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# Generation Rescheduling Using PSO Based OPF

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**ABSTRACT**

Economic load dispatch is an area of serious attention for reducing the final cost of electric power consumption. Generator rescheduling is done by optimal allocation of generating units to obtain a better effective and economic load dispatch. This paper uses a Newton Raphson technique to obtain optimal power flow for load flow analysis and Particle swarm optimization technique is used to find the optimal generator rescheduling. The proposed technique is tested on standard IEEE 14 bus system. The minimum fuel cost concurred under this technique is the parameter which determines the fitness of the function.

*Keywords— Optimal Power Flow (OPF); Particle Swarm Optimization (PSO); Quadratic Programming (QP)*

## I. INTRODUCTION:

### A. Scenario

The optimal power flow solution deals with the optimal allocation of electrical power to meet the growing and complex expanded power system. It is done to find out the most optimal, economic, least faulty system of power transmission or load dispatch [1].

The power flow, load dispatch and the economics behind it is influenced by various measurable or mathematically derivable parameters called as constraints. Such constraints can be formulated into equations which would define the load dispatch problem [3]. The optimal solution to such multivariable equations will give the optimal power flow solution.

Conventional, optimization techniques are not enough to solve nonlinear objective function with number of constraints as it depends on first and second derivatives of the objective function [5, 7]. Since the proposed problem is of complex optimization use of heuristic algorithm is inevitable.

Various global optimization techniques such as SA (Stimulated Annealing), GA (Genetic Algorithm), and PSO (Particle swarm Optimization) are used to solve such power optimization problem. SA is general purpose stochastic optimization technique that converges with probability [9]. It requires more computational time to reach near global solution. GA is faster than SA as it is a parallel search algorithm than replicates natural genetic operations [4]. But sometimes premature convergence degrades its performance.

PSO is another exciting evolutionary computational methodology that solves such wide range problems. It is somewhat similar to GA which is initiated by population of random solutions.

In this paper Particle swarm optimization is used to find the optimal solution for a system.

### B. PSO

PSO is modern heuristic algorithm developed through simulation of a simplified social system. It is robust in solving continuous nonlinear optimization problems [6]. It is a population based search algorithm in which each particles change their position with time. In PSO, particles fly around in multidimensional search space. During flight each particle adjust its position according to its own experience and experience of neighboring [9]. The global optimizing model PSO is as

( ) ( )

; i= 1, 2…N

Where,

N - Particle number.
I - $i^{th}$ particle in swarm.
S - Position of particle
V - Velocity of particle
$P_{best}$ - Best position of particle
$g_{best}$ - Global best position

$C_1$ & $C_2$ - Conjunctive & social parameter.

Acceleration constant $C_1$ pulls each particles toward local best position where as $C_2$ pulse particles toward global best position suitable selection of w helps in convergence.

## II. PROBLEM FORMULATION

The IEEE 14 bus system is taken in this paper to test the proposed algorithm and it is used as standard test system to study different power problems. It consist of 5 generating units and 20 transmission lines

In general the generation fuel cost function is expressed as follows:

$\sum$ $\sum$ ( ) \$/Hr (1)

In order to get optimal power flow with minimum generation cost we have to minimize generation fuel cost function.

( $\sum$ ) (1.1)

The OPF problem has two types of constraints

1). Equality constraints: These are set of nonlinear power flow equations that governs the power systems i.e.

- Active power balance in network :

( ) – (K=1, 2, 3,..$B_n$)- (1.2)

- Reactive power balance in the network :

( ) – (K=$V_n$+1, $V_n$ +2… $B_n$- (1.3)

2) Inequality Constraints: these are set of constraint that represent the system operational and security limits. They are as

- Limits on real power generation

(K=1, 2, …..$G_n$)- (1.4)

Limits on voltage generation

(K=$V_n$+1, $V_n$ +2… $B_n$) - (1.5)

- Limits on voltage angles

(K= 2, ... $B_n$) - (1.6)

Where

Real power equation:

( )

$\sum$ [ ( ) ( )] - (1.7)

Reactive power equation:

( )

$\sum$ [ ( ) ( )] - (1.8)

, are elements of admittance matrix.

$G_n$ - Number of generator buses.
$B_n$ - Number of buses.
$V_n$ - Number of voltage controlled buses.
$P_k$ - Injection of active power.
$Q_k$ - Injection of reactive power.

1. Active load on $K^{th}$ bus.
2. Reactive load on $K^{th}$ bus.
3. Active power generation on $K^{th}$ bus.
4. Reactive power generation on $K^{th}$ bus.

VK - $K^{th}$ bus voltage.
$\delta_K$ - $K^{th}$ bus phase angle.

## III. RESULTS

The proposed PSO algorithm is tested on IEEE based 14 bus test system. Fig 2 shows the 14 bus system consists of 3 generator buses 20 lines, 11load bus, 3 tap changer transformer and total load capacity of 259.3 MW. Table 1 shows the optimal power flow using classical newton Raphson technique. The Table 2 shows the PSO based cost optimization and corresponding generator allocation.

| IEEE 14 bus parameters | |
|---|---|
| Number of buses | 14 |
| Number of branches | 20 |
| Number of generators | 03 |
| Total load MW | 259.3 |
| Number of transformer taps | 03 |
| **PSO parameter** | |
| Population size | 100 |
| Maximum generation | 300 |
| C1, C2 | 2.05 |
| Initial weight | 0.85 |

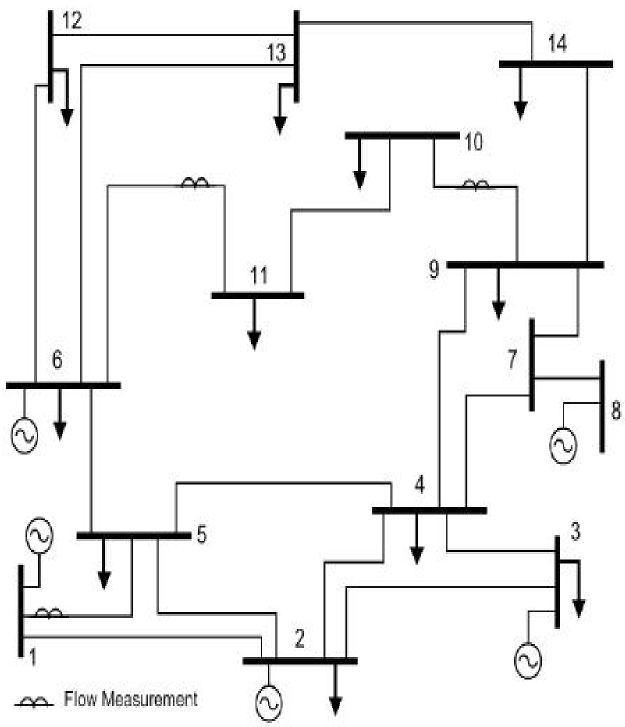


Fig 1. 14 Bus system.

The result shows better and efficient generator rescheduling and eventually better fuel cost optimization than the classical methods. Thus the proposed method gives better results in comparison to different classical methods reported in literature in terms of generator rescheduling.

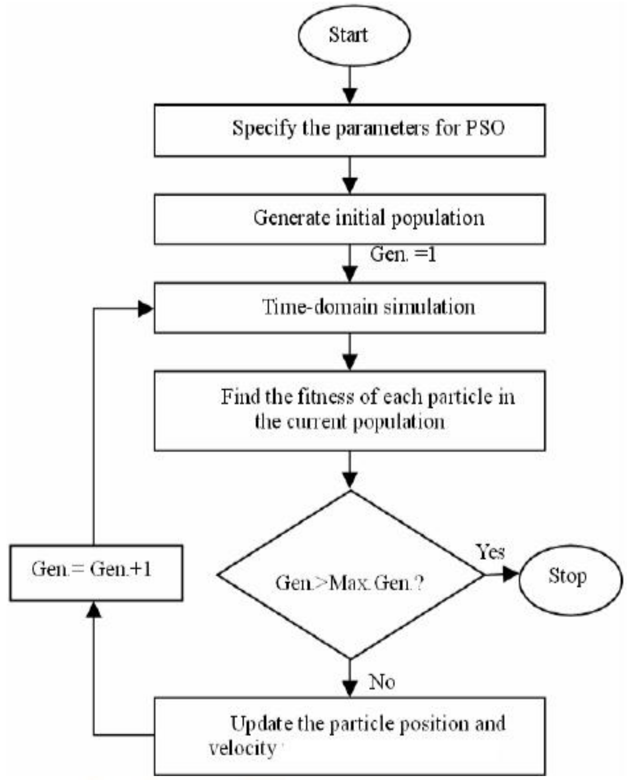


Fig 2. PSO flow chart.

Table1. OPF Using newton Raphson

| Line no | Line flows (MVA) without constraints | Line flows (MVA) With constraints | Line Flows limits |
|---|---|---|---|
| **1** | 123.63 | 119.765 | 120 |
| **2** | 58.602 | 57.909 | 65 |
| **3** | 23.547 | 21.923 | 36 |
| **4** | 45.089 | 42.801 | 65 |
| **5** | 14.467 | 13.054 | 50 |
| **6** | 39.72 | 40.399 | 63 |
| **7** | 42.621 | 42.868 | 45 |
| **8** | 51.120 | 51.133 | 55 |
| **9** | 30.024 | 30.015 | 32 |
| **10** | 0.737 | 0.737 | 45 |
| **11** | 17.862 | 17.857 | 18 |
| **12** | 29.828 | 29.819 | 32 |
| **13** | 8.646 | 8.641 | 32 |
| **14** | 6.371 | 6.379 | 32 |
| **15** | 7.937 | 7.938 | 32 |
| **16** | 18.245 | 18.249 | 32 |
| **17** | 11.324 | 11.319 | 18 |
| **18** | 2.476 | 2.485 | 12 |
| **19** | 1.527 | 1.528 | 12 |
| **20** | 4.809 | 4.815 | 12 |

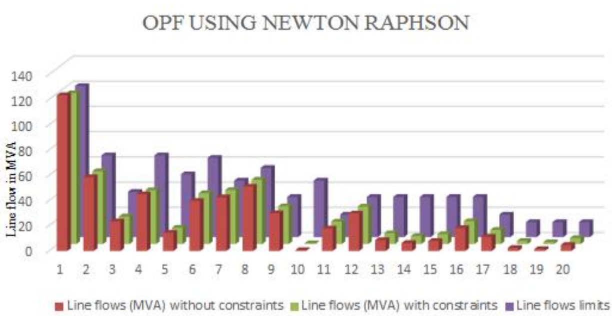


Fig 3. Comparative chart of OPF using Newton Raphson.

Fig. 3 shows that earlier the power flowing in some lines are beyond limits when power flow is analyzed without applying any constraints but after applying the constraints to the problem power flowing in the line are within limits.

Table 2. Fuel cost comparison between different techniques of optimization

| Power Flow Methods | Total fuel cost ($/hr) |
|---|---|
| | |
| Classical | 1155.5 |
| Quadratic | 1146.9 |
| GA-OPF | 1144.9 |
| **PSO** | **1142.701** |

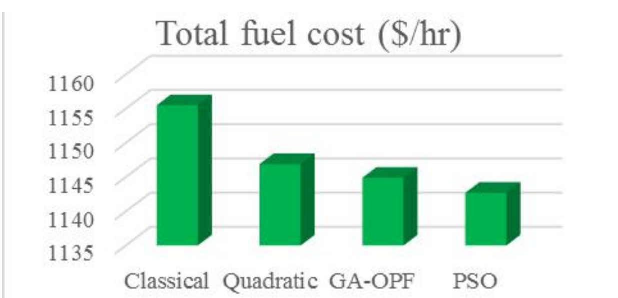


Fig 4. Comparison between different methods of OPF on the basis of total fuel cost ($/hr)

The above Table 2 and Fig 4 represent the comparison between different methods of OPF on the basis of total fuel cost. It is evident that by changing the generation schedule methods the total fuel cost is reduced. It is clear from the graph that in PSO technique the fuel cost is minimum.

Table 3. Percentage reduction in fuel cost.

| | CLASSICAL | PSO-OPF | % REDUCTION |
|---|---|---|---|
| F1 | 597.94 | 593.40 | 0.75 |
| F2 | 333.54 | 329.90 | 1.1 |
| F3 | 215.75 | 212.43 | 1.5 |

## IV. CONCLUSION

Generator rescheduling has been efficient in reducing the fuel cost of the generators compared to the conventional methods.

The reduction in fuel cost has obtained up to 1.5% by the proposed method. All the specified standard constraints has been satisfied and maintained.

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