Reserve Constrained Multi-Area Economic Dispatch Employing Evolutionary Approach

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ABSTRACT

The objective of Multi-area economic dispatch (MAED) is to determine the generation levels and the interchange power between areas that minimize fuel costs, while satisfying power balance and generating limit and transmission constraints. If an area with excess power is not adjacent to a power deficient area, or the tie-line between the two areas is at transmission limit, it is necessary to find an alternative path between these two areas to transmit additional power. When a MAED problem is solved with spinning reserve constraints, the problem becomes further complicated. The power allocation to each unit is done in such a manner that after supplying the total load, some specified reserve is left behind. In this paper, the authors compare classic PSO and DE strategies and their variants for reserve constrained MAED. The superior constraint handling capability of these techniques enables them to produce high quality solutions. The performance is tested on a 2-area system having 4 generating units and a 4-area, 16-unit system.

Keywords: Differential Evolution, Particle Swarm Optimization, Reserve Constrained Multi-Area Economic Dispatch, Time Varying Acceleration Coefficients (TVAC), Transmission Capacity Constraints

INTRODUCTION

In the power sector, economic dispatch (ED) is used to allocate power demand among available generators in the most economical manner, while satisfying all the physical and operational constraints. The cost of power generation, particularly in fossil fuel plants, is very high and economic dispatch helps in saving a significant amount of revenue (Wood & Wollenberg, 1984). Many utilities and power pools have limits on power flow between different area/regions over tie lines. Each area/region has its own pattern of load variation and generation characteristics. They also have separate spinning reserve constraints. The ED technique should select the units in each area in such a way that reserve requirements and transmission constraints are satisfied. The objective of MAED is to determine the generation levels and the interchange power between areas which minimize fuel costs in all areas while satisfying power balance, generating limit and transmission constraints. Power utilities try to achieve high operating efficiency to produce cheap electricity. Competition exists in the
electricity supply industry in generation and in the marketing of electricity. The operating cost of a power pool can be reduced if the areas with more economic units generate larger power than their load and export the surplus power to other areas with more expensive units. The benefits thus gained will depend on several factors like the characteristics of a pool, the policies adopted by utilities, types of interconnections, tie-line limits and load distribution in different areas. Therefore, transmission capacity constraints and area reserve constraints are important issues in the operation and planning of electric power systems.

A complete formulation of multi-area generation scheduling with import/export constraints was presented in Shoults, Chang, Helmick, and Grady (1980). Desell et al. (1984) proposed an application of linear programming to transmission constrained production cost analysis. Farmer et al. (1990) presented a probabilistic method which was applied to the production costing of transmission constrained multi-area power systems. Hopfield neural network based approach was proposed to solve the MAED problem (Yalcinoz & Short, 1998). Doty and McIntyre (1982) solved multi-area economic dispatch problem by using spatial dynamic programming. Linear programming application is proposed in Desell, McClelland, Tammar, and Van Horne (1984) while area control error is solved in multi-area economic dispatch (Hemick & Shoults, 1985). Wang and Shahidehpour (1992) proposed a decomposition approach using expert systems. The Newton-Rapshon’s method is applied to solve multi-area economic dispatch problem (Wernerus & Soder, 1995) by calculating short range margin cost based prices. An incremental network flow programming algorithm was proposed for the MAED solution with tie-line constraints (Streiffert, 1995). The multi-area economic dispatch is solved by direct search method with considering transmission constraint (Chen & Chen, 2001). Evolutionary programming is proposed in Jayabarath, Sadasivam, & Ramachandran, (2000) for multi-area economic dispatch problem. Recently covariance matrix adapted evolutionary strategy has been proposed for MAED problems where a Karush Kuhn Tucker (KKT) optimality based stopping criterion is applied to guarantee optimal convergence (Manoharan, Kannan, Baskar, & Willjuice, 2009).

When ED problem is solved with spinning reserve constraints the problem becomes further complicated. The power allocation to each unit is done in such a manner that after supplying the total load, some specified reserve is left behind (Nasr Azadani, Hosseinian, & Moradzadeh, 2010; Aruloss, Victoire, & Jeyakumar, 2005; Wang & Singh, 2009; Lee & Breipohl, 1993). In MAED problems inter area reserve sharing can help in reducing the operational cost. Evolutionary methods are increasingly being proposed for ED problems with complex constraints due to their ease of implementation and random parallel search capability. The methods found in literature include tabu search, simulating annealing, neural networks (Yalcinoz & Short, 1998; Park, Kim, Eom, & Lee, 1993), genetic algorithm (Walter & Sheble, 1993), particle swarm optimization (Wang & Singh, 2009; Chaturvedi, Pandit, & Srivastava, 2009; Chaturvedi, Pandit, & Srivastava, 2008; Alrashidi & El-Hawary, 2007), harmony search (Vasebi, Fesanghary, & Bathae, 2007), ant colony optimization (Song, Chou, & Stoham, 1999), bacterial foraging (Panigrahi & Pandi, 2009), artificial immune system (Vanaja, Hemamalini, & Simon, 2008) and differential evolution (DE) (Noman & Iba, 2008). Among these techniques, PSO, DE and their variants have been extensively popular due to their superior convergence characteristics, consistency and ease of implementation.

Although these methods do not always guarantee global best solutions, they often achieve a fast and near global optimal solution. Researches have constantly observed that all these methods very quickly find a good local solution but get stuck there for a number of iterations without further improvement sometimes causing premature convergence. Time varying acceleration coefficients (TVAC) (Chaturvedi, Pandit, & Srivastava, 2009) are employed for countering the effect of premature convergence in PSO for solving nonconvex ED problems.
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