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Analysis of Network Reconfiguration Technique for Loss Reduction in Distribution System

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***Abstract:*A distribution system delivers electricity to the customers by carrying it from transmission system. An electric distribution structure plays asignificantcharacter in achieving satisfactory power supply. The quality of power is measured by voltage stability and profile of voltage. But because of losses in distribution system, its voltage profile affects. In this paper we analyze different techniques to reduce these lossesin distribution system and examine the Network Reconfiguration method based on various parametersin detail and find out the optimum one.**

Keywords— Distribution system; Losses; Network Reconfiguration; Capacitor.

I. INTRODUCTION

The keyrole of an electrical distribution system is to deliver electricity to specific clientsites. Distribution of electric power to variousclients is completed with much minimum voltage point. The distribution of electric power from bases to the end levels is complemented with power losses at all times. Power losses arise in distribution systems due to Joule's effect which can calculation for as much as 13% of the produced energy [1, 2]. Such majorquantity of losses has a straighteffect on the economicsubjects and the totalefficacy of supply utilities [4]. Distribution power losses can be shared into two types technical and non-technical losses.

a. Technical losses: The losses that occurs naturally and depend upon the type of conductor used, transformer capacity, and other component used for supply and distribution of electricity. These losses are inherent to the distribution of electricity and cannot be removedbut can be reduced. These losses are stated as losses that occurs due to temperatureindulgenceresultant from current transmitting through conductors and magnetic losses in transformers.

b. Non-technical losses: The losses that occurs because of illegal consumption of electricity. These are caused due to discrepancy in reading of meters, theft of power, faulty meter and inefficiency in collection of bills. Failure to pay, as the termindicatesstates to cases where clientsdecline or incapable to pay bill for their energy usage. It is projected that powershopliftingoverheads in our nation is in crores per annum.

Large degree of technical and non-technical losses might cause [1]

- Low QoS deliver to clients.
- High budget because ofunusable or early investments.
- Lessening in profitscausing in moneyproblems with all resultantfinancialconcerns.

Primary losses motivate the system to support the organization, thus growing the positions'economic load. Minimizing the losses and getting an adequate stage will re-establish the self-assurance of investors and isolatedfinanciers to inspire them to partakeeconomically in the expansion of the electric power division. The ensuedadvances from losses lessening can be categorized into

economic and financial gains, and formalprofits [4]. So, the lessening of technical losses chiefs to anactual benefit in power and minimize financialfunds. Further, the lessening of non-technical losses not only increases the economicscale of the concerned organization, but also the load curve by endangeringusage to the pricelistparameter [4].

The final stage in the delivery of electricity to the customers is electricity distribution. A distribution system delivers electricity to the customers by carrying it from transmission system. It is, in several cases, the high investment, maintenance and processexpenditure, and the subject of attention to authorities, monetaryorganisations, and groups of concerned peoples. The distribution of electric power from bases to the end levels is complemented with power losses at all times. In thispaper we analyse various methods to minimize the power losses in distributed systemtheir merits and demerits and we analyze the different techniques used in network reconfiguration.

II. RELATED WORK

The various loss reduction techniques are:

A. Network Reconfiguration

Network Reconfiguration is the procedure of operating switches to modify the circuit topology so that operationaloverloads and charges are condensed while sustaining the stated constraints [13].

B. Network Reconductoring

Network reconductoring is the technique in present conductor on the feeder is replaced by conductor of optimum size for optimumdimension of feeder. This technique is used when present conductor is no more optimum because of quick growth of load. This technique is good for the emergingnations like India where annual accountgrowing rates are great and the conductor are selected to reduce the preliminaryfinacial investment.

C. Distribution Transformers Locating and Sizing

Usually, DTs are not positioned centrally in the aspect of clients. Due to which the farthest customersattain avery low voltage even though a reasonably high voltage level is retained at anothertransformer. This centrals to maximum losses in distribution system. In this technique, distribution transformers should be located nearer to the load centre as possible and replace large transformers by the transformers of small rating such that it serves small number of consumers so that optimum voltage level is maintained**.**

D. Automatic Voltage Booster (AVB)

Automatic Voltage Booster increases the voltage at its point of site in distinct steps which in turn develops profile of voltage and minimize the losses in the sections outside its location point towards receiving. Generally, AVB boost voltage upto 10% in equal steps. Loss minimization is directly proportionate to voltage enhancement.

E. Reactive Power Compensation

It is described as the management of reactive power to increase the enactment of ac energy system. This technique clasp a diverse and wide area of both system and consumerdifficulties, particularly related with power superioritysubjects, as most of power QoS issues can be resolved with requisite control of reactive power. As the load is mostly inductive on the distribution system and requires large reactive power. As, shunt capacitor provides reactive power compensation at its site, not dependent to the load and Series capacitor introduces negative reactance. It means series compensation alters the conduction or distribution system factors, while shunt compensation vagaries the corresponding impedance of the load. In both scenarios, the reactive power that flows through the system can be efficientlyorganizedrefining the performance of the overall distribution system [14].

F. Aerial Bunched Cables (ABC)

These cables are newmodel for overhead energy distribution. It offersgreat safety and reliability, reduces power losses and final system budget by decreasingsetting up, repairs and operational cost. This technique is perfect for rural distribution and especiallystriking for setting up in problematicareas likemountainousspaces, woodlandparts, seasidezones etc. This is also measured as greatestselection for power distribution congested urban areas with fine lanes and by-lanes. ABC is the best choice in urban complex due to flexibility for switching lane as request by modifications in urban development design.

G. High Efficient of Transformers

The use of high efficient of transformers will also reduce losses, i.e. using amorphous core transformers

instead of CRGO transformers. As it have high magnetic vulnerability, with less coactivity and maximum electrical resistance. As in transformers, minimum losses due to the high resistance by eddy currents.

H. High Voltage Distribution System (HVDS)

This technique is most effective and efficient in minimizing the technical losses and refining the power quality in distribution system. In this technique, transformation of previous Low Voltage Distribution System to High Voltage Distribution System is done. This technique aims at extending high voltage lines as nearer to the load as possible and replacing large transformers with various small rating transformers. By using high this method, we can reduce the losses as current is low in high voltage systems.

I. Building New Substation

In this loss reduction technique, a new substation is constructed in addition to the existing one. Location of the new substation is determined by feasibility study. This scheme has to be adopted as the last option.

III. PROBLEM FORMULATION

The Network Reconductoring approach techniques increases the feeder's capacity to handle load growth, extremely fruitful to minimize the losses and it improves voltage profile but this technique may cause ofextra investment which rises the initial investment of feeders.

Distribution Transformers Locating and Sizing technique supports further reconfiguration and requires less investment. It helps in reduction of peak load and energy losses in the distribution system and improves voltage to the tail end consumers. But the extent of improvement of voltage is limited and for further improvement of voltage profile, other methodologies have to be adopted which involves extra investment.

Automatic Voltage Booster (AVB) method reduces the voltage drop by 10%, therefore, it is very effective tool to solve voltage drop problem. But the reduction of losses with the use of AVB is marginal and as such rate is poor.

Reactive Power Compensation technique increases the voltage level and also minimize losses to very much extent. It also increases the security of system and reduces number of outages. But it is difficult technique as compared to others as there is problem in determining the number and size of capacitors toinstall and where to installed and lengthy process and the voltage improvement due to shunt compensation is marginal except in case of heavily loaded feeders. Shunt compensation alone cannot correct voltage drop.

In Aerial Bunched Cables approach; Lower voltage drop, higher current capacities and as compared to bare conductors these cables are much safer. In this approach total line costs are reduced and maintenance is very easy. But initial capital cost is high as compared to bare conductors.

High Efficient of Transformers methodology reduces CO2 emission and core losses. But increases capital cost of power system.

High Voltage Distribution System technique reduces losses, increases energy saving and improves voltage profile and reduces the theft of electricity and decreases illegal connections as the LT lines are reduced and required will be insulated cables. It also helps in avoiding unnecessary iron losses in overrated DTs and hence reduces technical losses. It also reduces the number of outages and makes distribution system more reliable. But it requires additional investment and needs regular maintenance.

Building New Substation technique is more reliable and improves voltage profile and reduces losses. But it increases capital cost as it requires additional investment for building new substation.

From the above discussion about loss reduction techniques we conclude Network Reconfiguration is one of the most optimum and economic methods for loss reduction in distribution systems due to its feature of returning power to any outage segments of a feeder, reducing overloads on feeders by shifting the load in actual time to nearby feeders, and resistive line losses will be reduce. So, in this paper we analyze the Network Reconfiguration technique in our dissertation work.

IV. NETWORK RECONFIGURATION

The Network reconfiguration is the one of the possible techniques in distribution system for

reducing losses in which the power flow is altered by the formation of new links within a feeder to form tree structure or by processing or OFF the proper switches on the feeders. And by forming new links to the change part of feed from one substation to another, balance the load between the substations. Network Reconfiguration is the procedure of functioning switches to alter the circuit topology so that operational costs are minimized while sustaining the stated constraints [13]. Following are the techniques used for Network Reconfiguration:

A. Based on Genetic Algorithm

There are several criteria conditional on the enactment of the system for an operator to define the switch statuses in the distribution system. It is recognized that network operator faiths the MW losses are reduced if the system is in usual state or after the fault clearance. In network reconfiguration based on Genetic algorithm; the problem can be expressed as:

- Reduce the total loss in the distributed system: Minimize$f_1(V,X)$

Where 'V' is the voltage level vector of the different buses. 'X' is the vector of the switches status. $f_1(V\,X)$ is the active power loss.

- Reduce the number of switching operations

$$Min(f_2(\bar{X})) = \sum_{i=1}^{N_S} |S_i - S_{0i}|$$

Where, $f_2(\bar{X})$signifies number of switching operations under state$\bar{X}$. S_i is the final status of switchesand S_{0i} is the initial status of switch.

To preserve a radial network structure, the Genetic algorithm comprises the following switching functioning sequences.

- The switch (as an isolating or sectionalizing switch) to be opened is operated first.
- If the radial configuration is violated after closing a switch, this switch cannot be carefully chosen as a backup switch.That will reason a feeder with two power supplies from both sides.
- If inter-loops are still produced after the above phases, one switch in the loop must be randomly opened.

Bus Voltage and feeder line current limits.
$V_{min}<V_j<V_{max}$
$I_{min}<I_j<I_{max}$

Where, $V_{max}$and$V_{min}$are maximum and lowest acceptable bus voltages respectively. $V_j$is the voltage atbus j. I_{max} and $I_{min}$are maximum and minimum currents respectively.

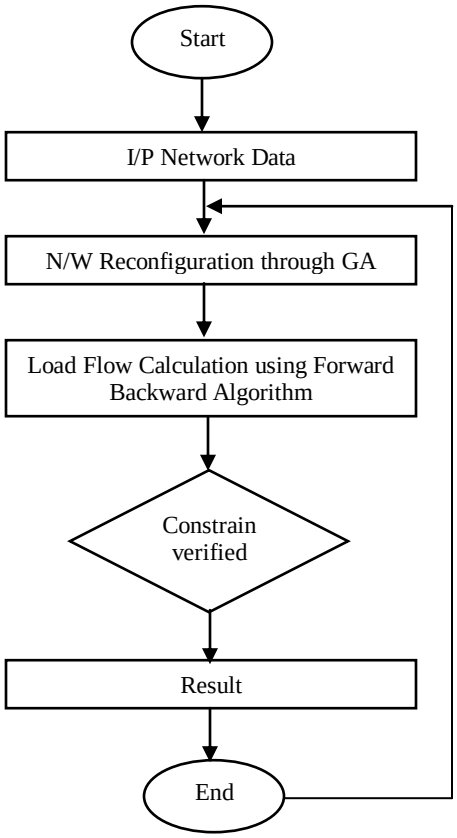

Fig.1 Network Reconfiguration based on GA

B. Based on Differential Evolution Algorithm

This algorithm provide the corresponding cyclic decimal coding solution and corresponding mutation, crossover and selection strategy according to problems that during the distribution network reconfiguration, large number of infeasible solution are produced. Through this algorithm we achieve the less active power loss. In this algorithm the network is layered network with branch level matrix B and node level matrix N.

$$Min\, f = \sum_{i=1}^{N_b} r_i |I_i|^2 K_i$$

Where, $N_b$denotes the total number of branches in distributed system, $r_i$is the resistance of branch,I_i is the load current of branch and K_i is the states of branch either 0 or 1.

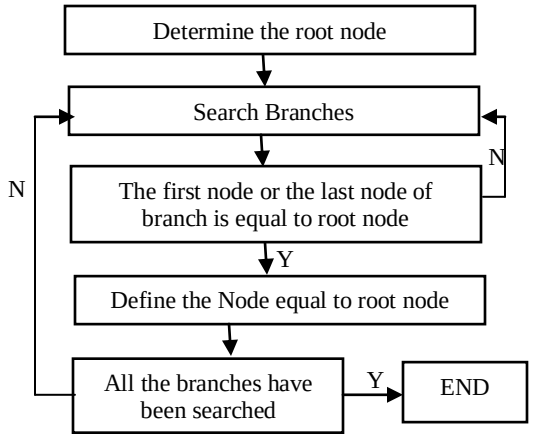

Fig.2 Network Reconfiguration based on DEA

C. Based on Particle Swarm Optimization

The search space for PSO algorithm is a collection of branches (switches) which are usually closed or usually opened, this search space may be different for different magnitudes. The procedure of resolving distributed network reconfiguration issue is distributed into two phases. First, identify search spaces after closing all switches and second, using this algorithm, find switches that would be opened.

Reconfiguration is accomplished by choosing, among allprobable configurations, the one that incurs the minimum power losses and that satisfies a set of constraints. Generallyminimization of network losses is reflected to be objective. Thereforeobjective function is to reduce the actual power losses of distribution system PL considering the following constraints.

- Branch current constraint

$$I_b<I_{bmax}$$

Where Ib is the current of branch b, and $I_{bmax}$is the extremeallowable current of branch b.

- Node voltage constraint

$U_{jmin}< |U_j| <U_{jmax}$

whereU_{jmin} and U_{jmax} are the minimum and maximum allowablerms voltages of node j, respectively.

- Load connectivity.

Each and every bus should be connected via one path to the substation.

- Radial network structure.

This indicates that no loops are allowed in the network.

V. COMPARATIVE ANALYSIS

For the performance of thesealgorithm used for network reconfiguration, we analyze these algorithm based on some parametersis depicted in table 1.

Algorithm/Parameters	**GA**	**DEA**	**PSO**
Power Loss	Allow	Allow	Allow
Objective Function	Minimize total loss and switching operations	Least active power loss	Minimize real power loss
Focus	Bus voltage and feeder line current	Branch level and node level matrix	Number of dimension and search space
Collision Resistant	Cross over and mutation	Cyclic Coding Strategy	Swarm with random positions

Table.1 Comparative Analysis

VI. CONCLUSION

In this paper, we provide various losses in distributed system and different techniques to reduce them with their benefits and limitations. Reconfiguration is one of the most economic approach for loss reduction in distribution systems. These systems are usually meshed in design but are operated radially for protective issues, so we discussed network reconfiguration in detail and analyze the different algorithm used for network reconfiguration with their structures.

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