Artificial Electric Field Algorithm for Optimal Power Flow Aiming Cost and Loss Minimization

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Abstract*: Optimal Power Flow (OPF) is a vital concern in a Electric power Network. Because of the intricacy and incoherence of strictures, the conventional formulations are not suitable to solve the problem. Hence, this study aims to resolve OPF problem consisting the objectives, by reducing the generation cost and Minimizing the Transmission power losses. So, the incessant and intermittent variables take part in the problem formulation. Artificial Electric Field Algorithm (AEFA) have been suggested to resolve the OPF problem. The simulations have been performed on IEEE -30-bus test system. The outcomes have been matched with other algorithms to exemplify the efficiency and heftiness of AEFA.

Keywords: AEFA, Cost reduction, IEEE 30 bus system, Loss minimization, OPF

I. INTRODUCTION

Carpentier introduced OPF problem in 1962 [1]. The intention of OPF problem is to estimate the best situations of an electrical network that enhance the objective functions for instance generation cost, power loss, voltage deviation, pollutant emission and no of mechanisms while nourishing power flow equations, system safety and operative bounds. Dissimilar control parameters namely real power outputs and voltages, transformer tap altering sets, and functioning rubrics for phase shifters and apparatuses have been employed to attain a best network locale according with the problem [2]. Owing to the capability of OPF problem, extensive researches have been carried out. OPF problem has been formulated and resolved by fulfilling Constraint like equality and inequality. To reduce the generating cost and Transmission power losses have been fixed as the major objectives in this study.

Recently, Artificial bee (ABC) algorithm [3], Differential Evolution algorithm (DE) [4, 5], particle swarm optimization (PSO) [6], and Multi-Hive Multi-Objective foraging Bee algorithm (MMOBA) [7] has also been utilized to resolve OPF problem. Early, the author has solved OPF problem incorporating wind generation using PSO on IEEE-30 bus test system [8]. For optimizing the Economic Dispatch problem, Euclidean Affine Flower Pollination Algorithm (eFPA) and Binary FPA algorithm (BFPA) have been proposed [9]. Recently, the hybrid algorithm namely Moth Swarm- Gravitational Algorithm MSA-GSA; has been proposed to schedule wind generators on IEEE 30, IEEE 57 and IEEE 118 buses [10]. In this study, AEFA is implemented to solve OPF problem. AEFA has been modeled to act as population, idea of charge is protracted to best solution in population by the pioneering method.

II. PROBLEM FORMULATION

A. *Reduction of cost and losses*

Reduction of cost and loss have been considered as the objectives, by the way one objective should not dominate the other.

$$MinF=\sum_{i=1}^{ng}\left(A_i+B_iP_{gi}+C_iP_{gi}^2\right)+W_{P_{loss}}\sum_{i=1}^{n}\left(G_k\left(V_i^2+V_j^2-2V_iV_j\cos\delta_{ij}\right)\right) \quad (1)$$

where Ai, Bi and Ci are the cost coefficients of the generator bus i, Pgi is the generated active power at ith bus and ng is no. of generators comprising the slack bus, n is the branch number on the network, K is a branch with conductance G connecting the i-th bus to the j-th bus. Ploss is real power loss and $W_{P_{loss}}$ is the weighting factor ($W_{P_{loss}}$ =1950).

B. *Constraints*

Good

The equality constraints

$$P_{gi}-P_{di}=V_i\sum_{j=1}^{N}V_j\left(g_{ij}\cos\delta_{ij}+z_{ij}\sin\delta_{ij}\right) \quad (2)$$

$$Q_{gi}-Q_{di}=V_i\sum_{j=1}^{N}V_j\left(g_{ij}\sin\delta_{ij}+z_{ij}\cos\delta_{ij}\right) \quad (3)$$

The inequality constraints

Generators bounds:

$$P_{gi}^{\min}\le P_{gi}\le P_{gi}^{\max} \quad (4)$$

$$Q_{gi}^{\min}\le Q_{gi}\le Q_{gi}^{\max} \quad (5)$$

$$V_{gi}^{\min}\le V_{gi}\le V_{gi}^{\max} \quad (6)$$

Tap transformer bounds:

$$T^{\min}\le T\le T^{\max} \quad (7)$$

Voltage magnitude for load buses bounds:

$$V_{Li}^{\min}\le V_{Li}\le V_{Li}^{\max} \quad (8)$$

Power flow of transmission lines bounds:

$$S_{Li}^{\min}\le S_{Li}\le S_{Li}^{\max}$$
(9)

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III. Artificial Electric Field Algorithm (AEFA)

The detailed description about AEFA has been presented in [11]. The operational flowchart of AEFA has been illustrated in Figure 1.

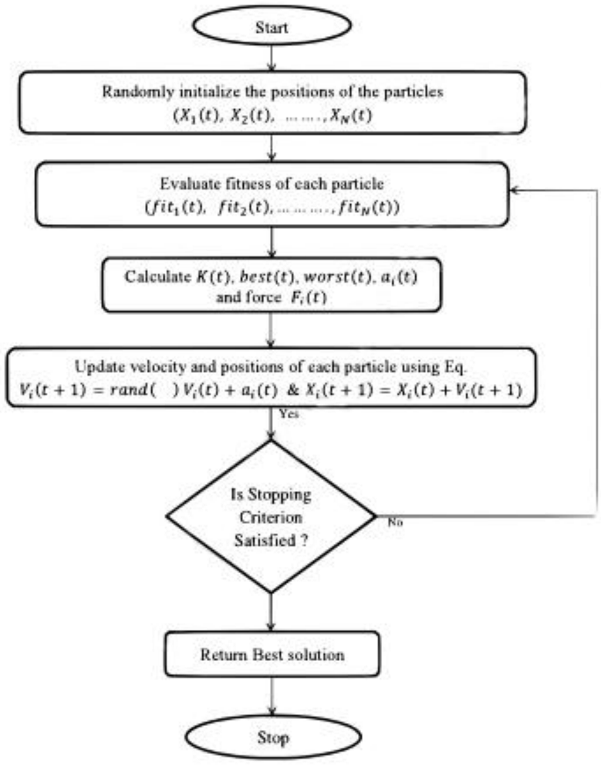

Fig. 1.Working principle of AEFA

IV. RESULTS AND DISCUSSION

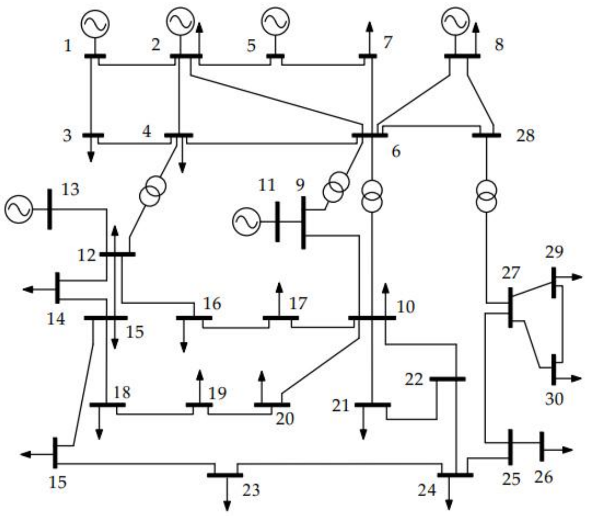

Fig. 2.Structure of IEEE- 30 bus system

The structure of IEEE - 30 bus system has been shown in Figure 2.

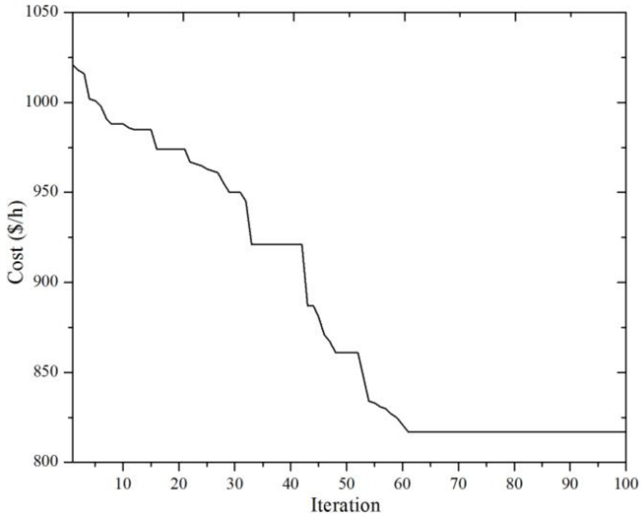

Fig. 3.Convergence characteristics of cost minimization

Table- I: Best results of OPF problem

Control variables	Min	Optimal Capacity (MW)	Max
Pg1	50	128.9488	200
Pg2	20	62.1454	80
Pg5	15	41.0154	50
Pg8	10	25.1457	35
Pg11	10	27.2404	30
Pg13	12	32.7812	40
Vg1	0.9	1.0433	1.1
Vg2	0.9	1.0078	1.1
Vg5	0.9	1.0155	1.1
Vg8	0.9	1.0852	1.1
Vg11	0.9	1.0976	1.1
Vg13	0.9	1.0948	1.1
T6-9	0.9	1.0954	1.1
T6-10	0.9	1.0578	1.1
T4-12	0.9	1.0624	1.1
T28-27	0.9	1.0278	1.1
Qc10	0	3.4597	5
Qc12	0	2.7451	5
Qc15	0	3.2687	5
Qc17	0	3.0127	5
Qc20	0	2.4782	5
Qc21	0	2.1755	5
Qc23	0	4.5478	5
Qc24	0	3.9834	5
Qc29	0	2.1201	5
MinCost [$/h]	817.0944		
$MinP_{loss}$ [MW]	4.1782		

Table– II: Comparison of results of AEFA with other optimization algorithm

Technique	*MinCost* [$/h]	$MinP_{loss}$ [MW]
ABPPO [12]	822.7693	5.4521
EGA [13]	822.8715	5.6130
PSOGSA [14]	822.4063	5.4681
AEFA	817.0944	4.1782

Using AEFA I00 trail runs have been taken out for OPF problem. The convergence curve has been shown in Figure 3. Table I provides the best result for OPF problem using AEFA. The association of results of AEFA with other optimization algorithm has been presented in Table II.

V. CONCLUSION

For OPF Problem the Generating Cost and power losses

Minimization has been taken as objectives. The enactment of AEFA has been simulated on standard IEEE 30-bus system for solving the OPF issues and the outcomes have been compared with other optimization algorithms. The comparison validated that the outcomes of AEFA provided least cost results than other algorithms. Furthermore, the convergence characteristics has been attained in less number of iterations. As a result, based on the performance, AEFA is a capable method to solve an intricate OPF problem.

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