Performance Comparison of Meta-Heuristic Algorithms PSO and ACO for Optimum Power Flow in Power Systems

Raheel Jawad
Electro mechanical. Eng. Dept.,
University of Technology
Baghdad, Iraq
eme.51262@uotechnology.edu.iq

Ali A. Kadhum
Al-Furat Al-Awsat Technical University
kufa, Najaf, Iraq
Kin.ali1@atu.edu.iq

Malak Moneer
Electro mechanical. Eng. Dept.,
Al-Mustafa University
, Baghdad, Iraq
malak.muner@almustafauniversity.edu.iq

2021 International Conference on Communication & Information Technology (ICICT) | 978-1-6654-3914-5/21/$31.00 ©2021 IEEE | DOI: 10.1109/ICICT52195.2021.9568440

***Abstract*- The objective function of Optimum Radial Power Distribution (ORPD) is to reduce losses of transmission line utilizing optimizing of control variable for example reactive power, switchable generation voltage, and On-Load Tap Changers (OLTC) beneath control and reliant variables constraint. IEEE 33bus system is utilizing as the test system. The aim of this paper is comparing metaheuristic algorithms of optimum load flow utilizing Particle Swarm Optimization (PSO) and Ant Colony Optimization (ACO) algorithms. The purpose of ORPD is reduce losses of transmission line in control and reliant variables constraints which are projected sensitivity parameter of reactive power which depend on adjustment of model for Fast Decoupled Power Flow (FDPF). The testing system has been utilizing to illustrate ability of algorithm proposed and compared between them (ACO and PSO). The PSO algorithm is leads to minimum power losses with minimizing of voltage deviation, cost of switchable reactive power and maximizing reactive power preserve comparing with other algorithm proposed. As well as, PSO algorithm is give a high accuracy and solution efficiently is of ORPD problems. Moreover, the algorithms proposed represent as s tool potential for aiding of power system operation of on-line environment.**

Keywords- PSO, ACO, Optimum Radial Power Distribution (ORPD), Optimization.

I. INTRODUCTION

Electric power systems consist of a group of units from generation to production. The components of the power system are: a unit for the production of electricity, devices that use electricity, and an electrical network connecting them. The power grid is to allow the transfer of energy from production to use, so from generation to production and then sustain it faces many losses. For the purpose of maintaining satisfactory stability and outrun effort for all clients. The conventional power system is designed for unidirectional power flow from a few generator sets to the scattering area of the demand during transmission and distribution network extension. As the generator is in a large power plant, most of it is thermal (fossil and nuclear fuel) and water, which is located far from the consumption center. Analyze the operation of the distribution system and how the integration processes of generation affect reactive power and voltage control. Maximize the efficiency of distribution systems by minimizing power losses and improving operation for responsible equipment of control voltage and reactive power, which act on load pressure commutator of transformer substation and switching of transformer capacitor bank [1],[2].

Many researches study the optimization of load flow as : R. Mageshvaran,et.al (2008)[3]: present to achieve optimum load flow solutions utilizing three different intelligent techniques for example particles swarm optimization (PSO), and Hybrid Differential Evolutions (HDE) subjected matter to different systems constraint. The optimization technique has ability to provide global optimum solution of problem domain anywhere total traversing for all search spaces are completely infeasibility . The propose techniques have been experienced on Ward and Hale 6 bus systems and IEEE-14 bus tested systems. The result show quite hopeful and utilizing to find solve optimam load flow problems . The algorithms and simulation are accepted utilizing Matlab software. Camila P. Salomon(2010)[4]: proposed Particle Swarm Optimization (PSO) algorithm of calculation Load Flow of Power System . The propose method is based on minimize of power mismatch of utilizing system. The study of power flow provide the status of system in steady-state and essential for operation power system, control and planning. PSO is apply in new model computation of power flow system obtainment. This model search for enhanced convergence, also wide applications in comparisons with traditional method for Newton-Raphson methods. This method tested with numerical accomplished experiment in IEEE 6-Bus Systems . Alejandro Garces (2015)[5]: presented linear load flow at three-phase power distributions system. Balanced and unbalanced operating is consider and ZIP model for load. The method don't required any assumption communicate to R/X ratios. In spite of simplicity, it is very accuracy comparing to with back-forward sweep algorithms .

Ozan Akdağ ,et.al(2017)[6]: Amplitude, phase angle, active and reactive powers flowing in each bus lkbar of a power system can be seen by performing a load flow analysis. From these data, it is possible to determine the voltage drop, the distribution for the forces, the loading of the equipment and the losses of the related power system. Then, Active power losses can be reduced by making improvements at the points where losses are present in the power system. Power losses can be reduced by reactive power compensation considerably. In this study, Differential Evolution (DE) algorithm is utilizing to determine the values for the capacitor groups to be added to the correspondingbus bar to reduce the losses of 154 kV transmission system. The optimum load flow is ensured by optimizing a transmission system with the developed algorithm.

Vireshkumar Mathad,(2018)[7]: In current year power demand is increased ; it become extra difficult in power systems for operating in safe manner. Unified Power Flow Controller (UPFC) give a novel opportunity for increasing of load capacity in transmission lines using control power flow under conditions normal and contingency. For finding an optimal power flow at minimum fuel cost, Also to reduced overall cost of multi-objectives function utilizing Particle Swarm Optimization(PSO) Algorithms . The equipment of UPFC is exhibit better voltages profile comparison without UPFC. The IEEE 30-bus systems are utilizing as test system.

The aim of this paper is comparing Meta-heuristic algorithm of optimum load flow utilizing Particle Swarm Optimization (PSO) and Ant Colony Optimization (ACO) algorithms leads to minimum power losses with minimizing of voltage deviation, cost of switchable reactive power and maximizing reactive power preserve comparing with other algorithms proposed. Many researchers compared the PSO and ACO for IEEE 14 bus not applied IEEE 33 bus. In this work applied a comparison between ACO,PSO for IEEE 33 bus.

II. MATHEMATICAL MODEL OF RADIAL DISTRIBUTION NETWORK

To develop a term for network voltage and admittance . The remind reader which all quantity are unspecified on per unit, as utilizing power relation single-phase. Sketch familiar relative of complex power, as expressed S_k as[8-13]:

$$S_k=V_k I_k^* \qquad (1)$$

As formula (2), show current injection into any bus k :

$$I_k=\sum_{j=1}^{N} Y_{kj} V_j \qquad (2)$$

where, again, the Y_{kj} term is admittances matrix element and not admittances. Substitutions of "(2)" as "(1)" yields:

$$S_k=V_k\left(\sum_{j=1}^{N} Y_{kj} V_j\right)^* = V_k \sum_{j=1}^{N} Y_{kj}^{\ *} V_j^{\ *} \qquad (3)$$

Where: V_k is phasors, have amount and angle, so which $V_k=|V_k|\angle\theta_k$. As well as, Y_{kj}, functions of admittance , as multifarious, and define parts d G_{kj} and B_{kj} as real and imaginary for admittances matrix elements Y_{kj}, correspondingly, so which $Y_{kj}=G_{kj}+jB_{kj}$ .as " (3)"

$$\begin{aligned} S_k &= V_k\sum_{j=1}^{N} Y_{kj}^{\ *} V_j^{\ *} = |V_k|\angle\theta_k \sum_{j=1}^{N}(G_{kj}+jB_{kj})^*\left(|V_j|\angle\theta_j\right)^* = |V_k|\angle\theta_k \sum_{j=1}^{N}(G_{kj}-jB_{kj})\left(|V_j|\angle-\theta_j\right) \\ &= \sum_{j=1}^{N}|V_k|\angle\theta_k\left(|V_j|\angle-\theta_j\right)(G_{kj}-jB_{kj}) = \sum_{j=1}^{N}\left(|V_k||V_j|\angle(\theta_k-\theta_j)\right)(G_{kj}-jB_{kj}) \end{aligned} \qquad (4)$$

Where , Euler relative, which phases can be express as multifarious functions for sinusoid, i.e., V=|V|∠θ=|V|{cosθ+jsinθ}, as " (4)" :

$$\begin{aligned} S_k &= \sum_{j=1}^{N}\left(|V_k||V_j|\angle(\theta_k-\theta_j)\right)(G_{kj}-jB_{kj}) \\ &= \sum_{j=1}^{N}|V_k||V_j|\left(\cos(\theta_k-\theta_j)+j\sin(\theta_k-\theta_j)\right)(G_{kj}-jB_{kj}) \end{aligned} \qquad (5)$$

If now execute algebraics multiplication for two term inside parentheses of formula (5), and then gather parts real and imaginary, and recall which $S_k=P_k+jQ_k$, may be expressed "(5)" as two formula , at real part, P_k, and and imaginary part, Q_k, As:

$$\begin{aligned} P_k &= \sum_{j=1}^{N}|V_k||V_j|\left(G_{kj}\cos(\theta_k-\theta_j)+B_{kj}\sin(\theta_k-\theta_j)\right) \\ Q_k &= \sum_{j=1}^{N}|V_k||V_j|\left(G_{kj}\sin(\theta_k-\theta_j)-B_{kj}\cos(\theta_k-\theta_j)\right) \end{aligned} \qquad (6)$$

The two equations of "(6)" are describe power flow , and essential block building that assault of power flow problems.

It is attractive of considered case of " (6)" if bus k, reliable as bus p, then connect to one other bus, said bus q. Also the bus p injection and flow in line pq. The state is illustrate in Fig.1.

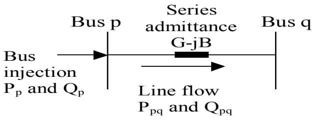


Fig. (1): Bus p Connected to Only Bus q

For the situation illustrated in Fig. (1), "(6)" become:

$$\begin{aligned} P_p &= |V_p|^2 G_{pp} + |V_p||V_q|G_{pq}\cos(\theta_p-\theta_q) + |V_p||V_q|B_{pq}\sin(\theta_p-\theta_q) \\ Q_p &= -|V_p|^2 B_{pp} + |V_p||V_q|G_{pq}\sin(\theta_p-\theta_q) - |V_p||V_q|B_{pq}\cos(\theta_p-\theta_q) \end{aligned} \qquad (7)$$

If line pq admittances are $y=G-jB^1$, as show in the Fig. 1, as G_{pq}=-G and B_{pq}=B If present is no bus p reactance shunt or charging line, as G_{pp}=G and B_{pp}=B. As, " (7)" :

$$\begin{aligned} P_p &= |V_p|^2 G - |V_p||V_q|G\cos(\theta_p-\theta_q) + |V_p||V_q|B\sin(\theta_p-\theta_q) \\ Q_p &= |V_p|^2 B - |V_p||V_q|G\sin(\theta_p-\theta_q) - |V_p||V_q|B\cos(\theta_p-\theta_q) \end{aligned} \qquad (8)$$

If simple rearranged order for terms in reactive formula as

$$P_p = |V_p|^2 G - |V_p||V_q| G\cos(\theta_p - \theta_q) + |V_p||V_q| B\sin(\theta_p - \theta_q) \quad (9)$$
$$Q_p = |V_p|^2 B - |V_p||V_q| B\cos(\theta_p - \theta_q) - |V_p||V_q| G\sin(\theta_p - \theta_q)$$

III. PROPOSED ALGORITHM FOR OPTIMIZATION

A. Ant Colony Optimization

Ants live in colonies and use chemical signals referred to as pheromones to provide a complex communication system. The ant moves from the nest to the food in different paths and during that movement from the nest to the food the ants secrete the pheromone substance, the pheromone substance disappears over time, but in the paths that contain a lot of ants, the pheromone substance is strengthened and becomes a lot of the temptation of this path [14]. The higher behaviour of real ants impressed ACO which tried to be a good metaheurism technique for identifying several issues. This method uses a colony of artificial ants that act as cooperating agents throughout a space wherever they are allowed to search for pathways (solutions) and reinforce them in order to search for optimal solutions. [15].

1. Schedule Construction Stage

After each step, each ant moving from the nest to the food leaves a secretion pathway on the continuous pathway to be collected by the different ants to see the transmission potential. Starting with the first session i, a nursing participant selects a pismire m the probability sessions j for the next observation using a post-hoc
Rule [14],[16]

$$p_{(i,j)} = \begin{cases} \arg\max_{k \in s_m(i)} [\tau_{(i,k)} \cdot \eta_{(i,k)}^{\beta}] & if\ q \le q_0 \quad (10) \\ I & otherwise \end{cases}$$

where

$\tau_{(i,j)}$: the intensity live for secretion deposit by every hymenopterans at trail (i,j). The intensity change throughout program run.

$\eta_{(i,j)}$: the visibility live of the standard at trail (i,j).

2. Pheromone Updating Stage

Ant is change a pheromone levels on path between sessions utilizing as follow updating rule:

$$\tau_{(i,j)} \leftarrow (1-\varphi)\cdot\tau_{(i,j)} + \varphi\cdot\tau_0 \qquad (11)$$

where

ρ : trail evaporation parameters.

$\Delta\tau_{(i,j)}$: pheromone levesl.

The amount of deposited secretion is that the mechanism by that ants communicate to share info concerning smart ways. Stagnation might occur throughout the secretion change and this will be happened once the secretion level is considerably totally different between ways connecting the ascertained schedule. This suggests that a number of these ways have received higher quantity of secretion quite alternative associate degree an hymenopterans insect can unendingly choose these ways and neglect the others. during this scenario, ants keep constructing constant schedule over and yet again and also the exploration of the search stops. Stagnation may be avoided by influencing the likelihood for selecting future path that depends directly on the secretion level. to form higher utilizing of the secretion and exploit the search house of a schedule a lot of effectively, many ideas supported the secretion management strategy are enforced, tested and analysed. a number of these ideas are: further secretion path limits, smoothing of the secretion trails, re-initialization of the secretion trial and extra reinforcement of the pheromone[17], etc. Flow chart of ACO show in fig.(2).

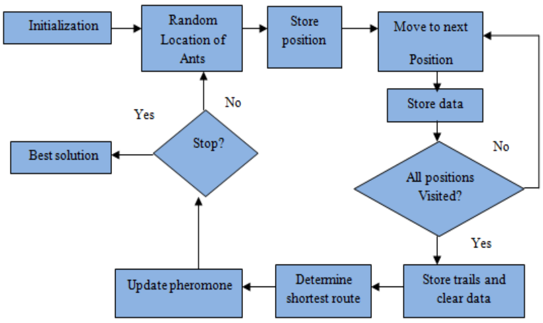


Fig.2: flow chart of ACO

B. Particle Swarm Optimization

Algorithms are recognized solutions to complex nonlinear problems by simulating the behavior of flocks of birds. The concept generates job improvement by means of particle swarms [18]. Consider the universality of the optimum for jobs with n dimensions specified by "(12)" :

$$f(x_1,x_2,x_3,\ldots x_n) = F(x) \qquad (12)$$

where: x_i : is variable of search , which represent by sets of free variable for given function**.**

The algorithm of Particle Swarm Optimization (PSO) is multi-agent parallel search techniques which maintain swarms for particle and every particles represent by solution potential in swarm. Every one particles fly during multi-dimensional search spaces, every particles are adjust it is position according to its own experiences and neighbor. Suppose $\mathbf{x}_i^t$ denote position vector for particles in multi-dimensional search space time step, then position for every particles are updated in search space as given in "(13)" **:**

$$x_i^{t+1} = x_i^t + v_i^{t+1} \qquad (13)$$

Where**:** $\mathbf{v}_i^{t+1}$ is the vector velocity for particle which drive optimization process and reflect each the own experiences knowledge and social experiences knowledge from every particles.

Therefore, PSO method, all particle is initiated arbitrarily and evaluated for computing fitness jointly with finding personal better (best value for every particles) and global best (best value entire swarm for particles). After a loop start for finding solution which is optimum., first particles update velocity through personal best and global best, also every particle is updated position by current velocity. Then loop is ended with stop criterion pre calculated in advance [19].

Basically, PSO has global best (*gbest*) and local best (*lbest*) which residential differ in size for their neighborhood as shown in Fig.3 structures of particle swarm optimization. The global best PSO (*gbest* PSO) is technique for position each particles are influenced by best-fit particles in entire swarm. As well as P_{best} its main to note personal best is position best which individual particles have visit since first at step time For *gbest* PSO technique, velocity for particle (i) is determined by " (14)" :

$$v_{i\,j}^{t+1} = v_{i\,j}^{t} + c_1 r_{1\,j}{}^{t}\ (p_{best,i}^{t} - x_i^{t}) + c_2 r_{2\,j}{}^{t}\ (G_{best}^{\ t} - x_{i\,j}^{t})\ \ldots\ldots \tag{14}$$

Where : is vector velocity at time t for particles (i) at dimension (j); $\mathbf{x_{i\,j}^{t}}$ position vector at time t for particles (i) at dimension (j); $\mathbf{P_{best\,(i)}^{\ t}}$ is personal best position establish from initialization during time t for particle (i) in dimension (j) ,$\mathbf{G_{best}^{\ t}}$ is global position best found from initialization during time t for particles (i) at dimension (j), $\mathbf{c_1}$ **and** $\mathbf{c_2}$: are acceleration positive constant which utilizing to level contributions for cognitive and socials component respectively; $\mathbf{r_{1\,j}{}^{t}}$ **and** $\mathbf{r_{2\,j}{}^{t}}$ random number at time t from uniform distribution.

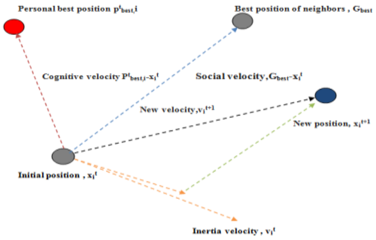


Fig. 3: Construction of particle swarm optimization

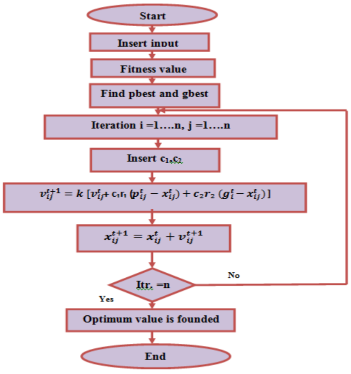
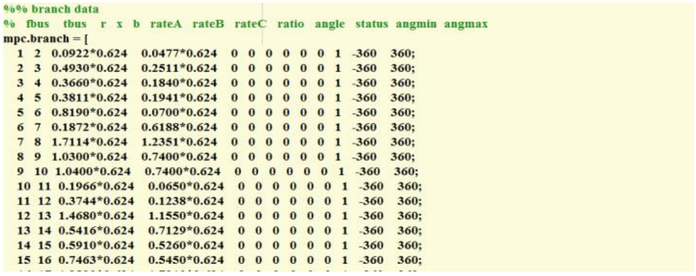


Fig..4 : Flow chart of PSO

IV. SOFTWARE IMPLEMENTATION

The canonical form of branch data in MATPOWER 5.1 are : [f_bus , br_x br_r, br_b, ratio, rate_a, rate_b, rate_c , angle, angmin, angmax]. The parameters are settings of a branch data in IEEE 33 bus systems are presented main branch name column and their corresponding meanings are listed in Table I.

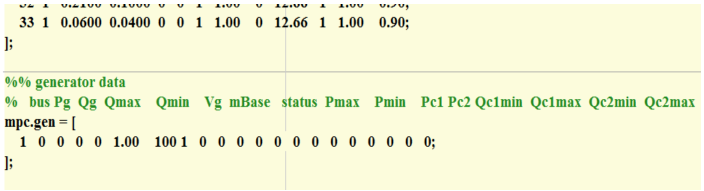
TABLE I . BRANCH DATA OF IEEE 33 BUS



```
%% branch data
%  fbus  tbus  r  x  b  rateA  rateB  rateC  ratio  angle  status angmin angmax
mpc.branch = [
  1  2  0.0922*0.624  0.0477*0.624  0  0  0  0  0  0  1  -360  360;
  2  3  0.4930*0.624  0.2511*0.624  0  0  0  0  0  0  1  -360  360;
  3  4  0.3660*0.624  0.1840*0.624  0  0  0  0  0  0  1  -360  360;
  4  5  0.3811*0.624  0.1941*0.624  0  0  0  0  0  0  1  -360  360;
  5  6  0.8190*0.624  0.0700*0.624  0  0  0  0  0  0  1  -360  360;
  6  7  0.1872*0.624  0.6188*0.624  0  0  0  0  0  0  1  -360  360;
  7  8  1.7114*0.624  1.2351*0.624  0  0  0  0  0  0  1  -360  360;
  8  9  1.0300*0.624  0.7400*0.624  0  0  0  0  0  0  1  -360  360;
  9  10 1.0400*0.624  0.7400*0.624  0  0  0  0  0  0  1  -360  360;
  10 11 0.1966*0.624  0.0650*0.624  0  0  0  0  0  0  1  -360  360;
  11 12 0.3744*0.624  0.1238*0.624  0  0  0  0  0  0  1  -360  360;
  12 13 1.4680*0.624  1.1550*0.624  0  0  0  0  0  0  1  -360  360;
  13 14 0.5416*0.624  0.7129*0.624  0  0  0  0  0  0  1  -360  360;
  14 15 0.5910*0.624  0.5260*0.624  0  0  0  0  0  0  1  -360  360;
  15 16 0.7463*0.624  0.5450*0.624  0  0  0  0  0  0  1  -360  360;
```

The MATPOWER 5.1 canonical of data bus are [bus_i, bus_type, Pd, Qd, gs, bs, area, Vm, Va, base_kv, zone, Vmax, Vmin] for IEEE 33 bus system main bus name column and their consequent meaning are listed in Table II .

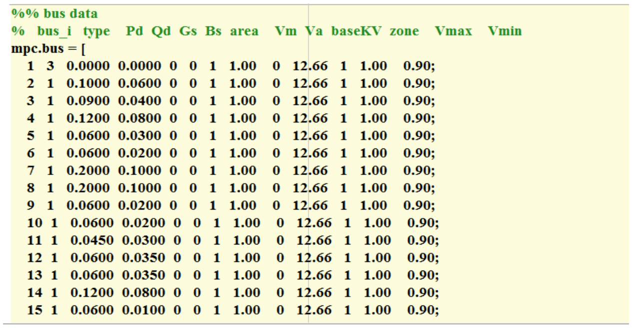
TABLE II. GENERATOR DATA OF IEEE 33 BUS



```
  33  1  0.0600 0.0400  0  0  1  1.00  0  12.66  1  1.00  0.90;
];

%% generator data
%  bus Pg  Qg  Qmax  Qmin  Vg  mBase  status  Pmax  Pmin  Pc1 Pc2 Qc1min  Qc1max  Qc2min  Qc2max
mpc.gen = [
  1  0  0  0  0  1.00  100 1  0  0  0  0  0  0  0  0  0  0  0  0  0;
];
```

TABLE III. BUS DATA OF IEEE 33 BUS



```
%% bus data
%  bus_i  type  Pd  Qd  Gs  Bs  area  Vm  Va  baseKV  zone  Vmax  Vmin
mpc.bus = [
  1  3  0.0000 0.0000  0  0  1  1.00  0  12.66  1  1.00  0.90;
  2  1  0.1000 0.0600  0  0  1  1.00  0  12.66  1  1.00  0.90;
  3  1  0.0900 0.0400  0  0  1  1.00  0  12.66  1  1.00  0.90;
  4  1  0.1200 0.0800  0  0  1  1.00  0  12.66  1  1.00  0.90;
  5  1  0.0600 0.0300  0  0  1  1.00  0  12.66  1  1.00  0.90;
  6  1  0.0600 0.0200  0  0  1  1.00  0  12.66  1  1.00  0.90;
  7  1  0.2000 0.1000  0  0  1  1.00  0  12.66  1  1.00  0.90;
  8  1  0.2000 0.1000  0  0  1  1.00  0  12.66  1  1.00  0.90;
  9  1  0.0600 0.0200  0  0  1  1.00  0  12.66  1  1.00  0.90;
  10 1  0.0600 0.0200  0  0  1  1.00  0  12.66  1  1.00  0.90;
  11 1  0.0450 0.0300  0  0  1  1.00  0  12.66  1  1.00  0.90;
  12 1  0.0600 0.0350  0  0  1  1.00  0  12.66  1  1.00  0.90;
  13 1  0.0600 0.0350  0  0  1  1.00  0  12.66  1  1.00  0.90;
  14 1  0.1200 0.0800  0  0  1  1.00  0  12.66  1  1.00  0.90;
  15 1  0.0600 0.0100  0  0  1  1.00  0  12.66  1  1.00  0.90;
```

V. RESULT AND DISCUSION

This work illustrated a simple power flow analysis. The reactive and active power generations come from substation. Fig.5 show a voltage profile utilizing PSO of all system within required range. Maximum and minimum voltage profile value are given at bus 1 and bus 32 respectively. Maximum and minimum voltage profile value are given at bus 18 and bus 32 respectively utilizing ACO as shown in the fig.6 .The magnitude of deviation voltage as 0.0139 pu. Fig.7 shown a compassion voltage profile PSO with ACO. Total power losses for the 24-hour period are listed at Table (4) show value of minimum and maximum tap position listed at the Table V. Table IV and Table V are showed a result of 33 Bus distribution network using PSO and ACO respectively at Elapsed time is 119.580785 seconds of PSO and Elapsed time is 16.516503 seconds of ACO. Table VI illustrated comparison results of PSO and ACO from this table can be conclude a power losses when using PSO is 138.9275 kW while using ACO is146.8999 kW.

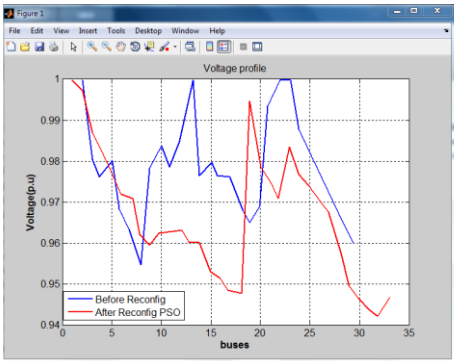


Fig.5 : Voltage profile utilizing PSO

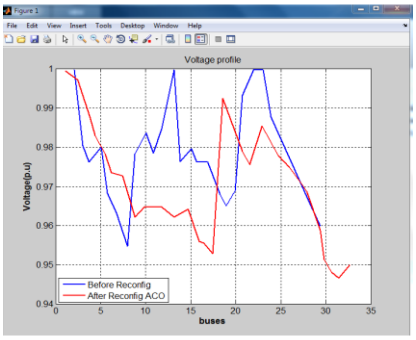


Fig.6 : Voltage profile utilizing ACO

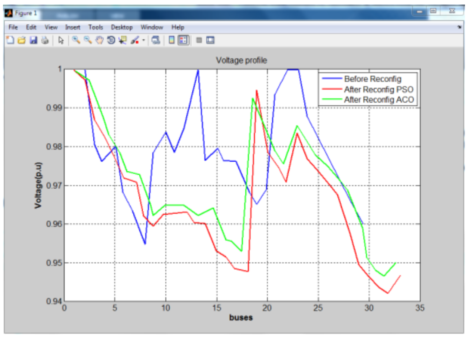


Fig.7 : Compassion Voltage profile PSO with ACO

TABLE IV :SIMULATION RESULT OF 33 BUS DISTRIBUTION NETWORK USING PSO

	How many	**How much**	**P**	**Q**
Butilizings	33	Total Gen Capacity	0.0	0.0 to 0.0
Generators	1	On-line Capacity	0.0	0.0 to 0.0
Committed Gens	1	Generation (actual)	5.9	3.4
Loads	32	Load	3.7	2.3
Fixed	32	Fixed	3.7	2.3
Dispatchable	0	Dispatchable	-0.0 of -0.	-0.0
Shunts	0	Shunt (inj)	-0.0	0.0
Branches	37	Losses (I^2 * Z)	1.27	1.11
Transformers	0	Branch Charging (inj)		0.0
Inter-ties	0	Total Inter-tie Flow	0.0	0.0
Areas	1			

	Before Reconfiguration	**After Reconfiguration**
Tie switches	33 34 35 36 37	14 32 37
Power loss	NaN kW	138.9275 kW
Power loss reduction		NaN%
Minimum voltage	0.95524 pu	0.94234 pu

	Minimum	**Maximum**
Voltage Magnitude	0.632 p.u. @ bus 32	1.000 p.u. @ bus 1
Voltage Angle	-3.04 deg @ bus 27	0.03 deg @ bus 2
P Losses (I^2*R)		0.33 MW @ line 21-8
Q Losses (I^2*X)		0.33 MVAr @ line 21-8

TABLE V: SIMULATION RESULT OF 33 BUS DISTRIBUTION NETWORK USING ACO

	How many	**How much**	**P (MW)**	**Q (MVA)**
Butilizings	30	Total Gen Capacity	335.0	-95.0 to 405.9
Generators	6	On-line Capacity	335.0	-95.0 to 405.9
Committed Gens	6	Generation (actual)	202.0	NaN
Loads	20	Load	189.2	107.2
Fixed	20	Fixed	189.2	107.2
Dispatchable	0	Dispatchable	-0.0 of -0.0	-0.0
Shunts	2	Shunt (inj)	-0.0	0.0
Branches	41	Losses (I^2 * Z)	NaN	NaN
Transformers	0	Branch Charging (inj)		NaN
Inter-ties	3	Total Inter-tie Flow	28.7	23.5
Areas	3			

	Minimum	**Maximum**
Voltage Magnitude	0.955 p.u. @ bus 18	1.000 p.u. @ bus 1
Voltage Angle	-4.78 deg @ bus 19	0.76 deg @ bus 13
P Losses (I^2*R)		0.39 MW @ line 2-6
Q Losses (I^2*X)		2.11 MVAr @ line 12-13

	Before Reconfiguration	**After Reconfiguration**
Tie switches	33 34 35 36 37	6 9 34 36 37
Power loss	NaN kW	146.8999 kW
Power loss reduction		NaN%
Minimum voltage	0.95524 pu	0.9645 pu

TABLE VI : COMPARISON RESULTS OF PSO AND ACO

	PSO	ACO
Voltage Minimum	0.945 p.u. @ bus 32	0.96 p.u. @ bus 18
Voltage Maximum	1 p.u. @ bus 1	1 p.u. @ bus 1
P Losses (I^2*R)	138.9275 kW	146.8999 kW

VI. CONCLUSION

This paper presents an Optimum Radial Power Distribution (ORPD) based on PSO and ACO algorithms. The purpose of ORPD is reduce losses of transmission line in control and reliant variables constraints which are projected sensitivity parameter of reactive power which depend on adjustment of model for Fast Decoupled Power Flow (FDPF). The testing system has been utilizing to illustrate ability of algorithm proposed and compared between them (ACO and PSO). The PSO algorithm is leads to minimum power losses with minimizing of voltage deviation, cost of switchable reactive power and maximizing reactive power preserve comparing with other algorithm proposed . As well as , PSO algorithm is give a high accuracy and solution efficiently is of ORPD problems . Moreover, the algorithms proposed represent as s tool potential for aiding of power system operation of on-line environment. The contributions of this work is reduce losses of transmission line and minimum power losses with minimizing of voltage deviation, minimum cost of switchable reactive power and maximizing reactive power.

REFERENCES

[1] D. P. Kothari, "Power system optimization,"IEEE, 2nd National Conference on Computational Intelligence and Signal Processing (CISP), Guwahati, Assam, 2012, pp. 18-21, doi: 10.1109/NCCISP.2012.6189669.

[2] T. Leveringhaus and L. Hofmann, "Optimized voltage and reactive power adjustment in power grids utilizing the least-squares-method: Optimization of highly utilized power grids with stochastic renewable energy-sources,IEEE," *International Conference on Power and Energy Systems*, Chennai, 2011, pp. 1-6, doi: 10.1109/ICPES.2011.6156648.

[3] R. Mageshvaran, I. Jacob Raglend, V. Yuvaraj, P. G. Rizwankhan, T. Vijayakumar and Sudheera, "Implementation of non-traditional optimization techniques (PSO, CPSO, HDE) for the optimal load flow solution," *TENCON 2008 - 2008 IEEE Region 10 Conference*, Hyderabad, 2008, pp. 1-6, doi: 10.1109/TENCON.2008.4766839.

[4] C. P. Salomon, G. Lambert-Torres, H. G. Martins, C. Ferreira and C. I. A. Costa, "Load flow computation via Particle Swarm Optimization," *2010 9th IEEE/IAS International Conference on Industry Applications - INDUSCON 2010*, Sao Paulo, 2010, pp. 1-6, doi: 10.1109/INDUSCON.2010.5740044.

[5]A. Garces, "A Linear Three-Phase Load Flow for Power Distribution Systems," in *IEEE Transactions on Power Systems*, vol. 31, no. 1, pp. 827-828, Jan. 2016, doi: 10.1109/TPWRS.2015.2394296

[6]O. Akdağ, İ. Karadoğan, F. OkumuŞ, C. Yeroğlu and A. Karci, "Load flow optimization of 154 kV Malatya transmission line utilizing differential evolution algorithm," *IEEE, International Artificial Intelligence and Data Processing Symposium (IDAP)*, Malatya, 2017, pp. 1-6, doi: 10.1109/IDAP.2017.8090262.

[7]V. Mathad and G. Kulkarni, "Enhancing Power System Performance by Unified Power Flow Controller (UPFC) Utilizing Particle Swarm Optimization Algorithm," *International Conference on Electrical, Electronics, Communication, Computer, and Optimization Techniques (ICEECCOT)*, Msyuru, India, 2018, pp. 773-776, doi: 10.1109/ICEECCOT43722.2018.9001378

[8] A. A. Radwan, M. O. Foda, A. M. Elsayed and Y. S. Mohamed, "Modeling and reconfiguration of middle Egypt distribution network," *Nineteenth International Middle East Power Systems Conference (MEPCON)*, Cairo, Egypt, 2017, pp. 1258-1264, doi: 10.1109/MEPCON.2017.8301343.

[9] Y. Zhang and F. Li, "Network pricing for high voltage radial distribution networks," *IEEE Power and Energy Society General Meeting*, Detroit, MI, USA, 2011, pp. 1-5, doi: 10.1109/PES.2011.6039762.

[10] K. D. Mistry and R. Roy, "Load flow solution for ill-condition radial distribution network including static load model and daily load values," *International Conference on Environment and Electrical Engineering*, Rome, Italy, 2011, pp. 1-4, doi: 10.1109/EEEIC.2011.5874863.

[11] N. Feng and Y. Jianming, "Line losses calculation in distribution network based on RBF neural network optimized by hierarchical GA," International Conference on Sustainable Power Generation and Supply, Nanjing, China, 2009, pp. 1-5, doi: 10.1109/SUPERGEN.2009.5348236.

[12] G. Pranava, G. Ravindranath and K. R. Reddy, "Simulink implementation of sensitivity analysis of radial distribution network," *International Conference On Smart Technologies For Smart Nation (SmartTechCon)*, Bangalore, 2017, pp. 1504-1508, doi: 10.1109/SmartTechCon.2017.8358615.

[13] S. S. Parihar and N. Malik, "Load Flow Analysis of Radial Distribution System with DG and Composite Load Model," *International Conference on Power Energy, Environment and Intelligent Control (PEEIC)*, Greater Noida, India, 2018, pp. 295-300, doi: 10.1109/PEEIC.2018.8665424.

[14]R. Jangra and R. Kait, "Analysis and comparison among Ant System; Ant Colony System and Max-Min Ant System with different parameters setting," *International Conference on Computational Intelligence & Communication Technology (CICT)*, Ghaziabad, 2017, pp. 1-4, doi: 10.1109/CIACT.2017.7977376

[15]M. M. Alobaedy, A. A. Khalaf and I. D. Muraina, "Analysis of the number of ants in ant colony system algorithm," *International Conference on Information and Communication Technology (ICoIC7)*, Malacca City, 2017, pp. 1-5, doi: 10.1109/ICoICT.2017.8074653.

[16]Y. Zhai, L. Xu and Y. Yang, "Ant Colony Algorithm Research Based on Pheromone Update Strategy," *International Conference on Intelligent Human-Machine Systems and Cybernetics*, Hangzhou, 2015, pp. 38-41, doi: 10.1109/IHMSC.2015.143.

[17]G. Ping, X. Chunbo, C. Yi, L. Jing and L. Yanqing, "Adaptive ant colony optimization algorithm," *International Conference on Mechatronics and Control (ICMC)*, Jinzhou, 2014, pp. 95-98, doi: 10.1109/ICMC.2014.7231524.

[18] S. Das, A. Abraham and A. Konar, " Particle Swarm Optimization and Differential Evolution Algorithms: Technical Analysis, Applications and Hybridization Perspectives", Springer, Advances of Computational Intelligence in Industrial Systems vol. 116, pp 1-3, 2008.

[19] M. F. Tasgetiren and Y. Liang, "A Binary Particle Swarm Optimization Algorithm for Lot Sizing Problem", Journal of Economic and Social Research, VOI. 5, No. 2, PP. 1-20, January, 2004.

Abbreviations	**Meaning**
ACO	Ant colony Optimization
PSO	Particle Swarm Optimization
FDPF	Fast Decoupled Power Flow
ORPD	Optimum Radial Power Distribution
OLTC	On-Load Tap Changers
HDE	Hybrid Differential Evolutions
DE	Differential Evolution
gbest	global best
lbest	local best