Economics Load Dispatch Using Particle Swarm Optimization with Quadratic Cost Function

Ankur Saxena
Department of Electrical Engineering, Madhav Institute of Technology and Science, Gwalior (M.P.), India
Saxenaankur365@gmail.com

Abstract: **Economic load dispatch is a non linear optimization problem which has greater value in power system. By economic dispatch means to know the generation of different units of plant so so find the total fuel cost is minimum .This paper presents the solution of economic load dispatch problem with quadratic cost function by using Particle Swarm Optimization (PSO). PSO technique is useful at solving optimization problems with both single and multiple objective functions with discontinuous, non-convex, non-differentiable solution and noisy .Various factors like optimal dispatch, total cost, and incremental cost of delivered power are evaluated. These methods for economic dispatch in power system problem in power system is tested and proved on the Nigerian Grid System.**
Keywords: Grid system, Economic Load Dispatch, Particle Swarm Optimization, Quadratic Cost Function. Non-Convex

1. INTRODUCTION

The main aim of 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. [1].

For the purpose of economic dispatch studies, online generators are represented by functions that relate their production costs to their power outputs. Quadratic cost functions are used to model generator in order to simplify the mathematical formulation of the problem and to allow many of the conventional optimization techniques to be used [2].

The ELD problem is traditionally solved using conventional mathematical techniques such as lambda iteration and gradient schemes. These approaches require that fuel cost curves should increase monotonically to obtain the global optimal solution. The input-output of units are inherently non-linear with valve point loading or ramp rate limits and having multiple local minimum points in the cost function [3].

Techniques such as dynamic programming might not be efficient since they require too many computational resources in order to provide accurate results for large scale systems. But, with the advent of evolutionary algorithm which are stochastic based optimization techniques that searches for the solution of problems using simplified model of the evolutionary process found in nature, this type of constrained optimization problem can easily be solved providing better and faster results. The success of evolutionary algorithm is partly due to their inherent capability of processing a population of potential solutions simultaneously, which allows them to perform an extensive exploration of the search space [3].

Evolutionary algorithm includes Genetic Algorithm, Simulated Annealing, Hybrid Particle Swarm Optimization with Sequential Quadratic Programming approach, Evolutionary Programming and Artificial Bee Colony (ABC) etc. A global optimization technique known as genetic algorithm (GA), a probabilistic and heuristic approach is used to solve power system optimization problems. Genetic algorithms are attractive and serve as alternative tool or solving combinational optimization problems and these are found superior in parallel search. PSO converges more quickly than EP, but it has a slow fine tuning ability of the solution.

2. PROBLEM FORMULATION

The Economic dispatch in a power system of wind power plant has the allocation of generation included wind and thermal plants so as to minimize the total production cost in fact satisfying various types of constraints.

The ELD problem is formulated as follows:

Minimize F_T

$$\text{Minimize } F_T = \sum_{i=1}^{n} F_i(P_i) \qquad (1)$$

F_T is the total generation cost
F_i is the power generation cost of the i^{th} unit
$F_i(P_i)$: $\alpha i + \beta i\ P + \gamma i\ P2$ is a quadratic cost function of the unit i^{th}, α, β, and γ are cost coefficient of the i^{th}generator, which are found from the input-output curves of the generators and on the particular type of fuel used. P_i: It is the power output of i^{th} unit of thermal plants. The minimization is subject to the following constrains: Power balance

$$= \sum_{i=1}^{n} P_i = P_D \qquad (2)$$

where :
P_D is the power demand and P_L is the transmission loss.
The transmission loss can be represented by the B-

$$PL = \text{Sum} \; Pi \; Bij \; Pj \qquad (3)$$

where B_{ii} is the transmission loss coefficient of maximum and minimum power limits
The power generated by each generator has some limits and can be expressed as:

$$P_i^{min} \leq P_1 \geq P_1^{max}$$

P_i^{min} =The minimum power output
P_1^{min} =The minimum power output

3. PSO CONCEPT

Particle swarm optimization (PSO) is motivated from the simulation of the behavior of the social systems such as fish schooling bird flocking. PSO algorithm requires less memory because of its inherent simplicity.

PSO shares many similarities with evolutionary computation techniques such as Genetic Algorithms (GA). The system is initialized with a population of random solutions and searches for optimal by updating generations. However, unlike GA, PSO has no Evolution operators such as crossover and mutation. In PSO, the potential solutions, called particles, fly through the problems space by following the current optimum particles. Each which are associated with best solution (fitness) it has achieved so far. (The fitness value is also stored.) This value is called pbest. Another "best" value that is tracked by the particle swarm optimizer is the best value, obtained. This location is called ibest. When a particles takes all the population as the velocity (accelerating) each particle toward its pbest and ibest locations (local version of PSO). Acceleration is weighted by a random term, with separate random numbers being generated for acceleration toward pbest and ibest locations.

In a physical n-dimensional search space, the position and velocity of individual i are represented as the vectors
$Xi = (X_{ii} \ldots\ldots X_{in})$ and
$V_i = (v_{ii} \ldots vi)$ in the PSO algorithm.

Let
$Pbest_{,} = (x_{ii}^{pbest}, \ldots, x_{in}^{pbest})$ and

$Gbest = (x_{ii}^{Gbest}, \ldots, x_{ii}^{Gbest})$

be the best position of individual i and its neighbors' best position so far, respectively. Using the information, the updated velocity of individual i is modified under the following equations in the PSO algorithm.

$$V_i^{k+I} = \omega V_i^k + c_i rand_i \times (Pbest_i^k - X_i^k) + c_2 rand_2 \times (Gbest_i^k \, X_i^k)$$

where, V_i^k is the velocity of individual i at iteration k ω is the weight parameter c_1, c_2 the weight factors, $rand_1$, $rand_2$ random numbers between 0 and 1, X_i^k position of individual i at iteration k, $Gbest_i^k$best position of the group until iteration k. In this velocity updating process, the values of parameters such as ω,c_1, c_2 should be determined in advance. In general, the weight ω is set according to the following eqn.(11)

$$w = w_{max} - \frac{w\ maz}{iter\ max} - \frac{w\ maz}{iter\ max} \times iter \qquad (5)$$

Where, ω_{max} ,ω_{min} initial, final weights $Iter_{max}$ maximum iteration number $Iter$ current iteration number

Each individual moves from the current position to the next one by the modified velocity in eqn.(10) using the following equation

$$X_i^{k+1} = X_i^k + V_i^{k+I} \qquad (6)$$

A simple block diagram showing the basics of particle swarm optimization is shown in Fig.1.as

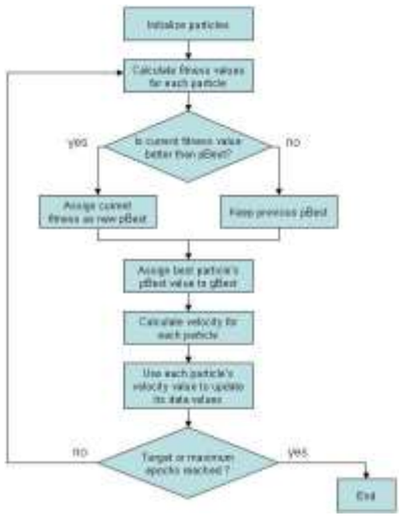

Fig.1. Block diagram of PSO

Pseudo Code

For each particle
Initialize participle
Do unit maximum iterations or minimum error criteria
For each particle
Calculate Data fitness value
If the fitness value is better then pbest
set pbst = current fitness value
If pbest is better than gbest
Set gbet = pbest

4. SIMULATION, RESULTS AND DISCUSSION

The EEE 3-generating units, 6-bus test system and the Nigerian network were considered in order to verify the performance of the approach in practical applications.

A. study 1: IEEE 3- Generating Units, 6-Bus Test system

This example is a 6-bus test system fed by three thermal generating units [ ]. The system unit data is given in Table 1. Two load demand scenarios of 350MW and850MW respectively were considered in the simulation using PSO algorithm. The schedules for the three generators were obtained with the corresponding transmission losses. The Power loss equation is given as:

$$P_L = 0.00003P_{G1}^2 + 0.00009P_{G2}^2 + 0.00012P_{G3}^2 \quad (7)$$

Table 1. Data for the three unit system

	Unit 1	Unit 2	Unit 3
P_{max} (MW)	650	450	250
P_{min} (MW)	160	120	70
α($/MWh)	569	319	95
β($/MWh)	8.97	8.89	8.85
γ ($/MWh)	0.00165	0.0025	0.0067

B. Case Study 2: Nigerian Power System Grid

The standardized 1999 model of the Nigerian network comprises 7 generators, out of which 3 are hydro whilst the remaining generators are thermal, 28 bulk load buses and 33 extra high voltage (EHV) lines.. The single line diagram of the 440kV Nigerian grid system is shown in Fig.2.

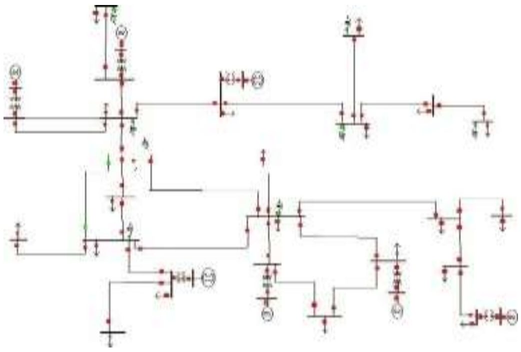

Fig.1. Single line diagram of Nigeria 440kV 31-bus grid systems

The typical power demand is 3465.9 MW and bears technical power network loss of 65.97MW

Table 2.Nigerian thermal power plants Data

Units	α	β	γ	$P_i$min	$P_i$max
P	8769	9.84	0.18	147.5	650
Q	735.94	-7.13	1.5	79	400
R	1784	86	0.07	139	5740
S	13962	23.1	0.046	278	2100

Table 3: Parameters setting for PSO

Control parameters		
Number Particle	100	
Maximum Iteration number	500	
Weight Factors c_1, c_2	2,	1
Weight Parameter ω_{max} , ωmin	0.9,	0.1

The results find for Case Study 1 using PSO is shown in Table 3 with the different generators scheduling and the corresponding production cost for each of the two load demand.

Table 4: PSO Data Result for Case Study 1

Parameters	350 MW	850MW
PG1	170.64	425.2
PG2	120.42	302.65
PG3	51.38	148.35
P_T	340	850
P_L	2.44	16.2
$P_D + P_L$	342.44	876.2
Total Cost ($/hr)	3842.1	8446.43

The total cost of production for the demand P_D = 350MW and 850MW is 3842.1$/hr and 8446.43$/hr respectively. The transmission losses is 2.48MW for P_D= 350MW and 18.2 MW for P_D=850MW

Table 5: Result for Case Study 2

	PSO
A	873.20
B	193.45
C	109.37
D	381.32
E	490
F	350
G	450
P_G	2852.34
P_D	2823.1
P_L	37.27
Cost $/hr	108430

Table 4 shows the results of the economic load dispatch of the Nigerian Grid system. The hydro units' power allocations are fixed in conformity with the utility's operating practices. Subsequently, PSO is applied to schedule the thermal units with the transmission losses considered. The total production cost is given as 108430$/hr while the losses is 37.27MW.

5. CONCLUSION

In this paper PSO based economic load dispatch was searched on two sample networks (a 6-bus IEEE test system and 31-bus Nigerian grid system).The results proved that PSO can minimize total production cost and also compute transmission losses. The penetration of renewable will expose a major challenge to power utility's planning and operations as a result of their intermittence and uncertainty nature. Therefore, further ELD research should be emphasize on larger networks with renewable penetration in power systems.

REFERENCES

[1]. Perez-Guerrero, P.E. and Cedeno-Maldonado,. C.R. 2005.Economic power dispatch with non-smooth cost function using differential evolution, IEEE Power symposium proceeding. http://ieeexplore.ieee.org.

[2]. Thitithamrunehai., C. Eua-Arpon, B. 2006. Economic load dispatch for piecewise quadratic cost function using hybrid self- adaptive differential evolution with augmented lagrange multiplier method. IEEE Power conference. http://ieeexplore.ieee.org.

[3]. Chang, C.L. 2007. Genetic based algorithm for power economic dispatch. IET Generation-Transmission Distribution.

[4]. Liu. Y and Shang T. 2007.Economic Dispatch of Power Incorporating Wind Power Plant. http://ieeexplore.ieee.org.

[5]. Bakare, G.A., Krost, G., Venayagamoorthy, G.K., Aliyu,U.O. 2007. Differential Evolution Approach for Reactive Power Optimization of Nigerian Grid System. IEEE Power Engineering Society Meeting.http://ieeexplore.ieee.org.

[6]. Wood, A.J. and Woolenberg, B.F, 2014. Power Generation Operation and Control**.** John Wiley and Sons, New York.

[7]. Awodiji, O.O., Bakare, G.A., Aliyu, U.O. Short Term Economic Load Dispatch of Nigerian Thermal Power Plants Based on Differential Evolution Approach. IJSER. Vol 5 Issue 3, 2014

