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Cost Prediction of Economic load Dispatch Problem Using Bees Algorithm

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Abstract: This paper illustrates Bees Algorithm (BA) for solving the economic load dispatch (ELD) problem to obtain the best for all generation sets to achieve the minimum total fuel cost of the system. To show the efficiency of suggested algorithm two power system were tested. The first system consist of six thermal units and the second system consists of fifteen thermal unit with a wide range of operational constraints. The numerical data obtained from suggested method is examined with those obtained from different methods as Particle swarm optimization (PSO) and Genetic Approach Search (GAS) to illustrate the validity and verify the feasibility of the suggested method. The Bees Algorithm is an optimization method that mimics honey bee foraging behavior and has been effectively used to solve a number of real-world issues. The data results explain that, the suggested method which is suitable to deal with mathematical difficulties of economic load dispatch study.

Keywords: Keywords: Economic load dispatch, genetic Approach Search, Particle swarm optimization, Bees Algorithm.

1. 1. INTRODUCTION

Electrical power system maneuvers depend on economic dispatch study as essential steps which needs fast optimization method for reducing the generation cost and taking into consideration the constrains of generation sets [1]. Many efforts have been employed in various mathematical software techniques and Algorithm optimizing methods to detect the solution of Economic dispatch study. The Particle swarm method includes the lambda-iteration method, the base point and participation factors method, and the gradient method [2],[4]. Economic load dispatch Center plays important role in energy management of electrical power network. The load dispatch center must be including forecasting data from the analysis of electrical system instantaneously for cost generation and the suggested operating unit to supply the loads of electrical network. The component of thermal generation station has a lot of nonlinear parameters which cause difficulty in determine the optimum solution of cost. Electrical network has different elements which includes nonlinear behavior at certain condition, therefore the analysis of Electrical network is very difficult to solve with ordinary methods as Newton Raphson technique [5]. Economic Load dispatch deal with nonlinear parameter due to the component of system and its behavior as transfer heat therefore the proposed equation is illustrated as in Gaussian mutation or other by Cauchy mutation (in IFEP). The ELD problem can be described as an optimization of fuel cost within constrain the minimum and maximum power in order to simulate the function of fuel cost [6]. Multi of optimization methods are taken from the behavior of animal life as Genetic Algorithm, Particle swarm optimization and bee method and Harmony Search [7], etc., which are used in learning the mechanical system how takes the best action by based optimization Teaching and working on the principles of different natural phenomena [8]. The Particle swarm optimization appears inaccurate at some features, numerous studies are currently being conducted to demonstrate electrical features in dealing with complicated electrical network issues [14].

Motion behavior of bees in artificial Bee Method on discovering the hone is represented in software to help in the analysis of load dispatch difficulties to find the estimated response of six generating unit or fifteen generators as case study [10].

2. 2. Problem Description

The load dispatch problem is nonlinear problem and the decision of economic achievement depend on the system demand and the status of generations [9].

$$\text{Min } F_t = \sum_{i=1}^{m} F_i (P_i)=\sum_{i=1}^{m} \alpha_i + \beta_i P_i+\gamma_i P_i^2 \quad (1)$$

Where, Ft is the total fuel cost of generation sets, α, β, γ are the parameters of thermal generation set which is related to the characteristic of generation system and Pi is the generated power of the connected thermal station with electrical network system.

Electrical network system are studied with the proposed algorithm (Bees Algorithm) Electrical System constrains are illustrated as following:

2.1 Power Balance

$$\sum_{i=1}^{m} P_i=P_D+P_L,\ i=J,\ldots,m \quad (2)$$

Where, Pi the power output of the i-th generator; P_D power demand and $P_{L,}$ power losses.

2.2 Ramp Rate Limit

According to [10] The restriction situation due to ramp rate of generation sets are represented as

a) generation increases when the difference between P_i and P_i^0 is smaller than or equal UR_i.
b) generation decreases when the difference between P_i and P_i^0 is larger than or equal DR_i.

Where P_i^0 is the current power generation output, and P_i is the previous power generation output and also the available ramp rate is located between UR_i and DR_i (MW/time-period).

Generator Operation Constraints

$$\max(P_i^{min}, P_i^0 - DR_i) \le P_i \le \min(P_i^{max}, P_i^0 + UR_i) \quad (3)$$

Where, P_i^0 is the current power generation output, UR_i is the upramp limit of the i-th generator (MW/time-period) and DR_i is the downramp limit of the i-th generator (MW/time-period)

2.3 Function Of Power Losses

in network that can be represented using coefficients

$$P_L= \sum_{i=1}^{m}\sum_{j=1}^{m} P_i B_{ij} P_j + \sum_{i+1}^{m} B_{0i} P_i + B_{00} \quad (4)$$

Where, P_i the power output of the i-th generator; $P_{Lij}$is the real power flow of line ,m is the number of transmission lines; B_{00} and B_{ij} the total transmission network losses is a function of unit power outputs that can be represented using coefficients

2.4 Prohibited Operating Area

The input-output characteristic for a typical thermal generator with multiple valve points is depicted in references [3] and [11]. Numerous forbidden zones are created by these valve points. In actual practice, modifying A unit's generated output must refrain from operating in the restricted areas. The following is a description of the unit's practicable operational zones:

$$P_i \epsilon \begin{cases} P_i^{min} \le P_i \le P_{i,1}^{l} \\ P_{i,j-1}^{u} \le P_i \le P_{i,j}^{l}, & j = 2,3,\ldots,n_i \\ P_{i,n_i}^{u} \le P_i \le P_j^{max} \end{cases} \quad (5)$$

where P_i^{min} Unit i's minimum generation limit in MW, P_j^{max}Unit i's maximum generation limit in MW

2.5 The practical generation has performance and fuel consumption with operation constraints [10], as following.

$$P_i \epsilon \begin{cases} P_i^{min} \le P_i \le P_{i,1}^{l} \\ P_{i,j-1}^{u} \le P_i \le P_{i,j}^{l}, j = 2,3,\ldots,n_i,\ i = l,\ldots,m \\ P_{i,n_i}^{u} \le P_i \le P_j^{max} \end{cases} \quad (6)$$

3. 3. Bees Algorithms Method Plan

3.1 Representation Plan

Given the range of potential solutions to the issue

$$U = \{x \in R_n;\ max_i < x_i < min_i\ i = 1,\ldots, n\} \quad (7)$$

and an objective equation f(x)

f(x): U → R, each candidate solution is formulated in n-dimension of $\{x_1,\ldots,x_n\}$

f(x) is the fuel cost in the research, the power generated P_i is considered the x_i variable max_i is the maximum of variable x as P_i^{max} and also min_i is the minimum of variable x as P_i^{min} [15].

3.2 Initialization Steps

(n_s) scout bees make up the fixed population. The algorithm then enters the primary loop, a structure with four steps [15].

3.3 Waggle Dance

In order of increasing cost, the scouts' discovered (ns) solutions are ranked. The best (cheapest) scouts arrived n_b smaller than n_s results are taken to get the promising Area [15].

3.4 Local Search

The probability distribution is uniform because the bees are located around the scout bees to find the solution results. The feedback process in nature differs since there are all bees engaged in the searching travel in form the waggle dance [15].

3.5 Bees Collection Search

The search of bees collection, $n_s - n_b$ bees are distributed at random over the area of the solution. By using the objective function, these scouts assess the answers they found. The Bees Algorithm's exploring effort is represented by random scouting [15].

3.6 Population Update

The identical of Bee population is created in twice group at the conclusion of each round.

3.7 Stopping Theory

The terminating criterion relates to the issue zone and may be discover the optimum cost after improvement steps [15].

4. The Fundamental Bees Approach Method

4.1 Neighborhood Retraction.

The size a = {a_1,..., a_n} of the flower Initially, patches is considered in high level and also a_i (t) is related to each variable x_i .

$$a_{i\,(t)} = ngh_{(t)} \cdot (max_i - min_i) \quad (8)$$

If the local search method turns up points that are less expensive, the flower patch's size is left unaltered. The size of an is reduced if the results of the local search do not result in an improvement in the value of the goal function. Using the following heuristic formula, the neighborhood size is updated:

$$ngh_{(t+1)} = 0.8 \cdot ngh_{(t)} \quad (9)$$

This method causes the limited zone exploration search to be specified above the multi numbers for the starting of exploration of neighborhood (ngh) and to have a mostly exploratory nature [15].

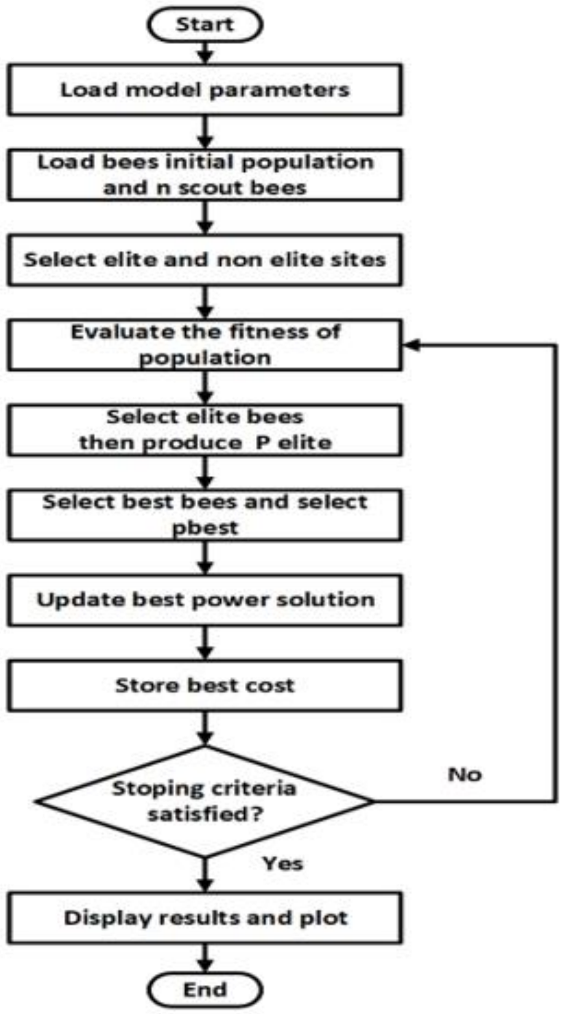

Fig 1: Workflow proposed of suggested bees approach research

4.2 Site Abandonment.

When a search inside a flowerbed stalls, this approach is used. A new random solution is created as a result, and the patch investigation is stopped. The location of the peak is noted if the site that is being abandoned corresponds to the currently cheapest solution. The recorded best is used as the ultimate answer if no further flower patch will yield a less expensive option during the remaining phases of the search [15].

5. The Bees Proposal Algorithm

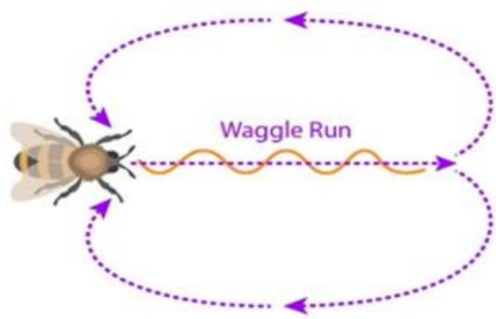

Fig 2: The honeybee waggle dance.

The waggle dance of honeybees and following bees. The dancer starts with a waggle run then turns to the left side to return to the waggle run's beginning and move to the right. She then begins when the flowers are the same nature and shape as in figure (2), the option is not expensive during this phase of the exploration. One more waggle travel and typical move the same travel in the opposite side and it is repeated. She conducts more waggle runs the better the food source. The dancer creates airborne sounds and airflows while performing the waggle run. It is still unclear how important the various stimuli are for the follower to relay position information from the dancer. These elements might serve a significant psychological purpose for nearby bees in addition to supplying location information. Signal investigation and Information training can both be improved by multi-component signaling [16].

6. Case study and numerical Results.

The Bees Approach is operated as program search using MATLAB software program on system with CORE i7 intel processor with cash memory three Giga Hertz and 8 Giga Byte SD Ram.

Test case 1: The Electrical network contains 6 thermoelectric generation sets and utilize the quadratic (convex) unit cost functions, twenty-six different buses, and forty-six overhead transmission lines. The customer load is one thousand and two hundred sixty-three Mega watts. The parameters of the 6 thermoelectric generation sets are illustrated in Table 1.

Table 1: Generating Unit Capacity and Coefficients

Unit	P_i^{min}	P_i^{max}	$\alpha_i(\$)$	$\beta_i(\$/MW)$	$\gamma_i(\$/MW^2)$
1	100	500	240	7.0	0.0070
2	50	200	200	10.0	0.0095
3	80	300	220	8.5	0.0090
4	50	150	200	11.0	0.0090
5	50	200	220	10.5	0.0080
6	50	120	190	12.5	0.0075

Table 2: Ramp Limits and Forbidden Zones of Generating Units

Unit	$\mathbf{P_i^0}$	$\mathbf{UR_i}$ **(MW/h)**	$\mathbf{DR_i}$ **(MW/h)**	**Prohibited zones (MW)**
1	**440**	**80**	**120**	**[210 240] [360 380]**
2	**170**	**50**	**90**	**[90 110] [140 160]**
3	**200**	**65**	**100**	**[150 170] [210 240]**
4	**150**	**50**	**90**	**[80 90] [110 120]**
5	**190**	**50**	**90**	**[90 110] [140 150]**
6	**110**	**50**	**90**	**[75 85] [100 105]**

$$B_{ij}=\begin{bmatrix} 0.0017 & 0.0012 & 0.0007 & -0.0001 & -0.0005 & -0.0002 \\ 0.0012 & 0.0014 & 0.0009 & 0.0001 & -0.0006 & -0.0001 \\ 0.0007 & 0.0009 & 0.0031 & 0.0000 & -0.0010 & -0.0006 \\ -0.0001 & 0.0001 & 0.0000 & 0.0024 & -0.0006 & -0.0008 \\ -0.0005 & -0.0006 & -0.0010 & -0.0006 & 0.0129 & -0.0002 \\ -0.0002 & -0.0001 & -0.0006 & -0.0008 & -0.0002 & 0.0150 \end{bmatrix}$$

B_{oi} = 1.0e^{-03}*[-0.3908 -0.1297 0.7047 0.0591 0.2161 -0.6635]

B_{oo} = 0.056

Table 3: Best Solution for six generation sets of electrical network100 Iteration)

Unit power output	**PSO method [10]**	**GA method [10]**	**BEES method**
P1 (MW)	**447.4970**	**474.8066**	**458.4348**
P2(MW)	**173.3221**	**178.6363**	**164.6386**
P3(MW)	**263.4745**	**262.2089**	**258.8901**
P4(MW)	**139.0594**	**134.2826**	**130.6607**
P5(MW)	**165.4761**	**151.9039**	**178.1283**
P6(MW)	**87.1280**	**74.1812**	**85**
Total power output (MW)	**1276.01**	**1276.03**	**1275.7**
Ploss (MW)	**12.9584**	**13.0217**	**12.5498**
Total generation cost ($/h)	**15450**	**15459**	**15447**
Time	**3.73 second**	**10.49 second**	**0.369683 Second**

Electrical Network which has six generators, are studied with different approach search methods as particle swarm optimization (PSO), Genetic algorithm (GA) and Bees Algorithm (BA). The result of study is represented in table 3 to show the essential output power of generation for the electric network and also the total output power, the losses and total cost respectively. Study of different methods are operated with considering the the suggested ramp limits of generations and the forbidden zone of generation sets According to [11], [12], and [13]. The bees Method consumes the minimum time 0.3696 second with central processing Analogy to get the output results comparing with (PSO) method and (GA) method.

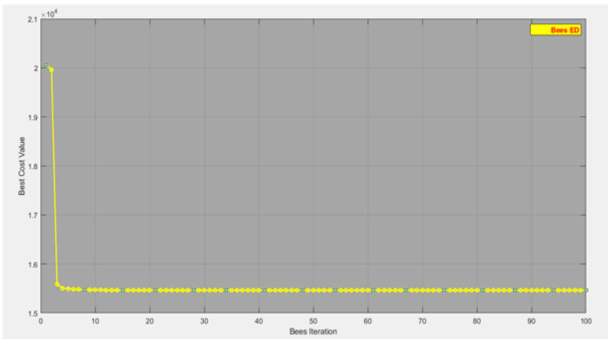

Fig 3: Relationship between best cost value and bees iteration (SYSTEM 6 UNIT)

The best cost for 6-unit dispatch is not change when the best iteration increased above 100 iterations

Test Case 2: The electrical network consist of fifteen thermoelectric generation sets which has behaviors and Its parameter as in tables 4 and table 5, the customers of electrical network need two thousand and sixty hundred thirty of Mega watts. The experimental results are shown in Tables according to the iteration number 100 respectively, that also satisfy the system constraints.

TABLE 4: Generating Unit Capacity, Coefficients and Ramp Rate Limits

Unit	P_i^{min}	P_i^{max}	$\alpha_i(\$)$	$\beta_i(\$/MW)$	$\gamma_i(\$/MW^2)$	UR_i (MW/h)	DR_i (MW/h)	P_i^0
1	150	455	671	10.1	0.000299	80	120	400
2	150	455	574	10.2	0.000183	80	120	300
3	20	130	374	8.8	0.001126	130	130	105
4	20	130	374	8.8	0.001126	130	130	100
5	150	470	461	10.4	0.000205	80	120	90
6	135	460	630	10.1	0.000301	80	120	400
7	135	465	548	9.8	0.000364	80	120	350
8	60	300	227	11.2	0.000338	65	100	95
9	25	162	173	11.2	0.000807	60	100	105
10	25	160	175	10.7	0.001203	60	100	110
11	20	80	186	10.2	0.003586	80	80	60
12	20	80	230	9.9	0.005513	80	80	40
13	25	85	225	13.1	0.000371	80	80	30
14	15	55	309	12.1	0.001929	55	55	20
15	15	55	323	12.4	0.004447	55	55	20

Table 5: Forbidden Zones of Generating Units

Unit	Prohibited zones (MW)
2	[185 225] [305 335] [420 450]
5	[180 200] [305 335] [390 420]
6	[230 255] [365 395] [430 455]
12	[30 40] [55 65]

Table 6: Best Solution for fifteen generation sets of electrical network (100 Iteration)

Unit power output	PSO method [10]	GA method [10]	BEES method
P1 (MW)	439.1162	415.3108	412.526
P2(MW)	407.9727	359.7206	390.234
P3(MW)	119.6324	104.4250	105.757
P4(MW)	129.9925	74.9853	97.66
P5(MW)	151.0681	280.2844	186.814
P6(MW)	459.9978	426.7902	447.392
P7(MW)	425.5699	341.3164	418.402
P8(MW)	98.5699	124.7867	118.739
P9(MW)	113.4936	133.1445	124.174
P10(MW)	101.1142	89.2567	83.843
P11(MW)	33.9583	60.0572	74.517
P12(MW)	79.9583	49.9998	72.277
P13(MW)	25.0042	38.7713	44.142
P14(MW)	41.4140	41.9425	48.314
P15(MW)	35.6140	22.6445	39.042
Total power output	2662.4	2668.4	2663.8
Ploss(MW)	32.4306	38.2782	28.2086
Total generation cost ($/h)	32858	33113	32109
Time	13.41 second	24.72 second	0.5937 second

The load dispatch problem is tested with fifteen generation units by bees algorithm with a huge number of iterations to achieve the good result which help the electrical system for the optimum situation with minimum fuel cost. One hundred iterations suggested for bees algorithm to display the same results of one hundred iteration for the system as in table 6. The bees algorithm is applied on the network and consumed **0.5937** seconds as average CPU time to detect the results after one hundred iterations.

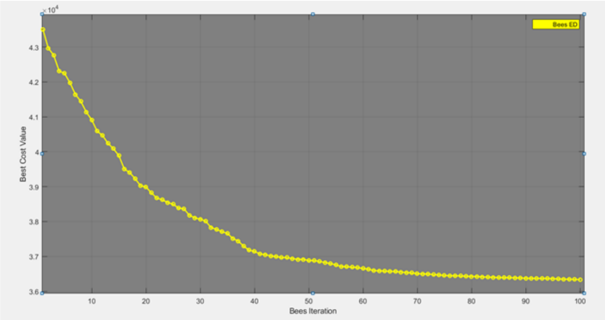

Fig 4. Relationship between best cost value and bees iteration (SYSTEM 15 UNIT)

The best cost for 15-unit dispatch is not change when the best iteration increased above 100 iteration.
The loss B matrix of a 15-unit system is not explained with considering that, a base capacity MVA is one hundred base capacity and [10].
Bees Algorithm (BA) is a developed branch from nature inspired algorithms which are known as Swarm Intelligence is focused on insect behavior in order to develop some meta-heuristics as Particle Swarm Optimization (PSO) etc. The Bees Algorithm (BA) was preferred [17]. The Bees algorithm mimics the food foraging behavior of swarms of honey bees. This algorithm is a very simple, robust and population based stochastic optimization algorithm.

7. CONCLUSION

Finally, the economic load dispatch Study records the best data when the bees method is used. The bees algorithm method is operated and give high-quality solutions within small processing time in fraction of second due to the convergence characteristic of bees method which achieve a good computing efficiency. Additionally, the performance of bees' algorithm methodology are the best win comparing with the GA method and PSO method.

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