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An enhanced reactive power dispatch with finest location of dg using PSO algorithm

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ABSTRACT

In the safety and economic point of view, Reactive Power is the most problematic thing during the operation of the electrical power system network. Reactive Power supply completion is a nonlinear and has both equality and inequality constraints. In this work, to find the solution of reactive power supply issue, Particle Swarm Optimization (PSO) algorithm and MATPOWER 5.1 toolbox are utilized. PSO is an excellent optimization technique that is also having effective finding ability. One of the best asset of PSO is that the ability of PSO is less sensitive to the complication of the objective function. MAT POWER 5.1 is an open source MATLAB toolbox concentrating on finding the power flow issues. The proposed method in this paper diminishes the active power loss in the conventional power system and determines the optimal location of a new installed Distributed Generator (DG). The IEEE 14 bus system is utilized to find the performance and test results show the perfectness of the proposed method.

1. INTRODUCTION

Earlier, Optimum Power Flow (OPF) issue and real power is solved by loss formulae and various strategies. Reactive power is also being optimized by approximate methods. Later, many research works depict solution for OPF, Real and Reactive power flow precisely. In 1962, the objective function for OPF problem subjects to the equality and inequality constraints is formulated. Later extensions have been made evolved those provide very fast and accurate solutions even for practical large systems [1].

Electric power utility variations in power systems are usual hour to hour. Changes in power result in voltage variations. For reliable customer services, maintaining voltage levels in allowable range is one of the challenging tasks [2]. For safety and viable operation of power system, consideration of reactive power is mandatory. Now the issue is to assign reactive power to reduce the real power wastage and maintaining same voltages by sustaining the quantity of fairness and disparity constraints. Real power is related to equality constraints and on other hand unequal constraints are related to upper and lower voltages limits, capacity limit of different var sources like generators, shunt capacitor banks and transformer tap settings [3-4].

In an electrical distribution system reactive power control is a critical task. Accurate reactive power control reduces the true power losses and maintains the system potential within the limits. Reactive power control can be done automatically or manual control by changing the tapings of the power transformer and shunt compensation. In the view of environmental considerations and shortages' of conventional fuels, inverter based distributed-generation (dg) resources are playing a key role. To full fill electrical energy demand, Wind-turbine generator is one of the DG resource and it is meeting considerable power demand in the distribution system [5-6].

The optimum reactive power dispatch (ORPD) is the major issue and mainly effects the commercial and safety operation of power system. To solve OPF problem, we have different conventional methods like Direct Programming, Quadratic Programming and Newton Rapsonbased approaches and in this all conventional methods, distinct valuesarepreserved asconstant variables and smoothed off to nearest rate after optimization, thus mathematical calculations take place, also increases the objective function assessment and finally that all effects on convergence difficulty and limits the possibility of useful application [8]. Main theme of placing DG unit is to diminish losses and DG is located in primary distribution system. During the location and sizing problem of DG cannot consider the cost of it and other advantages. The capacity and location of DG established on single direct demand at topmost, where the losses are maximized [9].

Mainly detached task of ORPD tricky refers to diminish the conductive real power losses, bysustainingnumerousfairness and disparity constraints. Suggested scheme obtains the issue of introducing the optimum DG category to be locatedby standingsof localityand size, substance to inverse power flow controls, is observedthrough a Particle Swarm Optimization process(PSO)beneathinnovativebesidesextradecontrolledperception. PSO is best Evolutionary Computation (EC) techniques,improved methodology,applied to several problems and the inventivetechnique is capable to maintain theconstant state variables simply [5-7]. Furthermore, the technique can be extended to maintain constantas well asdistinct variables simply.

2. OPTIMAL REACTIVE POWER DISPATCH (ORPD)

The following two key reasons applied for implementation of ORPD.

2.1 Necessity of optimal reactive power dispatch

In general ORPD is employed to enhanceeconomy as well assafety power system operation, thus obtains a lot of consideration at present, the reason for the ORPD in a power system operation is to identify the finest standards of the regulating variables such as alternator voltage magnitudes, compensation devices and transformer tap setting positions to be switched. The main theme of ORPD problem is to reduce actual power losses voltage deviations and enhanced the voltage constancy of the arrangement [8].

2.2 Need for real power loss minimization

The most essential operating condition of consistent power systems is to keep the voltage within the acceptable limits to establish a good customer service feature. Sensitive power and voltage regulating issues have gained importance to establish a reliable quality of power supply with the least possible losses in the power system network [9-10].

An extended load for electric power, the deficient power generation and transmission efficiency forces the power system is being operated under focused on conditions. In the event that the power system network is worked in focused conditions then security of a power system network is under risk and may bring about voltage instability. The voltage insecurity has turned into a new challenge to the power system network operation besides planning. Lacking volatile power convenience or non-optimized reactive power flow be allowed to the power system network of instability action during heavy loaded conditions [11].

3. REACTIVE POWER DISPATCH PROBLEM FORMULATION

In power system network, loads are changing contineously. To operate the power system network at the ideal and convenient state, the optimization of reactive power dispatch is to be conducted constantly. Thus appears to be good fornetwork, but constant switching operations are not possible in practical applications. These operations won't carry additional capacity to the operator of the systemthen additionally hasten the era of the apparatus in power system network. Occasionally constant exchanging operations may even impend the protective operation of the network. Hence, the number of switching operations as well as tap positions changing operations is severely limited [12].

3.1 Objective function

In power systems network, reactive power dispatch has many objectives. Thus can limit real power losses and obtains best voltage profile by using smallest capacitors also attains maximum economic return. This paper aims the reactive power disatch to get the minimum tangible power loss [11]. Proposed system indicates that active power loss is equal to addition of the real power loss on each branch and its representation is as follows [13].

$$P_{loss}=\sum_{K=1}^{N} g_{ij}(v_i^2+v_j^2-2v_iv_j\cos\theta_{ij}) \tag{1}$$

where N: is branch numbers,
g_{ij}: branchconductance between i and jbuses,
v_i: bus voltage at i,
v_j: bus voltage at j,
θ_{ij}: slant between i and j buses

3.2 Equality constraints

The for equality constraints are nothing but power equivalence conditions which are specified by the following equations [12]

$$Pgi - Pdi - Vi \sum V\, j\, (Gij\cos\theta ij + Bij\sin\theta ij) = 0 \tag{2}$$

$$Qgi - Qdi - Vi \sum V\, j\, (Gij\sin\theta ij - Bij\cos\theta ij) = 0 \tag{3}$$

where P_{gi}: generation of active power at bus i
P_{di}:plea of active power at bus i
Q_{gi}: generation of reactive power at bus i
Q_{di}: pleaof reactive power at bus i
G_{ij}: conductance of communication line from i bus to j bus
B_{ij}: susceptance of communication line from i bus to j bus

3.3 Inequality constraints

The inequality functions ranges are nothing but voltage magnitudes injecting of reactive power and transformer tap setting positions [14], are continuous and injecting of reactive power is discreate [15-16]. To manage the discrete values, the commonly used method views the constant standards at the initial optimization. Then after mapping the constant standards back to the distinct standards at the termination. In proposed article, distinct variables are perceived as constant variables initially besideskeeping3 decimal places at the search end [13].

$$V_i^{\min} < V_i < V_i^{\max} \tag{4}$$

$$t_j^{\min} < t_j < t_j^{\max} \tag{5}$$

$$Q_{gi}^{\min} < Q_{gi} < Q_{gi}^{\max} \tag{6}$$

4. PROCEDURE FOR PARTICLE SWARM OPTIMIZATION (PSO) BASED ORPD

PSO having a multiple finding point based process which searchesfinestresult through improving an objective task [4]. every examining point is amediatorby a relative point. every agent's location is characterized by n dimensional space and every measurement is combined with a velocity. this velocity indicates the agents displacement rate. Every mediator tends to adjust its position from the current location $\boldsymbol{s_i^k}$, and from the current quickness for the following reiteration $\boldsymbol{v_i^{k+1}}$ as shown in eqn (7) and (8).

$$s_i^{k+1} = s_i^k + v_i^{k+1} \tag{7}$$

$v_i^{k+1} = w_k v_i^k + c_1 r_1 \times \left(p_{best-i} - s_i^k\right) + c_2 r_2 \times (g_{best} - s_i^k)$ (8)

where,

v_i^k:agent velocityi at iteration k

w_k: weighing factor

c_1, c_2 : Positive weight constants

r_1, r_2: sum between zero and one randomly

s_i^k : Agenti at reiteration k of current point

p_{best-i} :Specificfinest of mediatori

g_{best} :Finest of the set

Principle optimization steps for the Particle Swarm Optimization (PSO)built reactive power communication as follows [17].

(1) Load event data: In MATPOWER IEEE 14 buses arrangement information is kept in case14 .m organizer. Clients can likewise make the customized instance via taking after sanctioned arrangement types of buses, branches and alternators.

(2) Initialization: Arrange the absolute iteration value, particle total number, initial acceleration at random allow the fix of each particle in the design area. At that point assess the wellness of every unit and spare the worldwide finest well-known point and nearby finest well identified point of every unit.

(3) Redesign the locations and speediness: Upgrading the location and speed of every unit. At that point check-up if the explanation violate the breaking point on the other hand not. On the off chance that the solution violates the breaking points, utilize the Exterior Penalty Function (EPF) strategy to penalize the desecrations.

(4) Assess every unit: Add every particle location into the objective task to add the assessment rate.

(5) Upgrade nearby finest well identified point: In the event that the present wellness value is littler than authentic super wellness value, upgrade the confined best well known point.

(6) Upgrade worldwide best-known location.

Choose closing condition: Regulate, uncertainty the repetition had achieved the greatest repetition quantity. Uncertainty, close the optimization procedure besides design outcome; or else, iter=iter+1 then return to stage 3.

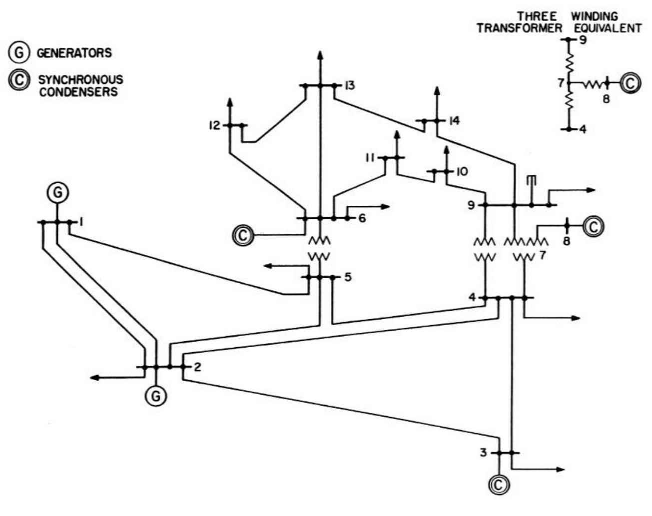

Figure 1. IEEE 14 bus system

5. SIMULATION RESULTS AND DISCUSSIONS

Execution of the proposed strategy confirmed to IEEE 14 busesarrangement. Structure of 14 buses network is presented in Fig.1 [2].

Mainly two alternators are used in IEEE 14 buses arrangement. First alternator is connected at the slack bus and second alternator is connected at bus two and there are three synchronous condensers are situated at buses two, six, and eight respectively and likewise three transformers and one shunt reactive power compensator are placed. The total active power demand as well as reactive power demand is 259 MW and 73.5 MVar respectively.

Table 1. IEEE 14 buses model load parameters

Load Bus	P (MW)	Q (Mvar)
2	21.7	12.7
3	94.2	19.0
4	47.8	3.9
5	7.6	1.6
6	11.2	7.5
9	29.5	16.6
10	9.0	5.8
11	3.5	1.8
12	6.1	1.6
13	13.5	5.8
14	14.9	5.0

5.1 Reactive power dispatch without new DG

Many times, there would be no significant enhancement on the optimization results after process of iterations go on, the value of weight also will be dropped to 04 from 0.9. The evry particle position is defined by a nine dimensional space which is represented by fig. 2. The individual population for the PSO algorithm is chosen as 50. In general the population is chosen more than 4 times for the good optimization results in the literature. Initial inertia is chosen to be 0.9 and it is reduced to 0.4 for final iteration with step size decrement relative to number of iterations. Maximum number of iterations is taken as 200 as it is observed that our solution is not convergent for 150 iterations. Similarly initial acceleration constant is chosen as 2.0 and maximum velocity is chosen as 0.1 as the acceleration is 2.0 it should not change abruptly because we have to compute 200 iteration with 50 particles each.

V1	V2	V3	V6	V8	T1	T2	T3	S9

Figure 2. Coordinates of the particle

In Fig. 2, V indicates the magnitude of voltage at the slack bus or PV bus, T indicates the transformer tap setting point, and S9 represents injection of reactive power at bus 9.Whenever optimization procedure takes place, every particle position will be continuously modified until reaching the stopping criteria.

Fig. 3 represents the without installing DG with optimization procedure of reactive power dispatch. Intial optimization process,the particles positions are selectedrandomly. At this time, the global active power loss is 13.5 MW. After updation of positions of particles continually near the globalfinestresult, real power loss becomes reducing. Once completion of hundredrepetitions, no significant enhancement can be found and the real power loss converged to 12.36 MW finally.

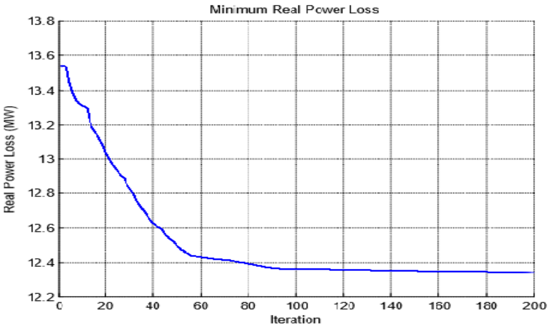

Figure 3. Loss reduction method

Table 2. Comparison of the real power loss at each branch

Branch Number	Before Optimization (MW)	After Optimization (MW)
1-2	4.298	3.907
1-5	2.763	2.552
2-3	2.323	2.147
2-4	1.677	1.546
2-5	0.904	0.828
3-4	0.373	0.347
4-5	0.514	0.462
4-7	0	0
4-9	0	0
5-6	0	0
6-11	0.055	0.055
6-12	0.072	0.073
6-13	0.212	0.213
7-8	0	0
7-9	0	0
9-10	0.013	0.013
9-14	0.116	0.120
10-11	0.013	0.013
12-13	0.006	0.006
13-14	0.054	0.053

5.2 Reactive power dispatch with new DG

The alternative case study defines the introducing separate DG towards the IEEE 14 buses arrangement besides optimizing the reactive power of the arrangement via PSO. Wind drive, Solar Photovoltaic and Micro-turbine arrangements are preferred as substitute source to conventional DG unit. Proposed scheme implemented by installing Enercon E82 Wind drive instead of DG. Installed gust drive acts as direct-drive synchronous generator having the capacity of 200 KW. This arrangement operates at rated power in alternative case study.

If the wind drive installed at PQ bus, to modify the amount of reactive as well as real power to the innovative parameters, voltage level of the newly established DG bus ought to be preserved as newly regulating variable, which illustrates in fig. 4.

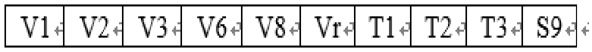

Figure 4. Coordinates of the Particle

where Vr represents voltage magnitude of the new DG.

With addition of new DG, the load bus changes to a new generator bus. So system parameters bus data, generator data are changed. These changes are the combined with a 14 bus data case file and produce a new 14 bus data. This data is passed to PSO along with coordinates of the particle. PSO would then initialize for these 10 variables (fig.4) and send it to Newton Raphson (NR) technique using MATPOWER to find the load flow of system with losses. As the sum of the losses determine through NR method indicates fitness of particle, the best particle solution provides least losses with different voltages and tap setting at various points of IEEE 14 bus system providing optimal power flow with least real power losses.

Table 3. Real power loss comparison

Branch	Before optimization (MW)	Optimization without DG(MW)	Optimization with DG(MW)	Percentage improvement (%)
1-2	4.298	3.907	3.826	10.9819
1-5	2.763	2.552	2.517	8.9034
2-3	2.323	2.147	2.051	11.7090
2-4	1.677	1.546	1.531	8.7060
2-5	0.904	0.828	0.818	9.5133
3-4	0.373	0.347	0.309	17.1582
4-5	0.514	0.462	0.461	10.3113
4-7	0	0	0	0
4-9	0	0	0	0
5-6	0	0	0	0
6-11	0.055	0.055	0.038	30.9091
6-12	0.072	0.073	0.068	5.5556
6-13	0.212	0.213	0.194	8.4906
7-8	0	0	0	0
7-9	0	0	0	0
9-10	0.013	0.013	0.019	-46.1538
9-14	0.116	0.120	0.135	-16.3793
10-11	0.013	0.013	0.006	53.8462
12-13	0.006	0.006	0.005	16.6666
13-14	0.054	0.053	0.039	27.7777

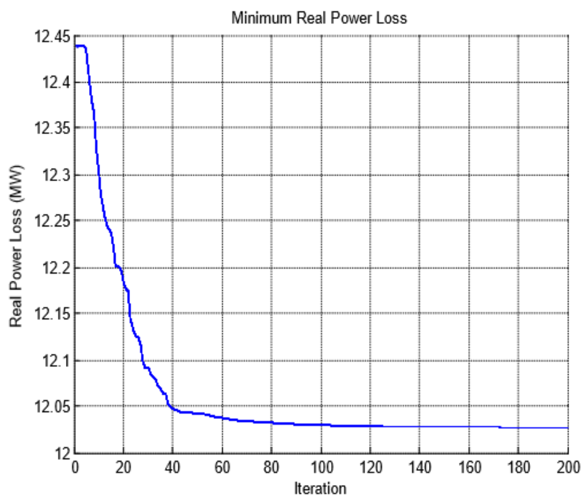

Figure 5. Loss reduction process when the new DG is installed at Bus 3

Figure 5 shows the optimal procedure of the suggested strategy, when newly wind drive is established at bus number 3.

Therefore primary active power loss of the coordination is nearly 12.45 MW. The elements flinch to meet when conduction takes eighty iterations. Lastly entire power loss of the arrangement is 12.017 MW.

6. CONCLUSION

Reactive power dispatch is a nonlinear advancement issue that contains both constant and discrete control factors. PSO is a heuristic global optimization algorithm that possess of high efficiency and robustness. PSO is less delicate to the complication of the objective functions. Therefore it shows enormous potential for solving reactive power dispatch problems. This article utilizes the IEEE 14 bus system as the test system. Both PSO technique and MATPOWER 5.1 toolbox are tested to reduce the real power loss in the power networks. Reactive power dispatch approach can significantly diminish 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. The mature MATPOWER 5.1 are introduced to calculate power flow and manage the equality constraints in PSO based reactive power dispatch. The accuracy of the results and the robustness of the code get improved.

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