Asian Journal of Applied Science and Technology (AJAST)
Volume 1, Issue 3, Pages 297-300, April 2017

Power Loss Minimization Using Glowworm Swarm Optimization Technique

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Article Received: 15 April 2017 *Article Accepted: 25 April 2017* *Article Published: 30 April 2017*

ABSTRACT

This paper presents Glowworm Swarm Optimization (GSO) algorithm to compensate the reactive power. The objective is to minimize the power loss. In the glowworm swarm optimization algorithm each glowworm find all the glowworm which have brighter luciferin in the local-decision range, then move to it based on assured probability, ultimately glowworm swarm optimization algorithm's search more accuracy and optimization efficiency has improved. This algorithm minimizes the loss and improving the voltage stability. This algorithm is a recent development in the area of nature inspired algorithm for global optimization. In our problem the agents are generation values of the generator. It can be finalized for multi-objective functions where an objective function is a composition of several factors, such as investment cost, reactive power loss and transmission losses, with many other constrains. This proposed method (GSO) has been examined and tested on standard IEEE 14 bus system in MATLAB and its prove to be an efficient optimization technique. In this paper load flow studies are done by using Newton Rapshon method.

Keywords: Glowworm Swarm Optimization, Newton Rapshon method, voltage Stability and Power loss minimization.

1. INTRODUCTION

Glowworm Swarm Optimization (GSO) algorithm [1] is a novel swarm optimization algorithm which is proposed by K. N. Krishnanad and D. Ghose. The main idea of this algorithm is derived from natural glowworm's activities in the night, the glowworm exercise in group in nature, they interaction inter attraction with each other by one's luciferin. If the glowworm emits luciferin more light, it can attract more glowworm move toward it. Through simulate this natural phenomena, combined with the characteristics of natural glowworm populations each glowworm at the owns field of view in search for the glowworm which release the strongest luciferin, also move to the strongest glowworm. So as to achieve the final optimization results. Currently ,the GSO algorithm has been successfully applied to the multi-optimization[2] .However , there are some drawbacks in the GSO algorithm , for example , premature convergence and search accuracy is not enough high, also has the low efficiency in the later iteractions [3].

Reactive power acting an important role in power system in arrange to provide power quality reliably and economically. Proper control of voltage and reactive power is necessary to control the system voltage as well as reduce the real power loss and also maintaining the system. The reason for reactive power in power system is to identify the control variables which minimize the given objective function [4]. In this paper, reactive power control problem is formulated as multi objective optimization problem. The main approach is minimized of real power loss and compensate reactive power loss. To get the optimal solution an Evolutionary Algorithm based new approach is introduced [5].

This paper in order to improve the GSO algorithm's search accuracy and increase the efficiency of optimization, we introduce the local search operator in the basic GSO algorithm. The glowworm find the others brighter glowworm in own local-decision range, before determine the direction of movement, with local search operator's powerful search capabilities, determine the better direction of movement, makes the glowworms move toward to a better direction. Ensure that each glowworm can move to a better location, thus reduce the optimization time, also improve the search accuracy. Simulation results show that the improved algorithm has better optimization power [6].

2. GLOWWORM SWARM OPTIMIZATION

GSO algorithm is normally used for optimization problems. When using the GSO to solve the function optimization problems, a swarm of glowworm are arbitrarily spread in the search space of object functions. Accordingly, these glowworm carry a luminescent quantity called luciferin along with them and they have their own result domain. A glowworm *i* considers another glowworm *j* as its neighbor if *j* is within the region range of *i* and the luciferin level of *j* be higher than that of *i*. In particular, the region is defined as a local-decision domain that has a changeable region range r_d^i surrounded by a radial sensor range r_s ($0<r_d^i \le r_s$). Each glowworm selects, using a probabilistic mechanism, a neighbor that has a luciferin value higher than its own and moves toward it. That is, glowworms are absorbed to neighbors that glow brighter. The glowworms emit a light whose strength is proportional to the associated luciferin and interact with other glowworm within a variable region .The glowworms' luciferin intensity is related to the fitness of their current locations. The higher the intensity of luciferin, the better the location of glowworm, in other words, the glowworm represents a good target value. Otherwise, the target value is poor. In addition, the size of the region range of each glowworm is influenced by the quantity of glowworms in the region range. The region range of the glowworm is proportional to the density of its neighbors. If the region range covers low density of glowworms, the region range will be increased. On the contrary, the region range will be reduced.

2.1 Basic Glowworm Swarm Optimization Algorithm

Function optimization using GSO algorithm usually requires the following seven steps:

Step 1 Initialize the limits.

Step 2 Placing a population of *n* glowworms randomly in the search space of the object function.

Step 3 Using the formula (1) put the $J(x_i(t))$ into the $l_i(t)$:$l_i(t)$ represents the luciferin level associated with glowworm *i* at time *t*. $J(x_i(t))$ represents the value of the objective function at Glowworm *i*'s location at time *t*.

Step 4 Each glowworm selects a neighbor that has a luciferin value higher than its own within a variable neighborhood range $r_d^i(t)$ $(0 < r_d^i \le r_s)$ to make up the $N_i(t)$. $N_i(t)$ is the set of neighbors of glowworm i at time *t*. $r_d^i(t)$ represents the variable neighborhood range associated with glowworm *i* at time *t*.

Step 5 Using the formula (2) calculate the probability that each glowworm *i* move toward a neighbor *j*.

Step 6 Glowworm *i* using the roulette method selects a neighbor *j* and move toward it, then using the formula (3) update the location of the glowworm *i*.

Step 7 Using the formula (4) update the value of the variable neighborhood range.

$$l_i(t) = (1-\rho)l_i(t-1) + \gamma J(x_i(t)) \quad (1)$$

$$p_{ij}(t) = \frac{l_j(t)-l_i(t)}{\sum_{k\in N_i(t)} l_k(t)-l_i(t)} \quad (2)$$

$$x_i(t+1) = x_i(t) + st * \left\{\frac{x_j(t)-x_i(t)}{\|x_j(t)-x_i(t)\|}\right\} \quad (3)$$

$$r_d^i(t+1)=\min\{r_s,\max\{0,r_d^i(t)+\beta(n_t-|N_i(t)|)\}\}. \quad (4)$$

Explanation: ρ is the luciferin decay constant $(0<\rho<1)$, Υ is the luciferin improvement constant, *st* is the step size. β is a constant limit and n_t is a limit used to control the number of neighbors. The quantities ρ, Υ, *st*, β, n_t, are algorithm limits for which we can get them using the experimental method and evolutionary learning.

3 PROBLEM FORMULATION

The purpose of this employment is to optimize the reactive power flow in a power system by minimizing the real power loss and sum of load bus voltage deviations. An increased objective is formed with the two objective components and weights.

A. Objective Function

The objective function of this work is to find the optimal settings of reactive power control variables as well as the evaluation shunt var compensating devices which minimizes the real power loss and voltage deviation. Hence, the objective function can be expressed as:

$$F=\{W_{PL}+(1-W)VD\} \quad (1)$$

Where w is the weighing part for real power loss and voltage deviation and is set to 0.7.

3.1 Real power loss minimization (PL)

The total real power of the system can be calculated as follows:

$$P_L=\sum_{K=1}^{N_L} G_K[V_i^2+V_j^2-2V_iV_j\cos(\delta_i-\delta_j)] \quad (2)$$

Where, N_L is the total number of lines in the system; G_K is the conductance of the line "K"; V_i and V_j are the magnitudes of the sending end and receiving end voltages of the line; δi and δj are angles of the end voltages.

3.2 Load bus voltage deviation minimization (VD)

Bus voltage magnitude should be maintained within the permissible range to ensure quality service. Voltage profile is improved by minimizing the deviation of the load bus voltage from the reference value (it is taken as 1.0 p.u. in this work).

$$VD=\sum_{K=1}^{N_{PQ}}|(V_K-V_{ref})| \quad (3)$$

B. Constraints

The minimization problem is focus to the following equality and inequality constraints.

1. Equality constraints:
Load Flow Constraints:

$$P_{Gi}-P_{Di}-\sum_{j=1}^{N_B} V_i V_{ij} V_{ij}\cos(\delta_{ij}+\gamma_j-\gamma_i)=0 \quad (4)$$

$$Q_{Gi}-Q_{Di}-\sum_{j=1}^{N_B} V_i V_{ij} V_{ij}\sin(\delta_{ij}+\gamma_j-\gamma_i)=0 \quad (5)$$

Where,

P_{Gi}, Q_{Gi} are the active and reactive power of generator, P_{Di},Q_{Di} the active and reactive power of the load bus.

3.3 Power Flow Equation in Complex Form

$$P_i-jQ_i=V_i^*\sum_{j=1}^{N} Y_{ij} V_j \quad \textbf{(6)}$$

Where, i=1,2,3 …N

P_i=real power,
Q_i=reactive power,
Q_{ij}=admittance.

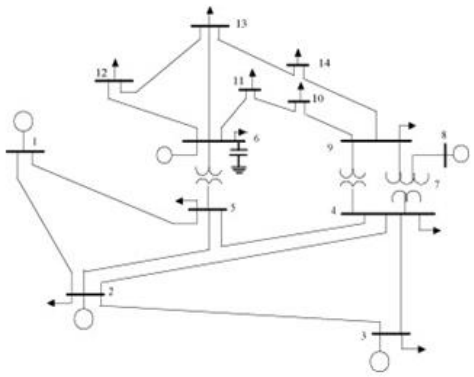


Fig.1. Single line diagram of the IEEE-14 bus system

4. NUMERICAL RESULTS AND DISCURSION

The performance of the proposed Glowworm Swarm Optimization for enhancement of voltage profile by minimizing real power loss is tested on IEEE 14 bus system.

Table 1. System parameters

Sl. No	Parameter	Quantity
1	Buses	14
2	Transmission lines	20
3	Generators	5
4	Static VAR compensators	1
5	Tap-Changing transformers	3

For reactive power optimization, the control parameters are used to that the objective function value is minimum. The come near of minimizing both real power loss and voltage minimization is most suitable one for reactive power optimization as all the indicators of reactive power optimization is included. The optimal value of control parameters for this case is tabulated below as table 1.

Table 2. Range of control variables

Sl. No	Variable	Quantity
1	Generator bus voltage	0.9-1.1 p.u.
2	Transformer tap position	0.9-1.1p.u
3	SVC var output	2-15 MVAR

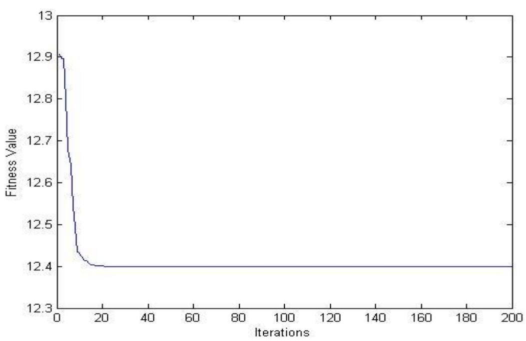
Optimal values of control parameters

Sl. No.	Parameter	Initial	GSO
1	V_{g1}	1.0600	1.1000
2	V_{g2}	1.0450	1.0779
3	V_{g3}	1.0100	1.0429
4	V_{g6}	1.0173	1.0313
5	V_{g8}	1.0193	1.0803
6	$T_{4\text{-}7}$	1.0700	1.0057
7	$T_{4\text{-}9}$	1.0604	1.0524
8	$T_{5\text{-}6}$	1.0900	1.0590
9	SVC_9	19	11.6552

The percentage loss reduction is level is from 12.884MW to 6.142 MW. It is obvious from table 3, that GSA reduces the loss level to only 12.453 MW.

4.1 Convergence of N-R Method

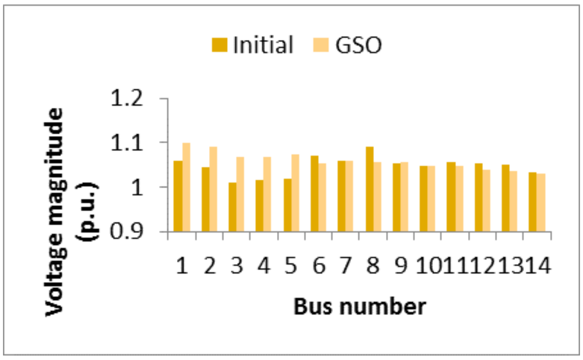
The convergence can be speeded up in N-R method by using Glowworm Swarm algorithm. In GSO method the weak coupling between P-δ and Q-V.



Convergence behaviour of GSO

Convergence of GSO when conduct increased objective function is greater as given in figure 3. The algorithm converges in a better method for different objectives and it proves the reliability of the algorithm. The algorithm takes less number of iterations best results and maintains the overall.

For clear understanding of the improvement in voltage profile, the p.u. voltage magnitude of all the buses in the system before and after the implementation the algorithm are compared in figure 4. It clear from the figure, that most of the load bus voltages are equal to about 1.0 p.u.



Bus voltage profile (GSO)

Parameter	Pre - Optimization (Initial) (IEEE 14 Bus System)	Post – Optimization					
		GSO	GSA	ACO	PSO	DE	EP
Real power loss	13.401	6.142	12.453	13.121	12.890	12.963	12.884
Reactive power loss	56.423	36.334	53.633	55.986	54.452	54.012	54.91

5. CONCLUSION

This glowworm swarm optimization algorithm has high accuracy and high efficiency in the part of iterative. In this GSO algorithm is used to minimize the real power loss and compensate reactive power loss. The performance of the proposed algorithm has been confirmed through tested on the IEEE 14-bus system.

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