Chapter 19

Optimal Power Flow with renewable power generations using hyper-heuristic technique

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19.1 Introduction

Optimal Power Flow (OPF) problem in power system operation is one of the well-known problems that have attracted numerous researchers and power engineers to propose better solutions since decades ago. The complexity of the Optimal Power Flow (OPF) solution makes it a challenging task. The solution of the OPF problem poses a challenge due to its complex nature, as it involves large-scale, non-linear, and non-convex optimization problems with various constraints, making it difficult to solve using traditional mathematical modeling techniques. To tackle this challenge, the paper proposes the use of metaheuristic algorithms as an alternative solution, which have been proven to be more effective compared to traditional methods [1,2].

Numerous metaheuristic algorithms, including Barnacles Mating Optimizer [3], Teaching Learning Based Optimization (TLBO) [4], Moth-Flame Optimizer (MFO) [5], Symbiotic Organisms Search Algorithm (SOSA) [6], Salp Swarm Algorithm (SSA) [7], and many others, have been proposed to date for solving OPF problems, in particularly for loss minimization. The modified, enhanced, and/or hybrid version of the metaheuristic algorithm, such as the hybrid modified Imperialist Competitive Algorithm and Sequential Quadratic Programming, have also been developed to improve the searching behavior of certain algorithms in solving OPF (ICA-SQP) [8], the Long-Term Memory Harris' Hawk Optimization (LTM-HHO) [9], the hybrid Artificial Bee Colony with Differential Evolution (ABC-DE) [10], the Improved Chaotic Electromagnetic Field Optimization algorithm (ICEFO) [1], the Grey Wolf Optimizer based on Crisscross Search (CS-GWO) [9], the Differential Evolution (DE) with variants [11–13], CS-GWO algorithm [14], Efficient Parallel GA (EPGA) [15], and Modified Grasshopper Optimization Algorithm (MGOA) [16].

This study proposes a new strategy to solve OPF problems together with the presence of wind-solar-small hydro power generations by implementing the hyper heuristic technique. Three recent metaheuristic algorithms are employed as low-level meta-heuristics (LLH) to discover the optimal solution of OPF problems namely Grey Wolf Optimizer (GWO) [17], Barnacles Mating Optimizer (BMO) [18–20], and Whale Optimization Algorithm (WOA) [21]. A high-level hyper heuristics (HHH) strategy called Exponential Monte Carlo with counter (EMCQ) is utilized as a selector when optimizing the control variables in order to get the best solutions. Related works on the HH approach to solve other optimization problems can be seen such as in t-way test suit generation [22,23], sorted-waste capacitated location routing problem [24], and image reconstruction [25].

The aim of this paper is to introduce a hyper-heuristic approach to address the optimal power flow (OPF) problem. Section 19.2 of the paper delves into the formulation of the OPF problem and provides a comprehensive explanation of the details required to comprehend the issue. In Section 19.3, the low-level heuristics (LLH) that have been selected for this study are briefly described. The hyper heuristic strategy is introduced and explained in detail in Section 19.4. In Section 19.5, the proposed hyper heuristic method for solving the OPF problem is put into action. The results and evaluation of the method are detailed in Section 19.6, and the conclusion, including key takeaways and future possibilities, is given in Section 19.7.

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