OPTIMAL FEEDER RECONFIGURATION AND SITING OF DG IN DISTRIBUTION NETWORK USING ADVANCED OPTIMIZATION TECHNIQUES

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***Abstract* – This paper provides a novel technique to resolve the reconfiguration issues in a radial distributed network. The inclusion of distributed generation (DG)'s is to reduce the power losses and to improve the voltage profile in an radial distributed network. Hybridizing Harmony Search with Biogeography Based Optimization (HSBBO) and Grey Wolf Optimizer is used to reconstruct and then detect an ideal position to place the DG units in the distributed system and results are compared. To obtain the ideal locations for placing DG units Sensitivity Analysis is utilized. Different schemes of DG employment and reconfiguration of system are conceived that to investigate the execution of the given method. The restrictions in current carrying and voltage in the branch is computed to estimate the objective function. Through IEEE 33 bus radial distribution network, the approach is tested in order to prove the execution and capability of the designed method.**

Keywords–Distributed generation, real power loss radial distribution system, reconfiguration, HSBBO algorithm, Grey wolf optimizer, voltage profile.

NOMENCLATURE

P_k	Real power flowing at bus k.
Q_k	Reactive power flowing at bus k.
P'_k	Real power flowing at bus k after reconfiguration.
Q'_k	Reactive power flowing at bus k after reconfiguration.
P_{Lk+1}	Real load power at bus k+1.
Q_{LK+1}	Reactive load power at bus k+1
$P_{LK,eff}$	Effective active power load at bus "k".
$Q_{LK,eff}$	Effective reactive power load at bus "k".
P_G	Real power given by DG.
Q_G	Reactive power given by DG.
$P_{T,Loss}$	Total power loss in the feeder .
$P'_{T,Loss}$	Total power loss in the feeder after reconfiguration.
V_k	Before reconfiguration voltage at bus K
V'_k	After reconfiguration voltage at bus k.
V_{max}	Maximum voltage in bus.
V_{min}	Minimum voltage in bus.
$I_{k,k+1}$	Current between buses k and k+1 in the line section.
$I_{k,k+1,max}$	Maximum Current between buses k and k+1 in the line section.
R_k	Resistance between buses k and k+1.
X_k	Reactance between buses k and k+1.

I.INTRODUCTION

The electric power system's purpose is to effectively produce, transmit, and spread electrical energy. It is possible to install the distribution operating center to oversee and manage the distribution networks along with the reconfiguring of the distribution system to minimize the power losses and also to balance the loads below the normal operating condition. Two types of switches are there in the distributed network: sectionalizing switches and tie switches. The former only is normally closed and the latter one will be normally opened. The network reconfiguration and DG installation in distribution network are conceived individually. But in the presented system, Network reconfiguration and DG installation assigned at the same time for reducing the loss and to enhance the voltage profile. Since network reconfiguration is a complex integrative, non-differentiable constrained optimization algorithms are suggested in the past. SrinivasaRao *et al* [2] present a Harmony Search to resolve the network reconfiguration issues in the distributed generation's presence to reduce the power loss in the distributed network. The optimization algorithms are applied to solve optimization problems. Recently, nature-inspired meta-heuristic algorithms perform powerful and efficiently in solving modern nonlinear numerical global optimization problems.

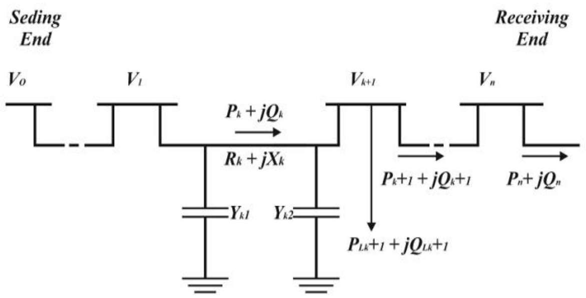

Fig.1.Single line diagram of the main feeder

Optimization algorithms cover all searching for extreme value problems. These kinds of meta-heuristic algorithms carry out on a population of solutions and always find best solutions. The most recently developed biogeography based optimization algorithm that is inspired by emigration and immigration of species between islands in nature. Biogeography based optimization (BBO) was proposed by Simon in 2008. Similar to GA, BBO is a also a population based , stochastic global optimizer. It has better global optimization ability, insensitivity for selection of initial values and parameters, strong robustness, simplicity, easy implementation. Firstly proposed by Geem et al. in 2001, harmony search (HS), is a new meta-heuristic approach for minimizing possibly non-differentiable and nonlinear functions in continuous space. HS is inspired by behaviour of musicians' improvisation process, where every musician attempts to improve its tune so as to create ideal harmony in a real world musical performance processes, this new approach requires few control variables , which makes HS easy to implement, more robust and is very appropriate for parallel computation.BBO is a powerful algorithm in exploration but at times , it may trap into some local optima so that it is unable to perform global search .For the purpose of making tradeoff between the exploration and exploitation of BBO, in this work we introduce a hybrid BBO with HS, that is HSBBO, for global numerical optimization problems. Gaige Wang *et al* [3] suggests HSBBO ,a hybrid mutation operator ,which incorporate the exploration of HS and the exploitation of BBO completely, by building more feasible path for a wide range of possible applications. Seyedali Mirjalili *et al* [1] Grey wolf optimizer imitates the leadership positioning and trapping system of grey wolf in nature. The GWO algorithm is able to provide very competitive results compared to other well known meta-heuristics.

Swagatam Das *et al* [4] This paper suggests a simple mathematical analysis of explorative search behaviour of a recently developed meta heuristic algorithm called harmony search. This paper analysizes the evolution of the population variance over successive generations in HS. Bilal Alatas, [5] Heuristic based computational algorithms are used in many different fields due to their advantages. A novel computational method which is more robust and less parameters is intended to be developed inspiring from types and occurring of chemical reactions. C. Muro *et al* [6].Computational simulations of multi agent systems is produced in which wolf agents chase prey agents. The hunting agents are autonomous, interchangeable and indistinguishable. Agalgaonkar*et al* [11] managed the placement and penetration level of the DGs under the SMD framework. The remaining part of the paper is organized as follows: Section II gives the issue formulations, Section III provides the execution of loss sensitivity analysis for DG installation, Section IV gives the survey of the Grey wolf optimization algorithm, and Section V provides the survey of HSBBO algorithm. Section VI gives the simulation results, and Section VII conclusions.

II.PROBLEM FORMULATION

A. Power Flow Equations in distribution system

In distribution system the power flows is measured by the following set of reduced equation which is obtained from the single-line design shown in Fig. 1:

The losses of power at the line section connecting buses *k* and k+1 is measured by

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$$P_{k+1} = P_k - P_{Loss,k} - P_{Lk+1}$$

$$= P_k - \frac{R_k}{|V_k|^2}\{P_k^{\,2} + (Q_k + Y_k\,|V_k|^2)^2\} - P_{Lk+1} \qquad (1)$$

$$Q_{k+1} = Q_k - Q_{Loss,k} - Q_{Lk+1}$$

$$= Q_k - \frac{X_k}{|V_k|^2}\{P_k^{\,2} + (Q_k + Y_{k1}\,|V_k|^2)^2\} - Y_{k1}\,|V_k|^2 - Y_{k2}\,|V_{k+1}|^2 - Q_{Lk+1} \qquad (2)$$

$$|V_{k+1}|^2 = |V_k|^2 + \frac{R_k^{\,2} + X_k^{\,2}}{|V_k|^2}(P^2{}_k + Q_k'^2) - 2(R_k P_k + X_k Q_k)$$

$$= \quad |V_k|^2 + \frac{R_k^2 + X_k^2}{|V_k|^2}(P_k^2 + (Q_k + Y_k\,|V_k|^2)^2) - 2(R_k P_k + X_k(Q_k + Y_k\,|V_k^2|)) \qquad (3)$$

The losses of power at the line section connecting buses *k* and k+1 is measured by

$$P_{Loss}(k,k+1) = R_{k.}\frac{(P_k^2 + Q_k{}^2)}{|V_k|^2}. \qquad (4)$$

The total losses of power in the feeder is described by total loss in the entire line in the feeder section.

B. Power Loss Using Network Reconfiguration

The issue in reconfiguring the network is to identify the premium configuration of radial system which provides less loss of power, while the enforced executing restrictions are fulfilled, with the existing ability of the feeder, profile of the voltage and the radiality of the structure in the distributed system .After reconfiguration of the network the losses of power connecting the buses among *k* and *k+1* which is given by

$$P'_{T,Loss}(k,k+1) = R_k.\frac{(P'^2_k + Q'^2_k)}{|V'_k|^2} \qquad (6)$$

$$P'_{T,Loss} = \sum_{k=1}^{n} P'_{Loss}(k,k+1). \qquad (7)$$

Total loss of power in every feeder sections, $P'_{T,Loss}$, are described by total losses in entire line sections of the system.

C. Loss Reduction at Network Reconfiguration

Net power loss reduction, ΔP^R_{Loss}, is given as the deviation of the losses of power before and after the reconfiguration, that is (5)–(7) and is provided as;

$$\Delta P^R_{loss} = \sum_{k=1}^{n} P_{T,loss}(k,.k+1) - \sum_{k=1}^{n} P'_{T,loss}(k,k+1) \qquad (8)$$

D. Power Loss Reduction Using DG Employment

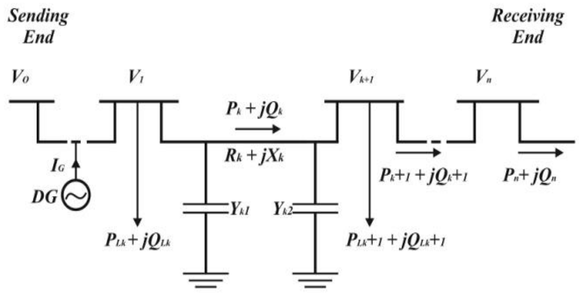
Several benefits are there in employing the DG units in ideal locations of a radial distribution network. That includes the minimizing losses in line; enhancing the voltage profile, mitigation of heavy load in distribution lines, peak demand shaving, overall energy efficiency which is raised and delayed to progress the actual generation, transmission, and distribution systems. When a DG is employed at an auditory location the power loss in the network as shown in Fig. 2, is given by

$$P_{DG,Loss} = \frac{R_k}{V_k^2}(P_k^2 + Q_k^2) + \frac{R_k}{V_k^2}(P_G^2 + Q_G^2 - 2P_kP_G - 2Q_kQ_G)\left(\frac{G}{L}\right). \qquad (9)$$

Net power loss reduction, ΔP^{DG}_{Loss}, in the system is the deviation in loss of power before and after the employing of DG unit, that is (9)–(14) which is provided as

$$\Delta P^{DG}_{Loss} = \frac{R_k}{V_k^2}(P_G^2 + Q_G^2 - 2P_kP_G - 2Q_kQ_G)\left(\frac{G}{L}\right). \qquad (10)$$

The positive sign of ΔP^{DG}_{Loss} express the less losses in system with the employment of DG. The counter-point is that the negative sign of ΔP^{DG}_{Loss} implies that DG gives more losses in system.



E. Objective Function of the presented method

The objective function of the given issue is devised in order to upgrade the power loss reduction at distribution network, provided by

$$\text{Maximize } f = \max.(\Delta P^R_{loss} + \Delta P^{DG}_{loss}) \qquad (11)$$

E.1.Operating Constraints

The given objective function deals with the following constraints:

$$V_{min} \leq |V_k| \leq V_{max} \qquad (12)$$

$$|I_{k,k+1}| \leq |I_{k,k+1,max}| \qquad (13)$$

$$\sum_{k=1}^{n} P_{Gk} \leq \sum_{k=1}^{n} (P_k + P_{Loss,k}) \qquad (14)$$

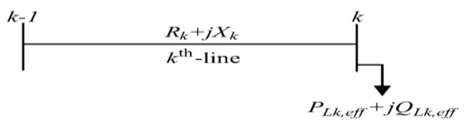
2.Radiality the network in Distribution system

$$\det(A) = 1 \text{ or } -1 (\text{radial system}) \qquad (15)$$

$$\det(A) = 0 (\text{not radial}) \qquad (16)$$

III.IMPLEMENTATION OF LOSS SENSITIVITY ANALYSIS FOR DG EMPLOYMENT

Sensitivity analysis is used to determine sensitivity factors [2] of candidate bus position for employing DG units in the scheme. By determine sensitivity factors of these candidate buses will help in decreasing the search space to find ideal position. Consider a line section which consist an impedance of R_k+jX_k and a load of $P_{Lk,eff}$+$jQ_{Lk,eff}$ connected among the between *k*-1and*k* buses as given below.



Real power loss in the k^{th}-line between k-1and k bus are provided by

$$P_{lineloss} = \frac{(P^2_{Lk,eff} + Q^2_{Lk,eff})R_k}{V_k^2}. \qquad (17)$$

The loss sensitivity factor (LSF) is acquired by the following equation:

$$\frac{\partial P_{lineloss}}{\partial P_{Lk,eff}} = \frac{2 * P_{Lk,eff} * R_k}{V_k^2} \quad (18)$$

Using (18), LSFs are calculated from load flows and the values are organized in descending order for all buses of the provided system. It deserves to note that LSFs agree the sequence in which buses are to be conceived for the DG unit installation. The size of DG unit at candidate bus is computed by utilizing the optimization algorithms.

IV. GREY WOLF OPTIMIZER

Grey Wolf Optimizer (GWO) is inspired by grey wolves (Canis lupus). The GWO algorithm simulates the leadership hierarchy and hunting mechanism of grey wolves. There are four types of grey wolves they are alpha, beta, delta and omega are installed for simulating the leadership hierarchy. It also includes the three main steps of hunting such as searching for prey, encircling prey and attacking prey, are simulated. The detail description of GWO algorithm is given in [1].

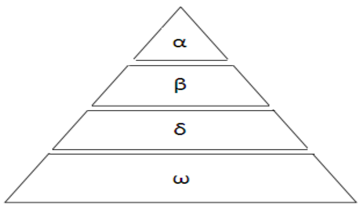


Fig.3. Grouping of Grey wolf

B. Step by step procedure for GWO method to solve network reconfiguration problem

In this division the mathematical models of the social hierarchy, tracking, encircling, and attacking prey are explained. Then the GWO algorithm is configurated. Using the concept explained in section IV, application of the proposed GWO algorithm suitable for network reconfiguration problem is given below:

1. Set the initial values of the population size n, parameter a, coefficient vector A, C and the maximum number of iterations Matrix.
2. Set t : = 0{ Counter initialization }
3. for (i= 1: i ≤ n) do
4. Generate an initial population Xi(t) randomly.
5. Evaluate the fitness function of each search agents (solution) f(Xi).
6. end for
7. Assign the values of the first ,second and the third best solution Xα,Xβ and Xδ , respectively.
8. repeat.
9. for (i=1 : i ≤ n) do
10. Update each search agent in the population .
11. Decrease the parameter a from 2 to 0.
12. Update the coefficients A and C .
13. Evaluate the fitness function of each search agent (vector) f(Xi).
14. end for
15. Update the vectors Xα, Xβ and Xδ .
16. Set t= t+1 { Iteration counter increasing}.
17. until (t < Maxitr). { Termination criteria satisfied}
18. Produce the best solution Xα.

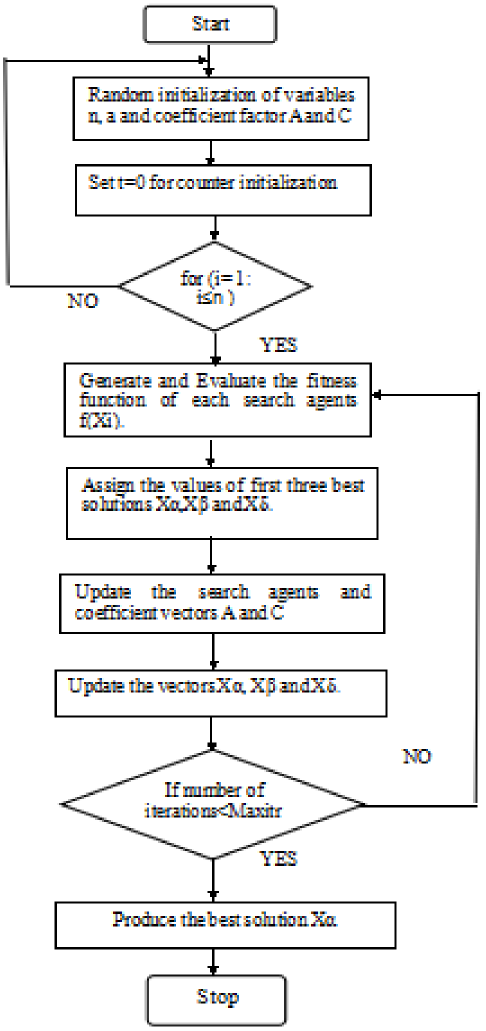


Fig.4.Flowchart of the proposed GWO method

V. HSBBO ALGORITHM

HSBBO, is determined to solve global numerical optimization problem. HSBBO incorporates [3] the exploration of harmony search (HS) with the exploitation of BBO definitely, and hence it can achieve assuring candidate solutions. In common, the basic HS algorithm is capable at exploring the search space and finding the region of global ideal solution, but it is not comparably superior at exploiting solution. On the other hand, basic BBO is usually active at the exploitation of the solution though its exploration ability is comparably low. Therefore, a hybrid meta-heuristic algorithm in this paper which induces the harmony search into biogeography based optimization to form the hybrid mutation operator; termed as harmony search/biogeography based optimization (HSBBO) is used to upgrade the benchmark functions. The variation between HSBBO and BBO is that the hybrid mutation operator is used to promote the initial BBO which induce unique values for each habitat. In this way, this method can explore the new search space by the hybrid mutation operator and exploit the population with BBO, and hence can overcome the lack of the exploitation of the BBO. In the pursuing, we will show the algorithm HSBBO which is an upgrade of HS and BBO.

Algorithm 1 Hybrid mutation operator of HSBBO

Begin

for i=1 to NP(all habitats) **do**

for j=1to D(all elements) **do** || Mutate

if (rand < HMCR) **then**

$x_v(j)=x^*(j)$ where $\mathbf{x^*}$is the current global best solution

if (rand < PAR) **then**

$x_v(j) = x_v(j)+bw\times(2\times rand - 1)$

endifelse

$x_v(j)= x_{min,j} + rand \times(x_{max,j} - x_{min,j})$

endif

end for j

end for i

End.

Algorithm 2 The hybrid meta-heuristic algorithm of HSBBO

Begin

Step 1: Initialization. Set the generation counter t=1;

initialize randomly a population of NP individuals P;

set maximum variation rate m_{max} and migration rate p_{mod} ;

set dimension for the optimization problem D;

set maximum capacity of habitat species S_{max};

set maximum of immigration operation I and maximum of emigration operation E;

set harmony memory consideration rate HMCR and pitch adjustment rate PAR.

Step 2: Evaluate the fitness (HIS) f for each individual in P determined by f(x).

Step 3: While the termination criteria is not satisfied or t < MaxGeneration **do**

Sort the population /habitats from worst to best according to its HSI.

Store the KEEP best habitats as BESTKEEP.

For each individual, map the HIS to the number of species

Calculate the immigration rate λ_i and the emigration rate μ_i for each individual X_i

for j= 1 to NP(all habitats) **do**

r_4= [NP* rand]

Modify the population to create the individual X_u with the migration operator

Update the probability for each individual

Mutate the population to generate the new individual X_v with the hybrid mutation operator as shown in **Algorithm 1**

Evaluate the fitness for the individual X_u, X_{r4}, X_N

Select the individual X_k with the best fitness among the individual X_u ,$X_{r\,4}$,X_N

$X_{r\,4} = X_k$

end for j

Replace KEEP worst habitats with KEEP best habitats stored in BESTKEEP.

Sort the population/habitats from best to worst and find the current best

Pass the current best to the next generation.

t=t+1;

Step 4: end while

Step 5: Post-processing the results and visualization ;

End.

VI. SIMULATION RESULTS

The presented method is examined on IEEE33-bus radial distribution network and the outcomes is acquired to compute its capability of the presented method (at the same time, reconfiguring the network and installation of DG units) utilizing the firefly algorithm. The presented method is executed by utilizing the MATLAB 10 software simulated in a computer with Intel_core_i3 CPU having 2.3GHz with 4GB of RAM. The simulation of the system consists of four schemes to examine the supremacy of the given method.

Scheme I: With the absence of distributed generators and feeder reconfiguration (Base case).

Scheme II: Similar as Scheme I but the network is reconfigured by the accessible sectionalizing and tie switches.

Scheme III: Similar as Scheme I but it consists of 3 numbers of DG units employed at the candidate buses in the network.

Scheme IV: Reconfiguration and employing DG units concurrently in the base configuration.

A. *Experimental System*

This experimental system consists of a 33-bus radial distribution network [8] with 32 sectionalizing switches and 5 tie switches. In the system, the sectionalize switches (usually closed) are integrated from 1 to 32, and then tie-switches (usually open) are integrated at 33 to 37.The total real and reactive power loads at the system are 3715 kW and 2300 kVAR. The line and load data are referred from [7].

By utilizing sensitivity examination [8] sensitivity factors are measured to employ the DG units at candidate bus locations for scheme III and IV. After calculating the sensitivity factors at every bus, it is arranged in the descendent order and ranked. Among all the locations, top three locations are selected to employ DG unit in the system. The limits of DG unit sizes are taken from (0to2) MW to employ it in the candidate bus location. From Table I and Table II shows reduced power loss and voltage profile improvement for scheme IV are greater when related to scheme III. To estimate the execution the system is simulated at three different load level that is 0.5(light), 1.0(nominal), and 1.6(heavy). It is noticed from the Table I, at light load level (0.5) the power loss (in kW) in the base case is 130.44kW that is minimized to 91.72, 82.39 and 71.35 by utilizing the schemes II, III, IV.

The minimized percentage loss in scheme II to IV is 29.83, 36.78 and 45.25respectively which is similar in the case of Table II at three load levels scheme IV shows better results. In spite of the increase in load from light to heavy, the percentage loss reduction progress in every scheme is close to the same. So the power loss reduction in scheme IV is the greatest, which increase the superiority of the presented method over the others. Nevertheless, the percentage reduction in loss is increased in scheme IV when compared to other cases.

This denotes that only DG employment (scheme III) will not return the required outcome of minimizing the power loss reduction and with improving the voltage profile. In 33-bus Radial Distribution System the voltage profile improvement of Grey wolf optimization algorithm and HSBBO is shown in Fig.5 (a) and (b), it is shown that enhancement in the voltage profile of the system as indicated in scheme IV gives a better improvement and it is employed at ideal candidate bus in sequence and outputs are given in Table III. To examine the outcome of numberof DG employment region on the power loss for scheme IV, DGs. The candidate bus positions conceived for DG employments are 32, 31 and 33 which is determined by sensitivity analysis. By installing three DG units provided near the ideal power loss with near ideal size is similar to other employment

TABLE I

TEST RESULTS OF 33 BUS SYSTEMS FOR GREYWOLF OPTIMIZATION ALGORITHM

Schemes		Load Level		
		Light (0.5)	Nominal (1.0)	Heavy (1.6)
Base Case (Scheme I)	Opened Switches	33,34,35, 36,37	33,34,35, 36,37	33,34,35, 36,37
	Power loss (kW)	130.44	281.58	632.13
	Min. voltage (p.u)	0.9302	0.9014	0.9231
Only Reconfiguration (Scheme II)	Switches opened	14,22,33, 34,36	7,9,33, 34,35	7,33,34, 35,37
	Power loss (kW)	91.72	150.91	252.96
	% Loss Reduction	29.83	46.64	59.98
	Min. voltage (p.u)	0.9559	0.9468	0.8624
Only DG employment (Scheme III)	Switches opened	33,34,35, 36,37	33,34,35, 36,37	33,34,35, 36,37
	Size of DG in MW (Bus number)	0.0655(6) 0.0406(9) 0.0146(18)	0.0590(8) 0.0627(25) 0.0982(30)	0.2992(6) 0.0963(14) 0.0102(21)
	Power loss (kW)	82.39	129.51	179.17
	% Loss Reduction	36.78	54.06	71.65
	Min.voltage (p.u)	0.9331	0.9026	0.9220
Reconfiguration with concurrent DG employment (Scheme IV)	Opened switches	22,33,34, 35,36	7,33,34, 35,37	7,22,33, 34,35
	Size of DG (MW) (Bus number)	0.1001(15) 0.0883(17) 0.0103(25)	0.1034(3) 0.1364(7) 0.0114(13)	0.1425(15) 0.0669(25) 0.1996(29)
	Power loss (kW)	71.35	101.94	133.39
	% Loss Reduction	45.25	63.79	78.89
	Min.voltage (p.u)	0.9574	0.9354	0.9624

To relate the performance of HSBBO Algorithm, entire schemes are assumed with Grey wolf optimization algorithm and the output is given in Table III. From the table it is described that the performance of the HSSBO Algorithm is improved when comparing it with Grey wolf optimization algorithm in terms of the aspects of solving the entire schemes.

TABLE II
TEST RESULTS OF 33 BUS SYSTEMS FOR HSBBO ALGORITHM

Schemes		Load Level: Light (0.5)	Nominal (1.0)	Heavy (1.6)
Base Case (Scheme I)	Opened Switches	33,34,35, 36,37	33,34,35, 36,37	33,34,35, 36,37
	Power loss (kW)	130.34	281.58	632.13
	Min.voltage (p.u)	0.9204	0.9312	0.9325
Only Reconfiguration (Scheme II)	Opened switches	7,9,33, 34,37	7,22,33, 34,35	9,22,33, 34,35
	Power loss (kW)	85.82	129.51	280.63
	% Loss Reduction	34.15	54.06	58.60
	Min.voltage (p.u)	0.9335	0.9026	0.8587
Only DG employment (Scheme III)	Opened switches	33,34,35, 36,37	33,34,35, 36,37	33,34,35, 36,37
	Size of DG in MW (Bus number)	0.0011(7) 0.0173(12) 0.0701(24)	0.0653(13) 0.1639(26) 0.1035(28)	0.2777(5) 0.0684(11) 0.1301(30)
	Power loss (kW)	79.39	118.14	162.68
	% Loss Reduction	39.08	58.04	74.26
	Min.voltage (p.u)	0.9341	0.9423	0.9273
Reconfiguration with concurrent DG employment (Scheme IV)	Opened switches	9,22,33, 34,35	7,9,33, 34,37	14,22,34, 35,36
	Size of DG (MW) (Bus number)	0.0648(7) 0.0414(12) 0.0100(29)	0.0237(13) 0.0970(24) 0.0842(29)	0.0663(11) 0.2286(27) 0.0682(30)
	Power loss (kW)	74.34	86.65	114.08
	% Loss Reduction	42.93	69.22	81.96
	Min.voltage(p.u)	0.9345	0.9403	0.9798

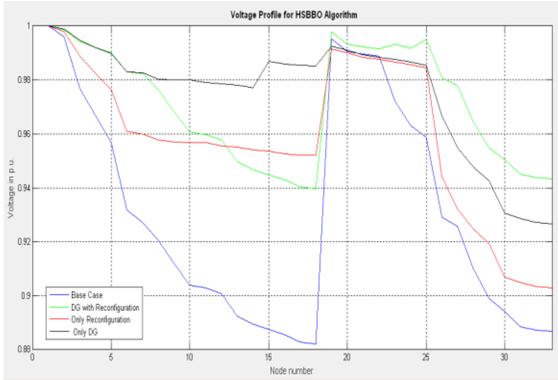


Fig.5(b).Voltage Profile for HSBBO Algorithm

TABLE III
COMPARISON OFSIMULTION RESULTS

Method	Parameter	Scheme II	Scheme III	Scheme IV
HSBBO Algorithm	Opened switches	7,22,33,34,35	33,34,35,36,37	7,9,33,34,37
	Power loss (kW)	129.51	118.14	86.65
	% Loss Reduction	54.06	58.04	69.22
	Min. voltage (p.u)	0.9026	0.9423	0.9403
Grey Wolf Optimization Algorithm	Opened switches	7,9,33,34,35	33,34,35,36,37	7,33,24,35, 37
	Power loss (kW)	150.91	129.51	101.94
	% Loss Reduction	46.64	54.06	63.79
	Min. voltage (p.u)	0.9468	0.9026	0.9354

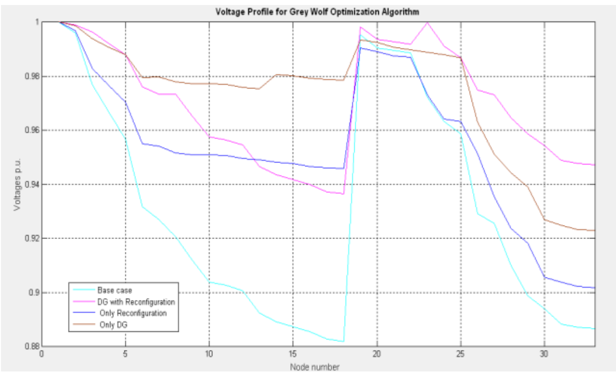


Fig.5(a).Voltage Profile for Grey Wolf Optimization Algorithm

VI.CONCLUSION

In this project, a novel proposal has been presented to reconfigure and employ DG units in distribution network. At the same time, several loss reduction techniques (only DG employment, only network reconfiguration, DG employment after reconfiguration) are also assumed to organize the superiority of the presented system. Hybridizing Harmony Search with Biogeography Based Optimization(HSBBO) and Grey Wolf Optimizer is utilized in the optimization process of the network reconfiguration and DG employment. The presented methods are examined on 33- bus system. The output shows that the network reconfiguration with DG employment methods is more effective in minimizing the power loss and enhancing the voltage profile when related with other method. The output shows that the power loss minimization is enhanced as the numbers of DG employment location are raised from one to four.

Nevertheless, the ratio of power loss reduction to DG size is greatest when the number of DG employment location three. The result acquired by using the HSBBO algorithm is related with the output of the Grey wolf optimization algorithm. The computational output gives that the performance of the HSBBO algorithm is better than Grey wolf optimization algorithm.

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