HILL PUBLISHING

Journal of Electrical Power & Energy Systems, 2020, 4(1), 1-10
https://www.hillpublisher.com/journals/jepes/
ISSN Online: 2576-053X
ISSN Print: 2576-0521

Factual Power Loss Diminution by Enriched Artificial Fish Swarm Algorithm

Kanagasabai Lenin

Department of EEE, Prasad V. Potluri Siddhartha Institute of Technology, Kanuru, Vijayawada, Andhra Pradesh -520007, India.

How to cite this paper: Kanagasabai Lenin. (2020) Factual Power Loss Diminution by Enriched Artificial Fish Swarm Algorithm. *Journal of Electrical Power & Energy Systems*, 4(1), 1-10.
DOI: 10.26855/jepes.2020.05.001

Received: March 22, 2020
Accepted: April 30, 2020
Published: May 8, 2020

***Corresponding author:** Kanagasabai Lenin, Department of EEE, Prasad V. Potluri Siddhartha Institute of Technology, Kanuru, Vijayawada, Andhra Pradesh -520007, India.
Email: gklenin@gmail.com

Abstract

In this work Enriched Artificial Fish swarm (EAFS) algorithm is projected to solve optimal reactive power problem. In the proposed algorithm, food concentration function, bulletin board approach, target position search mechanism, and position move method are utilized. Subsequently, an adjustment strategy of exploration range of artificial fish, which merge the global search with local search, is projected to enhance the explore capability of the projected algorithm. Every artificial fish will execute the swarming behavior, following behavior and foraging behavior in order to discover the goal move position X_i^{next} with the superior food concentration. The position with the uppermost food concentration of the new-fangled positions (Xnext1, Xnext2 andXnext3) are found by these behaviours' is used as X_i^{next} . Proposed Enriched Artificial Fish swarm (EAFS) algorithm has been tested in standard IEEE 14, 30, 57,118,300 bus test systems and simulation results show the projected algorithm reduced the real power loss comprehensively.

Keywords

Optimal Reactive Power, Transmission Loss, Enriched Artificial Fish Swarm Algorithm

1. Introduction

Reactive power problem plays an important role in secure and economic operations of power system. Numerous types of methods [1-6] have been utilized to solve the optimal reactive power problem. However many scientific difficulties are found while solving problem due to an assortment of constraints. Evolutionary techniques [7-16] are applied to solve the reactive power problem. This paper proposes Enriched Artificial Fish swarm (EAFS) algorithm to solve optimal reactive power problem. Artificial fish swarm algorithm inspired from the natural behaviours' of fish swarm searching food in water, the artificial fish swarm algorithm. In the proposed Enriched Artificial Fish swarm (EAFS) algorithm which uses the adjustment strategy of exploration range of the artificial fish in iterations. Bulletin board is utilized for recording the optimal position with the utmost food concentration which has been found by fish swarm. In initial iteration, the bulletin board will record the optimal position of the preliminary positions of artificial fish. When the artificial fish moves to a new-fangled position for finding food with superior food concentration, the bulletin board is modernized to record the optimal position discovered so far. After finding X_i^{next} , the ith artificial fish make a decision about the movement to X_i^{next} . When the food concentration of X_i^{next} is superior to X_i , then the ith artificial fish move towards to X_i^{next} from

X_i , then X_i is modernized by X_i^{next} . Or else, ith artificial fish gives up moving towards X_i^{next} , then X_i stay unmoved. Proposed Enriched Artificial Fish Swarm (EAFS) algorithm has been tested in standard IEEE 14, 30, 57,118,300 bus test systems and simulation results show the projected algorithm reduced the real power loss comprehensively.

2. Problem Formulation

Objective of the problem is to reduce the true power loss:

$$F = P_L = \sum_{k\in Nbr} g_k \left(V_i^2 + V_j^2 - 2V_iV_j\cos\theta_{ij}\right) \quad (1)$$

Voltage deviation given as follows:

$$F = P_L + \omega_v \times \text{Voltage } Deviation \quad (2)$$

Voltage deviation given by:

$$\text{Voltage Deviation} \quad = \sum_{i=1}^{Npq} |V_i - 1| \quad (3)$$

Constraint (Equality)

$$P_G = P_D + P_L \quad (4)$$

Constraints (Inequality)

$$P_{gslack}^{min} \le P_{gslack} \le P_{gslack}^{max} \quad (5)$$

$$Q_{gi}^{min} \le Q_{gi} \le Q_{gi}^{max}, i \in N_g \quad (6)$$

$$V_i^{min} \le V_i \le V_i^{max}, i \in N \quad (7)$$

$$T_i^{min} \le T_i \le T_i^{max}, i \in N_T \quad (8)$$

$$Q_c^{min} \le Q_c \le Q_C^{max}, i \in N_C \quad (9)$$

3. Enriched Artificial Fish Swarm Algorithm

Artificial fish swarm algorithm inspired from the natural behaviors of fish swarm searching food in water, the artificial fish swarm algorithm. In the proposed Enriched Artificial Fish swarm (EAFS) algorithm which uses the adjustment strategy of exploration range of the artificial fish in iterations.

The feasible preliminary positions of "N" artificial fish in the fish swarm are arbitrarily engendered to wrap the whole exploration space,

$$X_i = \left[x_{(i,1)}, x_{(i,2)}, x_{(i,j)}, .., x_{(i,n)}\right] \quad (10)$$

$x_{(i,j)}$ has to satisfy the predefined range,

$$x_{min} \le x_{(i,j)} \le x_{max} \quad (11)$$

Food concentration of the location of the artificial fish is utilized for assessing the capability of the solution to solve the reactive power problem,

$$Fc = F(obj, pty) \quad (12)$$

Obj ; objective function value of the position, and Fc; food concentration of the position

Bulletin board is utilized for recording the optimal position with the utmost food concentration which has been found by fish swarm. In initial iteration, the bulletin board will record the optimal position of the preliminary positions of artificial fish. When the artificial fish moves to a new-fangled position for finding food with superior food concentration, the bulletin board is modernized to record the optimal position discovered so far.

Every artificial fish will execute the swarming behavior, following behavior and foraging behavior in order to discover the goal move position X_i^{next} with the superior food concentration. The position with the uppermost food concentration of the new-fangled positions (Xnext1, Xnext2 andXnext3) are found by these behaviors is used as X_i^{next}.

Swarming Behaviour

Assume that the present state of artificial fish is $X_i\left(d_{i,j} < Visual\right)$, number of artificial fish is n_f , if $n_f < \delta$ indicate that the cohort [17] have more food and less crowded, if X_c better than X_i, subsequently move towards the center of the direction of the partnership,

$$Xnext1 = X_i + random(0,1) * step_{iteration} * \frac{X_c - X_i}{\|X_c - X_i\|} \tag{13}$$

Following Behaviour

Every artificial fish discover the most excellent position VBX with the uppermost food concentration in its visual range,

$$Xnext2 = X_i + random(0,1) * step_{iteration} * \frac{VBX - X_i}{\|VBX - X_i\|} \tag{14}$$

Foraging behavior

Choose the arbitrary position T X in the visual range of the ith artificial fish by using Equation below,

$$TX = X_i + visual_{iteration} * (-1 + 2 * random[1,n]) \tag{15}$$

$$Xnext3 = X_i + random(0,1) * step_{iteration} * \frac{TX - X_i}{\|TX - X_i\|} \tag{16}$$

Random behavior

The random behavior is implemented by the ith artificial fish, when swarming behavior, following behavior and foraging behavior is not successful,

$$Xnext4 = X_i + step_{iteration} * (-1 + 2 * random[1,n]) \tag{17}$$

Position move

After finding X_i^{next}, the ith artificial fish make a decision about the movement to X_i^{next}. When the food concentration of X_i^{next} is superior to X_i , then the ith artificial fish move towards to X_i^{next} from X_i , then X_i is modernized by X_i^{next}. Or else, ith artificial fish gives up moving towards X_i^{next} , then X_i stay unmoved.

The values of $visual_{iteration}$ and $step_{iteration}$ of artificial fish are animatedly attuned in the every iteration. The $visual_{iteration}$ and $step_{iteration}$ computed by,

$$visual_{iteration} = \frac{(maximum\ number\ of iteration - current\ iteration)^t}{(maximum\ number\ of iteration)^t} * (Vin - Vfn) + Vfn \tag{18}$$

$$step_{iteration} = \frac{(maximum\ number\ of iteration - current\ iteration)^t}{(maximum\ number\ of iteration)^t} * (Sin - Sfn) + Sfn \tag{19}$$

a. Begin
b. Position of the "N" artificial fish is initialized the in fish swarm
c. Iter=1
d. Bulletin board is initialized
e. Compute the values of $visual_{iteration}$ and $step_{iteration}$
f. Every artificial fish will execute the swarming behavior, following behavior and foraging behavior in order to discover the goal move position X_i^{next} with the superior food concentration.
g. After finding X_i^{next}, the ith artificial fish make a decision about the movement to X_i^{next}. When the food concentration of X_i^{next} is superior to X_i , then the ith artificial fish move towards to X_i^{next} from X_i , then X_i is modernized by X_i^{next}. Or else, ith artificial fish gives up moving towards X_i^{next} , then X_i stay unmoved.
h. Bulletin board updated
i. Iter= iter+1
j. $iter > maximum\ number\ of\ iteration$ if yes stop and output the result or else go to step e

4. Simulation Results

At first in standard IEEE 14 bus system the validity of the proposed Enriched Artificial Fish swarm (EAFS) algorithm has been tested, Table 1 shows the constraints of control variables Table 2 shows the limits of reactive power generators and comparison results are presented in Table 3.

Table 1. Constraints of control variables

System	Variables	Minimum (PU)	Maximum (PU)
IEEE 14 Bus	Generator Voltage	0.95	1.1
	Transformer Tap	0.9	1.1
	VAR Source	0	0.20

Table 2. Constrains of reactive power generators

System	Variables	Q Minimum (PU)	Q Maximum (PU)
IEEE 14 Bus	1	0	10
	2	-40	50
	3	0	40
	6	-6	24
	8	-6	24

Table 3. Simulation results of IEEE −14 system

Control variables	Base case	MPSO [19]	PSO [19]	EP [19]	SARGA [19]	EAFS
VG−1	1.060	1.100	1.100	NR*	NR*	1.028
VG−2	1.045	1.085	1.086	1.029	1.060	1.032
VG−3	1.010	1.055	1.056	1.016	1.036	1.029
VG−6	1.070	1.069	1.067	1.097	1.099	1.030
VG−8	1.090	1.074	1.060	1.053	1.078	1.013
Tap 8	0.978	1.018	1.019	1.04	0.95	0.907
Tap 9	0.969	0.975	0.988	0.94	0.95	0.929
Tap 10	0.932	1.024	1.008	1.03	0.96	0.940
QC−9	0.19	14.64	0.185	0.18	0.06	0.151
PG	272.39	271.32	271.32	NR*	NR*	271.27
QG (Mvar)	82.44	75.79	76.79	NR*	NR*	74.92
Reduction in PLoss (%)	0	9.2	9.1	1.5	2.5	12.37
Total PLoss (Mw)	13.550	12.293	12.315	13.346	13.216	11.873

NR* - Not reported.

Then the proposed Enriched Artificial Fish swarm (EAFS) algorithm has been tested, in IEEE 30 Bus system. Table 4 shows the constraints of control variables, Table 5 shows the limits of reactive power generators and comparison results are presented in Table 6.

Table 4. Constraints of control variables

System	Variables	Minimum (PU)	Maximum (PU)
IEEE 30 Bus	Generator Voltage	0.95	1.1
	Transformer Tap	0.9	1.1
	VAR Source	0	0.20

Table 5. Constrains of reactive power generators

System	Variables	Q Minimum (PU)	Q Maximum (PU)
IEEE 30 Bus	1	0	10
	2	-40	50
	5	-40	40
	8	-10	40
	11	-6	24
	13	-6	24

Table 6. Simulation results of IEEE −30 system

Control variables	Base case	MPSO [19]	PSO [19]	EP [19]	SARGA [19]	EAFS
$VG-1$	1.060	1.101	1.100	NR*	NR*	1.039
$VG-2$	1.045	1.086	1.072	1.097	1.094	1.026
$VG-5$	1.010	1.047	1.038	1.049	1.053	1.057
$VG-8$	1.010	1.057	1.048	1.033	1.059	1.028
$VG-12$	1.082	1.048	1.058	1.092	1.099	1.063
VG-13	1.071	1.068	1.080	1.091	1.099	1.056
Tap11	0.978	0.983	0.987	1.01	0.99	0.912
Tap12	0.969	1.023	1.015	1.03	1.03	0.928
Tap15	0.932	1.020	1.020	1.07	0.98	0.912
Tap36	0.968	0.988	1.012	0.99	0.96	0.919
QC10	0.19	0.077	0.077	0.19	0.19	0.098
QC24	0.043	0.119	0.128	0.04	0.04	0.126
PG (MW)	300.9	299.54	299.54	NR*	NR*	298.16
QG (Mvar)	133.9	130.83	130.94	NR*	NR*	130.93
Reduction in PLoss (%)	0	8.4	7.4	6.6	8.3	21.19
Total PLoss (Mw)	17.55	16.07	16.25	16.38	16.09	13.83

NR* - Not reported.

Then the proposed Enriched Artificial Fish swarm (EAFS) algorithm has been tested, in IEEE 57 Bus system. Table 7 shows the constraints of control variables, Table 8 shows the limits of reactive power generators and comparison results are presented in Table 9.

Table 7. Constraints of control variables

System	Variables	Minimum (PU)	Maximum (PU)
IEEE 57 Bus	Generator Voltage	0.95	1.1
	Transformer Tap	0.9	1.1
	VAR Source	0	0.20

Table 8. Constrains of reactive power generators

System	Variables	Q Minimum (PU)	Q Maximum (PU)
IEEE 57 Bus	1	-140	200
	2	-17	50
	3	-10	60
	6	-8	25
	8	-140	200
	9	-3	9
	12	-150	155

Table 9. Simulation results of IEEE-57 system

Control variables	Base case	MPSO [19]	PSO [19]	CGA [19]	AGA [19]	EAFS
VG 1	1.040	1.093	1.083	0.968	1.027	1.029
VG 2	1.010	1.086	1.071	1.049	1.011	1.015
VG 3	0.985	1.056	1.055	1.056	1.033	1.034
VG 6	0.980	1.038	1.036	0.987	1.001	1.012
VG 8	1.005	1.066	1.059	1.022	1.051	1.039
VG 9	0.980	1.054	1.048	0.991	1.051	1.010
VG 12	1.015	1.054	1.046	1.004	1.057	1.042
Tap 19	0.970	0.975	0.987	0.920	1.030	0.953
Tap 20	0.978	0.982	0.983	0.920	1.020	0.935
Tap 31	1.043	0.975	0.981	0.970	1.060	0.927
Tap 35	1.000	1.025	1.003	NR*	NR*	1.019
Tap 36	1.000	1.002	0.985	NR*	NR*	1.006
Tap 37	1.043	1.007	1.009	0.900	0.990	1.002
Tap 41	0.967	0.994	1.007	0.910	1.100	0.995
Tap 46	0.975	1.013	1.018	1.100	0.980	1.014
Tap 54	0.955	0.988	0.986	0.940	1.010	0.973
Tap 58	0.955	0.979	0.992	0.950	1.080	0.961
Tap 59	0.900	0.983	0.990	1.030	0.940	0.966
Tap 65	0.930	1.015	0.997	1.090	0.950	1.008
Tap 66	0.895	0.975	0.984	0.900	1.050	0.952
Tap 71	0.958	1.020	0.990	0.900	0.950	1.006
Tap 73	0.958	1.001	0.988	1.000	1.010	1.009
Tap 76	0.980	0.979	0.980	0.960	0.940	0.962
Tap 80	0.940	1.002	1.017	1.000	1.000	1.006
QC 18	0.1	0.179	0.131	0.084	0.016	0.179
QC 25	0.059	0.176	0.144	0.008	0.015	0.161
QC 53	0.063	0.141	0.162	0.053	0.038	0.142
PG (MW)	1278.6	1274.4	1274.8	1276	1275	1267.71
QG (Mvar)	321.08	272.27	276.58	309.1	304.4	271.84
Reduction in PLoss (%)	0	15.4	14.1	9.2	11.6	24.55
Total PLoss (Mw)	27.8	23.51	23.86	25.24	24.56	20.973

NR* - Not reported.

Then the proposed Enriched Artificial Fish swarm (EAFS) algorithm has been tested, in IEEE 118 Bus system. Table 10 shows the constraints of control variables and comparison results are presented in Table 11.

Table 10. Constraints of control variables

System	Variables	Minimum (PU)	Maximum (PU)
IEEE 118 Bus	Generator Voltage	0.95	1.1
	Transformer Tap	0.9	1.1
	VAR Source	0	0.20

Table 11. Simulation results of IEEE-118 system

Control variables	Base case	MPSO [19]	PSO [19]	PSO [19]	CLPSO [19]	EAFS
VG 1	0.955	1.021	1.019	1.085	1.033	1.019
VG 4	0.998	1.044	1.038	1.042	1.055	1.048
VG 6	0.990	1.044	1.044	1.080	0.975	1.023
VG 8	1.015	1.063	1.039	0.968	0.966	1.005
VG 10	1.050	1.084	1.040	1.075	0.981	1.014
VG 12	0.990	1.032	1.029	1.022	1.009	1.023
VG 15	0.970	1.024	1.020	1.078	0.978	1.039
VG 18	0.973	1.042	1.016	1.049	1.079	1.042
VG 19	0.962	1.031	1.015	1.077	1.080	1.035
VG 24	0.992	1.058	1.033	1.082	1.028	1.014
VG 25	1.050	1.064	1.059	0.956	1.030	1.033
VG 26	1.015	1.033	1.049	1.080	0.987	1.056
VG 27	0.968	1.020	1.021	1.087	1.015	0.905
VG 31	0.967	1.023	1.012	0.960	0.961	0.904
VG 32	0.963	1.023	1.018	1.100	0.985	0.912
VG 34	0.984	1.034	1.023	0.961	1.015	1.006
VG 36	0.980	1.035	1.014	1.036	1.084	1.005
VG 40	0.970	1.016	1.015	1.091	0.983	0.964
VG 42	0.985	1.019	1.015	0.970	1.051	1.003
VG 46	1.005	1.010	1.017	1.039	0.975	1.010
VG 49	1.025	1.045	1.030	1.083	0.983	1.001
VG 54	0.955	1.029	1.020	0.976	0.963	0.929
VG 55	0.952	1.031	1.017	1.010	0.971	0.962
VG 56	0.954	1.029	1.018	0.953	1.025	0.941
VG 59	0.985	1.052	1.042	0.967	1.000	0.969
VG 61	0.995	1.042	1.029	1.093	1.077	0.972
VG 62	0.998	1.029	1.029	1.097	1.048	0.988
VG 65	1.005	1.054	1.042	1.089	0.968	1.007
VG 66	1.050	1.056	1.054	1.086	0.964	1.003
VG 69	1.035	1.072	1.058	0.966	0.957	1.056
VG 70	0.984	1.040	1.031	1.078	0.976	1.033
VG 72	0.980	1.039	1.039	0.950	1.024	1.029
VG 73	0.991	1.028	1.015	0.972	0.965	1.018
VG 74	0.958	1.032	1.029	0.971	1.073	1.012
VG 76	0.943	1.005	1.021	0.960	1.030	1.010
VG 77	1.006	1.038	1.026	1.078	1.027	1.028
VG 80	1.040	1.049	1.038	1.078	0.985	1.029
VG 85	0.985	1.024	1.024	0.956	0.983	1.012
VG 87	1.015	1.019	1.022	0.964	1.088	1.015
VG 89	1.000	1.074	1.061	0.974	0.989	1.044
VG 90	1.005	1.045	1.032	1.024	0.990	1.033
VG 91	0.980	1.052	1.033	0.961	1.028	1.002

VG 92	0.990	1.058	1.038	0.956	0.976	1.039
VG 99	1.010	1.023	1.037	0.954	1.088	1.011
VG 100	1.017	1.049	1.037	0.958	0.961	1.022
VG 103	1.010	1.045	1.031	1.016	0.961	1.018
VG 104	0.971	1.035	1.031	1.099	1.012	1.007
VG 105	0.965	1.043	1.029	0.969	1.068	1.056
VG 107	0.952	1.023	1.008	0.965	0.976	1.015
VG 110	0.973	1.032	1.028	1.087	1.041	1.014
VG 111	0.980	1.035	1.039	1.037	0.979	1.003
VG 112	0.975	1.018	1.019	1.092	0.976	1.092
VG 113	0.993	1.043	1.027	1.075	0.972	1.001
VG 116	1.005	1.011	1.031	0.959	1.033	1.006
Tap 8	0.985	0.999	0.994	1.011	1.004	0.935
Tap 32	0.960	1.017	1.013	1.090	1.060	1.004
Tap 36	0.960	0.994	0.997	1.003	1.000	0.950
Tap 51	0.935	0.998	1.000	1.000	1.000	0.932
Tap 93	0.960	1.000	0.997	1.008	0.992	1.019
Tap 95	0.985	0.995	1.020	1.032	1.007	0.978
Tap 102	0.935	1.024	1.004	0.944	1.061	1.028
Tap 107	0.935	0.989	1.008	0.906	0.930	0.942
Tap 127	0.935	1.010	1.009	0.967	0.957	1.013
QC 34	0.140	0.049	0.048	0.093	0.117	0.025
QC 44	0.100	0.026	0.026	0.093	0.098	0.017
QC 45	0.100	0.196	0.197	0.086	0.094	0.169
QC 46	0.100	0.117	0.118	0.089	0.026	0.132
QC 48	0.150	0.056	0.056	0.118	0.028	0.050
QC 74	0.120	0.120	0.120	0.046	0.005	0.143
QC 79	0.200	0.139	0.140	0.105	0. 148	0.110
QC 82	0.200	0.180	0.180	0.164	0.194	0.164
QC 83	0.100	0.166	0.166	0.096	0.069	0.135
QC 105	0.200	0.189	0.190	0.089	0.090	0.168
QC 107	0.060	0.128	0.129	0.050	0.049	0.140
QC 110	0.060	0.014	0.014	0.055	0.022	0.010
PG(MW)	4374.8	4359.3	4361.4	NR*	NR*	4381.67
QG(MVAR)	795.6	604.3	653.5	* NR*	NR*	612.92
Reduction in PLOSS(%)	0	11.7	10.1	0.6	1.3	13.53
Total PLOSS (Mw)	132.8	117.19	119.34	131.99	130.96	114.83

NR* - Not reported.

Then IEEE 300 bus system [18] is used as test system to validate the performance of the Enriched Artificial Fish swarm (EAFS) algorithm. Table 12 shows the comparison of real power loss obtained after optimization.

Table 12. Comparison of Real Power Loss

Parameter	Method EGA [21]	Method EEA [21]	Method CSA [20]	EAFS
PLOSS (MW)	646.2998	650.6027	635.8942	611.6372

5. Conclusion

In this work Enriched Artificial Fish swarm (EAFS) algorithm successfully solved the optimal reactive power problem. In the proposed algorithm which uses the adjustment strategy of exploration range of the artificial fish in iterations. Bulletin board is utilized for recording the optimal position with the utmost food concentration which has been found by fish swarm. In initial iteration, the bulletin board will record the optimal position of the preliminary positions of artificial fish. When the artificial fish moves to a new-fangled position for finding food with superior food concentration, the bulletin board is modernized to record the optimal position discovered so far. Proposed Enriched Artificial Fish swarm (EAFS) algorithm has been tested in standard IEEE 14, 30, 57,118,300 bus test systems and simulation results show the projected algorithm reduced the real power loss comprehensively.

References

[1] K. Y. Lee. (1984). Fuel-cost minimisation for both real and reactive-power dispatches," Proceedings Generation, Transmission and Distribution Conference, vol/issue: 131(3), pp. 85-93.

[2] N. I. Deeb. (1998). An efficient technique for reactive power dispatch using a revised linear programming approach. Electric Power System Research, vol/issue: 15(2), pp. 121-134.

[3] M. R. Bjelogrlic, M. S. Calovic, B. S. Babic. (1990). Application of Newton's optimal power flow in voltage/reactive power control. IEEE Trans Power System, vol. 5, no. 4, pp. 1447-1454.

[4] S. Granville. (1994). Optimal reactive dispatch through interior point methods. IEEE Transactions on Power System, vol/issue: 9(1), pp. 136-146.

[5] N. Grudinin. (1998). Reactive power optimization using successive quadratic programming method. IEEE Transactions on Power System, vol/issue: 13(4), pp. 1219-1225.

[6] Ng Shin Mei, R., Sulaiman, M.H., Mustaffa, Z., Daniyal, H. (2017). Optimal reactive power dispatch solution by loss minimization using moth-flame optimization technique. Appl. Soft Comput. 2017, 59, 210-222.

[7] Chen, G., Liu, L., Zhang, Z., Huang, S. (2017). Optimal reactive power dispatch by improved GSA-based algorithm with the novel strategies to handle constraints. Appl. Soft Comput. 2017, 50, 58-70.

[8] Naderi, E., Narimani, H., Fathi, M., Narimani, M.R. (2017). A novel fuzzy adaptive configuration of particle swarm optimization to solve large-scale optimal reactive power dispatch. Appl. Soft Comput. 2017, 53, 441-456.

[9] Heidari, A.A., Ali Abbaspour, R., Rezaee Jordehi. (2017). A. Gaussian bare-bones water cycle algorithm for optimal reactive power dispatch in electrical power systems. Appl. Soft Comput. 2017, 57, 657-671.

[10] Mahaletchumi Morgan, Nor Rul Hasma Abdullah, Mohd Herwan Sulaiman, Mahfuzah Mustafa, Rosdiyana Samad. (2016). Benchmark Studies on Optimal Reactive Power Dispatch (ORPD) Based Multi-objective Evolutionary Programming (MOEP) Using Mutation Based on Adaptive Mutation Adapter (AMO) and Polynomial Mutation Operator (PMO). Journal of Electrical Systems, 12-1.

[11] Rebecca Ng Shin Mei, Mohd Herwan Sulaiman, Zuriani Mustaffa. (2016). Ant Lion Optimizer for Optimal Reactive Power Dispatch Solution. Journal of Electrical Systems, "Special Issue AMPE2015", pp. 68-74.

[12] Ram Kishan Mahate, & Himmat Singh. (2019). Multi-Objective Optimal Reactive Power Dispatch Using Differential Evolution. International Journal of Engineering Technologies and Management Research, 6(2), 27-38.

[13] Gagliano A., Nocera F. (2017). Analysis of the performances of electric energy storage in residential applications. International Journal of Heat and Technology. Vol. 35, Special Issue 1, pp. S41-S48.

[14] Caldera M., Ungaro P., Cammarata G., Puglisi G. (2018). Survey-based analysis of the electrical energy demand in Italian households. Mathematical Modelling of Engineering Problems, Vol. 5, No. 3, pp. 217-224.

[15] M. Basu. (2016). Quasi-oppositional differential evolution for optimal reactive power dispatch. Electrical Power and Energy Systems, vol. 78, pp. 29-40.

[16] T. Weise. (2009). Global Optimization Algorithms—Theory and Application, Germany: it-weise.de (self-published), [Online]. Available: http://www.it-weise.de/.

[17] M.A.K. Azad, A.M.A.C. Rocha, E.M.G.P. Fernandes. (2014). A simplified binary artificial fish swarm algorithm for 0-1 quadratic knapsack problems. Journal of Computation Applied Mathematics, 259, 897-904.

[18] IEEE. (1993). "The IEEE-test systems". http://www.ee.washington.edu/trsearch/pstca/.

[19] Ali Nasser Hussain, Ali Abdulabbas Abdullah and Omar Muhammed Neda. (2018). Modified Particle Swarm Optimization for Solution of Reactive Power Dispatch. Research Journal of Applied Sciences, Engineering and Technology 15(8): 316-327.

[20] S. Surender Reddy. (2017). Optimal Reactive Power Scheduling Using Cuckoo Search Algorithm. International Journal of Electrical and Computer Engineering. Vol. 7, No. 5, pp. 2349-2356.

[21] S.S. Reddy. (2014). Faster evolutionary algorithm based optimal power flow using incremental variables. Electrical Power and Energy Systems, vol. 54, pp. 198-210.