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Artificial Electric Field Algorithm Applied to the Economic Load Dispatch Problem With Valve Point Loading Effect:

AEFA Applied to ELD With VPLE

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ABSTRACT

Economic load dispatch is to operate thermal generators economically with fulfilling load demand. This economic dispatch problem becomes highly complex and non-linear after considering various operating constraints like valve-point loading effect, generator operating constraints, and prohibited operating zone. The recently developed physics law-based artificial electric field algorithm has been applied to solve highly complex and non-linear ELD problems. The exploration and exploitation strategy of the algorithm helps to avoid local optimum value, and to get global optimum value in less computation time. The AEFA method has been applied to 10, 13, 15, 40, and large 110 thermal generators to validate the effectiveness of the proposed algorithm. The results obtained by the proposed algorithm have been compared with other recently developed algorithms.

KEYWORDS

Artificial Electric Field Algorithm, Economic Load Dispatch, Prohibited zone, Soft Computing, Valve point loading effect

1. INTRODUCTION

In recent scenarios, the electrical energy market has become liberal and highly competitive because of increasing load demand. Economic load dispatch (ELD)s beneficial in the operation and planning of power system management (Soni et al., 2020). ELD is used to maintain the economy of the power system by reducing production costs and increasing reliability by maximizing the capability of the thermal unit (Soni & Pandya, 2018). The main aim of ELD is to predict variables for sharing all load to make the system economical by considering equal and unequal constraints. In practical ELD problems, other constraints should consider, like valve point effect, ramp rate, and prohibited

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operating zones(POZ). This ELD problem is initially solved by some classical methods like quadratic programming (Shah et al., 2019), Dynamic Programming, Linear Programming, gradient method, Lagrangian relaxation, and Hopfield framework (Dieu & Schegner, 2012). The main issue with this method is that they are susceptible to starting points and mostly converge and diverge at a local optimum solution. The solution to the ELD problem by DP technique makes large dimensions that require more computational efforts. These methods are not feasible due to nonlinear characteristics like ramp rate limits, discontinue POZ, and non-smooth cost function. Therefore, classical calculus-based methods are not used. To overcome these drawbacks, robust and reliable techniques are developed. Hence, some new optimization techniques like artificial intelligence (AI) were found to overcome the disadvantages of classical techniques. Hopfield neural network (HNN) is an example of an AI-based algorithm used to solve non-convex and non-differentiable ELD optimization problems. However, they require a large number of iterations to reach global optima. Hence, it takes more time to reach the solution (Bhattacharjee & Patel, 2020).

In recent times, A new population based modern intelligent heuristic and stochastic optimization methods is proposed like Backtracking search algorithm (BSA), search group optimization (SGO), hybrid version particle swarm optimization with mutation (HPSO) (Jiang et al., 2014), Bacterial forge optimization (BFO), artificial bee colony (ABC), Evolutionary programming (EP) (Bhattacharjee et al., 2022), lightning flash algorithm (LFA), Kinetic gas molecule optimization (KGMO) (Basu, 2016), Improved genetic algorithm with mutation (IGA MU), sine cosine algorithm (SCA) (Verma et al., 1 C.E.), A full mixed-integer linear programming (FMILP), A modified symbiotic organisms search (MSOS), Differential evaluation with multi population (MPDE), swarm base optimization (SBO) (Article et al., 2018), Civilized swarm optimization (CSO) (Narang et al., 2017), Modified cuckoo search algorithm (MCSA), Emended salp swarm algorithm (ESSA) (Bhattacharjee & Patel, 2020), Ant Direction Hybrid Differential Evolution (ADHDE) (Priyadarshi et al., 2020), Jaya Algorithm With Self-Adaptive Multi-Population (Jaya SML) (Yu et al., 2019), evolutionary approach for particle swarm optimization (EPSO) (Kamboj et al., 2016), conglomerated ion-motion and crisscross search optimizer (C-MIMO-CSOO), Water cycle algorithm (WCA) (Elhameed & El-Fergany, 2017), Two-phase mixed integer programming (TPMIP) (Wu et al., 2016), Rooted tree optimization (RTO), Exchange market algorithm (EMA) (Ghorbani & Babaei, 2016), Phasor particle swarm optimization (PPSO) (Gholamghasemi et al., 2019), Density-Enhanced Multi-objective Evolutionary Approach (DMOA) (Ji et al., 2021), Particle swarm inspired optimization (PARPSO), Improved PSOG (IODPSO-G), Improved PSOL (IODPSO-L) (Dou et al., 2020), chaotic bat algorithm (CBA) (Adarsh et al., 2016), Crow search algorithm (CSA), immune algorithm (IA EDP), Turbulent Flow of Water-based Optimization (TFWO) (Ghasemi et al., 2020), oppositional invasive weed optimization (OIWO), Ameliorated grey wolf optimization (AGWO). A teaching-learning-based optimization (TLBO) was proposed to solve the heat and power dispatch problem. It divides the search agents into the teaching and learning phases. Thus, the main drawback of the TLBO method is that it requires more memory space and consumes more time. Modified TLBO named quasi oppositional TLBO (QOTLBO) is proposed in (YANG et al., 2014). The OHSA algorithm used opposite numbers to improve the convergence rate. Gandomi and Alavi have proposed a krill herd algorithm (KHA) in (Kaur et al., 2021), which was also successfully applied to solve the ELD problems. Oppositional real coded chemical reaction optimization (ORCCRO) has a special ability to solve the non-linear and non-quadratic equations with a smoother transition. Oppositional KHA was proposed to solve the ELD problem in small, medium, and large power systems.

However, these heuristic methods have poor results for different sets of problems. Some of these algorithms have corrupted local and global search at the final stage of optimization. Some methods have good capability to find global search, but they have less capability to find local search. Thus a strong optimization technique is needed to overcome these disadvantages.

This paper uses a new algorithm called the Artificial electric field algorithm (AEFA) (Anita & Yadav, 2019). The solution does not stick at the local optimum point in complex optimization