RESEARCH ARTICLE OPEN ACCESS

Capacitor Placement in Radial Distribution Systems for Power Loss Reduction using Ant Lion Optimization

K. S. R. Vara Prasad*, K. Vimala Kumar**
** (M.Tech, Department of E.E.E, J.N.T.U Pulivendula, kadapa, India,*
*** (Assistant Professor, Department of E.E.E, J.N.T.U Pulivendula, kadapa, India,*
Email: ksrvaram220@gmail.com)

ABSTRACT
A narrative Ant Lion Optimization (ALO) is based on ant lions in hunting ants in environment. Capacitor placement of optimal sizes and best locations to decrease the system loss and enhances the bus voltages of the system. A number of population based techniques have been used by researchers over the past few years to address capacitor placements. The performance is valid by levy the algorithm proposed in the present paper on a small test system. The present paper also compares the results with those obtained by applying several other modern methods such as fuzzy reasoning, plant growth simulation algorithm, black-hole theory based modified black-hole particle swarm optimization (MBHPSO). The results of the system demonstrate that high quality elucidations can be acquireed by the projected method.

Keywords: Ant Lion Optimization, Capacitor Placement, Capacitor Size, Modified Black-Hole Particle Swarm Optimization, Power Loss, Radial Systems, Voltage Improvement.

Date of Submission: 09-11-2017 Date of acceptance: 22-11-2017

I. INTRODUCTION

The main purpose of allocation of compensating devices is the reduction of line loss, satisfying a set of constraints, including bus voltage limits and thereby minimizing the annual cost of the system. It is reported that around 13% loss of total power generation takes place at the distribution level as resistive losses [1]. Under such circumstances, proper amount of reactive power injection at strategic location to reduce structure losses, but also recovers the voltage stability to a great extent.

The foremost intention of capacitor placement is to maximize the system loss reduction or minimize the total loss and improvement of voltages. This will also direct to minimization of system annual cost. In [1], a fuzzy based method commenced to address the problems of capacitor sizing and placement. In [2], a novel algorithm based on fuzzy based evolutionary programming of reconfiguration to attain the minimal kilowatt losses.

Abdelaziz [3] explored the application of a fuzzy for loss reduction. The technique tested on radial distribution systems. A novel optimization algorithm based on fuzzy DE was projected by Kannan [4] for most favorable placement and sizing of capacitors. This paper also presented other techniques using a fuzzy based PSO method for the same problem.

El-Fergany [5] addressed the problem of capacitor allocations in distribution structures using Cuckoo Search Algorithm. Satish [6] proposed Bat Algorithm and Cuckoo Search Algorithm for the placement of predetermined size and capricious size of capacitors for real loss minimization and maximum savings. Mirjalili [7], proposed a new environment motivated algorithm is called Ant Lion Optimizer (ALO) and Sine Cosine Algorithm (SCA) is in [20]. The ALO algorithm mimics the hunting mechanism of ant lions in the natural world, firstly implemented in 2015. In [8] an application of particle swarm optimization described for reconfiguration problem with an objective of loss reduction.

Mandal [9] presented a hybrid particle swarm optimization technique based on black-hole hypothesis called modified black-hole particle swarm optimization for the capacitor problem. Sudhakar Reddy [10] described the ALO for capacitor placement in the reconfigured network to reduce the total system loss. Gnanasekaran [11], presented a new competent technique is called Shark Smell Optimization (SSO) algorithm used to locate best possible size and position of shunt capacitors with the objective of reducing the cost owing to energy loss and reactive compensation.

Mostafa [12], proposed to solve the capacitor placement to decrease KW losses. Sudhakar Reddy [13-14] described the DFA and GWO algorithms for the reconfiguration problem to decrease the total network loss. Prakash [15] explained particle swarm optimization for capacitor placement on radial distribution systems to reduce losses. Das [16] presented a simple and efficient technique for solving radial networks and to the benchmark load flow case.

Shirmohammadi [17] presented a technique for the reconfiguration to reduce their resistive losses. Jeon [18] presented the simulated annealing with tabu search algorithm for loss reduction by switching operation in distribution systems. Singh [19] proposed a bit shift based Particle Swarm Optimization to solve the problem of feeder reconfiguration for different load models in a power distribution system.

II. REAL POWER LOSS

The foremost intention of capacitor placement is to maximize the system loss reduction or minimize the total loss and improvement of voltages. This will also direct to minimize the system annual cost. The power losses devided are of real power loss and reactive power loss. The total real power loss in a radial distribution system consisting of b branches can be written as

$$L_{RP} = \sum_{i=1}^{b} I_i^2 . R_i \qquad (1)$$

The objective function of the problem is formulated to use the power loss reduction in the radial distributed system, which is given by

$$Objective\_Function = \min \{L_{RP}\} \qquad (2)$$

III. ANT LION OPTIMIZATION

A novel algorithm called Ant Lion Optimizer [7] as an alternative approach for solving engineering problems. "As its name implies, the ALO algorithm imitates the intelligent exploits of ant lions in hunting ants in the environment. Cone shaped traps and hunting behaviour of ant lions which is explored in Fig. 1.

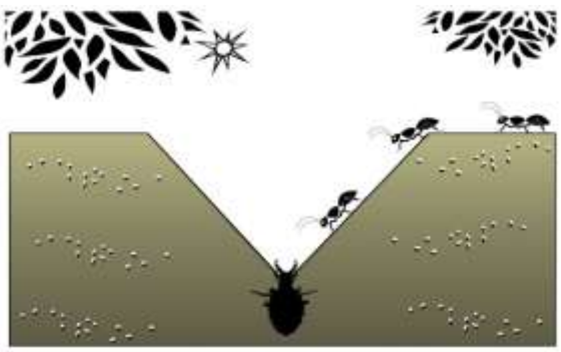

Fig. 1. Cone-shaped traps and hunting behaviour of ant lions

The ALO algorithm mimics relations between ant lions and ants in the trap. To mold, such dealings, ants are essential to move over the search space, and ant lions are authorized to hunt them and grow to be fitted using traps. Since ants travel stochastically in nature when searching for food, a random walk using roulette wheel is chosen for modelling ant's movement. Random walks of an ant inside an ant lion’s trap which is shown in Fig. 2. If they go beyond the search space, then bring back them to maintain boundary.

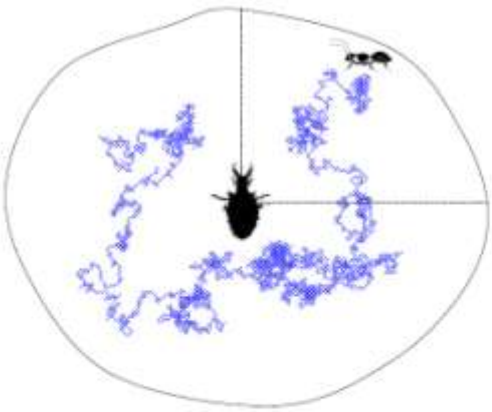

Fig. 2. Random walk of an ant inside an ant lion’s trap

In order to keep the random walks inside the search space, they are normalized min–max normalization using the following equation.

$$X = \left[0, CumSum\left(2 * \left(rand\left(\max\_iter, 1\right) > 0.5\right) - 1\right)\right] \qquad (3)$$

$$RW(i) = X(i) = \frac{\left((X - a) .* (d - c)\right)}{(b - a)} + c \qquad (4)$$

$$a = \min(RandomWalk)$$

$$b = \max(RandomWalk)$$

$$c = lb(dim)$$

$$d = ub(dim)$$

$$ant\_position(i) = \frac{\left[RA(C_{it}) + RE(C_{it})\right]}{2} \qquad (5)$$

The implementation of the proposed method has the following steps.

Step 1: Initialize the parameters. Run the load flow and calculate the fitness of ants and ant lions.
Step 2: Find the best ant lions and assume it as the elite.
Step 3: For each ant, select an ant lion using Roulette wheel
Step 4: Run load flow and calculate the fitness of all ants.
Step 5: Replace an ant lion with its corresponding ant if it becomes better.

Step 6: Update elite if an ant lion fitness becomes better than the elite fitness,
Step 7: Repeat from step 3 until a converging criteria is reached [10]"

IV. RESULTS

The MATLAB code is developed for the execution of projected technique. The effectiveness was valid by pertaining the proposed technique on a 9 section test system which is revealed in Fig. 3. By using Power Loss Sensitivity Index, we can identify the optimal capacitor locations in the system as in chronological order [10 9 6 8 5 7 4 2 3 1]. The various parameters are used in ant lion optimization which is revealed in Table. 1.

Table 1: Control Parameters for ALO algorithm

constraints	Ant Lion Optimization
Search Agents	30
Max no. of iter	500
Best Score	Elite fitness
Best Position	Elite position

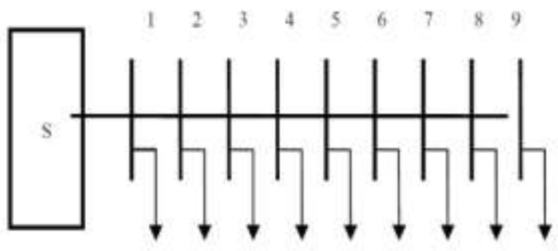

Fig. 3. Representation of the 9 section system

4.1 Optimal Location of Shunt Capacitor:

Power loss sensitivity index (PLSI) is used to identify the capacitor locations [8]. For the 10-bus system, the capacitor placement suitability index (CPSI) values in chronological order are considered for capacitor location. Nodes are selected for the optimal capacitor placement and ALO is used to calculate the sizing of capacitors. The simulation coding results are presented in Table. 2.

From the table.2, the base power loss is 783.73 kW and after capacitor compensation it is reduced to 671.25 kW. In a similar manner, the minimum voltage is 0.8375 p.u for before compensation and it is raised to 0.8985 p.u which is exposed in Table 2 and voltage waveform is shown in Fig. 4.

Table 2: Simulation Results of ALO algorithm

Parameters	Results
Power loss (before compensation)	783.73 kW
Voltage (before compensation)	0.8375 p.u
Power loss (after compensation)	671.25 kW
Voltage (after compensation)	0.8985 p.u
Run Time (Sec)	59.85

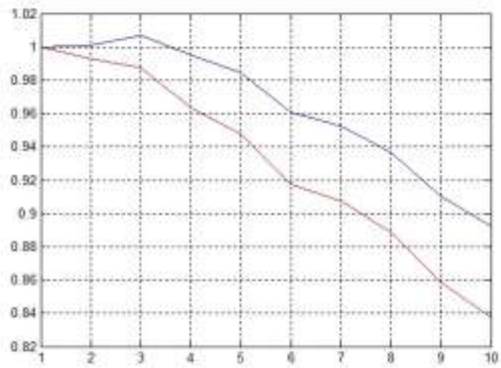

Fig. 4. Bus voltage of 9 section system before and after compensation

The comparison results of the ALO algorithm with the black hole theory based hybrid PSO is shown in Table 3.

Table 3: Comparison of Simulation Results

Parameters	Hybrid PSO [9]	Proposed ALO
Power loss (before compensation)	783.73 kW	783.73 kW
Power loss (after compensation)	672.9 kW	671.25 kW
Size of capacitor (MVAr)	8.70	10.42

V. CONCLUSION

Determination of optimal size and number of capacitors is a composite optimization. In the present effort, a new ant lion optimization technique based on hunting behaviour of ant lions and traps has been expanded. The effectiveness of the planned algorithm is validated by concerning on a test system and the results are presented. A comparison results with other published articles in literature is also presented.

REFERENCES

[1] C. T. Su and C. C. Tasi, "A new fuzzy reasoning approach to optimum capacitor allocation for primary distribution systems," *IEEE*, 1996, pp. 237–241.

[2] B.Venkatesh, Rakesh Ranjan "Optimal radial distribution system reconfiguration using fuzzy adaption of evolutionary programming," *Electrical Power and Energy Systems 25*, pp.775–780, 2003.

[3] A.Y. Abdelaziz, S.F. Mekhamer M.H. Nada "A fuzzy expert system for loss reduction and voltage control in radial distribution system." *Electric Power Systems Research, Vol. 80*, 2010,pp. 893-897.

[4] S.M. Kannan, P. Renuga, S. Kalyani, E. Muthukumaran, "Optimal capacitor placement and sizing using Fuzzy-DE and Fuzzy-MAPSO methods," *Applied SoftComputing 11*, 2011, pp. 4997–5005.

[5] A El-Fergany "Optimal Capacitor Allocations using evolutionary algorithms", *IET Generation, Transmission & Distribution*, pp.593-601, 2013.

[6] Satish Kumar I, Vinod Kumar T, Meera S, "Optimal allocation of capacitor banks in radial distribution systems for minimization of real power loss and maximization of network savings using bio-inspired optimization algorithms", *Electrical Power and Energy Systems*, 69, pp.441–455, 2015.

[7] Seyedali Mirjalili, "The Ant Lion Optimizer", *Advances in Engineering Software, 83*, pp.80–98, 2015.

[8] A. V. Sudhakara Reddy, Prof. M. Damodar Reddy, "Optimization of network reconfiguration by using Particle swarm optimization", *IEEE ICPEICES, Vol.4*, pp. 1-6, July 2016.

[9] S. Mandal, K.K.Mandal, "A New Hybrid Particle Swarm Optimization Technique for Optimal Capacitor Placement In radial Distribution System", *IEEE*, pp. 536-540, 2016.

[10] A. V. Sudhakara Reddy, Prof. M. Damodar Reddy, "Optimal Capacitor Allocation for the Reconfigured Network using Ant Lion Optimization Algorithm", *International Journal of Applied Engineering Research, 12(12)*, 2017, pp.3084-3089.

[11] N. Gnanasekaran, S. Chandramohan, P. Sathish Kumar, A. Mohamed Imran, "Optimal placement of capacitors in radial distribution system using shark smell optimization algorithm", *Ain Shams Engineering Journal*, 2016.

[12] Mostafa Sedighizadeh, Reza Bakhtiary, "Optimal multi-objective reconfiguration and capacitor placement of distribution systems with the Hybrid Big Bang–Big Crunch algorithm in the fuzzy framework", *Ain Shams Engineering Journal*, 7, pp.113–129, 2016.

[13] A. V. Sudhakara Reddy, Prof. M. Damodar Reddy, "Optimization of distribution network reconfiguration using dragonfly algorithm", *Journal of Electrical Engineering, Vol.16, Edition.4, No.30,* pp.273-282, ISSN:1582-4594, Mar-2017.

[14] A.V.Sudhakara Reddy, M.Damodar Reddy, M. Satish Kumar Reddy "Network Reconfiguration of Primary Distribution System Using GWO Algorithm", *International Journal of Electrical and Computer Engineering (IJECE) Vol. 7, No. 6*, , December 2017, pp. 3226-3234.

[15] K. Prakash, M. Sydulu, "Particle swarm optimization based capacitor placement on radial distribution systems," in: IEEE Power Engineering Society GeneralMeeting, 2007, pp. 1–5.

[16] D.Das, D.P.Kothari and A.Kalam, "Simple and efficient method for load flow solution of Radial distribution networks", *Electrical Power & Energy Systems, vol.17, no.5,* pp.335-346, 1995.

[17] D. Shirmohammadi and H. W. Hong, "Reconfiguration of electric distribution networks for resistive line losses reduction" *IEEE Trans. Power Del., vol. 4, no. 2,* pp. 1492–1498, Apr. 1989.

[18] Y. J. Jeon and J. C. Kim, "Network reconfiguration in radial distribution system using simulated annealing and tabu search", *IEEE*, 2000.

[19] Akansha Singh, Sudhansu Kumar Mishra, Deepak Kumar and Rakesh Chandra Jha, "Optimal Reconfiguration of Primary power Distribution System using Modified Teaching

Learning based Optimization Algorithm", *IEEE*, 2016.

[20] A. V. Sudhakara Reddy, Dr. M. Damodar Reddy, "Step by step switching of reconfiguration for loss reduction using Sine Cosine Algorithm," *International Journal of Engineering Research and Applications (IJERA)*, Vol.7, Issue.10, pp.34-39, October 2017.

International Journal of Engineering Research and Applications (IJERA) is **UGC approved** Journal with Sl. No. 4525, Journal no. 47088. Indexed in Cross Ref, Index Copernicus (ICV 80.82), NASA, Ads, Researcher Id Thomson Reuters, DOAJ.

K. S. R. Vara Prasad "Capacitor Placement in Radial Distribution Systems for Power Loss Reduction using Ant Lion Optimization." International Journal of Engineering Research and Applications (IJERA) , vol. 7, no. 11, 2017, pp. 61-65.