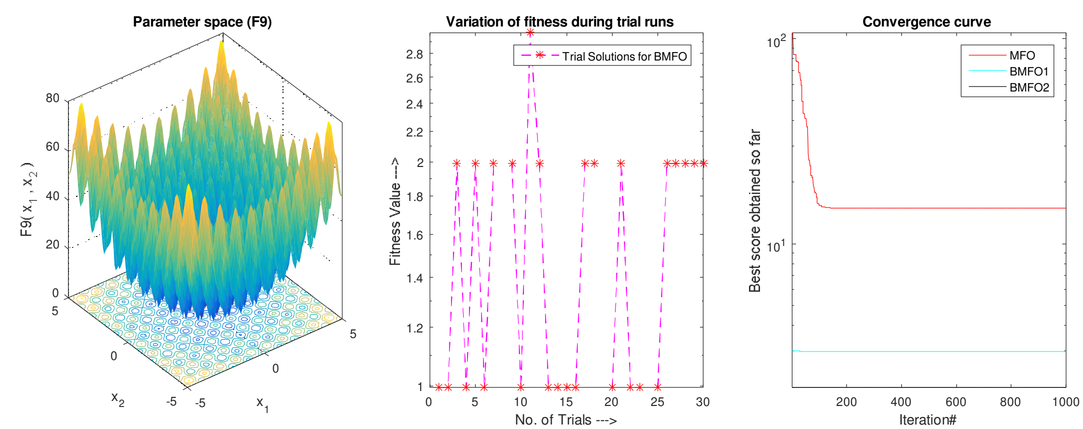
F2	1.392943	0.720324	2.984877	0	3.89E-06
F3	4.44E-15	0	4.44E-15	4.44E-15	4.32E-08
F4	0	0	0	0	1
F5	4.82E-32	8.59E-34	5.12E-32	4.71E-32	1.56E-06
F6	0.002558	0.010248	0.054779	1.35E-32	1.34E-06



(a)



(b)

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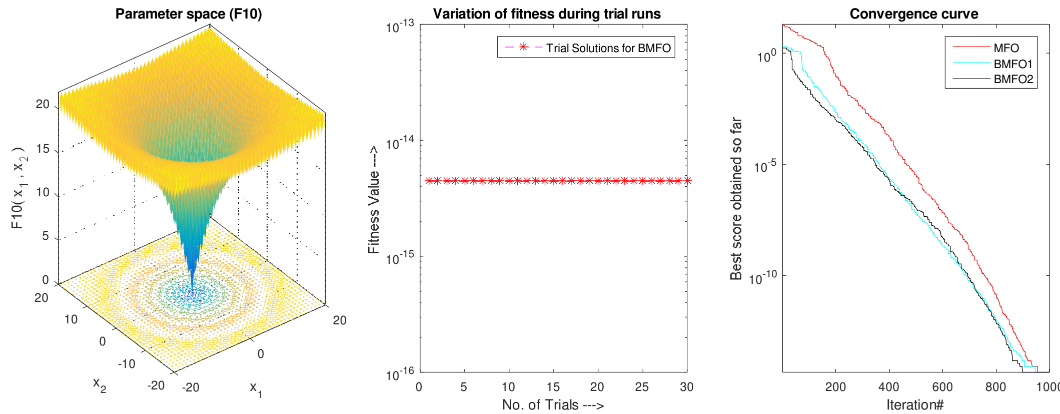
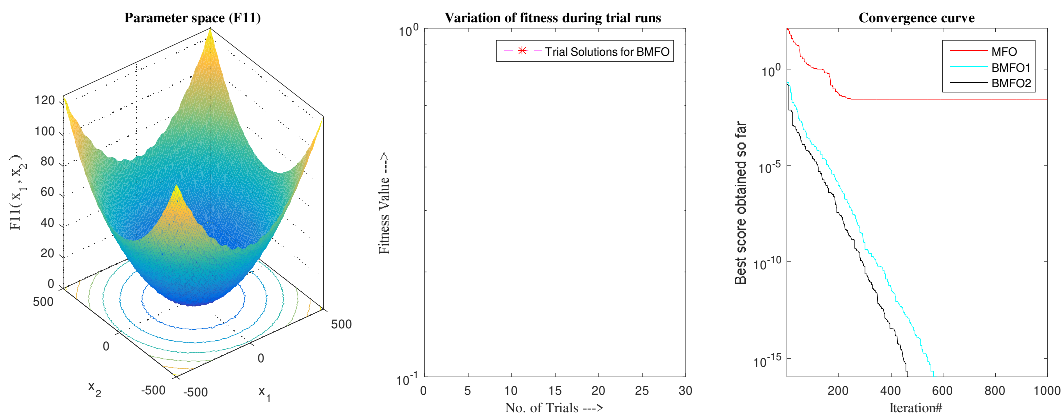
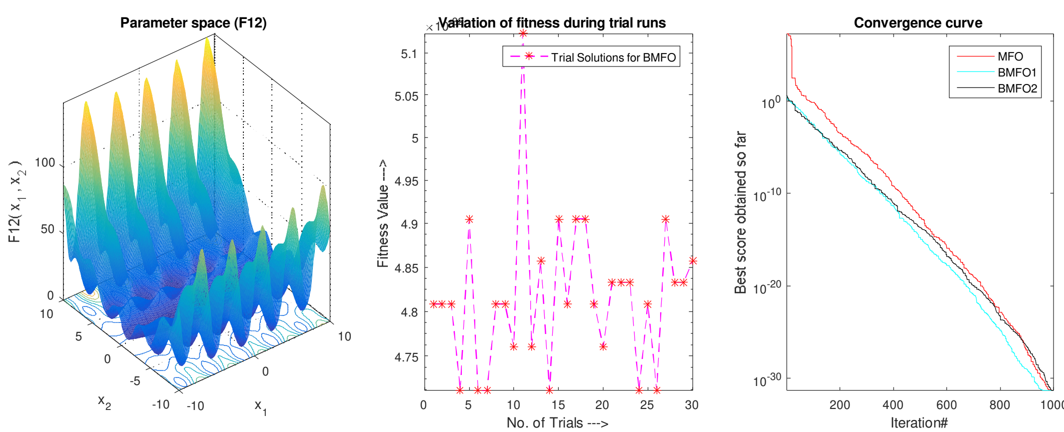


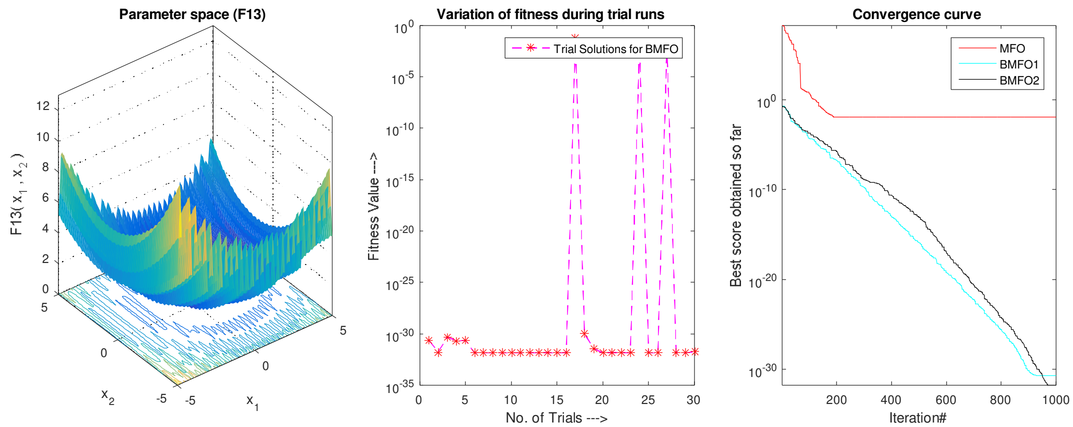
(c)



(d)



(e)



(f)

Figure 5: Convergence curve and Trial solutions of BMFO2 for multi-modal gauge functions

4. CONCLUSION

In the proposed analysis, 2 binary variants of moth flame optimizer has been given to resolve benchmark issues and automatic generation control downside of the electrical power grid. Results of 2 variants have been proved for non-precise, extremely unnatural, non-arched engineering style & optimization issues, that embody twenty three benchmark issues and AGC downside of multi space power grid below deregulating setting. The planned algorithm has been accustomed to examine the optimum gain of PI controller with suitable error criteria. Moreover, the efficiency of BMFO algorithm tuned with PI controller is additionally correlated with standard MFO and PSO formula tuned PI controller in several contract eventualities of a deregulated power grid. The analyses disclosed that proposed BMFO algorithm offers superior kind of solutions as correlated to alternative described meta-heuristics search algorithms. In future work, the effectualness of the BMFO formula is studied for the optimum answer of the many alternative engineering issues.

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