Int. J. Res. Ind. Eng. Vol. 9, No. 3 (2020) 209–215
DOI: 10.22105/riej.2020.229820.1133

IJRIE

International Journal of Research in
Industrial Engineering

www.riejournal.com

Real Power Loss Reduction by Acridoidea Stirred Artificial Bee Colony Algorithm

L. Kanagasabai

Department of EEE Prasad V.Potluri Siddhartha Institute of Technology,
Kanuru, Vijayawada, Andhra Pradesh -520007, India.
(gklenin@gmail.com)

ABSTRACT

Acridoidea Stirred Artificial Bee Colony (ASA) Algorithm is applied to solve the power loss reduction problem. In the projected algorithm natural Acridoidea jumping phenomenon has been imitated and the modeled design has been intermingled with Artificial Bee Colony Algorithm. In the proposed algorithm position update has been done through the distance of jumping done by Acridoidea. The distance (D) is horizontal (h) with angle (θ), velocity (V) parameter amplifying the rate which based on the gravity of Ballistic projectile. Normally the angle will be 45◦ horizontal and it depends on the take-off velocity. ASA Algorithm has been tested in standard IEEE 57 bus test system and results show that the proposed ASA algorithm reduced the real power loss effectively.

Keywords: Optimal reactive power, Transmission loss, Acridoidea stirred artificial bee colony algorithm.

Article history: *Received: 04 February 2020* *Reviewed: 13 March 2020* *Revised: 09 April 2020* *Accepted: 01 June 2020*

Kanagasabai, L. (2020). Real power loss reduction by acridoidea stirred artificial bee colony algorithm. *International journal of researchg in industrial engineering*, *9*(3), 209-215.

1. Introduction

For secure and economic operations of power system reactive power problem plays a lead role. Different methods like Newton's method, interior point, successive quadratic programming method) [2-5] have been solved the optimal reactive power problem. Conversely many difficulties are found while solving problem due various types of constraints. Evolutionary techniques like gravitational search, Ant Lion Optimizer, symbiotic organism search algorithm [6-15] are successfully solved the reactive power problem. In this work, Acridoidea Stirred Artificial Bee Colony (ASA) algorithm [1] has been projected to solve the optimal reactive power problem. Projected ASA algorithm has been formulated by intermingling the jumping action of Acridoidea with Artificial Bee Colony (ABC) algorithm. Employed bee, onlooker bee, and scout bee play key role in ABC algorithm [16]. Due to preset number of trials ABC algorithm employed bees solution unable to augment. So Acridoidea jumping phenomenon has been mathematically formulated and intermingled in the ABC algorithm. Acridoidea which possess the capability of jumping by overcoming the air resistance and the motion of a jumping is like to a bullet which emerges from gun. This progression is expressed as "ballistic movement"; equations which depict the kinetics of such actions are recognized. Modernization of position is computed from the Acridoidea jumping distance. Projected Acridoidea stirred Artificial Bee Colony (AAB) algorithm has been tested in standard IEEE 57 bus test systems and results show the proposed ASA algorithm reduced the real power loss efficiently.

2. Problem Formulation

Real power loss reduction is the key objective and it stated as

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

$$F = \text{Power loss} + \omega_v \times VD, \tag{2}$$

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

Constraint (Equality)

$$P_G = P_D + P_L. \tag{4}$$

Constraints (Inequality)

$$P_{gslack}^{min} \le P_{gslack} \le P_{gslack}^{max}, \tag{5}$$

$$Q_{gi}^{min} \le Q_{gi} \le Q_{gi}^{max}, i \in N_g, \tag{6}$$

$$V_i^{min} \le V_i \le V_i^{max}, i \in N_B, \tag{7}$$

$$T_i^{min} \le T_i \le T_i^{max}, i \in N_T, \tag{8}$$

$$Q_c^{min} \le Q_c \le Q_C^{max}, i \in N_C. \tag{9}$$

3. Acridoidea Stirred Artificial Bee Colony Algorithm

Employed bee, onlooker bee, scout bee are formed as groups in ABC algorithm. Due to the preset number of trials there won't be any augmentation in employed bees. Two foremost modes of behavior have been articulated to self-organize, and to make collective intelligence [16].

Initialization Stage. Food sources (population “SN”) are capriciously produced through scout bees; x_m (food source) is a vector to the problem; x_m has “D” and it indicates the dimension of exploration space.

$$x_m = l_i + \text{random}\ (0.1) * (u_i - l_i). \qquad (10)$$

Employed Bee Phase. Fresh food sources are found by the employed and the information will be shared with onlooker bees.

$$v_{mi} = x_{mi} + \Phi_{mi}(x_{mi} - x_{ki}). \qquad (11)$$

Fitness computation is done by,

$$\text{fit}_m(x_m) = \begin{Bmatrix} \frac{1}{1+f_m(x_m)}, f_m(x_m) > 0 \\ 1 + |f_m(x_m)|, f_m(x_m) < 0 \end{Bmatrix}. \qquad (12)$$

Onlooker Bee Phase. Profitability (Pm) of food sources is indicated by waggle dance.

$$P_m = \frac{\text{fit}_m(x_m)}{\sum_{m=1}^{SN} \text{fit}_m(x_m)}. \qquad (13)$$

Nearby area of food sources are explored by Onlooker bees by,

$$v_{mi} = x_{mi} + \Phi_{mi}(x_{mi} - x_{ki}). \qquad (14)$$

Scout Phase. When there is no enhancemnet in profitability of food source then it discarded by scout bees. Fresh solution x_m will be discovered by the scout and it defined by,

$$x_m = l_i + \text{rand}\ (0.1) * (u_i - l_i). \qquad (15)$$

Acridoidea jumping movement is termed as “ballistic movement”. The distance “D” is horizontal with angle θ, velocity V; “h” parameter amplifies the rate which based on the gravity Ballistic projectile and defined by,

$$D = \frac{V^2 \sin(2\theta)}{h}. \qquad (16)$$

Distance “D” in ***Eq. (16)*** will be employed as a fresh position of the best solution which will renew its position in the period of the exploration process.

$$x'_{bestj} = \sqrt{(x_{bestj})^2 + (x_{bestj} - x_{ij})^2} \times \sin(2\theta). \tag{17}$$

Where, “i" is capriciously preferred solution from the population; x'_{bestj} is the rationalized position of best solution; θ symbolizes the angle of rotation. $V^2 == \sqrt{(x_{bestj})^2 + (x_{bestj} - x_{ij})^2}$ is from the self-perseverance which capriciously is selected from the solution of the exploration space. "θ" varies from 0◦ to 360◦.

$$\text{angle of rotation } (\theta) = 10 \times t. \tag{18}$$

```
Start
Initialization of parameters
While stop criteria do
    Step a: for producing fresh food sources Employed bee phase will be applied.
    Step b: for renewal of the food sources Onlooker bee phase will be applied.
    Step c: fresh food sources in place of discarded food sources will be identified through Scout bee phase.
    Step d: Minimization f(x); Prefer best solution $x_{best}$ in the swarm and it modify its position;
    Iteration count =0
    While (t < T) do.
```

Produce a fresh solution x'_{bestj} as follows;

```
Input the best solution $x_{best}$ from the produced population;
capriciously select a solution $x_i$ from the population;
$\theta = 10 \times t /* t$ computed in iteration counter
For j = 1 to D do
    If U(0, 1) < Cr then (Cr - perturbation rate (0, 1))
        $x'_{bestj} = x_{bestj}$ otherwise
        $x'_{bestj} = \sqrt{(x_{bestj})^2 + (x_{bestj} - x_{ij})^2} \times \sin(2\theta)$
    End if
End for
Revisit $x'_{bestj}$
$f(x'_{bestj})$
If $f(x'_{bestj}) < f(x_{bestj})$ then $x_{best} = x'_{best}$
End if
t = t + 1;
End while
Engender best solution.
```

4. Simulation Study

Proposed ASA algorithm has been tested, in IEEE 57 Bus system [17]. ***Table 1*** shows the constraints of control variables; ***Table 2*** shows the limits of reactive power generators; comparison results of Particle Swarm Optimization (PSO), Modified Particle Swarm Optimization (MPSO), Canonical Genetic Algorithm (CGA), Adaptive Genetic Algorithm (AGA) are presented in ***Table 3***. Comparisons of real power loss are shown in ***Figures. 1*** & ***2***, indicate the real power loss reduction in percentage.

Table 1. Constraints of control variables.

Variables type	Minimum value (PU)	Maximum value (PU)
Generator Voltage	0.95	1.1
Transformer Tap	0.9	1.1
VAR Source	0	0.20

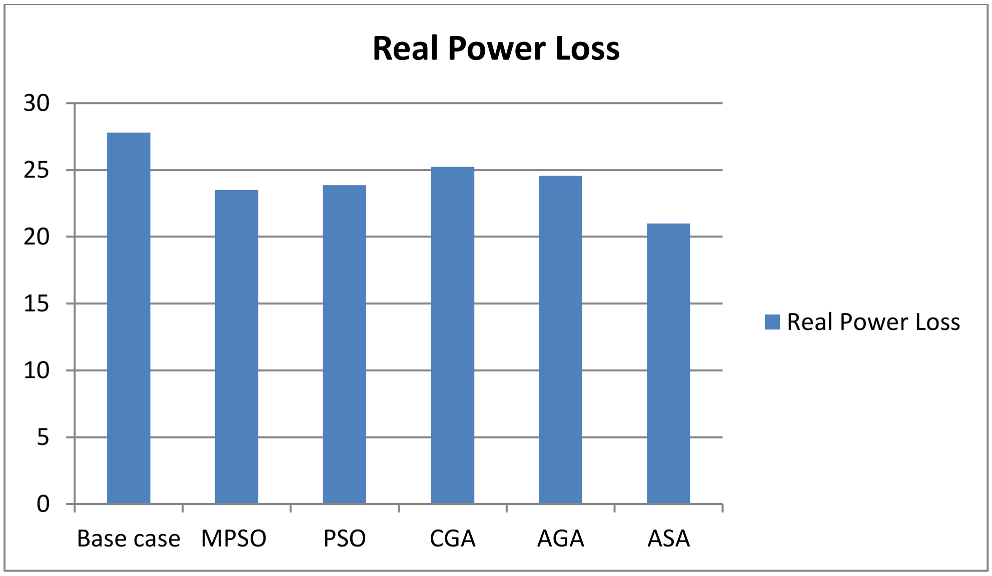
Table 2. Constrains of reactive power generators.

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

Table 3. Simulation results of IEEE −57 system.

Control variables	Base case	MPSO [18]	PSO [18]	CGA [18]	AGA [18]	ASA
VG 1	1.040	1.093	1.083	0.968	1.027	1.022
VG 2	1.010	1.086	1.071	1.049	1.011	1.013
VG 3	0.985	1.056	1.055	1.056	1.033	1.004
VG 6	0.980	1.038	1.036	0.987	1.001	1.013
VG 8	1.005	1.066	1.059	1.022	1.051	1.002
VG 9	0.980	1.054	1.048	0.991	1.051	1.011
VG 12	1.015	1.054	1.046	1.004	1.057	1.010
Tap 19	0.970	0.975	0.987	0.920	1.030	0.912
Tap 20	0.978	0.982	0.983	0.920	1.020	0.910
Tap 31	1.043	0.975	0.981	0.970	1.060	0.914
Tap 35	1.000	1.025	1.003	NR*	NR*	1.003
Tap 36	1.000	1.002	0.985	NR*	NR*	1.001
Tap 37	1.043	1.007	1.009	0.900	0.990	1.010
Tap 41	0.967	0.994	1.007	0.910	1.100	0.912
Tap 46	0.975	1.013	1.018	1.100	0.980	1.011
Tap 54	0.955	0.988	0.986	0.940	1.010	0.923
Tap 58	0.955	0.979	0.992	0.950	1.080	0.944
Tap 59	0.900	0.983	0.990	1.030	0.940	0.931
Tap 65	0.930	1.015	0.997	1.090	0.950	1.010
Tap 66	0.895	0.975	0.984	0.900	1.050	0.922
Tap 71	0.958	1.020	0.990	0.900	0.950	1.013
Tap 73	0.958	1.001	0.988	1.000	1.010	1.012

Tap 76	0.980	0.979	0.980	0.960	0.940	0.940
Tap 80	0.940	1.002	1.017	1.000	1.000	1.023
QC 18	0.1	0.179	0.131	0.084	0.016	0.141
QC 25	0.059	0.176	0.144	0.008	0.015	0.130
QC 53	0.063	0.141	0.162	0.053	0.038	0.112
PG (MW)	1278.6	1274.4	1274.8	1276	1275	1272.60
QG (Mvar)	321.08	272.27	276.58	309.1	304.4	272.31
Reduction in PLoss (%)	0	15.4	14.1	9.2	11.6	24.45
Total PLoss (Mw)	27.8	23.51	23.86	25.24	24.56	21.001



NR* - Not reported.

Figure. 1. Comparison of real power loss.

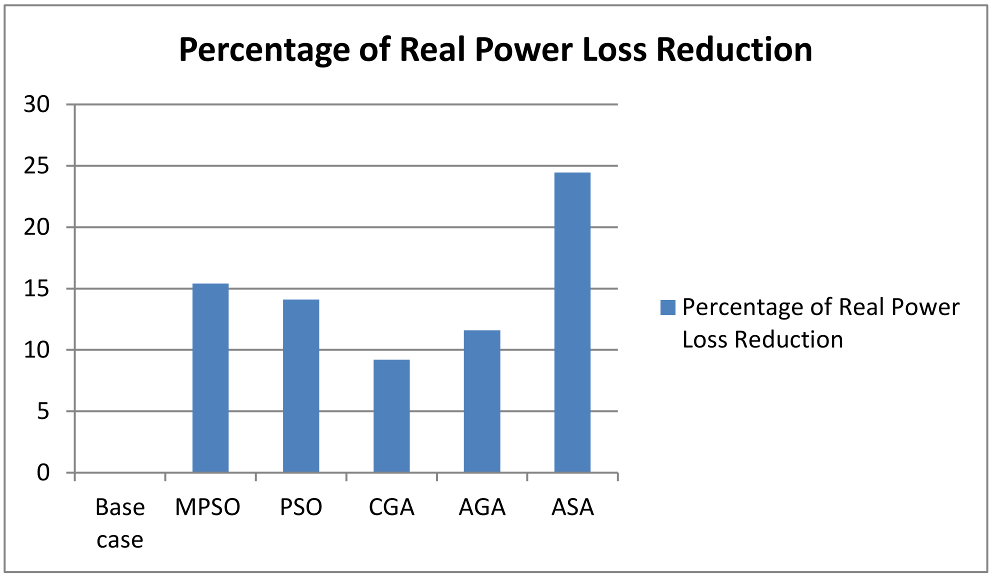


Figure. 2. Comparison of real power loss with respect to percentage of reduction.

5. Conclusion

ASA algorithm reduced the real power efficiently. Jumping phenomenon of Acridoidea mathematically formulated and it has been hybridized with ABC algorithm. The distance of the Acridoidea jumping is utilized to modernize the position. Projected ASA algorithm has been tested in standard IEEE 57 bus test systems and results show that ASA algorithm reduced the real power loss efficiently. In comparison with other standard algorithms, percentage of real power loss reduction has been improved.

References

[1] Lenin,K. (2019). Acridoidea stimulated artificial bee colony algorithm for solving optimal reactive power problem. *5th virtual international conference on science, technology and management in energy*. Niš, Serbia: Research and Development Center “ALFATEC”.

[2] Lee, K. Y., Park, Y. M., & Ortiz, J. L. (1984, May). Fuel-cost minimisation for both real-and reactive-power dispatches. *IEEE proceedings C (generation, transmission and distribution)* (Vol. 131, No. 3, pp. 85-93). IET Digital Library.

[3] Deeb, N. I., & Shahidehpour, S. M. (1988). An efficient technique for reactive power dispatch using a revised linear programming approach. *Electric power systems research*, *15*(2), 121-134.

[4] Bjelogrlic, M., Calovic, M. S., Ristanovic, P., & Babic, B. S. (1990). Application of Newton's optimal power flow in voltage/reactive power control. *IEEE transactions on power systems*, *5*(4), 1447-1454.

[5] Granville, S. (1994). Optimal reactive dispatch through interior point methods. *IEEE transactions on power systems*, *9*(1), 136-146. http://dx.doi.org/10.1109/59.317548

[6] Grudinin, N. (1998). Reactive power optimization using successive quadratic programming method. *IEEE transactions on power systems*, *13*(4), 1219-1225. http://dx.doi.org/10.1109/59.736232.

[7] Roy, P. K., & Dutta, S. (2019). Economic load dispatch: optimal power flow and optimal reactive power dispatch concept. In *Optimal power flow using evolutionary algorithms (pp. 46-64).* IGI Global.

[8] Bingane, C., Anjos, M. F., & Le Digabel, S. (2019). Tight-and-cheap conic relaxation for the optimal reactive power dispatch problem. *IEEE transactions on power systems*, *34*(6), 4684-4693. DOI:10.1109/TPWRS.2019.2912889,arXiv:1810.03040.

[9] Prasad, D., & Mukherjee, V. (2018). Solution of optimal reactive power dispatch by symbiotic organism search algorithm incorporating FACTS devices. *IETE journal of research*, *64*(1), 149-160, DOI: 10.1080/03772063.2017.1334600.

[10] Aljohani, T. M., Ebrahim, A. F., & Mohammed, O. (2019). Single and multiobjective optimal reactive power dispatch based on hybrid artificial physics–particle swarm optimization. *Energies*, *12*(12), 2333. https://doi.org/10.3390/en12122333

[11] Mahate, R. K., & Singh, H. (2019). Multi-objective optimal reactive power dispatch using differential evolution. *International journal of engineering technologies and management research*, *6*(2), 27-38. http://doi.org/10.5281/zenodo.2585477.

[12] Yalçın, E., Taplamacıoğlu, M. C., & Çam, E. (2019). The adaptive chaotic symbiotic organisms search algorithm proposal for optimal reactive power dispatch problem in power systems. *Electrica*, *19*(1), 37-47.

[13] Mouassa, S., & Bouktir, T. (2019). Multi-objective ant lion optimization algorithm to solve large-scale multi-objective optimal reactive power dispatch problem. *COMPEL-The international journal for computation and mathematics in electrical and electronic engineering*, 38(1), 304-324. https://doi.org/10.1108/COMPEL-05-2018-0208.

[14] Aljohani, T. M., Ebrahim, A. F., & Mohammed, O. (2019). Single and multiobjective optimal reactive power dispatch based on hybrid artificial physics–particle swarm optimization. *Energies*, *12*(12), 2333.

[15] 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. *Applied soft computing*, *50*, 58-70.

[16] Karaboga, D., & Akay, B. (2011). A modified artificial bee colony (ABC) algorithm for constrained optimization problems. *Applied soft computing*, *11*(3), 3021-3031.

[17] *The IEEE-test systems*. (1993). Retrieved May 1, 2020, from https://www.ece.uw.edu/

[18] Hussain, A. N., Abdullah, A. A., & Neda, O. M. (2018). Modified particle swarm optimization for solution of reactive power dispatch. *Research journal of applied sciences, engineering and technology*, *15*(8), 316-327. 2018 DOI:10.19026/rjaset.15.5917.