REVIEW ON REACTIVE POWER DISPATCH USING PARTICLE SWARM OPTIMIZATION (PSO) AND GREY WOLF OPTIMIZER (GWO)

Ms. Taramati Rabadiya[1], Mr.V.B. Patel[2]
[1]P.G. Scholar, [2]Assistant Professor,
Electrical Department, U.V Patel College of Engineering, Mehsana, Gujarat, India

Abstract: Reactive power dispatch is a nonlinear problem which has both equality and inequality constraints. In this thesis, PSO algorithm and MATPOWER 6.0 toolbox are applied to solve the reactive power dispatch problem. PSO is a global optimization technique that is equipped with excellent searching capability. The biggest advantage of PSO is that the efficiency of PSO is less sensitive to the complexity of the objective function. MATPOWER 6.0 is an open source MATLAB toolbox focusing on solving the power flow problems. The benefits of MATPOWER are that we can easily get the real time data of load flow.The proposed method in this paper minimizes the real power loss in a practical power system. IEEE 9 bus system is used to evaluate the performance. Simulation results are carried out for 9-bus and 30-bus using PSO and GWO techniques.
Keywords: PSO, GWO, IEEE 9-bus and 30-bus etc.

I. INTRODUCTION

In power system, if reactive power drawn from system than voltage goes decreasing & if reactive power inject to system than voltage will increases. Due to reactive power supplies at below rated voltage value system draws high reactive power & there were drops in voltage further. As voltage drop occurs, current must increasing to maintain power supplied. As current increases more and more line will be overload and it will impact on other lines so cascading failure occurs. Due to this some generators will disconnect or transmission facilities causes voltage drop. As this process will continue than there will be possibilities to trip elements to trip and blackout will occurs.The role of reactive power is important for secured and reliable operation of power system. Nowadays, demand of power is increases drastically and hence transmission lines are forced to operate closed to their limits. For optimal power flow and bus bar voltage closer to their limit, sufficient amount of reactive power is necessary. It is not possible to transfer reactive power though line because reactive power flowing on transmission network it causes active power loss, so we have to inject it at different locations depends upon receivers demand with help of reactive power supporter devices (i.e. shunt capacitors).Also, reactive power can limit a generator’s actual power capability. Optimal reactive power dispatch scheme can improve the power quality as well as reduce the real power loss.On the opposite, if the reactive power is unreasonably allocated, then it will bring great economic losses and might even threaten the security of the power grid.

Optimization is the process of getting best solution under the given circumstances & minimum time. Optimization can find maximum or minimum function. Optimization can also find the appropriate input which gives best result.In Optimal Power Flow (OPF), the values of all or some of the control variables need to be appropriate so as to optimize (minimize or maximize) a predefined objective functions.OPF aims to optimize a certain objectives subjected to network power flow equations and system or equipments operating limits. The optimal condition is attained by adjusting the available control variables to minimize an objective function subject to specified operating and security requirements.So, from above discussion we can say that for better voltage regulation and optimal power control the DG unit location and sizing is very important in radial distribution system. For that topic, it is necessary to study about the Load flow analysis for optimization of DG unit in main grid.

II. CHALLENGES AND RESEARCH OBJECTIVES

The main task in the electrical power system is to optimize a selected objective function such as fuel cost minimization by adjusting the state variable as well as at the same time satisfying the equality and inequality constraints. Generator real power, generator bus voltage, transformer tap changer and the reactive power source such as shunt capacitor are the control variables. Non-linear programming, quadratic programming, linear programming; Newton-based method sequential unconstrained minimization and interior point method are techniques available to handle such OPF problems. The convergence characteristics are Sensitive to the initial condition is to a drawback of these methods. Generally, non-convex, non-smooth and non-differential are the problem of OPF.

Efficient to overcome their drawbacks and handle the difficulties easily by a new optimization technique. A heuristic algorithm such as GA, gradient method and evolutionary computation technique has been processed to solving by the OPF problem. GA performance has been identified with some deficiencies. A new evolutionary technique called particle swarm optimization has been introduced by the Kennedy. PSO is based on the sociological behavior of fish schooling and bird flocking. In this paper, the OPF problem solved by the PSO based. Continuities and discrete variable easily handle by the PSO. Therefore, this method can be easily applied to mixed integer nonlinear program. It can handle such constraints easily so PSO is suitable for cost minimization. Here the proposed PSO and

GWO approach is tested for IEEE 9 bus and 30-bus system.

Research Objectives: -
Reactive power dispatch in power systems may have different goals. Some of them can be formulated below:

- Active Power Loss Minimization.
- Voltage Profile Improvement.
- Voltage Stability Enhancement.
- Cost Minimization of Reactive Power Compensation Devices.

In this paperthe objectives are developing an optimal way for managing the reactive and real power andimproving the voltages of the nodes in IEEE 9-bus system.Study of different optimization techniques for reactive power optimization. Applying Particle Swarm Optimization algorithm to make correct the values of variables likes voltage magnitudes, tap positions, & shunt capacitance in the power system for active power loss minimization.

III. REVIEW IN THE FIELD OF OPTIMAL POWER FLOW

Khaled Ben Oualid MEDANI and Samir SAYAH [1] present a particle swarm optimization with time varying acceleration coefficients (PSO-TVAC) algorithm is applied to solve the optimal reactive power dispatch problem (ORPD).The authors have developed IEEE-14 and 118-bus system with MATPOWER Newton- Raphson load flow, harmonic load flow and fault position method using two algorithms such as the gravitational search algorithm (GSA) and particle swarm optimization (PSO).In this paper, they have shown voltage sag problem to determine the expected number of sags using fault position method at a given fault position. It is based on the short circuit simulations that are repeated at all the system buses. If the fault voltage is below a preset threshold value, it is considered as a voltage dip. In this paper the voltage dips are mitigated by the PSO algorithm and voltage profile is improved using DG unit implementation.The proposed PSO-TVAC approach has been evaluated on IEEE 14, and IEEE 118-bus systems to show its effectiveness and robustness. Simulation results obviously demonstrate the proposed PSO-TVAC algorithm can reduce the active power loss and compared to other optimization methods.
Daniel Hropko, Marek Hoger, Marek Roch,Juraj Altus [2] focus on the optimal sizing of a DG unit of Solar PV &diesel-based Hybrid system for power generation using harmony search (HS) algorithm. This paper deals with a method for the optimal settings of distributed sources in order to reduce power losses and to keep bus voltages within permissible range in the distribution network. The optimal reactive dispatch of generators may be considered as a complex optimization problem.

The authors have described three new approaches for harmony search (HS) algorithm. In this paper, the authors design the simulation of the algorithm is created in the MATLAB computing environment. To reach optimal performance of PSO algorithm, it is needed to set a suitable control parameter as acceleration constants, velocity of particles, no. of particles and no. of iteration. In this paper, for every case was used constriction factor which is equal 0.729.In this paper, the simulation results of the HS algorithm of Optimization is compared with the genetic algorithm (GA) and particle swarm optimization (PSO).

Lokender Reddy and G.Yesuratnam[3] shows the results of the MATLAB modeling contain the comparative operation of inverter topologies which are conventional two-level and multilevel inverter topology. This Paper presents an approach to solve the single objective optimal power flow problem considering the critical objective function of minimization of sum of squares of voltage deviations from desired voltages at all load buses while satisfying a set of constraints associated with the control variables such as generator excitations, tap positions of on load tap changing transformers and switched var compensators and also dependent variable reactive power generation of all generators.In this paper, this problem has been solved by using the Particle Swarm Optimization (PSO) proposed by the authors for optimization with the help of reducing the power loss and voltage stability index values. The proposed algorithm comparison is done with PSO for multiple DG units in large scale Radial distribution system in this paper by the authors.

N.B. SALIM, Takao TSUJI, Tsutomu OYAMA and Kenko UCHIDA [4] shows that only the first-order terms and the constant terms need to be considered. The advantage of this method is linear programming theory is mature and the computation time is short. Therefore, the linear programming method is very likely to get trapped into one of these local optima and cannot achieve a global optimal solution. Moreover, in linear programming the accuracy of the results can also be affected due to ignores the higher-order terms. Reactive power distribution system design with Distributed Generators (DG) presence is a multi-objective problem for which it is uneasy to specify primarily due to faults and uncertainties of future demand.This paper investigates the comparison with having single and multiple objective functions via meta-heuristic algorithm known as Particle Swarm Optimization (PSO).
The advanced Front Non-Dominated sorting based multi-objective PSO algorithm is shown in this paper by authors successfully using MATLAB Simulink for IEEE bus system network. In this paper, the simulation results are validated for IEEE 33 and IEEE-69 bus system and the results shows the comparison of PSO algorithm and advanced Front Non-Dominated sorting based multi objective PSO algorithm in the IEEE bus system network. First, the numerical output results of objective functions are obtained in the Pareto-optimal set. Later, fuzzy decision model is engendered for final selection of the compromised solution. The proposed method is employed and tested on standard IEEE 33 bus systems.

Ahmed Amin, Salah Kameland Mohamed Ebeed[5]presents that the Particle Swarm Optimization (PSO) technique is a parallel search technique which utilizes multi-agents (a swarm of particles). Each agent in the swarm represents a

solution. All agents go through entire search space and update its position and velocity based on their own experience and on the experience of other agents.In this paper, Grey Wolf Optimization (GWO) algorithm is developed for solving the optimal reactive power dispatch (ORPD) problem. The ORPD problem is solved with incorporating SSSC for improving the voltage profile and enhancing voltage stability of the electric system. The optimal location and parameter setting of SSSC controller is determined under a contingency state.
The developed algorithm is validated using standard IEEE 30-bus test system and the obtained results are compared with the particle swarm optimization (PSO) algorithm.The distributed generation consists of single and multiple numbers of active power DG, reactive power DG and simultaneous placement of active-reactive power DG. Thus, in PSO technique, all agents are randomly initialized, and fitness value is computed by updating the personal best (best value of each agent) and global best (best value of all agents in the entire swarm). The loop starts by assuming initial values of the position of the particles as personal best and then updates every particle position by using the updated velocity. For any given optimization problem, some of the parameters in the PSO algorithm may affect its efficiency. Some of these parameter's values and their choices have a major impact on the performance of the PSO technique, and other parameters have small or no effect.

MohdHerwanSulaiman, ZurianiMustaffa, MohdRusllim Mohamed, Omar Aliman[6] describes that Power system is heavily loaded with increase in electricity demand. Frequency instability during islanding scenarios is an important issue to be addressed. Frequency instability happens when the power balance between generation and load demand is not met. During islanding, Under-Frequency Load Shedding (UFLS) technique is implemented to stabilize the system frequency and to ensure uninterrupted power supply to the customers.This paper proposes an optimal load shedding approach using Particle Swarm Optimization (PSO) technique for islanded mode of operation. The technique determines the optimal amount of load that needs to be shed considering power imbalance. The proposed load shedding approach is developed using MATLAB and is validated on distribution system modeled using PSCAD software. This paper presents the use of a new meta-heuristic technique namely gray wolf optimizer (GWO) which is inspired from gray wolves' leadership and hunting behaviors to solve optimal reactive power dispatch (ORPD) problem. In this paper, two case studies of IEEE 30-bus system and IEEE118-bus system are used to show the effectiveness of GWO technique compared to other techniques available in literature.

IV. OPTIMIZATION TECHNIQUES

Classification of Optimization Techniques

Based on the fundamental mechanism, reactive power optimization techniques are classified into two categories. One is conventional in which Non-linear programming, Linear Programming, Dynamic Programming & Mixed Integer Programming. The other one is Evolutionary Algorithms Optimization which includes Artificial Intelligence and Computational Intelligence based techniques like Bee Colony Optimizer, Tabu Search, Ant Lion Optimizer, Particle Warm Optimizer, Ant Colony Optimizer, and Gray Wolf Optimizer etc. In this chapter most of the optimization techniques for ORPD are discussed in brief and concept of Particle Swarm Optimizer and Gray wolf optimizer discussed in detailed.

Conventional Optimization Techniques

Earlier for solution of OPF conventional methods are used. The application of the conventional method had been an area of active research in the past. The conventional method is based on programming of mathematical approaches and it is commonly used to solve different types of optimal power flow problems to meet the requirements of different objective functions, nature of constraints and type of application.

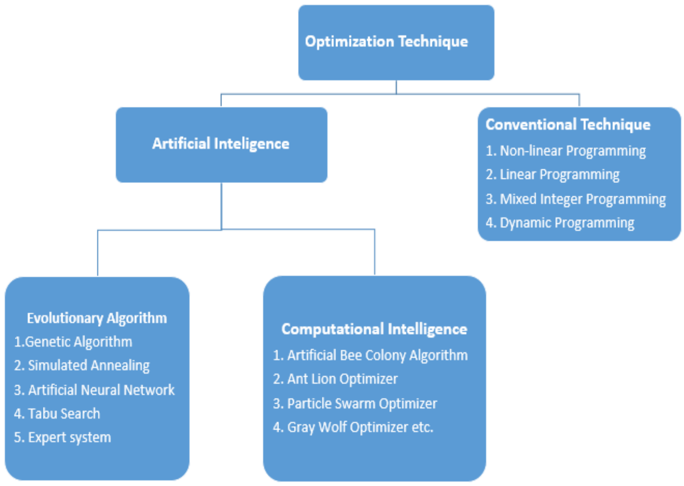

Figure.1 Classifications of Optimization Techniques

Nonlinear Programming

Nonlinear programming was used to resolve this problem because the objective functions and constraint in the reactive power optimization are nonlinear.Typical methods in Nonlinear Programming are Newton-Raphson Method, Reduced Gradient Method, & Quadratic Programming.

Reduced Gradient Method

H. Dommel and W. Tinney presented a Reduced Gradient method for optimal power flow calculation, in 1968. Reduced Gradient method is based on polar form, using the Lagrange Multiplier method to handle equality constraints and penalty function to handle inequality constraints. This algorithm uses the gradient information to guide optimization with first-order convergence. Its mechanism is relatively easy with lower storage requirements & programming is not complicated, thus becoming the first algorithm for calculating large-scale optimal power flow.

Newton-Raphson (NR) Method

Application of Newton-Raphson method for solving optimal power flow was first presented in 1984. This method considers the tendency of gradient change by using secondary derivative of objective function and constrains. Compare with reduced gradient method, Newton-Raphson method has fast convergence because of its second-order convergence rate. At the same time, it gives controlled & state variables equal consideration of the actual physical characteristics of electric system.The key application of this method is to dealing with the set of real inequality constraints, the application of special Linear Programming in inequality constraints makes it possible that optimal power flow calculation is able to converge in only iteration.

Quadratic Programming Method
Quadratic programming method is also applied to ORPD optimization problem as the objective functions of optimization are quadratic. In this technique non-linear constraint are first linearized then use successive approximations in the series with a Quadratic Programming to obtain the Global Optimal Solution.The output of practical application shows that convergence of quadratic programming method is relatively high and fast. Some details still need to be discussed as basic Quadratic Programming method requires better initial point to converge effectively.

Linear programming
Linear programming methods are the most mature methods applied in solving reactive power flow optimization. These methods locally linearize the nonlinear objective functions and constrained functions then use linear programming to solve the problem. Typical linear programming methods include Sensitivity Analysis method & Interior Point method.

Sensitivity Analysis Method
Sensitivity Analysis method analyze the relationship between control variables & state variables by finding the impact of control variables on state variables. This method can determine the sensitivity of certain bus reactive power change under branch real power change and set the bus with high sensitivity as a reactive power compensation bus.Sensitivity Analysis method reduce the variables in optimization problem, but it requires inverse calculation of Jacobian matrix which occupies more computer memory and slower computation process.

Interior Point Method
The use of Interior Point method in optimal power flow was raised in 1984. It can be solve both linear and non-linear optimization problems. This method is in fact a polynomial algorithm which was suggested by John Von Neumann as an Interior Point Method which essentially combines the advantages of Lagrange function and Newton-Raphson method.

Mixed Integer Programming
Mixed integer programming methods were raised to solve some problems in Linear Programming methods. In this method, first it determines the integer variables, and then handles the continuous variables with linear programming methods co-ordinately to make the mathematical model more practical.Mixed Integer Programming method does not require continuous operation for discrete variables so it is truly able to reflect the values of transformer turns ratio and capacitor bank.

Dynamic Programming
In Dynamic Programming method, it can transfer into a series of single stage problems from a multi-stage process & then solve the problems one by one using the relations of different stages. This method was applied in solving optimal power flow for its excellent ability of dealing nonlinear optimization problems. However, its mathematical model is much more complicated and calculation process is time consuming, especially in solving optimization problems in grid.

Artificial IntelligenceTechniques
In short time before years, Artificial Intelligence technology has been widely applied in different areas including the research of optimal power flow. Artificial intelligence methods don't have the continuity or derivative requirements of objective functions, at the same time, don't depend on precise mathematical model. Its robustness is a guarantee to the reliable solution of the optimization problems.

Genetic algorithm
The idea of genetic algorithm (GA) comes from imitating natural evolutionary processes. Chromosomes are equivalent to the solutions, the initial population corresponds to the initial design vectors of the first generation, and the fitness value represents the evaluation of the solutions. Two types of genetic operators, crossover, and mutation, define the methods of generating new populations. Immigrants are randomly generated population to keep the diversity of the group.

Simulated Annealing
Simulated annealing (SA) was proposed by Kirkpatrick in 1983. Simulated annealing is a probabilistic technique for approximating the global optimum of a given function. It is a meta-heuristic approach to get global solution in large search space for an optimization problem. It is often used when search space is discrete. The stopping criteria of SA vary for different problems. The optimization process could be stopped if i) a given minimum value is obtained, ii) a certain number of iterations are conducted, or iii) no obvious improvement is achieved after some iteration.

Artificial Neural Network
Artificial Neural network is an interconnected group of nodes, which is inspired by a simplification of neurons in a brain. An Artificial Neural Network is a computational model based on the structure and functions of biological neural network. ANN are considered as non-linear statistical data modelling tool at where the complex relationships between input and output are modelled or patterns are found. A group of ANN is trained by selected system properties first and then performs the task equivalent to the power flow program in the general OPF problem. If ANN learns the

functions properly, they are capable of fast estimating corresponding outputs with high accuracy.

Tabu search

Tabu search is a global neighbourhood search algorithm presented in 1970s. It is featured with simulation of human memory and able to avoid circuitous search by using local neighbourhood search mechanism and relative Tabu norms. It also releases some “Tabu” optimal condition by using pardon mechanism to guarantee the effectiveness and diversity of optimizing and finally realizing global optimization. Tabu Search technique have strong local search capability and relatively fast optimization speed with it’s a global iterative optimization algorithm.

Expert system

Based on the conventional methods, Expert System method combines other methods and uses expert experiences to set the initial point, and then continuously adjust control variables to obtain a good solution. The combination of algorithm and practical experience provides a great enhancement in performance. But the interface is not friendly enough, knowledge representation is incomplete and knowledge acquisition method is not flexible.

Computational Intelligence Techniques

Computational Intelligence (CI) consists of a variety of mechanisms to solve complex problems in different environments. Computational intelligence concerns with solving mechanism itself to produce acceptable solutions, while Artificial Intelligence (AI) focus on outcome of the mechanism that produces optimal solutions.

Artificial Bee Colony

Artificial Bee Colony (ABC) algorithm was proposed by Karaboga in 2005. ABC algorithm is population based algorithm which is developed by taking consideration that how honeybee swarm finds food. In ABC algorithm honeybee swarm divided into two groups: worker bees and non-worker bees including Onlooker bees and explorer bees. The bees having the best fitness value among all the reproduction.

Ant Lion Optimization (ALO) algorithm

Ant lion optimizer is a new optimization algorithm which recently add to the meta-heuristics list which is introduced by Seydali Mirjalili for solution of engineering problems with constrain. ALO considered as a global optimizer, because it performs a good balance between exploration and exploitation ability and yields a high probability of avoiding stagnation into local optima. Another interesting point of ALO is that it has not any internal parameters for adjustment. The ALO algorithm mimics the hunting behaviour of ant lions. Like all other insects in nature, ants can easily detect the location of food by using a stochastic movement.

Particle Swarm Optimization (PSO):-

The particle swarm optimization method is a new and powerful intelligence evolution algorithm for the optimization problem. Particle swarm optimization (PSO) is a population-based stochastic optimization technique inspired by social behaviour of bird flocking or fish schooling. It was first developed in 1995 by Dr. James Kennedy and Dr. Russell Eberhart.In particle swarm optimization, the search for an optimal solution is to find a population of particles, each particle represent the solution of the optimization problem. The particle can change their position by flying around a multidimensional space by following the current optimal particle until a relatively unchanged position has been getting or until computational limitation is getting. Each particle adjusts its trajectory toward its own previous best position and toward the best position it gets.Particle swarm optimization method is very easy to implement and it provides very fast convergence for many optimization problems. Now a day’s in a power system application PSO is gained a lot of attention. In particle swarm optimization has no evolution operators such as a mutation and crossover. In particle swarm optimization potential solution is called particle in particle swarm optimization each particle makes its decision using its personal experiences together with it is a neighbour’s experiences.

Grey Wolf Optimizer (GWO):-

Grey wolf optimizer (GWO) algorithm is an efficient optimization technique proposed by S. Mirjalili which has been applied successfully for solving many optimization problems. GWO simulates the social hierarchy and hunting behaviour of grey wolves where the wolves in the pack (6 - 12) follow the leader wolves in hunting process. Grey Wolf Optimizer (GWO) algorithm is Swarm Intelligence (SI) algorithms conceptualized from the social behaviour and hunting process of the grey wolves. The grey wolves living together in groups called pack and the hierarchy leadership in the pack is divided as alpha, beta, delta and omega. Alpha wolf (α) is the first level in social hierarchy where it is considered the leader and the other wolf in the pack has to follow his/her instructions. Beta wolf (β) is being in the second level of leadership where, the beta wolf assists the alphas for the activities of the pack. The third member in social hierarchy is the delta (δ) wolves which follow α and β wolf’s instruction and subordinates omega wolves. The rest of wolves are the omegas (ω) nd they have to follow the instructions of alpha, beta and delta. The GWO algorithm based on depend upon the following three steps:

(1) Searching, following and approaching the prey (A)
(2) Surrounding and harassing the prey (B-D).
(3) Attacking the prey (E).

Figure 2 Hunting Behaviour of Grey Wolves

Comparison between Conventional & Artificial Intelligence (AI) methods:
Classical method is weak in handling qualitative constraints and classical method has a poor convergence. Because of these disadvantages, the classical method may get stuck at local optimum which they can find only a single optimized solution in a single simulation run. Besides, they become too slow if the number of variables is large and they are computationally expensive for the solution of a large system.

The major advantage of the AI methods is that they are relatively versatile for handling various qualitative constraints. AI methods can find multiple optimal solutions in a single simulation run. So, they are quite suitable for solving multi-objective optimization problems. In most cases, they can find the global optimum solution.

Reactive Power Dispatch Problem Formulation
The loads on power network keep changing all the time. If maintain power system operating at the timely optimum state, the reactive power optimization required be continuously conducted in theory. However, frequent switching operations are not achieved in the practical application. These operations will not only bring extra workload to the operator of the network, but also increasing aging of the equipment in the power systems. Sometimes, frequent switching operations may even threaten the safety operation of the network. Therefore, the number of switching operations and tap positions changing operations are strictly limited.

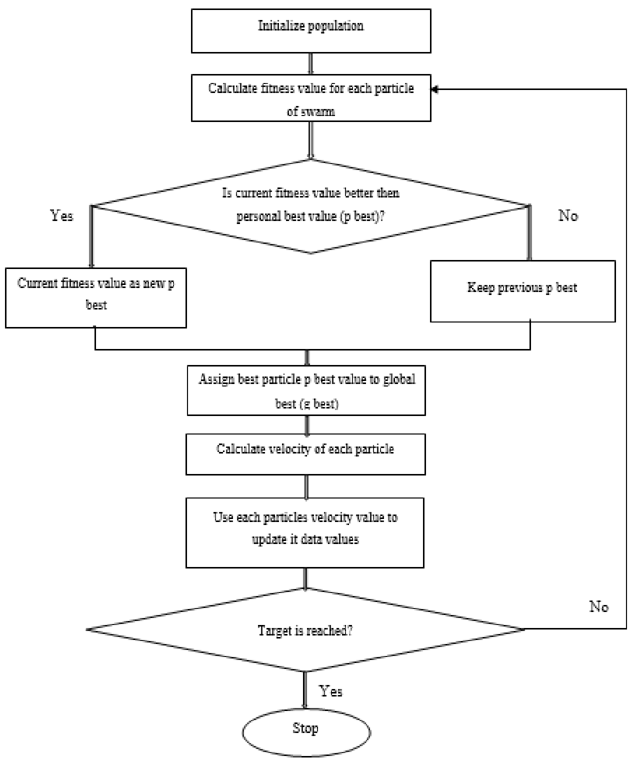

Figure 3 Flow Chart of Particle Swarm Optimization

Only the continuous control variables keep changing to reduce the power loss. The minimum real power loss during a day is set as the optimization object. The advantage of this method is that it can reduce the total power loss of the system while significantly decreasing the number of switching operations.

Implementation of ORPD using GWO
To solve the ORPD problem, a search agent would look like:
$[\,[Vg_s \;\; Vg_1 \ldots Vg_nPV\,] \quad [Pg_1 \;\; Pg_2 \ldots Pg_nPV\,] \quad [a_1 \;\; a_2 \ldots a_nTAP\,]\,]$
Therefore, size of total population would be:
$[\,(pop + 3) * (2 * nPV + nTAP + 1)]$
Where,
pop = Number of search agents

Generation at slack bus is not considered as a decision variable and is computed from power flow solution.Initially, network data is fed to the program such as bus data, line data and generation cost coefficients, and then random positions for search agents are generated based on number of decision making variables.Power flow solution obtained for each search agent and fitness is calculated based on objective function.Based on this fitness, positions of all the search agents are updated using GWO program.It is expected that the fitness obtained in next iteration would be better than previous.

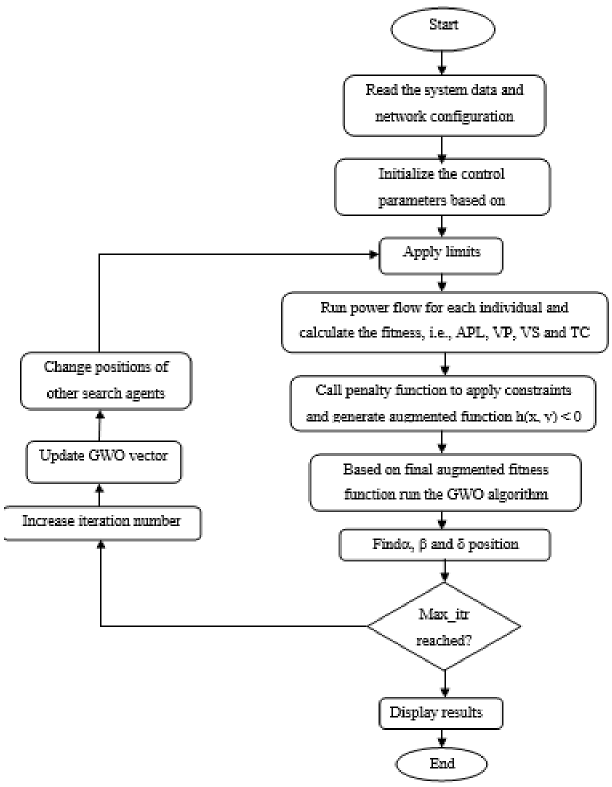

Figure 4 Flow chart of Grey Wolf Optimizer

V. CONCLUSION

The RPD (Reactive Power Dispatch) is Non-linear Optimization Problem in which both continuous & discrete control variables. Particle Swarm Optimization is a Global Optimization Technique that possess of high robustness & efficiency. PSO is less sensitive to the complexity of the objective functions. Therefore, it shows enormous potential for solving reactive power dispatch problems.Reactive power dispatch approach can significantly reduce the power loss in power systems, and this method is both cost-effective and can be easily employed in real life.PSO algorithm shows excellent searching ability in solving nonlinear optimization problems. Applying PSO algorithm to address the reactive power dispatch problems is technical feasible and can achieve considerable economic benefits.Simulation results showed that the technique is effective and efficient for solving ORPD.

REFERENCES

[1] Khaled Ben Oualid MEDANI and Samir SAYAH, "Optimal Reactive Power Dispatch using Particle Swarm Optimization with time varying acceleration coefficients", 8th International Conference on Modelling, Identification and Control (ICMIC-2016) Algiers, Algeria- November 15-17, 2016, IEEE 2016.

[2] Daniel Hropko, Marek Hoger, Marek Roch,Juraj Altus, "Reactive Power Optimization of Generators by using Particle Swarm algorithm", 978-1-4799-3721-9/14/$31.00 ©2014 IEEE.

[3] P.Lokender Reddy and G.Yesuratnam, "PSO Based Optimal Reactive Power Dispatch for Voltage Profile Improvement", 2015 IEEE Power, Communication and Information Technology Conference (PCITC) Siksha 'O' Anusandhan University, Bhubaneswar, India, ©2015 IEEE.

[4] N.B. SALIM, Takao TSUJI, Tsutomu OYAMA and Kenko UCHIDA, "Comparison of Single and Multi-Objectives for Optimal DGs Reactive Power Dispatch using PSO", 2016 IEEE Innovative Smart Grid Technologies - Asia (ISGT-Asia) Melbourne, Australia, Nov 28 - Dec 1, 2016.

[5] Ahmed Amin, Salah Kamel and Mohamed Ebeed, "Optimal Reactive Power Dispatch Considering SSSC Using Grey Wolf Algorithm", 978-1-4673-9063-7/16/©2016 IEEE.

[6] MohdHerwanSulaiman, ZurianiMustaffa, MohdRusllim Mohamed, Omar Aliman, "Using the gray wolf optimizer for solving optimal reactive power dispatch problem", Applied Soft Computing, Elsevier, 8 April 2015

[7] HossamFaris, Ibrahim Aljarah, MohmmedAzmi AL-Betar, Seyedali Mirjalili "Grey Wolf Optimizer: A Review of Recent Variant and applications" Neural Computing and Applications (2017).

[8] Mohd Herwan Sulaiman, ZurianiMustaffa, MohmRusllim Mohamed, Omar Aliman "Using the Gray Wolf Optimizer for solving Optimal Reactive Power Dispatch Problem" Applied soft computing (ELSEVIER) vol.32, (2015) 286-292.

[9] KasemNuaekaew, PraminArtrit, NantiwatPholdee, SujinBureerat "Optimal Reactive Power Dispatch Problem using a Two-Archive Multi-objective Grey Wolf Optimizer" Expert Systems With Applications (2017), doi: 10.1016 /j.eswa. 2017.06.009.

[10] DipayanGuha, Provas Kumar Roy, Subrata Banerjee "Load Frequency control of inter-conected power system using grey wolf optimization" 2210-6502/& 2015PublishedbyElsevierB.V.

[11] J.Anusuya Devi, K. Niramathy "Optimal Location and Sizing of Multi Type FACTS Devices using Grey Wolf Optimization Technique" IJSRD – International Journal for Scientific Research & Development/ Vol.3, Issue 03, 2015/ ISSN (online): 2321-0613

[12] JinZhong, Student Member IEEE and Kankar Bhattacharya, "Reactive Power Management in Deregulated Electricity Markets- A Review" 0-7803-7322-7/02, 2002, IEEE.

[13] Xiao-Ping Zhang "Restructured Electric Power System-Analysis of electricity market with equilibrium models" IEEE, Jhon Wiley & Sons.

[14] Kankar Bhattacharya, math H.J. Bollen, Jaap E. Daalder, Kluwer"OperationOf Restructured power Systems" Academic Publishers Boston.

[15] Saied Salamat Sharif, "Optimal Reactive Power Flow Problem", Msc Iran University of Science and Technology, Sept.1987.

