Optimal Power Pooling for a Multiple Area Power System through PSO

Shaligram Agrawal[1], Tuli Bakshi[2], and Dipika Majumdar[3]

[1] Deptt. of EE & CSE, Calcutta Institute of Technology, Howrah, India
[2] Deptt. Of MCA, Calcutta Institute of Technology, Howrah, India
[3] Deptt. EEE, Bengal College of Engineering, Durgapur, India

[1]agrawaljsr@yahoo.co.in, [2]tuli.bakshi@gmail.com, [3]deepika.eee@gmail.com

Abstract: In a multiple area power system power can be transferred from one area to other to improve the load factor, reliability, security and economics of the power system. The generation cost of each unit in an area and the cost of power transfer from other area are given. For a given load in an area the problem is how much power to be generated internally by all the generating units in the area (unit wise) and how power has to be transferred (pooled) from other area for a given total load demand in the area (for economic operation of the power system). This problem has been solved using Lagrange multiplier method recently. The limitation of this method is that it is applicable only if the generation cost of each generating unit is quadratic. Sometimes the power generation cost of each unit is not quadratic but is other type of nonlinear function e.g. the valve-point effect problem it is addition of quadratic and sinusoidal function. The main objective of this paper is to overcome this limitation by solving this general type of nonlinear optimal problem using a Meta heuristic method, PSO (Particle Swarm Optimization) and its variants. It is to point out that for implementation of PSO it is required to select a population size. Generally the population size is selected on ad-hoc basis. This effects the computation time as well as number of iteration for solution. A method has been suggested to select population size on the basis of optimal computation time as second objective. The method is explained by an example. The results obtained by PSO and its variants are compared among themselves and with the results obtained by analytical method. MATLAB 7 software is used for computation.

Keywords: Integrated Power System, Optimization, PSO, Economic Power Dispatch.

1. Introduction

Electric power system is the largest man made system in the world. It consists of synchronous generators, transformers, transmission lines, active and reactive power controllers, relays and switches. For proper operation and control of such a large nonlinear no stationary system along with operational constraints requires solution of an optimization problem for a given objective. In a simple form it can be defined as:

For a given objective function f(x) (x as variable) find the optimum value of x under the given inequality constraints $h(x) \leq 0$ and equality constraints $g(x) = 0$.

The electric power is generated by different modes of generation such as fossil fired generation, using diesel oil, petrol, nuclear fuels, hydro generation and non-conventional energy sources such as wind power, tidal waves, solar energy and biogas etc. The generation cost of each method different depending on the fuel cost and method of generation. As for example the operating cost of coal fired (thermal) , diesel, petrol units are higher due to the cost of fuel is higher in comparison to the hydro generating units or wind power generation whereas the fixed cost of hydro unit or wind power units are higher. The constraints of the different units are also different such as the availability of water is a constraint in case of hydro generation.

Received: November 8th, 2013. Accepted: May 16th, 2014

In early stage each unit were serving a limited local area. It has got its own limitations such as reliability, quality of service, security, spinning reserve capacity. Keeping in view of these problems the concept of interconnection of different generating units forming an area (region) developed where all the generating units are working in unison. In an area there are a number of generating units, each has different cost characteristic. The problem arises that for a given load what should be the generation of each unit (operating under given constraints) so that the total cost involved is minimum known as Economic Dispatch (ED) problem. This is computed and controlled by a power system grid and the information is sent to different generating units. The solution of this problem is found in standard books [1-2] and reputed journals [3-5]. Various mathematical programming methods has been applied to solve this problem such as LP (Linear Programming) [6-7] where all the constraints & objective function are linear, Non Linear Programming (NLP) [8], Dynamic Programming (DP) [9-10]. The DP is suffering from the problem of "curse of dimensionality". Computational intelligence based techniques/ heuristic methods are also developed for solution of such problems e.g. Particle Swarm Optimization (PSO) [11&24], Genetic Algorithm (GA) [12], Artificial Neural Networks (ANN) [13] etc.

The load curve of different area of power system is of different shape. The peak load of different area occurs at different time in a day. The load can be transferred from one area to other, depending on the power generating capacity and load demand of each area and their difference, through tie line between the two areas resulting in a co-ordinated operation of the power system. It improves the load factor, reduces the spinning reserve of each area, and improves the power system security, reliability and power quality. Recently a paper has been published [14] considering power transfer from one area having a number of generating units to other on the basis of multiple flat rates (cost) depending on the quantity of power transfer. This results in a 2^{nd} order smooth nonlinear optimization problem. The solution method proposed was a conventional method of Lagrange multiplier.

In this paper it is proposed to solve the above problem using PSO a heuristic method and its variants and the results are compared. The advantage of the method is that it is applicable to both linear, smooth/non-smooth nonlinear/piece wise linear systems. The computations are carried out considering different population sizes and terminating the algorithm for a given number of iterations. The results of these methods and the result obtained using conventional method ref. [14] are also compared. It has been shown that the results obtained by PSO are approximately same as obtained by conventional method. On the basis of computation it has also been shown that as the population (number of particles) increases the number of iterations (generation) decreases for the solution but the CPU time of the computation increases after a particular population size. The optimum population size is suggested for minimum CPU time. If the number of particles (Population) is less than the dimension (number of variables) of the optimization problem it may give erratic result, and if the population size is too large the CPU time will be large. So it has been suggested that population should be somewhat more than the number of variables.

The method is explained by taking an example having two generating machines in an area interconnected to another area by tie line. It is assumed that the generation cost curve of each machine and the power generating limits are given. The results obtained by PSO and its variants are compared with the conventional one obtained in ref. [14]. All the computations are carried out using MATLAB- 7 software. In the next section a PSO and its variants are discussed in brief.

2. Particle Swarm Optimization (PSO)

It is a computational intelligence based optimization technique such as genetic algorithm (GA). It is a population based stochastic optimization technique developed by Kennedy and Eberhart in 1995 [15-18] and inspired by the social behavior of bird flocking in a group looking for food and fish schooling.