NOVEL APPROACH OF DISTRIBUTER GENERATOR PLACEMENT BY OPTIMIZATION APPROACH FOR REDUCING LOSS

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Abstract- ***To meet the increasing load demand requirement, the process of distributed generation (DGs) is integrated into distribution systems. The main objective of the system is to minimize the loss caused by the active and reactive power and to boost the overall voltage profile of the system. In power distribution network, the increased load demands is the major cause for the distribution systems to operate very closely to boundaries of voltage instability. When the DG units get integrated into distribution system, the network experiences various impacts based on its parameters such as power quality, power flow, voltage profile, stability, protection, and reliability. The problem of voltage stability and load flow loss are the major challenges for the power industry. In power distribution system, the issue of voltage instability is related to dynamics of the load flow, thus it requires distinct forms of load characteristics to deal with voltage stability as well the losses occurring during its process analysis. In modern electrical power systems, the injection of reactive power plays a significant role in power or load flow analysis and control of voltage stability, thus the losses based on reactive power are required to get incorporated in DG optimization process in order to improve the voltage profile. Many algorithms have been proposed to emphasize load flow losses and improve the voltage profile of the system. The proposed work involves the use of Grey Wolf Optimization (GWO) with genetic algorithm (GA) employed for obtaining restructured power distribution network (PDS) and helps in identification of optimal switches/transforms corresponding to power (minimum) loss in distribution network systems.***

Keywords: Distributed generation, grey wolf optimization, genetic algorithm.

I. INTRODUCTION

The energy plays a vital role for all the humans as the it can neither be created nor it get destroyed but it can move/transform from one place to other. The modern living has realized the increased importance of energy as the life is moving faster, there is big need for fast communication, fast transport and manufacturing processes. So, energy industry forms one of the biggest consumer market [1, 2]. The use of electric power system requires an alternative generation because of its large demand by the consumers. The electricity cost is calculated based on different proportions such as 50% for fuel consumption, 25% for distribution, 20% for generation, and % for transmission which has created an alert to use or generate the alternative resources of power. For the levels of distribution, the ratio of reactance to resistance (X/R) is low when compared to levels of transmission which has resulted in high power losses and voltage magnitude dip along the distribution (radial) lines. The distribution systems must be able to provide energy/electricity to each consumer at an appropriate form of voltage rating. The modern forms of power are complex in nature with multiple load centres and generating stations interconnected through the transmission and distribution networks. The main objective of the energy based power system is energy generation and to deliver the energy/power at to its customers at its rated voltage-based value with minimum losses [3]. In case of heavy loading condition, the reactive form of power flow is the major cause of losses, thus reducing the levels of voltage simultaneously. So, there is occurs a big need to minimize real losses of power and to improve the level of voltage in distribution systems. In such cases, a variation occurs in the network configuration usually varying by the operation based on switching meant for transferring the load among the feeders. The electrical power distribution represents the final stage of power delivery. It usually carries power or electricity from the transmission system to its customers on individual basis. When the distribution system gets connected to transmission system, it lowers the transmission voltage to a medium form of voltage lying between 2KV and 35KV with the help of transformers used in the system [4]. The primary lines of distribution carries medium voltage to the transformers in the distribution section placed near customer's location.

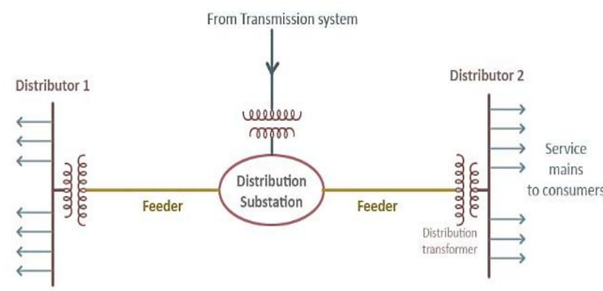

Fig.1 Simple radial AC power distribution system [14]

The distribution transformers again performs the voltage reduction for its utilization process in distinct areas such as household appliances, lighting, industrial equipment etc. Some of the consumers gets the supply from single (one) transformer through secondary-based distribution lines. The residential and the commercial consumers are linked to secondary distribution lines through the service-drop mechanism. The highly demanding consumer may be linked to primary level of distribution or sub-transmission level on direct basis.

1.1 Load Flow Analysis

The calculations of the load flow are generally carried to maintain system stability while it's running operation and determines optimal or possible selection grid component selection like machine regulators automatic control setting, transformers' voltage regulators etc. The inputs to be determined are the currents and/or voltages and/or the reactive/active power at the generator's port or the customer's port. The cables and the over-head line form the significant elements of the network [5, 6]. To carry simple grid-based calculations, few elements of the circuit are used for a specified task. For low line voltages, mostly there is work done by the ohmic resistance and for high line voltages, the longitudinal impedance is to be considered for the operational purpose and for long lines, the capacitive components must be kept in mind [7]. In order to classify the overloading of the equipment and the voltages at the busbar, the given limit values along with network operator are jointly provides as follows:

Table.1 Network equipment description

Network equipment description	Degree of loading
-	%
rated load	< 80
heavy load	≥ 80, < 100
over load	≥ 100

Table. 2 Voltage level description

Voltage level description	Voltage more than % nominal voltage
-	%
bus bar voltage is ok	≥ 94, ≤ 106
bus bar voltage is to low	< 94

The load flow can also be calculated with some of the most commonly used methods such as Newton-Raphson, Extended Newton-Raphson, Gauss-Seidel, Power iteration method, and DC flows.

1.2 Distribution System: Power Loss Minimization

The one major advantage of distribution system is the process of power loss reduction in the system line. In normal, the power loss based on real power generates more attention for the connected utilities as it is helpful in reducing the transmitted energy efficiency to the consumers. The reactive loss of power is not of greater importance as it is required to be maintained at a specific amount for adequate level of voltage [8, 9]. Hence, the reactive power (Q) enable transfer of the real power (P) through transmission and distribution lines to the consumers. This kind of methodology is very impressive in case recovered revenue by the DISCOs (distribution companies) that not only depend upon the value of assets but also depend upon the performance of the network [9].

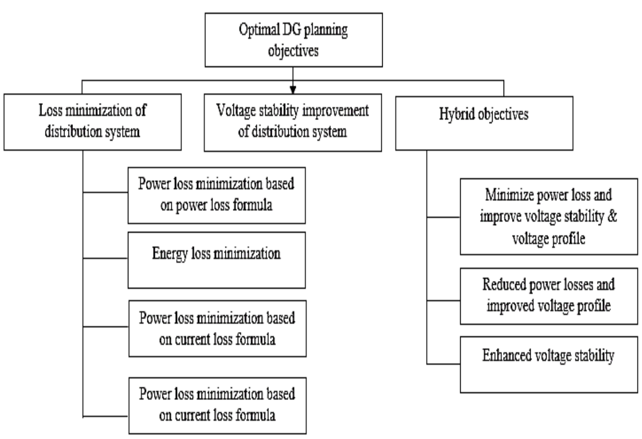

Fig.2 Optimal DG planning objectives

1.2.1 Loss Reduction Techniques

Various types of reduction techniques are described in the section below:

1. Network Reconfiguration: It is technique or procedure of switches operating to modify the topology of the circuit such that the charges and operational overloads get more concise while sustenance of the stated constraints.

2. Network Re-conductoring: In the given network, the technique of re-conductoring in the used (present) conductor on feeder is usually replaced by optimum size conductor for feeder optimum dimension. It is used when the present form of conductor ends it optimum behavior due to system's load growth [11, 12].

3. Distribution Transformers Sizing and Locating: In aspect of clients, the DTs are not located centrally i.e. the main reason for the farthest consumers to have low voltage whereas the high level of voltage gets retained at other transformer. This has contributed to distribution system maximum losses [13]. *4. Automatic Voltage Booster:* Popularly known as AVB which at point of site increases the voltage in different steps in turn developing the voltage profile and reduce the sectional losses outside its point of location towards its receiving side. The voltage boost done by AVB is approximately 10% in equal steps. So, the minimization of loss is directly proportional to enhancement process of voltage.

5. Reactive Power Compensation: It describes the energy management to boost ac energy system enactment. This kind of technique provides a large area of both the difficulties related to consumer and the system, specifically related to subjects of power superiority as some of the QoS (quality of service) can be easily resolved with reactive power requisite control

1.3 Distribution System: Network Configuration

The distribution based network configuration involves the following points:

(a) Branch exchanges for loss minimization: The minimized-power loss configuration is basically obtained where there occurs optimum flow pattern with the process of exchanging branch operations. The open tie switch at its normal operation is usually closed for loop formation. The power flow pattern on optimum basis is identified by solving KVL and KCL loop equations.

(b) Branch exchanges for minimized voltage unbalances: This kind of procedure helps in reduction of voltage unbalance due to loop formation, the redistribution of current flow takes place. It helps in improved quality of node unbalances and node voltages.

(c) Branch exchanges for compounded problem: The main effort is the attempt for system losses reduction

1.4 Sensitivity Factors & Multi-objective Function

This basically includes the formation is system multi-objective functions and sensitivity based factors [15].

1.4.1 System Power Flow: Sensitivity Factor

The power flow sensitivity of the system is defined as the power flow change in transmission or distribution line linked between two types of buses [bus (i) and bus (j)] due to change in unit in injected power at any system bus.

The power injected of complex form by source into bus say the power system with i^{th} bus is represented as:

$$S_i = P_i + jQ_i = V_i J_i^*; i = 1,2 \dots \dots, n \text{ ………………. (1.1)}$$

Where;

V_i = Voltage at the bus (i^{th}) w.r.t ground.

J_i= Source current injected into bus

For load flow to be handled in more convenient for either of the two is encouraged. The result indicate the complex conjugate of the equation written above.

$$S^*{}_i = P_i - jQ_i = V^*{}_i J_i\, ; i = 1,2 \dots \dots, n \text{ …………. (1.2)}$$

The current source is given by;

$$J_i = \sum_{j=1}^{n} Y_{ij} V_j ; i = 1,2, \dots \dots, n \text{ ………………..…. (1.3)}$$

After, substituting the equation into power injection based complex conjugate equation, we get:

$$P_i - jQ_i = V_j^* \sum_{j=1}^{n} Y_{ij} V_j ; i = 1,2, \dots \dots, n \text{ ……..…. (1.4).}$$

Equating real and imaginary parts of the equation above:

$$P_i = Re\left\{V_i \sum_{j=1}^{n} Y_{ij} V_j\right\} \dots \dots \dots \dots . (1.5a)$$

$$Q_i = -Im\left\{V_J^* \sum_{j=1}^{n} Y_{ij} V_j\right\} \dots \dots \dots \dots . (1.5b)$$

The polar form of V_i and $Y_{ij}$is expressed as follows:

$$V_i = |V_i|e^{j\delta i} \dots \dots \dots \dots . (1.6)$$

$$Y_{ij} = |Y_{ij}|e^{j\delta i} \dots \dots \dots . . (1.7)$$

The real and reactive powers from the above polar form are expressed as follows:

$$P_i = |V_i| \sum_{j=1}^{n} |V_i| |Y_{ij}| \cos(\theta_{ij} + \delta_{ij}) ; i = 1,2, \dots, n \dots\dots\dots (1.8a)$$

$$Q_i = -|V_i| \sum_{j=1}^{n} |V_i| |Y_{ij}| \cos(\theta_{ij} + \delta_{ij}) ; i = 1,2, \dots, n \dots\dots\dots (1.8b)$$

1. *Change in Real Power Flow Analysis:* The real power flow connecting two of the buses in a line *k*, the bus j and i are expressed as follows:

$$P_{ij} = V_i V_j Y_{ij} \cos(\theta_{ij} + \delta_{ij}) - V_i^2 Y_{ij} \cos\theta_{ij} \dots\dots\dots (1.9)$$

Where,
$V_i and\ V_j$= voltage magnitude at i and j buses
$\delta_i and\ \delta_j$ = voltage angles at i and j buses
Y_{ij}= ij^{th}element based magnitude of Y_{bus} matrix
θ_{ij}= ij^{th} element based angle of Y_{bus} matrix

The mathematical representation of real power sensitivity is given as:

$$\begin{pmatrix} \frac{\Delta P_{ij}}{\Delta P_n} \\ \frac{\Delta P_{ij}}{\Delta Q_n} \end{pmatrix} \dots\dots\dots (1.10)$$

With Taylor expansion methodology, the real line flow change (excluding higher order terms) is expressed as:

$$\Delta P_{ij} = \frac{\partial P_{ij}}{\partial \delta_i} \Delta\delta_i + \frac{\partial Q_{ij}}{\partial \delta_j} \Delta\delta_j + \frac{\partial Q_{ij}}{\partial V_i} \Delta V_i + \frac{\partial Q_{ij}}{\partial V_j} \Delta V_j \dots\dots\dots (1.11)$$

The appearing coefficients of equation (11) are obtained using real power flow based partial derivatives given as:

$$\frac{\partial P_{ij}}{\partial \delta_i} = V_i V_j Y_{ij} \sin(\theta_{ij} + \delta_{ij}) \dots\dots\dots 1.12(a)$$

$$\frac{\partial P_{ij}}{\partial \delta_j} = -V_i V_j Y_{ij} \sin(\theta_{ij} + \delta_{ij}) \dots\dots\dots (b)$$

$$\frac{\partial P_{ij}}{\partial V_i} = V_j Y_{ij} \cos(\theta_{ij} + \delta_{ij}) - 2V_j Y_{ij} \cos\theta_{ij} \dots\dots (c)$$

$$\frac{\partial P_{ij}}{\partial V_j} = V_j Y_{ij} \cos(\theta_{ij} + \delta_{ij}) \dots\dots\dots (d)$$

2. *Change in Reactive Power Flow Analysis:* The change is reactive power flow connecting two of the buses of the line k are expressed as:

$$Q_{ij} = -V_i V_j Y_{ij} \sin(\theta_{ij} + \delta_{ij}) + V_i^2 Y_{ij} \sin\theta_{ij} - \frac{V_i^2 Y_{sh}}{2} \dots\dots\dots (1.13)$$

Where,
$V_i\ and\ V_j$ = voltage magnitude at *i* and *j* buses.
$\delta_i\ and\ \delta_j$ = voltage angles at *i* and *j* buses.
Y_{sh} = shunt charging admittance (line k)

The mathematical representation of reactive power sensitivity is given as:

$$\begin{pmatrix} \frac{\Delta Q_{ij}}{\Delta P_n} \\ \frac{\Delta Q_{ij}}{\Delta Q_n} \end{pmatrix} \dots\dots\dots (1.14)$$

With Taylor expansion methodology, the reactive line flow change (excluding higher order terms) is expressed as:

$$\Delta Q_{ij} = \frac{\partial Q_{ij}}{\partial \delta_i} \Delta\delta_i + \frac{\partial Q_{ij}}{\partial \delta_j} \Delta\delta_j + \frac{\partial Q_{ij}}{\partial V_i} \Delta V_i + \frac{\partial Q_{ij}}{\partial V_j} \Delta V_j \dots\dots\dots (1.15)$$

The appearing coefficients of equation (11) are obtained using reactive power flow based partial derivatives given as:

$$\frac{\partial Q_{ij}}{\partial \delta_i} = V_i V_j Y_{ij} \cos(\theta_{ij} + \delta_{ij}) \dots\dots 1.16(a)$$

$$\frac{\partial P_{ij}}{\partial \delta_j} = -V_i V_j Y_{ij} \cos(\theta_{ij} + \delta_{ij}) \dots\dots\dots (b)$$

$$\frac{\partial P_{ij}}{\partial V_i} = -V_j Y_{ij} \sin(\theta_{ij} + \delta_{ij}) + 2V_j Y_{ij} \cos\theta_{ij} - V_j Y_{sh} \dots\dots (c)$$

$$\frac{\partial Q_{ij}}{\partial V_j} = -V_j Y_{ij} \sin(\theta_{ij} + \delta_{ij}) \dots\dots\dots (d)$$

1.4.2 System Power Loss: Sensitivity Factor

The circuit below shows both the real and the reactive power loss based on the sensitivity factors which helps in calculation of the power losses [16].

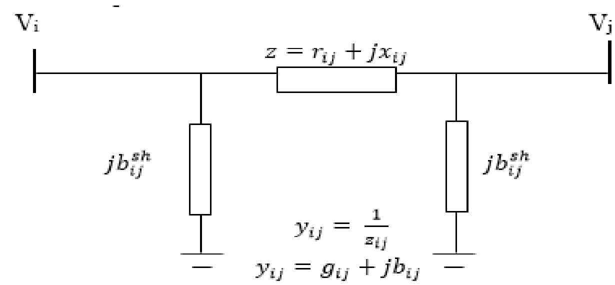

Fig.3 Line lumped circuit model

1. *Change in Real Power Loss Analysis:* The line lumped circuit model loss in case of active power shown in the circuit is represented as:

$$P_{L(ij)} = g_{ij}(V_i^2 + V_j^2) - 2 V_i V_j \cos\delta_{ij} \dots\dots\dots (1.17)$$

The active power loss in total is evaluated as:

$$P_{L(total)} = \sum_{i=1}^{nl} [g_{ij}(V_i^2 + V_j^2) - 2 V_i V_j \cos\delta_{ij}] \dots\dots\dots (1.18)$$

Where,
nL= network lines
g_{ij}= line i-j conductance
V_i = nodal voltage at bus-i
V_j = nodal voltage at bus-j
δ_{ij}= phase angle difference at busses i and j

Mathematically, the real power loss sensitivity is given as:

$$\begin{pmatrix} \frac{\Delta P_{L(ij)}}{\Delta P_n} \\ \frac{\Delta P_{L(ij)}}{\Delta Q_n} \end{pmatrix} \dots\dots\dots (1.19)$$

The taylor expansion ignoring second and higher order term is given as:

$$\Delta P_{L(ij)} = \frac{\partial \Delta P_{L(ij)}}{\partial \delta_i} \Delta\delta_i + \frac{\partial \Delta P_{L(ij)}}{\partial \delta_j} \Delta\delta_j + \frac{\partial \Delta P_{L(ij)}}{\partial V_i} \Delta V_i + \frac{\partial \Delta P_{L(ij)}}{\partial V_j} \Delta V_j \dots\dots\dots (1.20)$$

Where,

$$\frac{\partial \Delta P_{L(ij)}}{\partial \delta_i} = 2\, g_{ij} V_i V_j \sin\delta_{ij} \dots\dots\dots 1.21(a)$$

$$\frac{\partial \Delta P_{L(ij)}}{\partial \delta_j} = -2\, g_{ij}\, V_i V_j \sin\delta_{ij} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (b)$$

$$\frac{\partial \Delta P_{L(ij)}}{\partial V_i} = g_{ij}\left(2V_i - 2V_j \cos\delta_{ij}\right)$$
$$= 2\, g_{ij}\left(2V_i - 2V_j \cos\delta_{ij}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (c)$$

$$\frac{\partial \Delta P_{L(ij)}}{\partial V_j} = g_{ij}\left(2V_j - 2V_i \cos\delta_{ij}\right)$$
$$= 2\, g_{ij}\left(2V_j - 2V_i \cos\delta_{ij}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (d)$$

2. Change in Reactive Power Loss Analysis: The power loss based on the reactive power connecting the buses i and j in a line l is designed as follows:

$$Q_{L(total)} = \sum_{i=1}^{nl}\left[-b_{ij}^{sh}\left(V_i^2 + V_j^2\right) - b_{ij}\left(V_i^2 + V_j^2 - 2\,V_i V_j \cos\delta_{ij}\right)\right] \ldots\ldots\ldots\ldots (1.22)$$

Where,

b_{ij}^{sh}= shunt susceptance at bus i and j

b_{ij}= susceptance at bus i and j

Mathematically, it is represented as:

$$\begin{pmatrix} \frac{\Delta Q_{L(ij)}}{\Delta P_n} \\ \frac{\Delta Q_{L(ij)}}{\Delta Q_n} \end{pmatrix} \ldots\ldots\ldots\ldots (1.23)$$

The taylor expansion ignoring second and higher order term is given as:

$$\Delta Q_{L(ij)} = \frac{\partial \Delta Q_{L(ij)}}{\partial \delta_i}\Delta\delta_i + \frac{\partial \Delta Q_{L(ij)}}{\partial \delta_j}\Delta\delta_j + \frac{\partial \Delta Q_{L(ij)}}{\partial V_i}\Delta V_i + \frac{\partial \Delta Q_{L(ij)}}{\partial V_j}\Delta V_j \ldots\ldots\ldots\ldots\ldots (1.24)$$

Where,

$$\frac{\partial \Delta Q_{L(ij)}}{\partial \delta_i} = -2\, b_{ij}\, V_i V_j \sin\delta_{ij} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1.25(a)$$

$$\frac{\partial \Delta Q_{L(ij)}}{\partial \delta_j} = 2\, b_{ij}\, V_i V_j \sin\delta_{ij} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (b)$$

$$\frac{\partial \Delta Q_{L(ij)}}{\partial V_i} = -2b_{ij}^{sh}V_i - b_{ij}\left(2V_i - 2V_j \cos\delta_{ij}\right)$$
$$= -2\left[b_{ij}^{sh}V_i + b_{ij}\left(V_i - 2V_j \cos\delta_{ij}\right)\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (c)$$

$$\frac{\partial \Delta P_{L(ij)}}{\partial V_j} = -2b_{ij}^{sh}V_j - b_{ij}\left(2V_j - 2V_i \cos\delta_{ij}\right)$$
$$= -2\left[b_{ij}^{sh}V_j + b_{ij}\left(V_j - 2V_i \cos\delta_{ij}\right)\right] \ldots\ldots\ldots\ldots\ldots\ldots (d)$$

II. RELATED WORK

Carmen LT, et.al [1] presented an article with a methodology to evaluate the DG units installation impacts on the system reliability, electric losses, and the system's voltage profile in distributed networks. The voltage profile and losses were evaluated based on the method of power flow along with generator representation in the form of PV buses. The evaluation based on the reliability indices relied on analytic methods that was modified to handle or safeguard multiple generation. This type of methodology was used to evaluate DG capacity influence on the system performance for distinct type of generation based expansion with planned alternatives. Ha, Le Thu, et.al [2] explored the study considering the integrating possibility of two large wind farms into a sub-transmission network. It also analysed the impacts on the voltage stability and network losses considering the impacts when there was an increase in network loading of the system. The study was carried with the help of computer analyses performed on custom-designed radial type of power system.U. Eminoglu, et.al [3] presented a voltage stability index for identification of voltage collapse attractive sensitive bus in distribution system (radial). The index developed was based on transformed active and reactive power line distribution. The analysis of the index was tested distinct operating conditions of load and voltage levels of sub-station. The results suggested that the index proposed was of reliable nature which was easily applicable to the radial type network distribution. Viswanadh, M. M. G., et.al [4] studied an Optimization technique using Particle Swarm Optimization and an analytical approach used to determine the size of the wind generator and its placement optimally. A backward forward sweep load flow conventional method was used for the calculation purpose. The results obtained from two of the approaches were compared and voltage profile of different buses such as 69-bus, 13-bus and 33-bus in the distribution network was obtained. K.R. Devabalaji, et.al [5] proposed the work with the main objective to reduce the power loss in total along with maintenance and satisfaction of all the constraints. The implementation of LSF i.e. Loss Sensitivity Factor was done to pre-determine the DG optimal location. An effective use of BAT algorithm (biologically-inspired) has been done to pinpoint the DG banks optimal location. The method proposed was tested on IEEE 34-bus distribution system to observe the effectiveness and performance of the proposed technique. Chaw Su Hlaing, et.al [6] presented an approach based on voltage stability index utilizing an analogy of combined sensitivity factor to optimally place and size a DG multi-type using 48-bus Belin distribution test system with the objective of power losses reduction and the improvement of voltage profile with the placement of type 2 DG than the type 1 based DG placement i.e. DG generation using both real and reactive powers. It reaches a point where the increment in DG number results in improving voltage profiles and minimizing the power losses of the system. Yorukoglu, Sinan, Fuad Nasibov, et.al [7] conducted a study of distinct distribution system losses, Turkish electricity distribution network based privatization process, and percentage of current losses. In SYSTEM distribution network topology, possible alternations decreased the losses (non-technical) using analytical methods and the best form of strategy against losses was determined for distinct customer characteristics and network topologies with the help of AHP method. Yalisho Girma Loaena [8] provided a deep study on the issues related to power system like distribution system based on energy loss and its reduction techniques, reactive power flow along with its compensation, indicators of voltage quality such as regulation of voltage and voltage unbalance. In order to achieve the tasks, the existing form of distribution system based on study site has been designed using a Power Factory Software named DIgSILENT and the process of simulation was performed under balancing and unbalancing operating conditions. The measurement using Clamp-on meter was done to find the line to line voltages and the load demand. Patel, J. S., R. R. Patel, et.al [9] conducted a novel approach utilizing generated power with the help of distributed generation in case of primary distribution network such that the DG incorporation installed with capacity reduce the losses occurring in the overall system. The method of DG location and sizing using Genetic Algorithm was presented. A very simple load flow technique for accuracy was described and technique proposed was implied over two of the systems. One is the 2. 69 Bus Distribution System and the other is the IEEE 34 Bus distribution System using a software MATLAB tool. A. V. Sudhakara Reddy, et.al [10] proposed an algorithm popularly known as a Grey Wolf Optimization (GWO) algorithm to overcome the issues related to feeder reconfiguration with the help of fitness function corresponding to power distribution systems based optimized switch combination to overcome the issues related to reconfiguration including the real power loss reduction. Mohammad Darvishi, et.al [11] proposed an algorithm used in the problem of optimization. The algorithm designed a flowchart and after the flowchart extraction process in optimized placement of power plants in distribution systems. The computer based program was firstly developed and implemented over the network and it was firstly implemented on IEEE bus system. The results obtained from program implementation and its merits and de-merits were obtained which stated that the losses were reduced with reduced congestion and voltage was improved in the network lines. Josep M. Guerrero, et.al [12] presented the use of battery energy storage (BES) systems in order to overcome the problem of voltage rise during the process of PV generation peak and the drop of the voltage at the meet time of the peak load hours. The method proposed a coordinated control strategy which regulates the mechanism of BESs charging or discharging along with the scheme named local droop based control ensuring the feeder voltage within specified limit. Hence two distinct algorithms have been used. The first algorithm helps in determining the participation of BES in the process of voltage regulation relating to the capacity installed. The second algorithm helps in modification of BES performance in SOC i.e. state of charge terms which prevents large battery depletion and saturation process. The controller proposed enables the storage capacity use effectively in distinct condition of operation. In the final stage, the results based on simulation relies on radial distribution feeder data validating the effectiveness of the strategy used. Hasibuan, A., S. Masri, et.al [13] presented a study with an objective to analyze the distributed generation inpact over the losses of the distribution system. Some of the power system issues could be solved with DG installation where one such method was used in this study to lower the power losses in transmission system line. The simulation results were obtained on standard system IEEE 30 bus that shows that the power losses of the system were decreased from 5.7781 MW to 1,5757 MW i.e. 27.27%.

III. THE PROPOSED METHOD

3.1 Proposed Methodology

Step 1: Initialize the Load/Power.
Step 2: Initialize the generator Load_Power.
Step 3: Allocate the generators and calculate the cost.
Step 4: Apply the PSO for optimization.
Step 5: If the output of PSO is optimized then check the convergence otherwise Genetic algorithm starts it working with the following steps.

- *(a)* Initialize the chromosomes.
- *(b)* Crossover between chromosomes.
- *(c)* Apply Roulette Selection.
- *(d)* Check Optimization. If optimize then go to convergence Check otherwise loop is running until the Objective form is not obtained.

Step 6: Check the convergence. If converge then check the cost features otherwise again initialize the particles and Repeat the step 5.
Step 7: If the cost is less than Δ C then stop.

3.2 Proposed methodology: Flowchart

Figure 4: Proposed Flowchart

3.3 Algorithm Used

Grey Wolf Optimization: It is a meta-heuristic algorithm which simulates the leadership hierarchy and hunting behavior of wolves. The fitness of the wolves measured in the form of alpha, beta and delta. The fig. 5 given below shows the hierarchy level of the wolves

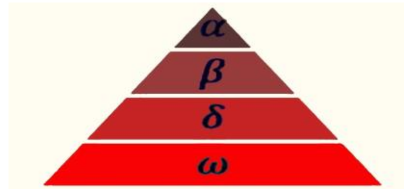

Fig.5 Hierarchy levels of the wolves

1. The first level wolver are called are alpha wolves which are dominant in nature and all other wolves follow their orders. Alpha are the best decision makers having the best fitness value in the whole pack and are also the leaders of the pack.
2. The second level wolves are the beta wolves and also called as subordinate wolves which help in decision making in alpha and also the other members of the pack.
3. The third level wolves are the delta wolves which work after the beta wolves. Delta wolves are considered when the beta wolves are not working properly. These wolves are also called as scouts.
4. The fourth and the last level of the hierarchy are related to the omega wolves. Omega wolves have low fitness value and are considering at the last. Omega wolves are also known as scapegoats.

IV. RESULT ANALYSIS

4.1 Results of Proposed Work

Table .1 Voltage with Proposed

Bus Number	Voltage
1	1.6
2	1.045
3	1.01
4	1.035
5	1.034
6	1.06
7	1.095
8	1.08
9	1.072
10	1.065
11	1.068
12	1.065
13	1.068
14	1.07

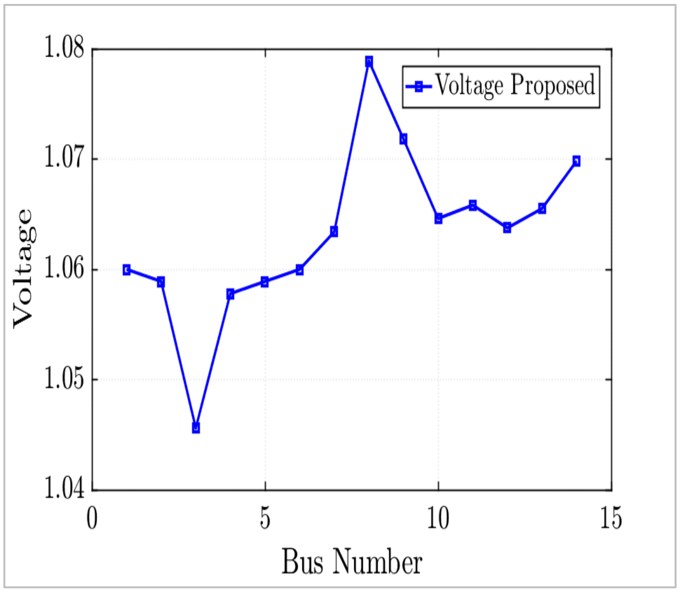

Fig 6 Voltage proposed DG

In fig 6 shows the voltages without DG on the different buses. The x-axis represents the bus number and y axis represents the voltage. The ups and down in the blue line on the graph shows the changes in the voltages according to the bus. The maximum voltage is on bus number 9 where the voltage is 1.072. The minimum voltage is at bus number 3 which is 1.01.

Table .2 Voltage without PROPOSED (GWO_GA) and voltage with PSO

Bus Number	Voltage without DG	Voltage with PSO
1	1.6	00
2	1.045	1.045
3	1.01	1.068
4	1.035	1.036
5	1.034	1.046
6	1.06	1.023
7	1.095	1.095
8	1.08	1.044
9	1.072	1.073
10	1.065	1.036
11	1.068	1.067
12	1.065	1.058
13	1.068	1.068
14	1.07	1.035

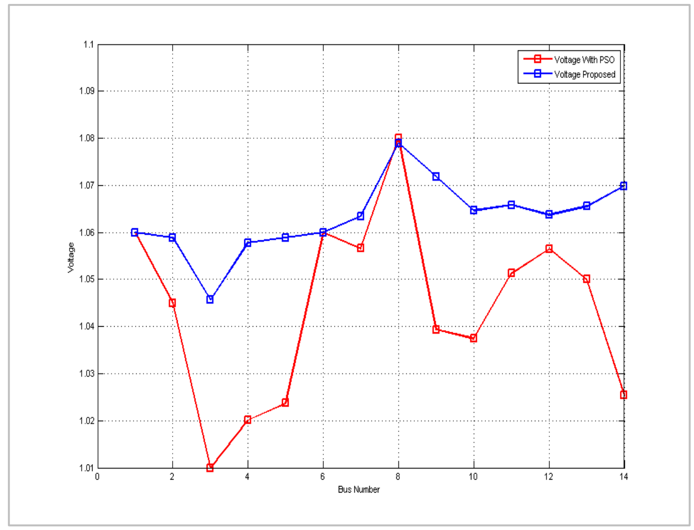

Fig.7 Voltage without Proposed and voltage with PSO

In fig. 7 shows the voltages without DG on the different buses. The x-axis represents the bus number and y axis represents the voltage. The ups and down in the blue line on the graph shows the changes in the voltages according to the bus. The maximum voltage is on bus number 9 where the voltage is 1.09. The minimum voltage is at bus number 3 which is 1.01. The green line show the voltage without DG and the minimum voltage in this is on bus number 6 which is 1.023 and maximum is on bus number 9 which is similar to voltage without DG.

Table.3 Comparison of voltages with DG, Proposed, PSO

Bus Number	Voltage with PROPOSED	Voltage with PSO	Voltage without
1	1.6	1.06	00
2	1.045	1.045	1.045
3	1.01	1.068	1.01
4	1.035	1.036	1.02
5	1.034	1.046	1.024
6	1.06	1.023	1.06
7	1.095	1.095	1.058
8	1.08	1.044	1.08
9	1.072	1.073	1.039
10	1.065	1.036	1.038
11	1.068	1.067	1.051
12	1.065	1.058	1.059
13	1.068	1.068	1.05
14	1.07	1.035	1.026

Table .4 Comparison of reactive Power Loss and stability index

Algorithm	**Reactive Power Loss**	**Stability Index**
Without optimization	12.6210	3.1061
PROPOSED	3.886	1.0032
PSO	4.2340	1.5432

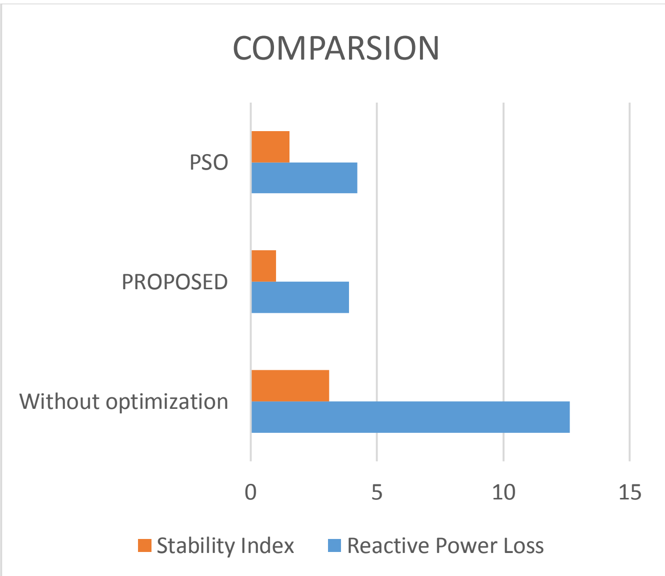

Figure 8 Comparison of reactive Power Loss and stability index

In figure 8 the comparison of three algorithms without optimization, PROPOSED (GWO_GA) and PSO is presented on the basis of reactive power loss and stability index. The blue bar in the graph presents reactive power loss and blue represents the stability index. The Flower Pollination Algorithm gives better results among all because it has low reactive power loss and stability index.

Table .5 DG Size and cost

Size K Var	150	300	450	600	900
Cost (Rs)	750	975	1140	1320	1040

Table .6 DG Location

Approach	**Location**	**Size**
PROPOSED	12,11,10	150,300,600
PSO	14,11,10	300,150, 150

Table.7 Losses on different DG and power factor

LOSSES	7.5MVA	17.5MVA	27.5MVA
REALLOSSES(PF=0.8)	16.34	14.34	12.34
REALLOSSES(PF=0.83)	15.45	13.45	11.23
REALLOSSES(PF=0.86)	14.34	13.23	11.1
REALLOSSES(PF=0.89)	13.23	12.34	10.34
REALLOSSES(PF=0.9)	13.13	12.23	9.23
REACTIVE LOSS(PF=0.8)	67.45	69.34	62.34
REACTIVE LOSS(PF=0.83)	66.23	67.45	60.34
REACTIVE LOSS(PF=0.86)	67	66.34	58.45
REACTIVE LOSS(PF=0.89)	68	65.34	56.45
REACTIVE LOSS(PF=0.9)	66	63.45	67.45

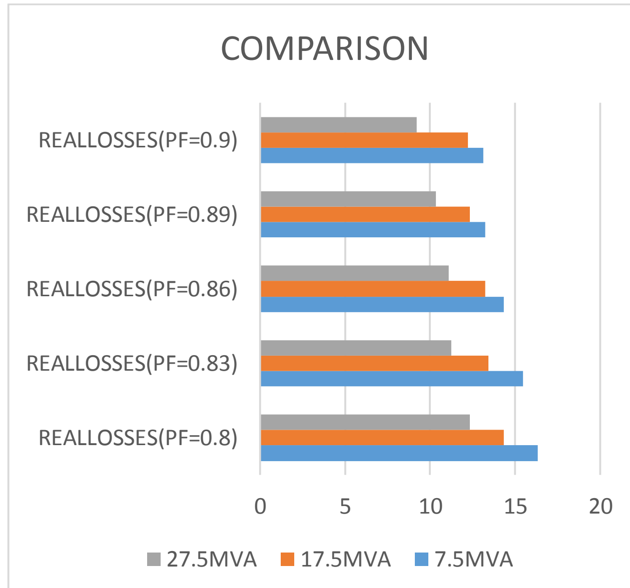

Fig. 9 Comparison of reactive Active or Real Power Loss

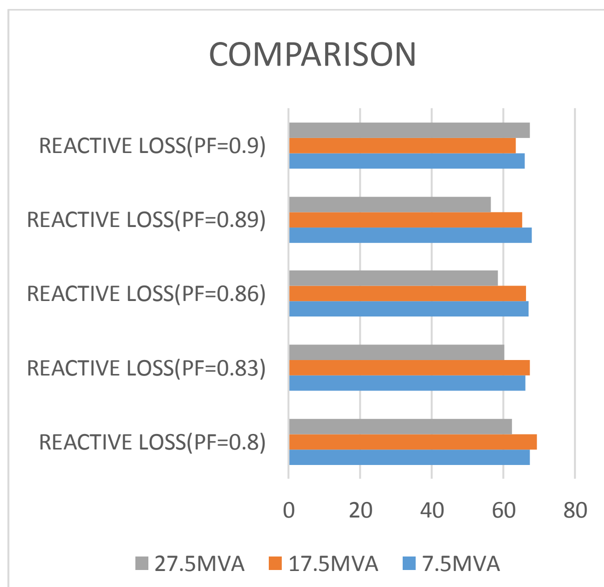

Fig. 10 Comparison of reactive Power Loss

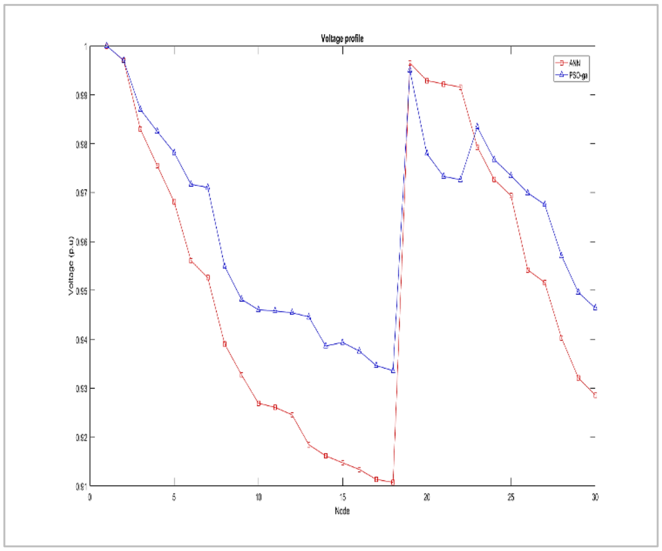

Fig.11 Comparison of Voltage profile

Table 8 Losses on different DG and power factor

PARAMETERS	ANN	PSO-GA
LOCATION	[9 19]	[24 28]
LOSS	15.3422	12.333
COST	120	90
DGSIZE	[10.23 7.45]	[7.23 6.45]

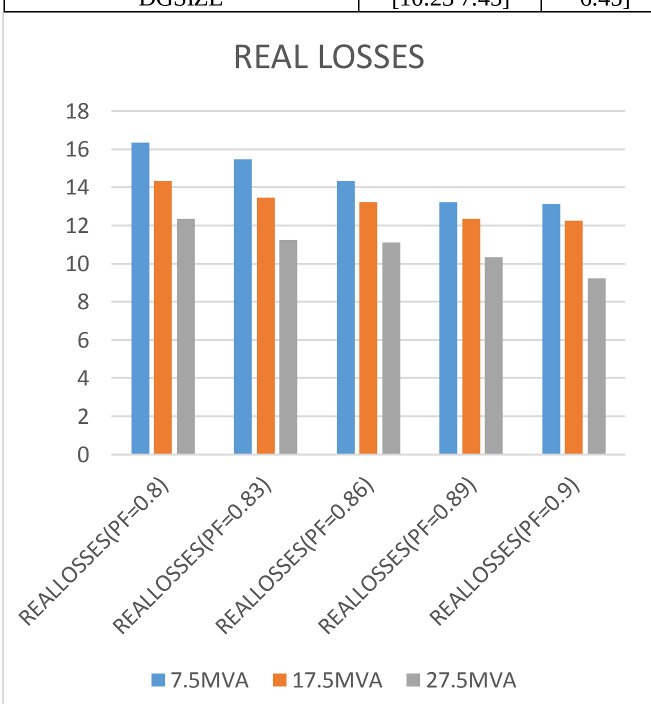

Fig.12 Comparison of real Power Loss

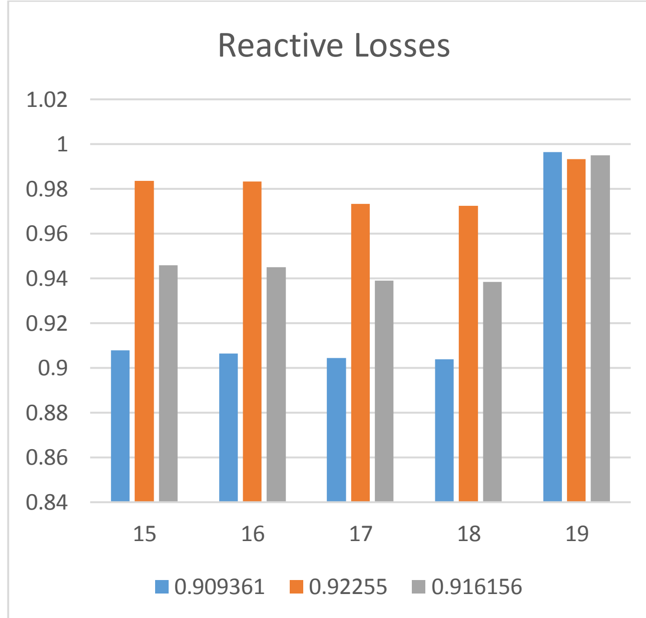

Fig.13 Comparison of reactive Power Loss

IV CONCLUSION

The objective of the proposed research is to reduce the power and voltage loss and also work on reducing the cost. The investment cost of the network is the finite number of DGs sizes that are multiple of the smallest size DG. The cost in this work represented per kVar which changes according to size because large sizes are less in price and smaller which are optimal in size is costly. The index method and size of the DG is used for the optimal placement of the DG which is given by the proposed method and classical method PSO. The performance evaluation of the proposed work is done by comparing DGs and voltages, losses. In PSO, power losses are higher and value of capacitive compensation is less. The values obtained by the PSO is slightly lower and they are in acceptable limits and reasonably good. PROPOSED (GWO_GA) method gives better reduction in power loss with lesser value of capacitive compensation. It can be concluded that PROPOSED (GWO_GA) is a superior method than PSO. In future enhance this work by hybrid optimization.

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