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HYBRID GRAVITATIONAL SEARCH FLOWER POLLINATION ALGORITHM FOR COMBINED ECONOMIC EMISSION LOAD DISPATCH

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Abstract - *Economic Load Dispatch is the most remarkable problem in optimization for forecasting the generation in the area of thermal generating units in power system .Combined economic and emission load dispatch determines the optimal generation of the power system by minimizing the fuel cost and emission levels simultaneously. In this work, a new Hybrid Gravitational Search Flower Pollination (GSFPA) based algorithm is proposed for achieving improved results in the ELD problem where gravitational search is used to decide the step size in levy flight mechanism. In the new technique gravitational search algorithm works in coordination with flower pollination algorithm to find desired and refined results. The proposed algorithm will be tested for IEEE 14 and 39 bus system to prove its credibility. This algorithm has less number of operators and hence it can be easily coded in any programming language. To prove the feasibility of this algorithm its performance is compared with other existing algorithms.*

Key Words: CEED, PBO, GSFPA, ELD, PSO

1.INTRODUCTION

In today's modern era of electrical power plays a very vital role to survive and to meet various demands. In order to meet these demands the generation, transmission and distribution of power must be optimized efficiently. Economic operation of power systems is met by meeting the load demand through optimal scheduling of power generation. Minimization of fuel cost is the main objective of finest power flow (OPF) problems. Optimal real power scheduling will guarantee economic benefits to the power system operators and reduce the release of polluting gases.ELD primarily aims at optimal scheduling of real power generation from committed units in such manner that it meets the total demand and losses while satisfying the constraints [10]. Achieving minimum cost while satisfying the constraints makes the ELD problem a highly non-linear constrained optimization problem. The non linearity of the difficulty is due to non linearity and valve point effects of input–output characteristics of generating units. The aim of cost minimization may have multiple local optima. There is always a demand for a proficient optimization technique for these kinds of highly non linear objective functions. Further, the algorithm is expected to produce accurate results for the ELD problem.

In the last decade, several bio inspired algorithms are introduced and attempted for many engineering optimization problems. Some of the notable bio inspired algorithms are particle swarm optimization algorithm (PSO), a well received algorithm and utilized in almost all engineering applications successfully. Firefly algorithm is another recently introduced algorithm for engineering optimization that has been effectively used to solve the dynamic ELD problem. Theses algorithms are highly successful and cannot be easily trapped in to local optima. In addition, they are comfortable with all types of objective functions. Flower pollination algorithm FPA is one such nature inspired algorithm developed by Xin She Yang [7]-[8] for engineering tasks.

The efficiency of nature/bio inspired algorithms is proved to be outperforming even the evolutionary based algorithms. In this paper, the new Hybrid Gravitational Search Flower Pollination based algorithm has been proposed for achieving improved results in the ELD problem where gravitational search is used to decide the step size in levy flight mechanism. This algorithm has lesser number of operators and hence can be easily coded in any programming language. To prove the strength of this algorithm its performance is compared with other existing algorithms.

1.1 Working of Hybrid Gravitational Search Flower Pollination Algorithm:-

Based on the concept of gravitational search and flower pollination, gravitational search pollination algorithm (GSFPA) is developed.
Rule1. Biotic and cross-pollination are considered as global pollination process and pollen is carried by a movement which obeys Levy flight movement incorporating gravitational search capability.
Rule2. A biotic and self-pollination are equivalent to local pollination process incorporating updating of gravitational equation.
Rule3. Pollinators can develop flower constancy, which is like reproduction probability and proportional to the similarity of two flowers involved.

Rule4. Changing from local pollination to global pollination or vice versa can be controlled by a probability p ϵ[0, 1].

For implementation of this FPA algorithm, a set of updating formulae are developed by converting the rules into updating equations. In the global pollination step, flower pollen gametes are carried by pollinators such as insects over longer distances. Therefore, the mathematical equivalent of Rule 1 and flower constancy is written as

$$x_i^{t+1} = x_i^t + L(\lambda)(x_i^t - x) * G_0 e \propto t/T \quad (1)$$

Where, x_i^{t+1} is the solution vector (pollen) *xi* at iteration *t*, *x*is the current best solution, $G_0 e \propto t/T$ is a gravitational scaling factor to control the step size. *L(λ)* is the parameter that corresponds to the strength of the pollination, which essentially is also the step size. Since insects may move over a long distance with various distance steps, we can use a Levyflight to mimic this characteristic efficiently. That is, we draw L > 0 from a Levy distribution

$$L \cong \frac{\lambda\Gamma(G(t))\sin({}^{\pi G(t)}/_{2})}{\pi}\frac{1}{S^{1+G(t)}} * G(t) * (M_i(t) * M_j(t))/R_{ij} + c * (X_{jd}(t) - X_{id}(t))(S \gg S_0 > 0) \qquad (2)$$

Here, G(t) is the standard gamma distribution valid for large steps. i.e. for s > 0.
Then, to model the local pollination, both Rule 2 and Rule 3 can be represented as:

$$x_i^{t+1} = x_i^t + \varepsilon\left(x_j^t - x_k^t\right) * G_0 e \propto t/T \quad (3)$$

Wherex_j^t and $x_k^t$are pollen from different flowers of the same plant species. This essentially mimics the flower constancy in a limited neighborhood. Mathematically, if $x_j^t$and x_k^t comes from the same species or selected from the same population, this equivalently becomes a local random walk if we draw from a uniform distribution in [0, 1].Pollination may also occur in a flower from the neighboring flower than by the far away flowers. In order to copy this, a switch probability (Rule 4) is used through a proximity probability p to switch between global pollination and local pollination. A preliminary parametric showed that p=0.8 might work better for most applications.

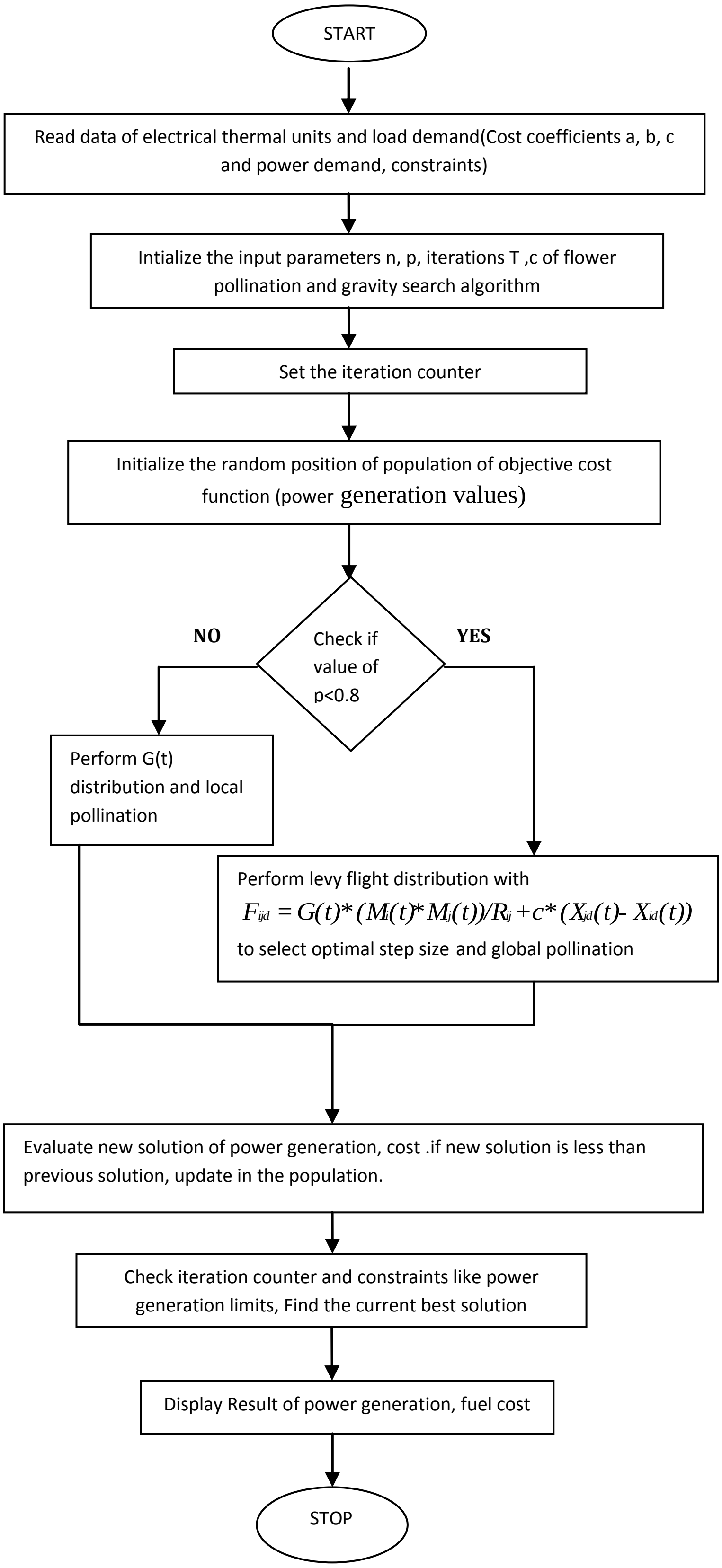

Fig 1. Flow chart for GSFPA

2. RESULTS

2.1 INPUT DATA

Table 1.Input data for 14 bus, 6 generator system [18]

Unit	P_i^{min}	P_i^{max}	a_i($/h)	b_i($/MWh)	c_i($/($MW^2$)h)
1	10	125	756.9888	38.5390	0.15247
2	10	150	451.3251	46.1591	0.10587
3	35	210	1243.5311	38.3055	0.03546
4	35	225	1049.9977	40.3965	0.02803
5	125	315	1356.6592	38.2704	0.01799
6	130	325	1658.5696	36.3278	0.02111

$$B = \begin{bmatrix} 0.000140 & 0.000017 & 0.000015 & 0.000019 & 0.000026 & 0.000022 \\ 0.000017 & 0.000060 & 0.000013 & 0.000016 & 0.000015 & 0.000020 \\ 0.000015 & 0.000013 & 0.000065 & 0.000017 & 0.000024 & 0.000019 \\ 0.000019 & 0.000016 & 0.000017 & 0.000071 & 0.000030 & 0.000025 \\ 0.000026 & 0.000015 & 0.000024 & 0.000030 & 0.000069 & 0.000032 \\ 0.000022 & 0.000020 & 0.000019 & 0.000025 & 0.000032 & 0.000085 \end{bmatrix}$$

Fig 2. B-Coefficients for 14 Bus, 6 Generator System [18]

Table 2. Input Data for 39 Bus System [18]

Unit	P_i^{min}	P_i^{max}	a_i($/h)	b_i($/MWh)	c_i($/($MW^2$)h)
1	10	55	1000.403	40.5407	0.12951
2	20	80	950.606	39.5804	0.10908
3	47	120	900.705	36.5104	0.12511
4	20	130	800.705	39.5104	0.12111
5	50	160	756.799	38.5390	0.15247
6	70	240	451.325	46.1592	0.10587
7	60	300	1243.531	38.3055	0.03546
8	70	340	1049.998	40.3965	0.02803
9	135	470	1658.569	36.3278	0.02111
10	150	470	1356.659	38.2704	0.01799

$$B = \begin{bmatrix}
0.000049 & 0.000014 & 0.000015 & 0.000015 & 0.000016 & 0.000017 & 0.000017 & 0.000018 & 0.000019 & 0.000020 \\
0.000014 & 0.000045 & 0.000016 & 0.000016 & 0.000017 & 0.000015 & 0.000015 & 0.000016 & 0.000018 & 0.000018 \\
0.000015 & 0.000016 & 0.000039 & 0.000010 & 0.000012 & 0.000012 & 0.000014 & 0.000014 & 0.000016 & 0.000016 \\
0.000015 & 0.000016 & 0.000010 & 0.000040 & 0.000014 & 0.000010 & 0.000011 & 0.000012 & 0.000014 & 0.000015 \\
0.000016 & 0.000017 & 0.000012 & 0.000014 & 0.000035 & 0.000011 & 0.000013 & 0.000013 & 0.000015 & 0.000016 \\
0.000017 & 0.000015 & 0.000012 & 0.000010 & 0.000011 & 0.000036 & 0.000012 & 0.000012 & 0.000014 & 0.000015 \\
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0.000018 & 0.000016 & 0.000014 & 0.000012 & 0.000013 & 0.000012 & 0.000016 & 0.000040 & 0.000015 & 0.000016 \\
0.000019 & 0.000018 & 0.000016 & 0.000014 & 0.000015 & 0.000014 & 0.000016 & 0.000015 & 0.000042 & 0.000019 \\
0.000020 & 0.000018 & 0.000016 & 0.000015 & 0.000016 & 0.000015 & 0.000018 & 0.000016 & 0.000019 & 0.000044
\end{bmatrix}$$

Fig 3. B-Coefficients for 39 Bus System [18]

2.2 RESULTS OBTAINED FOR MULTIOBJECTIVE ECONOMIC LOAD DISPATCH

Table 3. Cost comparison and power generation for 6 unit system

Sr.no.	Method	Power demand (MW)	P_1 (MW)	P_2 (MW)	P_3 (MW)	P_4 (MW)	P_5 (MW)	CPU Time(seconds)	P_6 (MW)	Emission (kg)	Fuel Cost ($)
1	**GSFPA [proposed work 2]**	**1200**	**85.73**	**93.24**	**209.72**	**227.45**	**324.76**	**3.16**	**356.16**	1282	**64312.7**
2	FPA [proposed work 1]	1200	91.24	96.26	215.38	245.43	323.19	3.12	342.72	1284	64762.8
2	MODE [18]	1200	108.6284	115.9456	206.7969	210.0000	301.8884	3.09	308.4127	1286	64843
3	PDE [18]	1200	107.3965	122.1418	206.7536	203.7047	308.1045	3.52	303.3797	1281	64920
4	NSGA II[18]	1200	113.1259	116.4488	217.4191	207.9492	304.6641	5.05	291.5969	1285	64962
5	SPEA 2[18]	1200	104.1573	122.9807	214.9553	203.1387	316.0302	7.42	289.9396	1285	64884

The table above shows the comparison of power dispatch and fuel cost of 6 generators, 14 bus system using flower pollination optimization technique. The above results clearly state that the power loss, fuel cost and computational time taken by flower pollination optimization is less as compared to other various techniques

Table 4. Losses of various techniques for CEED problem

Technique	Losses(MW)
GSFPO	**51.42**
FPA	51.47
MODE	51.61
PDE	51.78
NSGA II	52.12
SPEA2	51.15

Table 5. Weight Values and output IEEE 6 unit system

W1	W2	Fuel Cost	Emission(kg)
0.25	0.75	64362.9	1287
0.5	0.5	64572.8	1284
0.75	0.25	64577.4	1285
0.35	**0.65**	**64312.7**	**1282**
0.60	0.40	64122.4	1309
0.40	0.60	65314.2	1278

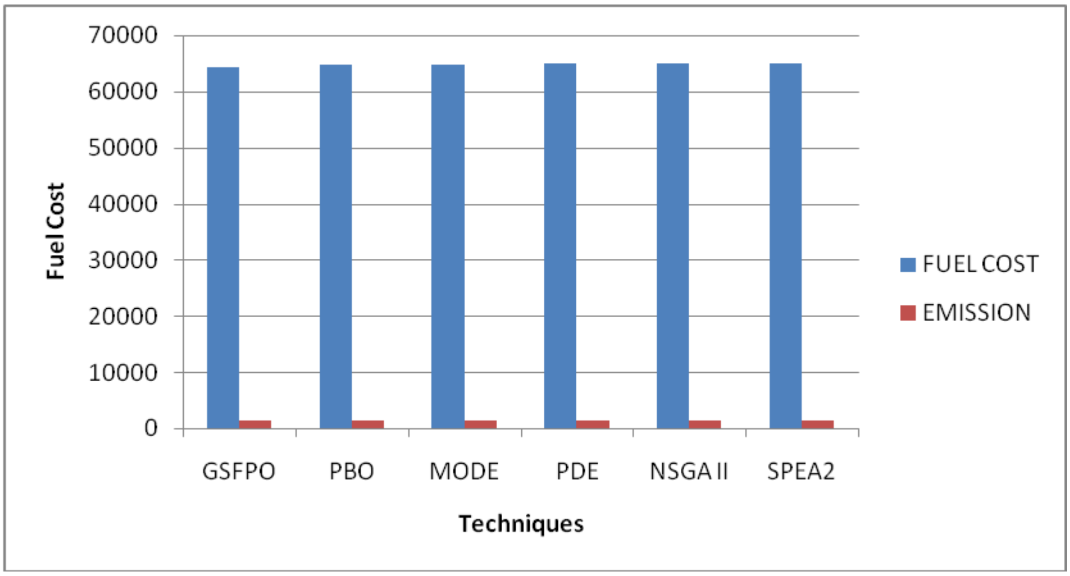

Fig 4. Cost and Emission Comparison Graph for Various Optimization Techniques

The graph shown above represents the fuel cost and emissions for various optimization techniques implemented on a 14 bus, 6generator system. The comparison shows that the cost using pollination based algorithm technique is the minimum of all other techniques.

Table 6. IEEE 10 unit system Result for CEED Problem

S.No	**Method**	**GSFPO [proposed work 2]**	FPA[proposed work 1]	MODE [18]	PDE [18]	NSGA II [18]	SPEA 2 [18]
	Power demand (MW	**2000**	2000	2000	2000	2000	2000
1	**P1 (MW)**	**47.28**	51.44	54.9487	54.9853	51.9515	52.9761
2	**P2(MW)**	**86.45**	82.45	74.5821	79.3803	67.2584	72.8130
3	**P3(MW)**	**89.54**	89.67	74.4294	83.9842	73.6879	78.1128
4	**P4(MW)**	**126.21**	134.25	80.6875	86.5942	91.3554	83.6088

5	**P5(MW)**	**81.44**	82.59	136.8551	144.4386	134.0522	137.2432
6	**P6(MW)**	**98.58**	92.13	172.6393	165.7756	174.9504	172.9188
7	**P7(MW)**	**278.29**	278.46	283.8233	283.2122	289.4350	287.2023
8	**P8(MW)**	**335.89**	321.78	316.3407	312.7709	314.0556	326.4023
9	**P9(MW)**	**466.91**	455.89	448.5923	440.1135	455.6978	448.8814
10	**P10(MW)**	**468.34**	439.96	436.4287	432.6783	431.8054	423.9025
	Emission(Kg)	**4114.67**	4123.78	4124.90	4111.40	4130.20	4109.10
	CPU Time(sec)	**4.12**	3.78	3.82	4.23	6.02	7.53
FUEL COST		**108965**	110177	113480	113510	113540	113520

The table above shows the comparison of power dispatch and fuel cost of 10 generator, 39 bus system using flower pollination optimization technique. The above results clearly state that the power loss, fuel cost and computational time taken by flower pollination optimization is less as compared to other various techniques

TABLE 7.Weight Values and output for IEEE 10unit system

W1	W2	Fuel Cost	Emission(kg)
0.25	0.75	113586	4122.92
0.5	0.5	111897	4125.89
0.75	0.25	**108965**	**4114.67**
0.35	0.65	124598	4112.93
0.60	0.40	118432	4118.37
0.40	0.60	116423	4113.76

Table 8.Losses of various techniques for CEED problem

Technique	Losses(MW)
GSFPO	**84.58**
PBO	84.89
MODE	84.64
PDE	84.69
NSGA II	84.81
SPEA 2	84.52

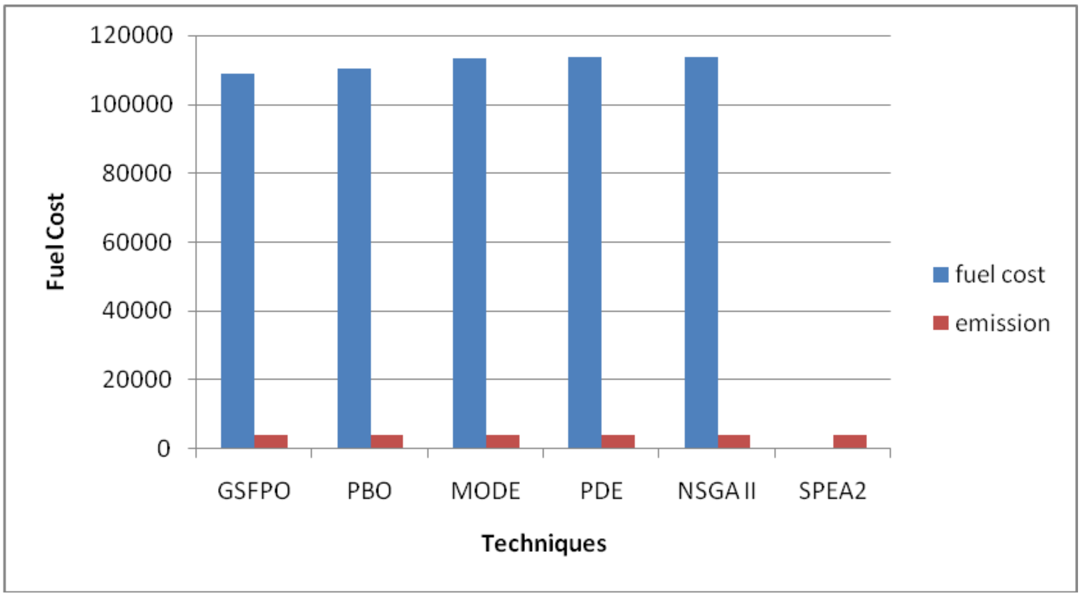

Fig 5. Cost and Emissions Comparison Graph for Various Optimization Techniques

The graph shown above represents the fuel cost and emissions for various optimization techniques implemented on a 39 bus, 10 generator system. The comparison shows that the cost using pollination based algorithm technique is the minimum of all other techniques.

The results show that the value of power output, fuel cost obtained and losses incurred by gravitational search flower pollination based optimization technique is better than other optimization techniques

4. CONCLUSIONS

In this paper hybrid gravitational search flower pollination algorithm (FPA) has been implemented to multi objective problem considering both cost and emission constraints for economic load dispatch.

The said algorithm works on the basis of pollinating behavior of flowering plants. Contrasting to the other bio inspired optimization techniques, FPA utilizes levy flight mechanism to generate population for the next generations. In the hybrid algorithm gravitational search algorithm (GSFP0) is imposed along with pollination optimization to enhance the results. The said algorithm can be easily modified according to different problems and the algorithm is highly efficient as it does not have the complication of very large number of parameters. The algorithm can be easily coded in any programming language. The proposed hybrid algorithm has been used and tested for IEEE 14 and 39 bus systems and the results achieved have shown to improve the optimization of the combined economic and emission dispatch problem. The results obtained by the above mentioned GSFPO algorithm when tested on Case I and II were far better than those obtained by the existing algorithms in the given literature. The given hybrid algorithm has lesser number of operators which minimizes the chances of solutions to get trapped in the local minima. The computational time of the following algorithm is also less than the existing algorithms. Further the said algorithm can be tested for bigger systems.

The results obtained are found to be superior and heartening

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