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OPTIMAL ECONOMIC DISPATCH BASED ON ARTIFICIAL BEE COLONY TECHNIQUE FOR IRAQI NATIONAL GRID

Hanan Mikhael Dawood [1], Younis M. Nsaif [2]
[1] Lecturer, [2] assistant lecturer
College of Engineering-University of Baghdad

ABSTRACT:- Economic dispatch (ED) in power system is one of important optimization problems for determining and providing an economic condition for generation units. The nonlinearity of this problem makes conventional methods unable to determine a fast and robust solution, especially when the power system contains the highest number of generation units. In this paper, optimization technique called Artificial Bee Colony (ABC) is used to solve economic dispatch problem in power system. ABC based on the behavior of bees to search for food sources. The obtained results are compared with the conventional method using test system. It shows that the ABC algorithm approach is more feasible and efficient for finding minimum cost. Therefore, ABC approach has been applied for Iraqi National Grid. The proposed methods are executed in MATLAB environment

Keywords: Economic dispatch, Iraqi National Grid, Artificial Bee Colony, Cost function

1- INTRODUCTION

The economic dispatch (ED) is f the fundamental issues in the power system operation. The primary objective of economic dispatch is to minimize the total cost of generation while honoring the operational constraints of the available generation resources. In traditional economic dispatch the operating cost is reduced by proper allocation of the amount of power to be generated by different generating units. However the optimum economic dispatch may not be the best in terms of the environmental criteria; therefore; Artificial intelligent techniques could make numerical methods more efficient for solving ED problems.

Swarm intelligence is a new class of stochastic search optimization algorithms based on procedures that simulate collective behavior and emergent intelligence in natural environment. One of these swarm intelligence algorithms has shown great possibility and good performance for solving various optimization problems is the artificial bee colony (ABC) algorithm [1].ABC is a population based method and inspired by the intelligent foraging behavior of the honey bee swarm.

Several optimization methods were proposed to solve ED problem such as Lagrange multipliers[2], dynamic programming [3],an iterated-based optimization [4], differential evolution immunized ant colony optimization [5], Differential Evolution Algorithm [6] and particle swarm optimization [7].It is obvious that for this type of optimization problem in electric power system, the final cost is really important. Additionally, saving the cost and decreasing it using technique leads to bulk thrift for the electric power system.

In this paper, we used quadratic programming (conventional technique) and artificial bee colony (ABC) optimization (Artificial intelligent technique) for solving ED problems. The present methods was applied on test data. Finally the best method was implemented on Iraqi national Grid.

2- ASSOCIATED PROBLEM

The aim of ED is to set the generator levels for all units, minimizing the fuel cost function (Fc) whilst satisfying the total power demand under some constraints [4] &[6]. It is determined according to the following equations(1), (2) & (3):

$$Min\, F_c = \sum_{i=1}^{n} F_i(P_i) = F(P) \quad (1)$$

$$P = [P_1, P_2, \dots, P_n] \quad (2)$$

$$F_i(P_i) = a_i P_i^2 + b_i P_i + c_i \quad (3)$$

Where:

P_i: Real output power of the i_{th}generator, $F_i(P_i)$: The generation cost of the i_{th}generator and a_i , b_i , and c_i: Three cost coefficients of the i_{th}generator.

The ED problem can be described mathematically as an objective with two constraints as:

1- Capacity Limits Constraint.

For normal operations of power system, real power output of each generator is restricted by lower and upper bounds as follows:

$$P_i^{min} \leq P_i \leq P_i^{max} \quad (4)$$

2- Power Balance Constraint.

The total power generation must be equal to the sum of load demand P_D and transmission line loss $P_L$as given by:

$$\sum_{i=1}^{n} P_i = P_D + P_L \quad (5)$$

Where P_i^{min} and P_i^{max} are the minimum and maximum power generated by generator i_{th}, respectively.andP_D.

theP_L is calculated from the power flow by the following equation:

$$P_L = real\left(\sum_{j=1}^{n} V_i Y_{ij} V_j\right) \quad (6)$$

3- ARTIFICIAL BEE COLONY

ABC is one of the modern algorithms based on group behavior of honey bees. The colony contains three groups of bees: employed bees (EB), onlookers (OBs) and scouts. A bee who is waiting on the dance area for making a decision to choose a food source is called onlooker and the other one is going to the food source visited by it before is named employed bee. The other type of bee is scout bee that carries out random search for detecting new sources. The position of a food source represents a possible solution to the optimization problem and the nectar amount of a food source corresponds to the quality (fitness) of the associated solution. In the algorithm, the first half of the colony consists of employed artificial bees and the second half constitutes the onlookers. The number of the EB or the OBs is equal to the number of solutions in the population [8].

At the first step, the ABC generates a randomly distributed initial population of *SN*solutions (food source positions), where NP denotes the size of population. Each solution *xi* where*i*=1, 2,...,*NP*is a *D*-dimensional vector, (*D* is the number of optimization parameters. After initialization), the population of the positions (solutions) is subjected to repeated cycles, *C* =1, 2,..., MCN of the search processes of the employed bees, the onlooker bees and scout bees.

An employed bee produces a modification of the position (solution) in her memory relying on the local information (visual information) and tests the nectar amount (fitness value) of the new source (new solution). Provided that the nectar amount of the new one is higher than that of the previous one, the bee memorizes the new position and forgets the old one. On the other hand, she keeps the position of the previous one in her memory.After all employed bees complete the search process; they share the nectar information of the food sources and their position information with the onlooker bees on the dance area. An onlooker bee evaluates the nectar information taken from all employed bees and chooses a food source with a probability related to its nectar amount. As in the case of the employed bee, she produces a modification on the position in her memory and checks the nectar amount of the candidate source. Providing that its nectar is higher than that of the previous one, the bee memorizes the new position and forgets the old one. An artificial onlooker bee chooses a food source depending on the probability value associated with that food source[8]&[9].

3.1 ABC ALGORITHM.

1-Initialize the population of solutions x_{ij}(i=1,2,…,*SN*,
j=1,2,…,*D*).

2-Evaluate the population

3- cycle (represented as *G*) = 1 repeat.

4- Produce new solutions (food source positions) using equation (7).

$$v_{ij} = x_{ij} + \varphi_{ij}(x_{ij} + x_{kj}) \qquad (7)$$

where$k \in$ {1, 2, …, *NP*} and *j*∈{1, 2, …, *D*} are randomly chosen indexes. Moreover, $k \neq$ i. $\varphi_{ij}$is a random number between [-1, 1].

5- Apply the greedy selection process between x_{ij},*G*and v_{ij},*G*.

6- Calculate the probability values P_i for the solutions
x_{ij},*G*using the equation (8).

$$P_i = \frac{fit_i}{\sum_i^{SN} fit_i} \qquad (8)$$

where $fit_i$is the fitness value of the solution *i*which is proportional to the nectar amount of the food source in the position *i*and *SN*is the number of food sources which is equal to the number of employed bees.

following equation is employed:

$$fit_i = \begin{cases} \frac{1}{1+f_i} & if\ f_i \geq 0 \\ 1 + abs(f_i) & if\ f_i < 0 \end{cases} \qquad (9)$$

Normalize P_i values into [0, 1].

7- Produce the new solutions (new positions) v_{ij},*G* for the onlookers from the solutions x_{ij},*G* , selected depending on P_i, and evaluate them.

8- Apply the greedy selection process for the onlookers

betweenx_{ij},*G* and v_{ij},*G*.

9- Determine the abandoned solution (source), if exists, and replace it with a new randomly produced solution $x_i$for the scout using the equation (10).

$$x_{ij} = x_j^{min} + rand()(x_j^{max} - x_j^{min}) \qquad (10)$$

where$x_j^{max}$and x_j^{min} are upper and lower bounds of parameter *j*, respectively.

10- Memorize the best food source position (solution)
achieved so far.

11- cycle = cycle+1.

12- until cycle = Maximum Cycle Number (MCN)[8][9].

4- RESULTS AND DISCUSSION

Firstly, the two techniques (conventional and ABC) were tested on test systems for solving ED problem. The test system consist of six units generating units considered are having different characteristics (Appendix-One). table (1) shows ED is solved by using conventional Method and ABC techniques for the test system.

As seen in Table (1), F_c in ABC (36912.2 $/hr) is less than Conventional method (38570.1 $/hr). So that solving ED by ABC technique is better than Conventional method.

The second step is finding ED of Iraqi National Grid (ING) by ABC technique. The model of 24 bus, 400 kV(HV) interconnected ING is shown in Figure (1).

Bus data of INGare shown in the Table (2).

Table (3) shows line data of ING.

Table (4) shows cost functions and generation limits.

From bus data and line data, we can calculate the transmission line loss, according to equation (6). After that, ABC has been applied for the first time on the ING (400 Kv, 24-bus)to get the lowest fuel cost generation. Table (5) shows the result of ED by using ABC for ING.

5- CONCLUSIONS

In this paper, the artificial bee colony algorithm was proposed as an algorithm to find the economic dispatch of power system and decrease the fuel cost generation. The ABC is better than conventional method because the conventional method performance is dependent on the number of segments of the linearized generating cost function, whilst ABC does not need to linearize the generating cost function. The proposed technique has been demonstrated by the test system and confirmed to have usable and effective in the solution of ED problems and decrease the fuel cost generation.

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Table (1) the test system results.

Cases		Economic dispatch	
		Conventional Method	ABC
Output Power (MW)	P1	28.29073	28.29231803
	P2	10	10
	P3	118.958	118.9581071
	P4	118.6747	118.6722033
	P5	230.7629	230.7561789
	P6	212.7455	212.753086
Fuel Cost(F_c),$/hr		38644.6	36912.2

Table (2) Bus data of ING

No.	Abb. Code	Code	Voltage Mag.	Angle Degree	Load		Generator				Injected
					Mw	Mvar	Mw	Mvar	Qmin	Qmax	Mvar
1	BAJP	1	1	0	140	105	0	0	-300	450	0
2	BAJG	2	1	0	0	0	400	0	-320	440	0
3	MSLD	3	1	0	0	0	450	0	-260	400	0
4	KRK4	4	0.99	0	200	150	200	0	0	0	0
5	HDTH	5	1	0	120	90	200	0	-120	140	0
6	QDSG	6	0.99	0	0	0	600	0	-140	280	0
7	MUSG	7	1	0	0	0	200	0	0	0	0
8	MUSP	8	1	0	210	157.5	700	0	-480	1080	0
9	NSRP	9	0.97	0	300	225	480	0	0	0	0
10	HRTP	10	0.96	0	180	135	300	0	-150	200	0
11	KAZG	11	0.96	0	200	150	220	0	-100	160	0
12	MSL4	12	1	0	500	375	0	0	0	0	0
13	QIM4	13	1	0	70	52.5	0	0	0	0	0
14	BGW4	14	1	0	500	375	0	0	0	0	0
15	BAB4	15	1	0	200	150	0	0	0	0	0
16	RSH4	16	1	0	90	67.5	0	0	0	0	0
17	KDS4	17	1	0	200	150	0	0	0	0	0
18	BGN4	18	1	0	390	292.5	0	0	0	0	0
19	BGS4	19	1	0	125	93.75	0	0	0	0	0
20	AMN4	20	1	0	75	56.25	0	0	0	0	0
21	KUT4	21	1	0	180	135	0	0	0	0	0
22	AMR4	22	1	0	175	131.25	0	0	0	0	0
23	BGE4	23	1	0	150	112.5	0	0	0	0	0
24	DYL4	24	1	0	110	82.5	0	0	0	0	0

Table (3) Line data of ING.

From Bus	Bus Name	To Bus	Bus Name	CKT No.	R P.U	X P.U	B P.U
3	MSLD	12	MSL4	1	0.001436	0.011768	0.364392
3	MSLD	12	MSL4	2	0.001436	0.011768	0.364392
12	MSL4	1	BAJP	1	0.004195	0.034371	1.064256
12	MSL4	1	BAJP	2	0.004195	0.034371	1.064256
1	BAJP	2	BAJG	1	2.17E-05	0.000197	0.005837
1	BAJP	5	HDTH	1	0.003446	0.031323	0.928083
1	BAJP	14	BGW4	1	0.005049	0.045901	1.360021
1	BAJP	14	BGW4	2	0.004962	0.045113	1.336673
2	BAJG	4	KRK4	1	0.001799	0.016351	0.484471
4	KRK4	23	BGE4	1	0.005049	0.045901	1.360021
5	HDTH	13	QIM4	1	0.002918	0.02391	0.740352
5	HDTH	14	BGW4	1	0.004845	0.044049	1.305153
24	DYL4	23	BGE4	1	0.000867	0.00788	0.23348
6	QDSG	18	BGN4	1	0.000152	0.001379	0.040859
6	QDSG	18	BGN4	2	0.000152	0.001379	0.040859
18	BGN4	23	BGE4	1	0.000288	0.00262	0.077632
18	BGN4	14	BGW4	1	0.000932	0.008471	0.250991
20	AMN4	23	BGE4	1	0.000433	0.00394	0.11674
20	AMN4	23	BGE4	2	0.000433	0.00394	0.11674
19	BGS4	20	AMN4	1	0.000824	0.007486	0.221806
19	BGS4	20	AMN4	2	0.000824	0.007486	0.221806
16	RSH4	14	BGW4	1	0.000607	0.005516	0.163436
16	RSH4	19	BGS4	1	0.000954	0.008668	0.256828
7	MUSG	8	MUSP	1	0.000125	0.001043	0.032791
7	MUSG	19	BGS4	1	0.001094	0.009106	0.286176
8	MUSP	19	BGS4	1	0.00122	0.010149	0.318967
8	MUSP	15	BAB4	1	0.000809	0.006734	0.211651
8	MUSP	15	BAB4	2	0.000809	0.006734	0.211651
19	BGS4	21	KUT4	1	0.0026	0.02364	0.70044
19	BGS4	17	KDS4	1	0.003075	0.027954	0.82827
15	BAB4	17	KDS4	1	0.002326	0.019349	0.608124
15	BAB4	17	KDS4	2	0.002326	0.019349	0.608124
21	KUT4	9	NSRP	1	0.004789	0.043537	1.289977
21	KUT4	22	AMR4	1	0.004321	0.039282	1.163898
17	KDS4	9	NSRP	1	0.003833	0.034849	1.032565
22	AMR4	10	HRTP	1	0.002904	0.026398	0.782158
9	NSRP	11	KAZG	1	0.004393	0.039932	1.18316
10	HRTP	11	KAZG	1	0.001183	0.010756	0.3187

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Table (4) cost functions and generation limits.

bus no.	a($/MW^2)	b($/MW)	c($)	P_{min}(MW)	P_{max}(MW)
1	0.05	2.115	2581	120	550
2	0.03	11.91	1698	120	450
3	0	0	0	130	550
4	0.0136	7.05	154	60	250
5	0	0	0	60	250
6	0.0017	0.64	200	180	600
7	0.154	63.42	517.3	75	250
8	0.0012	0.35	275	200	750
9	0.002	0.561	159	120	550
10	0.0025	0.8	120	100	300
11	0.0158	3.1	658	50	250

Table (5) the result of ED by using ABC for ING

unit no.	1	2	3	4	5	6	7	8	9	10	11	F_c ($/h)
P / MW	120	425.431	550	250	250	599.9857	161.2877	750	550	299.5808	250	39764

Appendix-One

Standard system data for Test System

Table (1-1) Generator cost data for Test System.

unit no.	a ($/MW^2)	b ($/MW)	c ($)	Pmin(MW)	Pmax(MW)
1	0.15247	38.53973	756.7989	10	125
2	0.10587	46.15916	451.3251	10	150
3	0.02803	40.3965	1049.998	35	225
4	0.03546	38.30553	1243.531	35	210
5	0.02111	36.32782	1658.569	130	325
6	0.01799	38.27041	1356.659	125	315

Table (1-2) The transmission loss coefficients B *1e-4.

No. plant	1	2	3	4	5	6
1	1.4	0.17	0.15	0.19	0.26	0.22
2	0.17	0.6	0.13	0.16	0.15	0.2
3	0.15	0.13	0.65	0.17	0.24	0.19
4	0.19	0.16	0.17	0.71	0.3	0.25
5	0.26	0.15	0.24	0.3	0.69	0.32
6	0.22	0.2	0.19	0.25	0.32	0.85

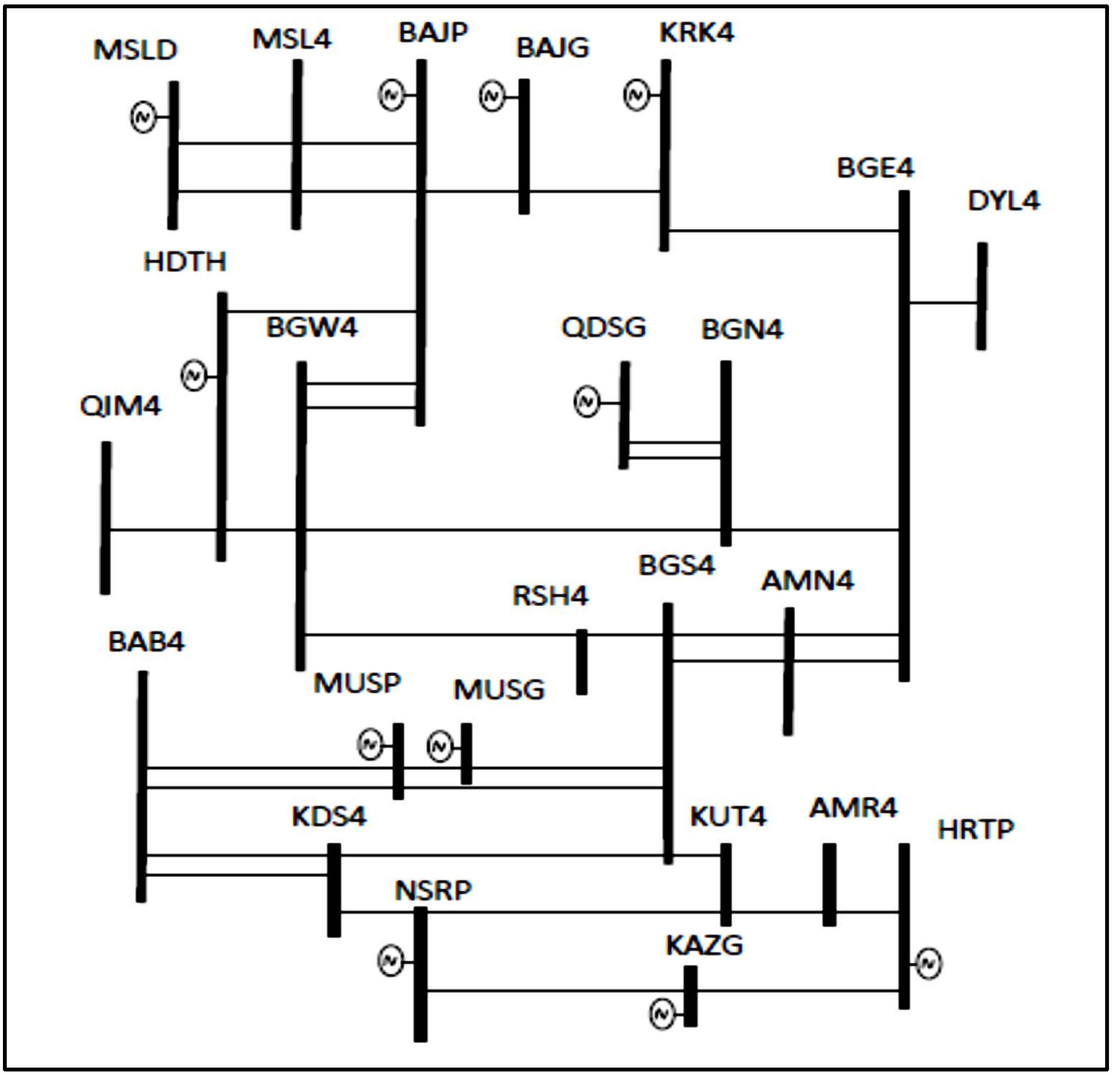

Figure (1) 24 bus, 400 kV(HV) interconnected ING.

الانجاز الاقتصادي الامثل للشبكة الكهربائية العراقية باستخدام تقنية مستعمرة النحل الاصطناعية

الخلاصة

يعتبر الانجاز الاقتصادي في انظمة الطاقة الكهربائية من اهم المشاكل الامثل لتوفير وايجاد الظروف الاقتصادية لوحدات التوليد. الصفة غير الخطية المرتبطة بهذه المشكلة تجعل الطرق التقليدية غير قادرة على تحديد حل سريع وقوي، خصوصا عندما يحتوي نظام القدرة على وحدات توليد كثيرة. في هذا البحث ، استخدمت تقنية التحسين باستخدام مستعمرة النحل الاصطناعية في حل مشكلة الاقتصادية في نظام القدرة. وهذه الطريقة مستوحاة من تصرف النحل للبحث عن مصادر الطعام. تم مقارنة النتائج المستحصلة من هذه الطريقة مع نتائج الطرق التقليدية باستخدام نظام اختباري. وقد بينت النتائج ان نهج الخوارزمية لمستعمرة النحل الاصطناعية له كفاءة واضحة لايجاد اقل الكلف. تم تطبيق خوارزمية النحل الاصطناعية على الشبكة الكهربائية العراقية. لقد نفذت الخوارزميات المقترحة بلغة الماتلاب.