Impact Factor (SJIF): 3.632

International Journal of Advance Research in Engineering, Science & Technology

e-ISSN: 2393-9877, p-ISSN: 2394-2444

(Special Issue for ITECE 2016)

Use of Ant colony search Algorithm in Radial Distribution System

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Abstract —This thesis aims to study distribution system operations by the ant colony search algorithm (ACSA). The objective of this study is to present new algorithms for solving the maximizing profit problem. . The ACSA is a relatively new and powerful swarm intelligence method for solving optimization problems. These algorithms can be defined in two categories: deterministic and non-deterministic algorithms. Deterministic algorithms usually have set execution schedules and are fairly exhaustive search methods. Non-deterministic algorithms use randomness and prove useful for problems where it may not be possible to execute a deterministic algorithm, aims to the behaviors of real ant colonies to solve real-world optimization problems e to the size. In this paper, MATLAB based algorithm is used to generate the Optimization results and correct placement of Capacitors and also describe various application of this theorem.

Keywords-Transmission Line, Transformer, Bus Bars, Domestic load, Capacitor Bank

I. INTRODUCTION

The analysis of a distribution system is an important area of activity, as distribution systems provide the vital link between the bulk power system and the consumers. A distribution circuit normally uses primary and main feeders and lateral distributors. A main feeder originates from the substation and passes through the major load centers. Lateral distributors connect the individual transformers at their ends. Many distribution systems used in practice have a single circuit main feeder and are defined as radial distribution systems. Radial distribution systems are popular because of their simple design and generally low cost [2].

In general, a distribution system is fed at only one point and the structure of the network is mainly radial. For such a system all active power demands and losses must be supplied by the source at the root bus. However, addition of shunt capacitors can generate the reactive power and therefore it is not necessary to supply all reactive power demands and losses by the source. Thus, there is a provision to minimize the loss associated with the reactive power flow through the branches. [2]

The modern power distribution network is constantly being faced with an ever growing load demand; this increasing load is resulting into increased burden and reduced voltage. The distribution network also has a typical feature that the voltages at buses (nodes) reduces if moved away from substation.

This decrease in voltage is mainly due to insufficient amount of reactive power. Even in certain industrial areas under critical loading, it may lead to voltage collapse. Thus to improve the voltage profile and to avoid voltage collapse reactive compensation is required.

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 at distribution level. Many arrangements can be worked out to reduce these losses like network reconfiguration, capacitor placements etc.[2].

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.[1,3]

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

The optimization problem has been formulated as the maximization of the total savings produced by the reduction in energy losses and the improvement of the voltage profile. The costs formulation includes investment, operation and maintenance costs of the installed compensation, as well as the costs of energy losses and kVA enhancement. To calculate the energy savings and the deferral investment cost exactly, a load flow for radial distribution network is executed before and after the compensation.

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.

However to achieve these objectives, keeping in mind the overall economy, the size and location of capacitors should be decided. One of the most successful examples of ant algorithms is known as “ant colony optimization”. ACO is inspired by the foraging behaviour of ant colonies, and target discrete optimization problems. The ant colony optimization algorithm (ACO) is a probabilistic technique for solving computational problems which can be reduced to finding good paths through graphs.

This algorithm is a member of ant colony algorithms family, in swarm intelligence methods, the first algorithm was aiming to search for an optimal path in a graph; based on the behaviour of ants seeking a path between their colony and a source of food. The original idea has since diversified to solve a wider class of Numerical problems, and as a result, several problems have emerged, drawing on various aspects of the behaviour of ants [26].

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.

Capacitor placement for loss reduction:

If all the nodes have capacitors giving the same reactive power as the loads at these nodes, it will be expected that almost no reactive power will flow on the distribution feeders, and the losses due to reactive power will be almost zero. However, although this type of compensation of the reactive power gives minimum system losses, it is not practical because the cost of the compensating capacitors may exceed the benefits gained from reducing the energy losses.

The method first finds the location of the capacitor in a sequential manner. Once the capacitor locations are identified, the optimal capacitor size at each selected location is determined through optimizing the loss saving equation. The method was tested on two different distribution systems and very encouraging results were found.

3 Problems occur during capacitor placement:

1. Capacitor Sizing
2. Over Current and Over Voltage Protection
3. Change Capacitor Location

II. ANT COLONY SEARCH ALGORITHM AND ITS APPLICATION

2.1 Introduction:

Ant colony search algorithm is a recently proposed method for solving hard combinatorial optimization problem. Inspiring source of ACSA is the pheromones as a communication medium. In analogy to the biological example, ACSA is based on the indirect communication of a colony of simple agents, called (artificial) ants, mediated by (artificial) pheromone trails [3].

ACSA algorithm is inspired by the behavior of real ant colonies used to solve combinatorial optimization problem. The real ants lay down in some quantity an aromatic substance, known as pheromone, in their way to food source. The pheromone quantity depends on the length of the path and the quality of the discovered food source. An ant chooses an exact path in connection with the intensity of the pheromone [4].

The ant colony search algorithm (ACSA) is a probabilistic technique for solving computational problems which can be reduced to finding good paths through graphs.

2.2 Basic Principles of Operation:

This algorithm starts with an ‘empty’ solution and adds solution components one at a time until a complete solution is built. ACSA algorithm is characterized by this solution construction and by their use of past solSutions in manipulating an artificial ‘pheromone’.

This pheromone is a numeric value which is associated to every unique solution component. It reflects the estimated utility of each unique solution component. These pheromone values are used to bias solution construction by influencing the probability of a solution component being added to a growing solution based on the magnitude of the pheromone value.

The ability of ACSA algorithm to solve more difficult artificial problem instances is important for researchers, as these difficult artificial problems are often close approximations of industrial (real-world) applications. However, as the complexity of the problem increases, the optimization performance of many standard ACSA algorithms will often decrease.

Methods used to solve optimization problems are usually defined into one of two categories:
Deterministic and non-deterministic algorithms.

- Deterministic algorithms are usually well defined and understood since their deterministic nature allows for more accurate analysis and estimation of performance. Non-deterministic (stochastic) algorithms are not always understood, and hence performance estimations for these algorithms are usually given as confidence measures.
- Non-deterministic algorithms are useful for problems where it may not be possible to execute a deterministic algorithm due to the size, or nature of the problem’s search space. Such problems are usually denoted as NP-hard or NP-complete. In these cases a deterministic algorithm may take days or months to find an optimal solution, whereas a non-deterministic algorithm can usually find an approximate but hopefully still near-optimal solution in a matter of minutes or second.

2.3 The Merits and Demerits of Ant colony search algorithm:

2.3.1. Advantages of ACO algorithms are as follows:

1) The Positive Feedback in ACO accounts for rapid discovery of good solutions
2) ACO employs Distributed computation, which avoids premature convergence.
3) The greedy heuristic used in ACO helps find an acceptable solution in the early solution in the early stages of the search process.

i. Disadvantages in ACO algorithms are:

1) These algorithms have slower convergence than other Heuristics.
2) They performed poorly for TSP problems larger than 75 cities.
3) There is no centralized processor to guide the Ant System towards good solutions.

2.4 Applications of Ant colony search algorithm: [6]

- Applications of ACO in NP-Hard Problems
- Application to Telecommunication Networks

- Application to Industrial Problems
- ACO for Combinatorial Optimization
- ACO for Electrical Systems
- ACO for Service Restoration and Reliability

III. Simulation Work

3.1 FLOW CHART FOR ANT COLONY SEARCH ALGORITHM:

This proposed method employs a different structure for the optimization algorithm. A near global Optimum feeder reconfiguration and capacitor setting is obtained, which shows the best results among other previous similar works. [4, 9]

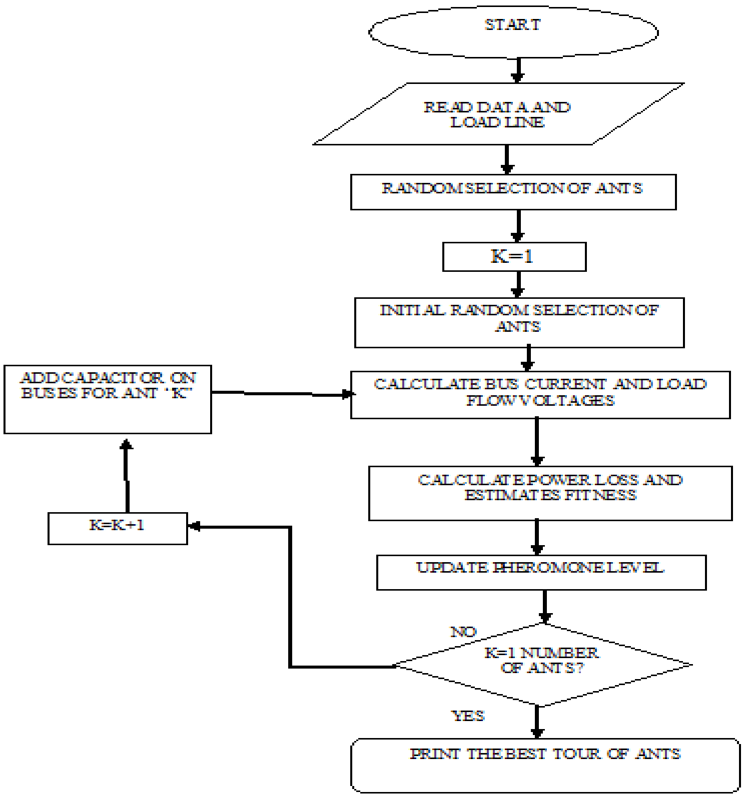

Figure 1

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 which is shown in fig. 1

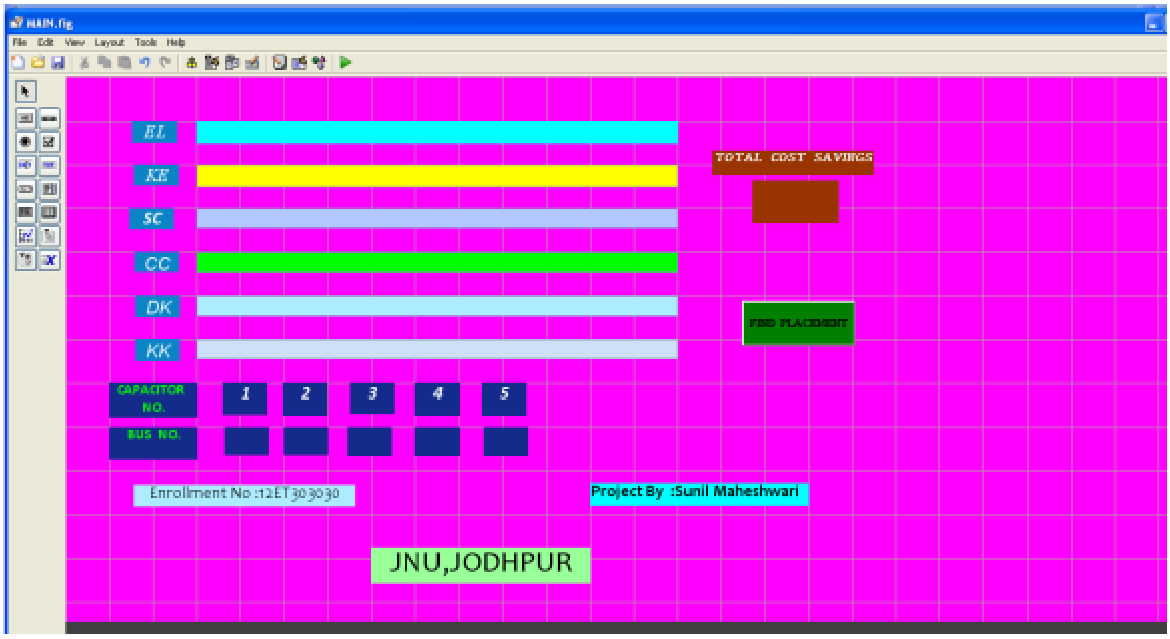

Figure 2

1.	***EL***	***Reduction In Energy Loss In Terms Of Dollars Per Year***
2.	***KE***	***Factor To Convert KVA Enhancement In To Dollars***
3.	***SC***	***Size Of Capacitor To Be Placed With The Proposed Algorithm***
4.	***CC***	***Cost Of Capacitor To Be Placed With The Proposed Algorithm***
5.	***DK***	***KVA Enhancement In Terms Of Dollars Per Year***
6.	***KK***	***Factor To Convert Energy Loss Into Dollars Per Kilo Watt Hours***

Table 1

Capacitor placement 15 bus radial distribution system:

Following table provides input parameter used in the placement process. For 15 bus system Ant Colony Optimization algorithm requires 15 capacitors for the calculation process.

Sr no	Input parameter	Value
1.	EL	**2500 3000 3300 2400 2600 8800 9000 3500 4000 450 2300 2400 2800 2900 3800**
2.	KE	**0.07**
3.	SC	**174 165 265 193 144 123 149 169 175 183 194 189 197 19 130**
4.	CC	**4**
5.	DK	**50 40 30 20 50 30 40 50 30 40 20 10 30 40 50**
6.	KK	**4.93**

Table 2 input parameter value

IV. Conclusion:

Radial distribution systems are typically spread over large areas and are responsible for a significant portion of total power losses. Reduction of total power loss in distribution system is very essential to improve the overall efficiency of power delivery. This can be achieved by placing optimum value of capacitors at proper locations in radial distribution systems.

Capacitors are installed at strategic locations to reduce the losses and to maintain the voltages within the acceptable limits. This thesis aims to study distribution system operations by the ant colony search algorithm (ACSA).

This is a powerful algorithm has been presented in this thesis for capacitor placement in radial distribution systems. This method was inspired by observation of the behavior of ant colonies. The ACSA applies the state transition rule to favors transition towards nodes connected by shorter edges. 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 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. MATLAB based algorithm is used to generate the Optimization results and correct placement of Capacitors.

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