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Working of ant colony search algorithm in radial distribution system

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Abstract—— A new powerful algorithm has been presented in this paper for capacitor placement in radial distribution systems. This method was inspired by observation of the behavior of ant colonies. This theorem applies on the state transition rule to favors transition towards nodes connected by shorter edges. Then it applies local updating rule. Finally it applies a global updating rule to make search more directed and enhance the capability of finding the optimal solution in capacitor placement problem. It was observed that optimal capacitor placement process not only reduce the power loss, but also improve the voltage profile and maximizing the net savings. The problem has been formulated as maximization of net savings obtained from energy loss reduction, kVA enhancement and improvement of voltage profile.

Keywords: capacitor placement, ant colony search algorithm, matlab tool.

1. INTRODUCTION

Distribution systems are the networks that transport the electrical energy from bulk substation to many services or loads. Distribution systems are becoming large and stretched too far leading to higher system losses and poor voltage regulation. Hence there is a need to reduce the system losses. By minimizing the losses, the system may acquire longer life span and has greater reliability [1].

The application of shunt capacitor in distribution feeders has always been an important research area. It is because a portion of power loss in distribution systems could be reduced by adding shunt capacitors to supply a part of the reactive power demand. For this reason, the source of the system does not necessarily to supply all reactive power demands and losses. Consequently, there is a possibility to decrease the losses associated with the reactive power flow through the branches in the distribution systems. It has been realized that the benefits of capacitor placement in distribution systems are power factor correction, bus voltage regulation, power and energy loss reduction, feeder and system capacity release as well as power quality improvement[2].

A variety of solution techniques have been employed to solve the capacitor placement problem. They are analytical methods, numerical programming methods, heuristic search methods and artificial intelligence (AI) based methods. When a realistic problem formulation with all considerations is to be solved, however, most analytical, numerical programming heuristic are unable to work well. In recent years, AI- based methods such as genetic ant colony search algorithm (ACSA) have been applied to the capacitor placement problem with promising results [1].

In this paper, The ACSA is a relatively new and powerful swarm intelligence method for solving optimization problems. Therefore, through a collection of cooperative agents called "ants," the near-optimal solution to the capacitor placement problems can be effectively achieved. Optimization, in the mathematical sense, is the process of finding solutions to a problem such that one or many objectives are minimized or maximized In this paper, MATLAB based algorithm is used to generate the Optimization results and correct placement of Capacitors.

2.PROBLEM FORMULATION

Capacitors are widely used in distribution systems for reactive power compensation to achieve power and energy loss reduction, system capacity release and acceptable voltage profile. Economic benefits of the capacitor depends mainly on where and how many capacities of the capacitor are installed and proper control schemes of the capacitors at different load levels in the distribution system.

The capacitor placement problem consists of determining the optimal numbers, types, locations and sizes of capacitor banks such that minimum yearly cost due to power/energy losses and cost of capacitors is achieved, while the operational and power quality constraints are maintained within the required limits.

It is well known that losses in a distribution system are significantly high compared to that in a transmission system. The need of improving the overall efficiency of power delivery has the power utilities to reduce the losses

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at distribution level. Many arrangements can be worked out to reduce these losses like network reconfiguration, capacitor placements etc.

The shunt capacitors supply part of the reactive power demand, thereby reducing the current in lines. Installation of shunt capacitors on distribution network will help in reducing energy losses, peak demand losses and improvement in the system voltage profile, system stability and power factor of the system. Reactive power compensation plays an important role in the planning of an electrical system. However to achieve these objectives, keeping in mind the overall economy, the size and location of capacitors should be decided.

The problem of capacitor placement determines the location and sizes of capacitors to meet a predetermined objective, such as maximizing the savings. Alternatively, it can improve voltage profile or loss reduction and capable of KVA enhancement. In this work, the function to be optimized is defined as the net annual savings of the system [2].

The present work considers Maximizing the saving by minimizing the energy loss, KVA enhancement and considering the annual charges due to the placement of capacitors as an objective for the capacitor placement problem.

The mathematical model of the problem can be expressed as follows :

Maximize

$$S = [K_e \Delta E + K_k \Delta K - K_C \Delta C][1 - \Delta V]$$

Where,

S = net annual savings in \$/year;

ΔE = reduction in energy loss in \$/yr;

ΔK = KVA enhancement in \$/yr;

ΔC = size of capacitor;

ΔV = deviation of nodes voltage;

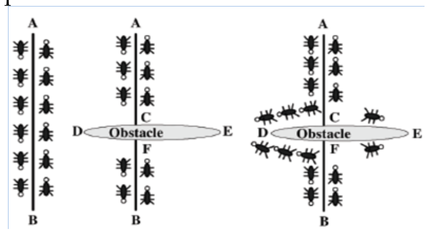
K_e = factor to convert kVA enhancement to \$;

K_k = factor to convert energy loss in \$/kWh;

K_C = cost of capacitor in \$ [3,4,5].

3. ANT COLONY OPTIMIZATION

The ant colony optimization (ACO) imitates the behaviors of real ants. Real ants can find the shortest path from food sources to the nest without using visual cues. Also, they are capable of adapting to changes in the environment, for example, finding a new shortest path once the old one is no longer feasible due to a new obstacle. In addition, the ants can establish the shortest paths through the medium that is called "pheromone." The pheromone is the material deposited by the ants, which serves as critical communication information among ants, thereby guiding the determination of the next movement. Any trail that is rich of pheromone will thus become the goal path.



(a) (b) (c)

Figure1. Natural ACO

In Fig. 1(a), the ants are moving from food source A to the nest B on a straight line. If an obstacle appears on the path as shown in Fig. 1(b), the usual path is cut off. The ants will no more be able to follow the same path. Under this situation, they have the same probability to turn right or left. But after some time the path CD will have more pheromones and all the ants will move in the path ACD. As the ants from C to reach F through D will reach quicker than that of the ants through E, i.e. CEF. Hence ant at F from B will find pheromone a path FDCA and will go through it, where Fig. 1(c) depicts that the shorter path CDF will collect larger amount of pheromone than the longer path CEF. Therefore, more ants will be travel through the shorter path[72].

4. SOFTWARE IMPLEMENTATION

Software Implementation is done in using the MATLAB Software. The simple algorithm is made which runs on the system First step in implementation is initializing the system. In the proposed work here the function to be optimized is the annual cost savings in an distributed electrical system. The objectives for capacitor placement and reconfiguration are the maximizing the cost savings by reducing the energy losses, KVA enhancements and considering the annual charges due to placement of the capacitors.

Each ant chooses the next states to go to in accordance with the probabilistic rule given in equation. When ant k moves from one node to another the state of node will be recorded at some place. After a tour is complete that stored data is used to compute current solution. When all ants in the colony complete their path, and the solution of each ant is achieved, the fitness of each ant is computed. Input data is fed to the main program and Ant Colony Optimization algorithm uses this data to calculate the optimal placement of the capacitors to be located in the 15 bus radial distribution system. Initial cost is calculated using the input data and with the help of the above fitness function.

Algorithm works on the basis of the iterations and so for this particular problem statement 100 iterations are decided so as to converge the ACO algorithm. One parameter which is denoted as beta is used to determine the relative importance of the pheromone level based on the distance. Sigma is the heuristically defined parameter.

Pheromone value is initially set to zero. Now the new pheromone value is equal to the new path to be searched or formed with the help of the ant which is capacitor here. The probability of the new path is equivalent to the new pheromone level. If the new pheromone value is lesser than the random value created using the generation of the random numbers than that particular bus is included in the path. With the help of the local updating rules the pheromone levels are updated locally first and then with the help of the global updating rules the pheromone level are updated globally.

After the completion of the pheromone updation final path is formed which is shortest path in the case of the ants. Here in the case of the distributed electrical system after the completion of the updating rules the buses at which the capacitor needs to be placed are identified and the value of the capacitors are also determined.

After the placement of the capacitors is determined the cost saving value is also determined by the ACO algorithm. With the help of the flowchart the main code is explained in the following sections.

Below table shows the general algorithm of the ACO for solving the optimal capacitor placement problem.

1	Step1	MATLAB Initialization
2	Step2	Main.m is run for GUI
3	Step3	ACO is called from Main function
4	Step4	Random number generation
5	Step5	Various Initialization
6	Step6	Random Path visit by Ants i.e capacitors
7	Step7	Pheromone updation locally and globally
8	Step8	Final Calculations of cost saving

3. RESULT ANALYSIS

The GUI has been developed in MATLAB R2012A for the evaluation and to provide user with an easy interface for feeding the input data to the system and to check the results obtained with the proposed method. Following describes the GUI screen obtained when the code is run initially,

Following figures gives the details of the of the various input parameters as described under :

EL is the reduction in energy loss in terms of Dollars per year,

KE is the factor to convert KVA enhancement in to dollars

SC is the size of capacitor to be placed with the proposed algorithm

CC is the cost of capacitor to be placed with the proposed algorithm

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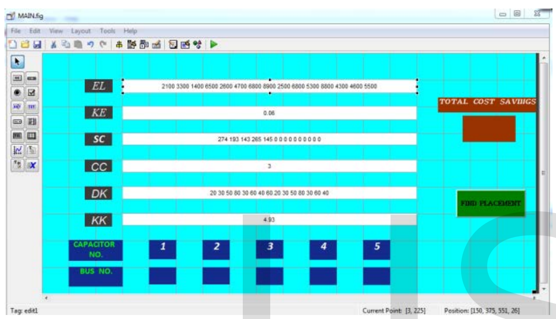
DK is the KVA enhancement in terms of dollars per year

KK is the factor to convert energy loss into Dollars per Kilo Watt Hours

INPUT PARAMETER

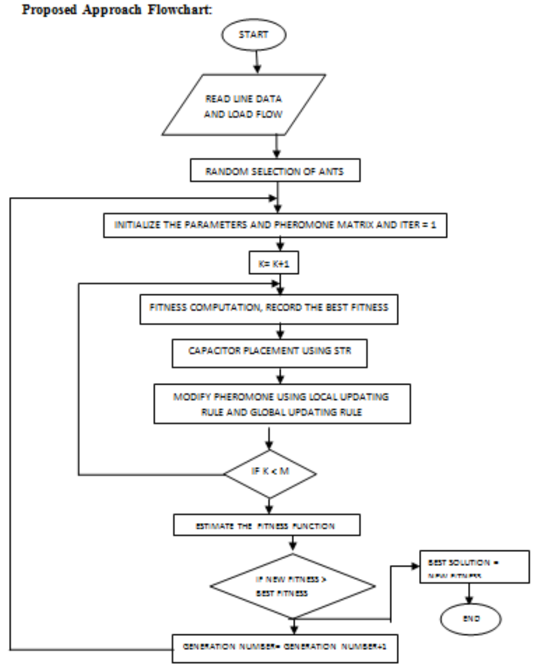
1	EL	2100 3300 1400 6500 2600 4700 6800 8900 2500 6800 5300 8800 4300 4600 5500
2	KE	0.06
3	SC	274 193 143 265 145 0 0 0 0 0 0 0 0 0 0
4	CC	3
5	DK	20 30 50 80 30 60 40 60 20 30 50 80 30 60 40
6	KK	4.93

After putting input value GUI FILE shows below,



So finally we get,

Proposed Approach Flowchart:



4. CONCLUSION AND FUTURE SCOPE

A new powerful algorithm has been presented in this paper for capacitor placement in radial distribution systems. This method was inspired by observation of the behavior of ant colonies. The ACO applies the state transition rule to favors transition towards nodes connected by shorter edges. Then it applies local updating rule. Finally it applies a global updating rule to make search more directed and enhance the capability of finding the optimal solution in capacitor placement problem. This ACO methodology for capacitor placement problem is efficient to find the optimal solution for the system used in the work.

It was observed that optimal capacitor placement process not only reduce the power loss, but also improve the voltage profile and maximizing the net savings. The problem has been formulated as maximization of net savings obtained from energy loss reduction, kVA enhancement and improvement of voltage profile.

FUTURE SCOPE

This algorithm also designs in .net frame work. It will be faster than this.

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