Grey Wolf Optimizer for Solving Economic Dispatch Problems

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***Abstract*—This work proposes a new meta-heuristic called Grey Wolf Optimizer (GWO) which inspired by grey wolves (Canis lupus). The GWO algorithm mimics the leadership hierarchy and hunting mechanism of grey wolves in nature. Four types of grey wolves such as alpha, beta, delta, and omega are employed for simulating the leadership hierarchy. In addition, the three main steps of hunting, searching for prey, encircling prey, and attacking prey, are implemented. The algorithm is then benchmarked on 20 generating units in economic dispatch, and the results are verified by a comparative study with Biogeography-based optimization (BBO), Lambda Iteration method (LI), Hopfield model based approach (HM), Cuckoo Search (CS), Firefly, Artificial Bee Colony (ABC), Neural Networks training by Artificial Bee Colony (ABCNN), Quadratic Programming (QP) and General Algebraic Modeling System (GAMS). The results show that the GWO algorithm is able to provide very competitive results compared to these well-known meta-heuristics.**

Keywords— Economic Dispatch; Grey Wolf Optimizer; Loss minimization; Meta-heuristic technique;

I. INTRODUCTION

Optimization problems are widely encountered in various fields in science and technology. Sometimes such problems can be very complex because of the actual and practical nature of the objective function or the model constraint. ED (Economic dispatch) is one of the most important optimization problems in power system operation and planning by scheduling of generators to minimize the total operating cost and to meet load demand of the power system over some appropriate period while satisfying various equality and inequality constraint. The ED basically considers the load balance constraint beside the generating capacity limits. However, in practical ED, ramp rate limits as well as prohibited operating zones (POZ), valve point effects, and multi-fuel option must be taken into the account to provide the completeness for the ED problem formulation [1].

Over the past few years, a number of approaches have been developed for solving the ED using classical mathemathical programming methods [2-8]. However, conventional method failed to solve the problem because they are highly sensitive to starting points and frequently converge to local optimum solution or diverge altogether. Besides, conventional method usually have simple mathematical model and high search speed. But, it will use approximation to search for the algorithms that have the required characteristics. This may cause to suboptimal operation and huge revenue loss over time[9].

Hence, to solve the ED problem by using meta-heuristic optimization techniques have become very popular over the last two decades especially Genetic Algorithm (GA), Ant Colony Optimization (ACO) and Particle Swarm Optimization (PSO) which have been applied in various fields of study. There are four reasons meta-heuristic have become remarkably common. There are simplicity, flexibility, derivation-free mechanism, and local optima avoidance [10]. First, they have been inspired by simple concepts with respect to physical phenomena, animals' behaviors, or evolutionary concepts. Second, flexibility refers to the applicability of meta-heuristics to different problems without any special changes in the structure of the algorithm. Third, the majority of meta-heuristics have derivation-free mechanisms. In contrast to gradient-based optimization approaches, meta-heuristics optimize problems stochastically. Finally, meta-heuristics have superior abilities to avoid local optima compared to conventional optimization techniques. This is due to the stochastic nature of meta-heuristics which allow them to avoid stagnation in local solutions and search the entire search space extensively. Thus, the new meta-heuristic, GWO proposed by S. Mirjalili [10] is implemented in solving ED problems.

II. ECONOMIC DISPATCH PROBLEMS

The Objective of Economic Dispatch is to minimize the fuel cost while satisfying several equality and inequality constraints. Hence, the problem is formulated as below.

A. Economic Load Dispatch Formulation

The primary concern of ED problem is to minimize of its objective function. The objective function is formulated as below, where F_t is total fuel cost, N is number of generating unit and F_i (P_{Gi}) is operating fuel cost of generating unit i.

$$\min(F_T) = \min \sum_{i=1}^{N} F_i(P_{Gi}) \qquad (1)$$

B. Minimization of Fuel Cost

The generator cost curve is represented by quadratic functions and the total fuel cost $F(P_G)$ in (RM/h) can be expressed as: