Review on Reduction of power loss in distribution electrical system

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Abstract-
The power system (PS) losses in transmission lines systems vary with numerous factors depending on system configuration, such as level of losses through transmission and distribution lines, transformers, capacitors, insulators, etc. Power losses can be divided into two categories, real power loss and reactive power loss. The resistance of lines causes the real power loss, while reactive power loss is produced due to the reactive elements. Normally, the real power loss draws more attention for the utilities, as it reduces the efficiency of transmitting energy to customers. The main objectives of the optimization of electric energy systems are to meet load demands with adequacy and reliability and to keep it at the same time economical, meaning to keep the prices as low as possible. Electric energy demand has been shown to be an exponential function doubling its rate over every decade. This ever increasing load has led to larger and more complex systems. Interconnections throughout the whole country is growing and expanding

Keywords: *Power,optimization,transmission,loss*

I. INTRODUCTION

Electric power distribution is the final stage in the delivery of electric power; it carries electricity from the transmission system to individual consumers. Distribution substations connect to the transmission system and lower the transmission voltage to medium voltage ranging between 2 kVand 35 kV with the use of transformers. *Primary* distribution lines carry this medium voltage power to distribution transformers located near the customer's premises. Distribution transformers again lower the voltage to the utilization voltage used by lighting, industrial equipment or household appliances. Often several customers are supplied from one transformer through *secondary* distribution lines. Commercial and residential customers are connected to the secondary distribution lines through service drops. Customers demanding a much larger amount of power may be connected directly to the primary distribution level or the sub-transmission level.

1.1 Electrical Power Distribution System

The main function of an electrical power distribution system is to provide power to individual consumer premises. Distribution of electric power to different consumers is done with much low voltage level. Distribution of electric power is done by distribution networks. Distribution networks consist of following main parts

1. Distribution substation,
2. Primary distribution feeder,
3. Distribution Transformer,
4. Distributors,
5. Service mains.

The transmitted electric power is stepped down in substations, for primary distribution purpose. Now these stepped down electric power is fed to the distribution transformer through primary distribution feeders. Overhead primary distribution feeders are supported by mainly supporting iron pole (preferably rail pole). The conductors are strand aluminum conductors and they are mounted on the arms of the pole by means of pin insulators. Some times in congested places, underground cables may also be used for primary distribution purposes.

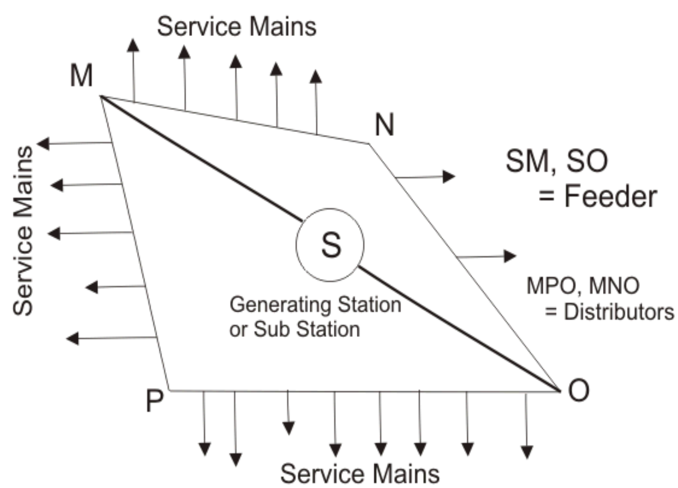

Figure 1.1 Power Distribution System

Distribution transformers are mainly 3 phase pole mounted type. The secondary of the transformer is connected to distributors. Different consumers are fed electric power by means of the service mains. These service mains are tapped from different points of distributors. The distributors can also be re-categorized by distributors and sub distributors. Distributors are directly connected to the secondary of distribution transformers whereas sub distributors are tapped from distributors. Service mains of the consumers may be either connected to the distributors or sub distributors depending upon the position and agreement of consumers. In this discussion of electrical power distribution system, we have already mentioned about both feeders and distributors. Both feeder and distributor carry the electrical load, but they have one basic difference. Feeder feeds power from one point to another without being tapped from any intermediate point. As because there is no tapping point in between, the current at sending end is equal to that of receiving end of the conductor. The distributors are tapped at different points for feeding different consumers; and hence the current varies along their entire length.

1.2 Power Loss Reduction inElectrical Distribution System

The electrical transmission and distribution losses accounts for the most of the power losses in the system. The largest amount of these losses occurs in the primary and secondary distribution lines and can be classified as either technical losses or non-technical losses

Technical electrical power losses

Technical losses occur when the energy is dissipated by the equipment and conductors in the distribution lines. The losses depend on the network characteristics, and mode of operation. There are two categories of technical power losses; the fixed technical losses and the variable technical losses.

Fixed technical losses

The fixed losses in the distribution lines account for between a quarter and a third of the total technical losses. These are usually in the form of heat and noise and occur whenever the transformer is energized.

The fixed losses are not influenced by the amount of load current flowing, but rather by the leakage current losses

- Open circuit losses
- Corona losses
- Dielectric losses

Causes of technical losses

- Inefficient equipment such as the transformers, pumps, electrical machines and industrial loads.
- Inadequate size of conductor in the distribution lines
- Long distribution lines
- Load imbalance among the phases
- Low power factor.
- Over loading of lines
- Transformers installed far from the load centers
- Haphazard installation of distribution systems to cope with demands to new areas

II. RELATED WORK

Amon et al. [1] In this paper a modified version of new Meta Heuristic algorithm based on Bat behavior is proposed to find the best system configuration with a low loss rate, we present two different approaches: reduction of search space and introduction of sigmoid function to fit the algorithm to the problem. The main advantages of the proposed methodology are: easy implementation and less computational efforts to find an optimal solution. To demonstrate its efficiency the proposed scheme is tested on 33 Bus distribution system and the results show loss reduction rate of 33%.

Flaih, Firas MF, et al. [2]In this paper the authors have proposed a method to reduce the power losses and therefore improve the voltage profile for low voltage (LV) distribution system that results in reduction of blackouts. The method involves the repositioning of the distribution transformer (DTR) from the existing location and the replacement of the overhead conductor cross section area for an existing low voltage distribution system (LVDS). This method has been applied to a 20-node low voltage radial distribution network in the general directorate of north distribution electricity (GDNDE), Iraq, where voltage profile and losses are unsatisfactory. Results demonstrate the effectiveness of the proposed method also in terms of the economic feasibility. It is observed that the system average voltage profile is improved by 15%, tail end voltage enhanced by 19.7% and losses are reduced by 78% for existing the LVDS.

Spandana, K. et al [3]This paper is to enlighten the importance of restructuring of an existing Low Voltage Distribution System (LVDS) into High Voltage Distribution System (HVDS) which has a better voltage and loss profile and high quality of supply. In India, the average transmission and distribution losses have been officially indicated as 25% of the electricity generated, because of the fact of usage of long lengths of Low Voltage (LV) distribution lines. In HVDS these long length LV lines are replaced by High Voltage (HV) lines up to the Distribution Transformer (DTR) and then a small length LV line is extended to the consumers end. Due to the usage of long lengths of HV lines, there is no scope for unauthorized power pilferage unlike in LVDS. A large rated distribution transformer in LVDS is replaced by many number of small rated distribution transformers in HVDS. Adequate investment in efficient working of transmission and distribution systems in developing economies with high growth of electricity demand is an important objective. Hence to overcome all these problems, implementation of HVDS is considered as the best move to enhance the performance of a distribution system.

Babu, P. Ravi et al. [4]This paper presents a new methodology for enhancing the distribution system performance by minimizing both technical and non -technical losses. Most of the utility companies in developing countries are victims of major revenue losses due to technical and non technical energy losses. The non-technical losses are like electricity theft, unauthorized connections, irregular billing and the technical losses are I^2R power losses. These losses affect the quality of supply in terms of voltage magnitude, and more tariffs imposed on genuine customers. To improve the efficiency of supply, one of the recommendations is "Boosting the distributor phase voltage, say from 100% to 152% that is, 230V to 350V and stepping down to normal operating voltage (230V) at the consumer premises by using a special voltage regulator device". The methodology can reduce the technical and non technical losses in the electrical distribution system up to 49.12% of total power supplied to electrical distribution system. Hence the voltage profile can be improved by reducing the I^2R losses. As the normal operating voltage of any home appliances is 230V, in the proposed methodology the electrical distributor phase voltage is maintained up to 350V.So if any domestic consumer tries to get unauthorized/illegal power tapping connection, the home appliances are get damaged due to over voltage.

Abdhullah, Sinha Sheikh, et al. [5]The main goal of this research is to study various load balancing algorithms that are in use, now a days. Nature inspired algorithms are applicable in every aspect of technology. In this work, the review of a meta-heuristic technique, namely, BAT Algorithm is carried out. The comparison of all the load balancing techniques and BAT algorithm techniques are described in this paper.

Attari et al. [6] Reconfiguration, by exchanging the functional links between the elements of the system, represents one of the most important measures which can improve the operational performance of a distribution system. Besides, reclosers use to eliminate transient faults, faults isolation, network management and enhance reliability to reduce customer outages. For load uncertainty a new method based on probabilistic interval arithmetic approach is used to incorporate uncertainty in load demand that can forecast reasonably accurate operational conditions of radial system distribution (RDS) with better computational efficiency. In this paper, the optimization process is performed by considering power loss reduction along with reliability index as objective functions. Simulation results on radial 33 buses test system indicates that simultaneous optimization of these two issues has significant impact on system performance.

Sarwar, Md, et al. [8] This paper presents a method to reduce the technical power loss in distribution systems. The high voltage distribution system is proposed to minimize the technical distribution losses. The analysis is done using CYMDIST. The developed methodology is carried on a Lalpura distribution feeder from the Palwal division (Haryana). The feeder is feeding to 89 Distribution transformers with 200 amperes peak load and having the length of about 76 km. The analysis reveals that converting the existing LVDS system for the agricultural load to HVDS system, there is net reduction in technical losses in the distribution system which in turn raises the efficiency of the system. Also it shows the economic viability of the proposed technique.

Babu, P. Ravi et al [9]This paper presents a new methodology for enhancing the distribution system performance by minimizing both technical and non-technical losses. Most of the utility companies in developing countries are victims of major revenue losses due to technical and non- technical energy losses. The non-technical losses are like electricity theft, unauthorized connections, irregular billing and the technical losses are I^2R power losses. These losses affect the quality of supply in terms of voltage magnitude, and more tariffs imposed on genuine customers. To improve the efficiency of supply, one of the recommendations is "Boosting the distributor phase voltage, say from 100% to 152% that is, 230V to 350V and stepping down to normal operating voltage (230V) at the consumer premises by using a special voltage regulator device". The methodology can reduce the technical and non-technical losses in the electrical distribution system to appreciable level. Hence the voltage profile can be improved by reducing the I^2R losses. As the normal operating voltage of any home appliances is 230V, in the proposed methodology the electrical distributor phase voltage is maintained up to 350V. So if any domestic consumer tries to get unauthorized/illegal power tapping connection, the home appliances are get damaged due to over voltage. Hence, with this approach there is no chance for power theft or unauthorized connections in the distribution system. When the electrical distributor operates with more voltage than the normal operating voltage, the I^2R losses in the distributor will be reduced considerably.

Nidhiritdhikrai et al. [10] Accurate assessment of power loss in a low-voltage distribution system is still an important issue under present competitive environment. Even though, power flow analysis is still efficient to calculate technical power loss, it requires numerous data which may not be available for some utilities. For this reason, the loss assessment for a low-voltage distribution system is not easy when the demand of any customer load points is still unclear. Therefore, distribution utilities obviously require a more suitable algorithm with their available information to calculate their system power loss. This paper proposes an alternative algorithm to crop with this problem. The proposed approach has been tested with an actual system, a low-voltage distribution system with 16 customer load points.

Khaniya, Dina et al. [11]This paper proposes the Newton Raphson power flow solution for three phase unbalanced and multiphase system for both radial and meshed topology. Different test cases have been simulated using the developed program to get satisfactory results. Developed program will be further used to investigate the voltage stability of distribution system.

Georgilakis, Pavlos S et al. [12]The aim of the optimal DG placement (ODGP) is to provide the best locations and sizes of DGs to optimize electrical distribution network operation and planning taking into account DG capacity constraints. Several models and methods have been suggested for the solution of the ODGP problem. This paper presents an overview of the state of the art models and methods applied to the ODGP problem, analyzing and classifying current and future research trends in this field.

Hung, Duong Quoc et al. [13]This paper investigates the problem of multiple distributed generator (DG units) placement to achieve a high loss reduction in large-scale primary distribution networks. An improved analytical (IA) method is proposed in this paper. This method is based on IA expressions to calculate the optimal size of four different DG types and a methodology to identify the best location for DG allocation. A technique to get the optimal power factor is presented for DG capable of delivering real and reactive power. Moreover, loss sensitivity factor (LSF) and exhaustive load flow (ELF) methods are also introduced. IA method was tested and validated on three distribution test systems with varying sizes and complexity. Results show that IA method is effective as compared with LSF and ELF solutions.

Imran, A. Mohamed et al. [14]This paper presents a novel integration technique for optimal network reconfiguration and distributed generation (DG) placement in distribution system with an objective of power loss minimization and voltage stability enhancement. Fireworks Algorithm (FWA) is used to simultaneously reconfigure and allocate optimal DG units in a distribution network. FWA is a new swarm intelligence based optimization algorithm which is conceptualized using the fireworks explosion process of searching for a best location of sparks. The radial nature of the network is secured by generating proper parent node-child node path of the network during power flow. Voltage Stability Index (VSI) is used to pre-identify the optimal candidate locations for DG installation.

Naik, S. Gopiya et al. [15]In this paper, a method based on analytical approach for optimal allocation (sizing and siting) of DG and capacitor with the objective to minimize the total real power loss subjected to equality and inequality constraints in the distribution network is presented. A sensitivity analysis technique has utilized to identify the optimal candidate locations for DG and capacitor placement and the heuristic curve fitting technique is used to determine their optimal capacity in the networks. To validate the suitability of the proposed method, it has been applied to 12-bus and IEEE 33-bus test distribution systems. The obtained simulation results and comparison of different cases considered reveals that allocation of DG and capacitor combination results in significant loss reduction with good voltage profile and also release in the line loading in the power distribution networks.

Sultana, Sneha et al. [16]In this paper, a framework for optimal design of battery charging/swap stations in distribution systems based on life cycle cost (LCC) is presented. The battery charging/swap station models are developed to compare the impacts of rapid-charging stations and battery swap stations. Meanwhile, in order to meet the requirements of increased power provided during the charging period, the distribution network should be reinforced. In order to control this reinforcement cost, stations should be placed at appropriate places and be scaled correctly. For optimal cost-benefit analysis and safety operation, the LCC criterion is used to assess the project and a modified differential evolution algorithm is adopted to solve the problem. The proposed method has been verified on the modified IEEE 15-bus and 43-bus radial distribution systems. The results show that battery swap station is more suitable for public transportation in distribution systems.

Liu, Zhipeng et al. [17]With the progressive exhaustion of fossil energy and the enhanced awareness of environmental protection, more attention is being paid to electric vehicles (EVs). Inappropriate siting and sizing of EV charging stations could have negative effects on the development of EVs, the layout of the city traffic network, and the convenience of EVs' drivers, and lead to an increase in network losses and a degradation in voltage profiles at some nodes. Given this background, the optimal sites of EV charging stations are first identified by a two-step screening method with environmental factors and service radius of EV charging stations considered. Then, a mathematical model for the optimal sizing of EV charging stations is developed with the minimization of total cost associated with EV charging stations to be planned as the objective function and solved by a modified primal-dual interior point algorithm (MPDIPA). Finally, simulation results of the IEEE 123-node test feeder have demonstrated that the developed model and method cannot only attain the reasonable planning scheme of EV charging stations, but also reduce the network loss and improve the voltage profile.

Djelloul, Halima et al[18] Bat algorithm (BA) is one of the most recent bio-inspired algorithm. It is based on the echolocation behavior of microbats. The standard BA is proposed only for continuous optimization problems. In this paper, the Author try to solve the graph coloring problem using a binary bat algorithm. To show the feasibility and the effectiveness of the algorithm, they have used the DIMACS benchmark, and the obtained results are very encouraging.

III. CONCLUSION

Important area in which distribution automation is being applied is the area of network reconfiguration. Network reconfiguration refers to the closing and opening of switches in a power distribution system in order to alter the network topology, and thus the flow of power from the substation to the customers. There are two primary reasons to reconfigure a distribution network during normal operation. Depending on the current loading conditions, reconfiguration may become necessary in order to eliminate overloads on specific system components such as transformers or line sections. In this case it is known as load balancing.

1. As the loading conditions on the system change it may also become profitable to reconfigure in order to reduce the real power losses in the network. This is usually referred to as network reconfiguration for loss reduction and is the topic of this thesis.
2. Network reconfiguration in both of these cases can be classified as a minimal spanning tree problem, which is known to be an NP–complete combinatorial optimization problem. A method is needed to quickly find the network configuration which minimizes the total real power loss of the network while satisfying all of the system constraints.
3. Several approaches have been applied to the solution of this problem with varying degrees of success. Heuristic methods have been used successfully to find sub-optimal solutions rapidly. The genetic algorithm and simulated annealing which require much more computation time, have been used to find optimal solutions.

It seems that these methods have only been applied to relatively small, balanced, or single-phase distribution systems. Power utility companies currently need an algorithm which can be applied to their large three-phase unbalanced distribution systems.

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