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A Review Article In Distribution System Minimum Loss Reconfiguration Using Ant Colony Optimization Algorithm

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***Abstract*- This paper presents a comparative study of three Ant Colony Optimization (ACO) algorithms applied to Distribution Network Reconfiguration Problem. The original ACO algorithm called the Ant System (AS) and two of its variants viz. MAX-MIN Ant System (MMAS) and Ant Colony System (ACS) were used to minimize active power loss in distribution systems. The algorithms were coded in MATLAB and numerical experiments were conducted on two benchmark systems. The results indicate that even though all the three algorithms are capable of solving distribution network reconfiguration problem, ACS is found to perform better for larger systems.**

***Keywords*- Distribution network reconfiguration, Ant Colony Optimization algorithm, Ant System, Max-Min Ant System, Ant Colony System.**

I. INTRODUCTION

Over the past few decades, distribution systems have received considerably less attention than have transmission and generating systems [l]. This is due mainly to the fact that transmission and generating systems are usually very capital intensive, and inadequacies in either often lead to widespread catastrophic consequences. Consequently, more etlort has gone into ensuring the adequacy of this part of the power system. Distribution systems are relatively cheap, and outages have a very localized effect [2].

However, while relatively inexpensive, large sums ofmoney are spent collectively on such systems. Distribution systems are critical links between the utility and customer in which sectionalizing switches are used for both protection and configuration management. Usually distribution systems are designed to be most efficient at peak load demand. Obviously, the network can be made more efficient by reconfiguring it according to the variation in load demand. Recent studies indicate that upto 13% of the total power generation is wasted in the form of line losses at the distribution level. Hence, it is of great benefit to investigate methods of network reconfiguration [3].

Electric power distribution networks reconfiguration means the reduction of losses or the minimization of losses in the distribution network through better feeder configuration [4], Reduced losses can result in generator fuel saving and possibly some reduction in generation capacity, hence, proving the proverb "energy saved is energy produced" and moreover environmental cost for pollution. Reconfiguration can be used for isolating faulted feeder section and restore service to faulted section

of distribution network after correction. Service restoration is achieved by switching loads on outage to adjacent energized feeders.

II.DISTRIBUTION NETWORK PLANNING

Distribution network planning is a combinational optimization problem where the objective is to determine the optimum way of supplying a given set of load, through a substation and a feeder configuration such that the network losses are minimized along with the network cost, while maintaining the radiality of the network and at the same time not violating the capacity and voltage drop constraints in any part of the networks [5,6,7]. Most electric distribution network feeders are configured radially for effective co ordination of their protection system [8].

In an automated distribution system, the configuration is changed from time to time so that the loads are supplied at the cost of the minimum line losses. Under normal operating condition the distribution engineer periodically reconfigure distribution network feeder, by opening or closing a network branches by switching operation of a switch, in order to reduce the losses occurring in the line and to increase network reliability. Resulting network should be a radial one and meet all the load requirements [9].Co-ordination of the protection scheme of the new configuration is then necessary. The function of the feeder reconfiguration is to determine the status of these feeder switches (ON/OFF) for different multi objective purpose [10].

III. POWER LOSSES REDUCTION DISTRIBUTION SYSTEM

The power losses reduction through the distribution system reconfiguration have been provided using different algorithms such as Johnson's algorithm [5], Ant Colony [6], Expended invasive weed optimization [7], Cuckoo search [8], Opposition learning genetic algorithm [9], Genetic algorithm [10], Grasshopper optimization [1], Augmented grey wolf optimization [2], Vector shift operation [3], Salp swarm optimization [4], Particle swarm optimization [5], Improved fireworks [6], and Back propagation neural network [7]. Furthermore, the authors in [8] had implemented the selective firefly algorithm and search space reduction for the complex problem of distribution system reconfiguration; a set of switches for opening based on mesh analysis is initially provided and eliminated from the switches possibility as search space based on lowest active power of branch.

The distribution system reconfiguration using qualified binary particle swarm optimization is authorized by [9]; two different power flows have been compared to perform the optimal reconfiguration. An optimal reconfiguration with multi-objective of reduced active power and reactive power losses as well as reliability improvement are studied in [20]; the authors had also applied particle swarm optimization to search for that optimal reconfiguration.

IV. LITERATURE REVIEW

Javad Olamaei, Distribution Feeder Reconfiguration for Loss Minimization Based on Modified Honey Bee Mating Optimization Algorithm: This paper presents an efficient algorithm for multi-objective distribution feeder reconfiguration based on Modified Honey Bee Mating Optimization (MHBMO) approach. The main objective of the Distribution feeder reconfiguration (DFR) is to minimize the real power loss, deviation of the nodes' voltage. Because of the fact that the objectives are different and no commensurable, it is difficult to solve the problem by conventional approaches that may optimize a single objective. So the metahuristic algorithm has been applied to this problem. This paper describes the full algorithm to Objective functions paid, The results of simulations on a 32 bus distribution system is given and shown high accuracy and optimize the proposed algorithm in power loss minimization.

Kola Sampangi Sambaiah, Loss minimization techniques for optimal operation and planning of distribution systems: A review of different methodologies: In an electrical power system, the generated power is transferred through a high voltage transmission system, and it reaches the low voltage consumers at the distribution side. In a distribution system, I 2 R loss is very high compared with the transmission system due to high R X ratio, high current, and low voltage. It is a known fact that the economic enticement of distribution companies (DISCOMs) is to minimize losses in their networks. In general, this enticement is the difference in cost obtained between real and standard losses.

Thus, when real losses are more than the standard losses, the DISCOMs are penalized economically, or when the opposite occurs, they earn a profit. Hence, loss minimization problem in distribution systems is a well-suitable researched topic for researchers. Various approaches are investigated and implemented to solve the loss minimization problem in the past. However, these are different from each other by choice of loss minimization tool, problem formulation, methods employed, and the solution obtained.

Several methods exist for loss minimization like capacitor allocation, network reconfiguration, distributed generation (DG) allocation, feeder grading, high voltage distribution system, etc. The present article gives a literature review, general background, and comparative exposition of the most often used techniques: (a) network reconfiguration, (b) capacitor allocation, (c) DG allocation, and (d) DSTATCOM allocation for loss minimization in distribution system and its combination versions for achieving maximum potential benefits are (e) simultaneous reconfiguration and capacitor allocation, (f) simultaneous reconfiguration and DG allocation, (g) simultaneous DG and DSTATCOM allocation, and (h) simultaneous reconfiguration, capacitor, and DG allocation based on several published articles. This will make the literature easy to new researchers working in this area.

Keerti Rai, A Comparative Performance Analysis for loss Minimization of Induction Motor Drive Based on Soft Computing Techniques: This paper presents a comparative performance assessment for loss minimization of vector controlled induction motor (IM) drive based on three different efficient optimization algorithms, namely Particle Swarm Optimization (PSO), Genetic Algorithm (GA) and Golden Search (GS). The present work deals with the recalculation of optimized flux component of current based on the mentioned techniques, for a better optimal efficiency operation of the IM drive.

All the three algorithms based IM drive operation show improvement in efficiency by reduction in the core loss of the drive system. However, it is PSO based IM drive operation that has the advantages of fast response and high accuracy compared to other two schemes. The PSO based energy optimization scheme adaptively adjust the flux component of current to minimize the system loss

Moreover, the three approaches have no effect on parameter variation and also need no additional hardware for hardware implementation. The simulation results for various speed patterns and operating conditions are presented here. Stability study of the whole drive system is also carried out utilizing the three optimizing schemes.

Waseem Haider, Voltage Profile Enhancement and Loss Minimization Using Optimal Placement and Sizing of Distributed Generation in Reconfigured Network: Power loss and voltage instability are major problems in distribution systems. However, these problems are typically mitigated by efficient network reconfiguration, including the integration of distributed generation (DG) units in the distribution network. In this regard, the optimal placement and sizing of DGs are crucial. Otherwise, the network performance will be degraded. This study is conducted to optimally locate and sizing of DGs into a radial distribution network before and after reconfiguration.

A multi-objective particle swarm optimization algorithm is utilized to determine the optimal placement and sizing of the DGs before and after reconfiguration of the radial network. An optimal network configuration with DG coordination in an active distribution network overcomes power losses, uplifts voltage profiles, and improves the system stability, reliability, and efficiency. For considering the actual power system scenarios, a penalty factor is also considered, this penalty factor plays a crucial role in the minimization of total power loss and voltage profile enhancement.

The simulation results showed a significant improvement in the percentage power loss reduction (32% and 68.05% before and after reconfiguration, respectively) with the inclusion of DG units in the test system. Similarly, the minimum bus voltage of the system is improved by 4.9% and 6.53% before and after reconfiguration, respectively. The comparative study is performed, and the results showed the effectiveness of the proposed method in reducing the voltage deviation and power loss of the distribution system. The proposed algorithm is evaluated on the IEEE-33 bus radial distribution system, using MATLAB software.

Arun Onlam, Power Loss Minimization and Voltage Stability Improvement in Electrical Distribution System via Network Reconfiguration and Distributed Generation Placement Using Novel Adaptive Shuffled Frogs Leaping Algorithm: This paper proposes a novel adaptive optimization algorithm to solve the network reconfiguration and distributed generation (DG) placement problems with objective functions including power loss minimization and voltage stability index (VSI) improvement.

The proposed technique called Adaptive Shuffled Frogs Leaping Algorithm (ASFLA) was performed for solving network reconfiguration and DG installation in IEEE 33- and 69-bus distribution systems with seven different scenarios. The performance of ASFLA was compared to that of other algorithms such as Fireworks Algorithm (FWA), Adaptive Cuckoo Search Algorithm (ACSA) and Shuffled Frogs Leaping Algorithm (SFLA). It was found that the power loss and VSI provided by ASFLA were better than those given by FWA, ACSA and SFLA in both 33- and 69-bus systems.

The best solution of power loss reduction and VSI improvement of both 33- and 69-bus systems was achieved when the network reconfiguration with optimal sizing and the location DG were simultaneously implemented. From our analysis, it was indicated that the ASFLA could provide better solutions than other methods since the generating process, local and global searching of this algorithm were significantly improved from a conventional method. Hence, the ASFLA becomes another effective algorithm for solving network reconfiguration and DG placement problems in electrical distribution systems.

A. Apparao, Optimal Allocation of DG Considering Loss Minimization and Voltage Profile Using PSO: Distributed Generation integration in distribution system is one of the options which give many benefits like loss minimization, peak saving, over load relieving, voltage profile improvement, power quality and improved reliability. The installation of DG units at non-optimal places can result in an increase in system losses, damaging voltage state. In this paper, objective function is designed for optimally determining the location of distributed generation, distribution system for power loss reduction and voltage profile improvement are presented. Newton Raphson's Power flow method with particle swarm optimization algorithm (PSO) is used and the effectiveness of the proposed method is tested on IEEE 33- bus radial distribution systems to demonstrate the performance and in the presence of distributed generation (DG).Results show the efficiency of the proposed algorithm in reducing power losses, improving voltage profile.

Shilpa Kalambe, Loss minimization techniques used in distribution network: Bibliographical survey: Distribution system provides a link between the high voltage transmission system and low voltage consumers thus I2R loss in a distributed system is high because of low voltage and high current. Distribution companies (DISCOs) have an economic enticement to reduce losses in their networks.

Usually, this enticement is the cost difference between real and standard losses. Therefore, if real losses are higher than the standard ones, the DISCOs are economically penalized or if the opposite happens, they obtain a profit.

Thus loss minimization problem is a well researched topic and all previous approaches vary from each other by selection of tool for loss minimization and thereafter either in their problem formulation or problem solution methods employed. Many methods of loss reduction exist like feeder reconfiguration, capacitor placement, high voltage distribution system, conductor grading, Distributed Generator (DG) Allocation etc. This paper gives a bibliographical survey, general background and comparative analysis of three most commonly used techniques (i) Capacitor Placement, (ii) Feeder Reconfiguration, (iii) and DG Allocation for loss minimization in distribution network based on over 147 published articles, so that new researchers can easily find literature particularly in this area.

S.Gopiya Naik, Sizing and siting of distributed generation in distribution networks for real power loss minimization using analytical approach: This paper presents a method based on analytical approach for real power loss minimization of distribution networks by injecting power by the Distributed Generation (DG) operating at a given power factors. This method does not require calculation of Zbus matrix, inverse of Ybus matrix or Jacobean matrix as well as requires less computation time. The proposed method is tested on an IEEE 33-bus radial distribution test system. The results obtained by this proposed method validate the suitability and importance of appropriate DG allocation in power distribution networks for the performance improvement.

Nibedita Ghosh, A Load Flow based Approach for Optimum Allocation of Distributed Generation Units in the Distribution Network for Voltage Improvement and Loss Minimization: DG is nothing but a small scale generation unit connected directly to the distribution network or near customer load center. This system may or may not be connected to the electric grid. DG has a limited size of 10MW or less especially when DG is used in a distribution network. DG is installed at the place where it becomes impracticable to build a central generation plant. DG is installed to improve the voltage profile as well as minimize losses. DG allocation is a crucial factor. Optimum DG allocation provides a variety of benefits. But inappropriate DG allocation can cause low or over voltage in the network. In this paper a load flow based method using ETAP software is used to determine the optimum location & optimum size of DG in a 33 bus distribution system for voltage profile improvement & loss reduction.

K. Nadhir, Distributed generation location and size determination to reduce power losses of a distribution feeder by Firefly Algorithm: In order to minimize power losses caused by high current and improve the voltage profile in the network distribution, the introduction of dispersed generations also called productions decentralized in distribution network (DG) plays an important role. The installation of DGs directly affects the power requested or purchased. The sizing and placement of DGs in the system must be optimal because a wrong choice has a negative impact on the system behavior. To solve this combinatorial problem, an algorithm known as Firefly algorithm is proposed in this paper. This is a meta-heuristic algorithm inspired by the behavior of fireflies flashing. The main objective of firefly flash is to act as a signaling system to attract other fireflies. Networks tested IEEE69-bus and IEEE33-bus are used to evaluate the effectiveness of this method. The results are compared with those obtained by genetic algorithm (GA) to IEEE69-bus, and Shuffled frog leaping algorithm (SFLA) for IEEE 33-bus.

M. Sedighizadeh, M. Fallahnejad, M. R. Alemi1, M. Omidvaran1, D. Arzaghi-haris, Optimal Placement of Distributed Generation Using Combination of PSO and Clonal Algorithm: The optimal placement of Distributed Generation (DG) has attracted many researchers' attention recently due to its ability to obviate defects caused by improper installation of DG units, such as rise in system losses, decline in power quality, voltage increase at the end of feeders and etc. This paper presents a new advanced method for optimal allocation of DG in distribution systems.

In this study, the optimum location of DG units is specified by introducing the power losses and voltage profile as variables into the objective function. Particle Swarm Optimization (PSO) and Clonal Selection Algorithm (CLONALG) are two methods which have been applied to optimize different objective functions in previous studies. In this paper, the Combination of Particle Swarm Optimization and Clonal Selection Algorithm (PCLONALG) is utilized as a solving tool to acquire superior solutions. Considering the fitness values sensitivity in PCLONALG process, it is necessary to apply load flow for decision making.

Finally, the feasibility of the proposed technique is demonstrated for a typical distribution network and is compared with the PSO and CLONALG methods. The experimental results illustrate that the PCLONALG method has a higher ability in comparison with PSO and CLONALG, in terms of quality of solutions and number of iterations. The approach method has the preferences of both previous methods. Via immunity operation, the diversity of the antibodies is maintained and; the speed of convergence is ameliorated by operating particle swarm intelligence.

Salah Kamal EL-Sayed, Optimal Location and Sizing of Distributed Generation for Minimizing Power Loss Using Simulated Annealing Algorithm: Distributed Generation integration in electric power system is one of the options which give many benefits such that loss Reduction, peak saving, voltage profile improvement, stability and reliability improvement. The installation of

DG units at non-optimal location can result in an increase in system losses, damaging voltage state. In this paper, simulated annealing Algorithm (SAA) techniqueis designed for optimally determining the location, sizing and numbers of distributed generations depending on power loss reduction and voltage profile improvement. The proposed technique is tested on IEEE 57- bus system to demonstrate the performance of the network after inserting the distributed generation in selected optimal location with optimal sizing. Results show the efficiency of the proposed algorithm in reducing power losses, improving voltage profile.

Merlin and Back (1975) were pioneers who solved the distribution system reconfiguration problem to reduce losses. They have determined a minimum loss configuration with the optimization method of a branch-and-bound-type. A meshed network is formed in this method, by closing all the switches in the network. The radial configuration is then restored by opening the switches successively [1].

Civanlar et al. (1988) proposed a heuristic algorithm involving exchange of switches through employing a simple formula to assess the reduction of loss by exercising a specific option of switching [2].

Zhu (2002) introduced a modified approach of GA which utilizes a process of adaptive mutation to solve the problem of DNR for loss minimization [8].

Prasad et al. (2005) introduced a novel genetic algorithm using a fuzzy mutation for the purpose of optimal reconfiguration for the minimization of losses as well as voltage deviations in radial distribution systems [4].

Sahoo and Prasad (2006) proposed a fuzzy genetic method to solve the DNR issue in order to maximize the network's stability of voltage for the specified set of loads. Their work implied that any increase in the stability of voltage may cause decrease the losses in the system [4].

Savier and Das (2007) examined the power loss allotment to the consumers connected to radial distribution networks before and after the reconfiguration of the network in a deregulated situation. A fuzzy multi-objective method in the fuzzy framework and the DNR algorithm based on the principle of max-min was employed for optimization [9].

Chung-Fu Chang (2008) proposed a novel approach that uses a search algorithm based on ant colony to solve the problems of optimal feeder reconfiguration, the optimal placement of capacitor and the problem of the combination of both. They established the efficacy in the feeder reconfiguration simultaneously with capacitor placement over the two when they are considered separately [5].

Wang and Cheng (2008) were proposed an optimization approach for network configuration which is inspired by a simulation algorithm based on plant growth, specifically suitable for larger scale distribution systems [6].
Khodr et al. (2009) combined the problems of DNR and optimal power flow to solve them using the Benders decomposition algorithm. This also aided the minimization of power loss and load-balancing among feeders [6].

Chandramohan et al. (2009) proposed a method to reconfigure a radial system using NSGA to minimize the operating costs with respect to the costs of real and reactive power along with maximization of reliability in operation also considering the normal constraints in regular operations [2].

Arun and Aravindhababu (2010) proposed a DNR algorithm based on fuzzy that enhances the stability and voltage profile with loss minimization, without incurring any additional expenditure towards installing the capacitors, tap-changing transformers and the other associated switching equipment used in the distribution system [7].

Ahmed (2011) proposed a new heuristic approach that aims at reduction of the combinatorial switching problem to a realizable one along with the reduction of the switching combinations to a lesser number. An algorithm of load flow founded on the graph theory is projected in order to avoid the formation of unconnected branches as well as the closed loops within the scope of the network [3].

Rao et al. (2011) presented the Harmony Search Algorithm which can solve the problem of the DNR that results in minimum loss through an optimal switching combination in the network [4].

Abdullah et al. (2012) proposed a method to identify global optima so that the total loss of power can be minimized, by solving the DNR problem. The proposed method depends on the approach of minimum-current circular-updatingmechanism approach and makes use of a heuristic algorithm. Meta-heuristics have been used for many AI-based and evolutionary algorithms which have been proposed so that the issue of network reconfiguration could be addressed through single objective optimization.

V. DISTRIBUTION SYSTEM LOSS

Distributed Generators (DGs) are power generation systems whose output are not connected to a central grid structure for transmission over long distances to the point of usage, rather they are located at the point of usage, with limited or no requirement for transportation [1, 2].

Due to their modularity and portability and little or no requirement for the transportation of the energy resources (fuel) from point of production to the point of usage, renewable energy technologies such as solar photovoltaic and solar thermal systems which harnesses solar energy from the sun and transform it into a suitable form of energy such as heat and electricity are prime candidates for distributed energy generation [3]. Other forms of renewable energy technologies applied in distributed generation systems are small hydro power systems, wind turbines, biogas and bio thermal systems and so on. Also, due to the harmful effect of fossil fuel usage on the environment such as the greenhouse effect and global warming, there has been a significant increase in the usage of renewable energy technologies.

VI. CONCLUSIONS

Reconfiguration of two benchmark distribution systems was carried out using Ant Search, Max-Min Ant System and Ant Colony System. To compare the performance, same parameter values were used for all the three algorithms. Even though all the three algorithms were found to be capable of solving both the benchmark systems, it emerged that ACS yielded optimal solution more number of times compared to others for the larger distribution system viz. Baran and Wu system whereas MMAS performed marginally better for the relatively smaller Civanlar system. In Max-Min Ant System, only the global best solution of each iteration is updated.

Therefore only good solutions are reinforced. This makes the search more focused. Upper and lower bounds on pheromone trails in this method avoid stagnation of the search. For small systems these rules of MMAS assures global optimal solution within lesser number of iterations. Local updating rule of Ant Colony Search algorithm ensures search diversification of the ants in a given iteration. This makes the algorithm more suitable for large systems because for such systems an extensive search of possible solutions should be done before converging to a common solution.

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