Optimal Power Flow Analysis of Bus System using Practical Swarm Optimization

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Abstract— In this present era, power system is very complex. Stability, reliablity and security of power system is major concern for power engineers. In the presented work optimal powerf flow technique is proposed. The major objective is to minimize fuel cost without violating system security constraints such as power output of generator, bus voltages, shunt capacitors/reactors and transformers tap setting. To achieve this, initially, IEEE-6 bus system and IEEE-30 bus system are tested for nonconventional OPF method. The work is carried out to make use of particle swarm optimization method for solving the optimal power flow (OPF) problem for units of the same systems. The optimal power flow (OPF) is being used to find the optimal setting to operate the system. When operating cost is minimized, the generator schedule is calculated by OPF. Traditionally, the cost function of each generator is represented by a simple quadratic function. However thermal units are sometimes made to run on multiple fuels like coal, natural gas and oil. The performance of the proposed method has been demonstrated under simulated conditions on IEEE- 6 bus system with 3-generator unit and IEEE-30-Bus system with 6-Generation units.

Key words: Practical Swarm Optimization, Bus System

I. INTRODUCTION

With large interconnection of the electric networks, the energy crisis in the world and continuous rise in prices, it is very essential to reduce the running costs of electric energy. A saving in the operation of the power system brings about a significant reduction in the operating cost as well as in the quantity of fuel consumed. The main aim of modern electric power utilities is to provide high-quality reliable power supply to the consumers at the lowest possible cost while operating to meet the limits and constraints imposed on the generating units and environmental considerations. These constraints formulates the economic load dispatch (ELD) problem for finding the optimal combination of the output power of all the online generating units that minimizes the total fuel cost, while satisfying an equality constraint and a set of inequality constraints. Traditional algorithms like lambda iteration, gradient method, and Newton method can solve this ELD problems effectively if and only if the fuel-cost curves of the generating units are piece-wise linear and monotonically increasing. Practically the input to output characteristics of the generating units are highly non-linear, non-smooth and discrete in nature owing to prohibited operating zones, ramp rate limits and multi fuel effects. Thus the resultant ELD becomes a challenging non-convex optimization problem, which is difficult to solve using the traditional methods. Methods like dynamic programming, genetic algorithm, evolutionary programming, artificial intelligence, and particle swarm optimization solve non-convex optimization problems efficiently and often achieve a fast and near global optimal solution. Among them PSO was developed through simulation of a simplified social system, and has been found to be robust in solving continuous non-linear optimization problems. The PSO technique can generate high-quality solutions within shorter calculation time and stable convergence characteristics.

II. OVERVIEW OF PARTICLE SWARM OPTIMIZATION

In many engineering disciplines a large spectrum of optimization problems has grown in size and complexity. In some instances, the solution to complex multidimensional problems by means of classical optimization techniques is extremely difficult and/or computational expensive. This realization has led to an increased interest in a special class of searching algorithms, namely, heuristic algorithms. In general, they are referred to as “stochastic” optimization techniques and their foundations lie in the evolutionary patterns and behaviors observed in living organisms.Particle Swarm Optimization (PSO) is a relatively new evolutionary algorithm that may be used to find optimal (or near optimal) solutions to numerical and qualitative problems. Particle Swarm Optimization was originally developed by James Kennedy and Russell Eberhart in 1995, and emerged from earlier experiments with algorithms that modeled the flocking behavior seen in many species of birds. Particle swarm optimization (PSO) which is a population based stochastic optimization technique shares many similarities with evolutionary computation techniques such as Genetic Algorithms (GA). The system is initialized with a population of random feasible solutions and searches for optima by updating generations. However, unlike GA, PSO has no evolution operators such as crossover and mutation. PSO algorithm has also been demonstrated to perform well on genetic algorithm test function. In PSO, the potential solutions, called particles, fly through the problem space by following the current optimum particles. The concept of the PSO consists of, at each time step, changing the velocity of (accelerating) each particle toward its pbest and lbest locations (local version of PSO). Acceleration is weighted by a random term, with separate random numbers being generated for acceleration toward pbest and lbest locations. In past several years, PSO has been successfully applied in many research and application areas. It is demonstrated that PSO gets better results in a faster, cheaper way compared with other methods. Another reason that PSO is attractive is that there are few parameters to adjust. One version, with slight variations, works well in a wide variety of applications. Particle swarm optimization has been used for approaches that can be used across a wide range of applications, as well as for specific applications focused on a specific requirement.

III. ADVANTAGES OF PSO

Many advantages of PSO over other traditional optimization techniques can be summarized as follows:

PSO is a population-based search algorithm. This property ensures PSO to be less susceptible in being trapped on local minima.

PSO makes use of the probabilistic transition rules and not deterministic rules. Hence, PSO is a kind of stochastic optimization algorithm that can search a complicated and uncertain area. This makes PSO more flexible and robust than conventional methods.

PSO can easily deal with non-differentiable objective functions because PSO uses payoff (performance index or objective function) information to guide the search in the problem space. Additionally, this property relieves PSO of assumptions and approximations, which are often required by traditional optimization models.

The solution quality of the proposed approach does not depend on the initial population. Starting anywhere in the search space, the algorithm ensures the convergence to the optimal solution. Therefore, this method is different from traditional techniques.

PSO has the flexibility to control the balance between the global and local exploration of the search space. This unique feature of a PSO overcomes the premature convergence problem and enhances the search capability which makes it different from Genetic Algorithm (GA) and other heuristic algorithms.

IV. RESULTS

PSO Parameters No of Particles=100 Inertia Weight=0.4

SR NO	POWER DEMND (MW)	PG1 (MW)	PG2 (MW)	PG3 (MW)	TOTAL FUEL COST (RS/HR)	LOSSES (MW)
1	300	202.6	80.73	27.39	3615.4	10.5
2	400	249.9	126.0	43.42	4815.01	19.4
3	500	250	150	100	8954.04	32.5

Table 1: Optimal Scheduling Of Generator for 3 Unit System

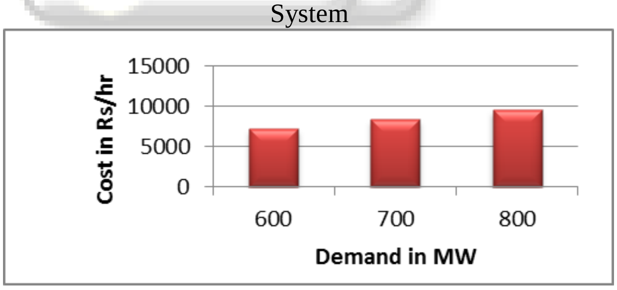

Fig. 1: Cost vs Demand

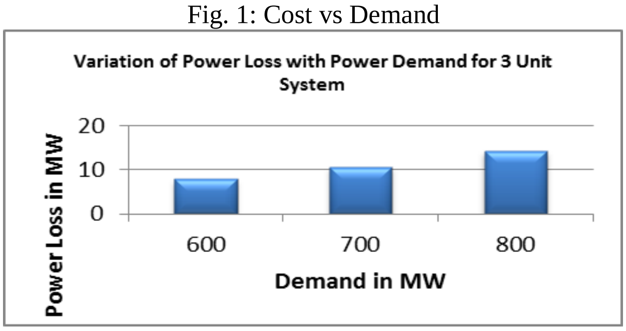

Fig. 2: Power Loss vs Demand

Optimal scheduling of Generator for 6 unit system
PSO Parameters
No of Particles=100
Inertia Weight=0.4

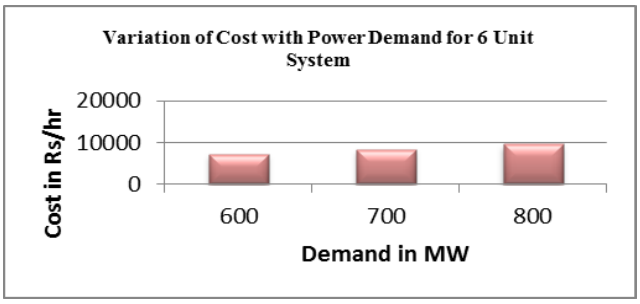

Fig. 3:

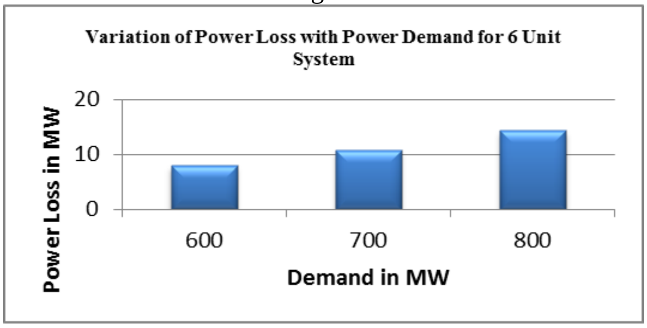

Fig. 4:

The result with different crossover probability
For 3 generator unit system
Enter the probability of crossover pc = 0.8

NO	DEMAND (MW)	PG 1 (MW)	PG 2 (MW)	PG3 (MW)	PG4 (MW)	PG5 (MW)	PG6 (MW)	FUEL COST (RS/HR)	LOSSES (MW)
1	600	280.05	50.0	127.38	50.0	50.0	50.0	7203.43	7.91
2	700	323.66	76.73	158.21	50.0	52,13	50.0	8352.61	10.73
3	800	355.80	99.47	181.54	50.0	77.52	50.0	9558.56	14.34

Table 2:

GA method parameters:
Fitness
Enter the length of string l = 30
F_{max}= 0.990234
Enter the population size L = 60

FOR 300 MW
pg1= 124.589335 MW
pg2= 147.153552 MW
pg3= 36.283372 MW
Total generation = 308.026258 MW
Transmission losses are = 10.984992 MW
Total cost of generation are = 3656.225375 Rs/h

Enter the probability of crossover pc = 0.7
GA method parameters:
Fitness
Enter the length of string l = 30
F_{max}= 0.990614
Enter the population size L = 60

FOR 300 MW
pg1= 170.923982 MW
pg2= 94.080907 MW
pg3= 43.395210 MW
Total generation = 308.400100 MW
Transmission losses are = 11.242684 MW
Total cost of generation are = 3591.454934 Rs/h

For 6 generator unit system
Enter the probability of crossover pc = 0.8
GA method parameters:

Fitness
Enter the length of string l= 50
F_{max} = 0.934591
Enter the population size L = 12O

FOR 600 MW
pg1= 214.415452 MW
pg2= 109.722177 MW
pg3= 82.231038 MW
pg4= 118.329119 MW
pg5= 64.242261 MW
pg6= 58.361519 MW
Total generation = 647.301568 MW
Transmission losses are = 5.309341 MW
Total cost of generation are = 8069.635055 Rs/h

Enter the probability of crossover pc = 0.7
GA method parameters:
Fitness
Enter the length of string l= 50
f_{max} = 0.862035
Enter the population size L = 120

FOR 600 MW
pg1= 161.078850 MW
pg2= 78.346335 MW
pg3= 190.213534 MW
pg4= 92.830311 MW
pg5= 93.563253 MW
pg6= 87.204674 MW
Total generation = 703.236957 MW
Transmission losses are = 7.209460 MW
Total cost of generation are = 8709.105497 Rs/h

Classical Optimal Power Flow Method
Lembda Iteration Method [30]
For 3 unit System

PD (MW)	Fuel Cost (RS/HR)
400	20898.83
500	25486.64

For 6 unit System [31]

PD (MW)	Fuel Cost (RS/HR)
700	35485.05
900	48567.70

V. CONCLUSIONS

The objective in the OPF (Optimal Power Flow) problem has been decided as minimizing of total cost of real power generation. The economic power flow problem for IEEE-6 and IEEE-30 Bus systems has been solved by genetic algorithm (GA).

The proposed method was indeed capable of obtaining higher quality solutions with better computation efficiency and convergence property.

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