CHAPTER 1

INTRODUCTION

1.1 Background

Economic Dispatch (ED) in power system has the objective of generation allocation of the power generators, in such a manner that the cost of generation is minimized while all operating constraints are satisfied. As electric energy cannot be stored, the power generation should be met the variations of loads. It is required to commit enough number of generating units to meet the load demand in real time. In short, the load demands are to be met while operating the power system in the most economic manner. Therefore, ED problem is considered to be one of the fundamental problems in electric power system operation.

Previously, conventional optimization methods assume generator cost curves to be continuous and monotonically increasing, but modern generators have a variety of nonlinearities in their cost curves, making this assumption inaccurate, and resulting approximate dispatches a lot of revenue loss. Thus, ED which combines a highly nonlinear and constrained problem is really needed for optimal in order to return a profit on the capital invested.

Optimization played a vital role in engineering and sciences field. This nonlinear constrained optimization problem has been resolved by various types of optimization techniques. Most conventional or classic algorithms are deterministic. For example, the simple method in linear programming is deterministic (Xin-she Yang, 2010). Many of them are gradient-based which depend on gradient information such as well-known Newton-Raphson algorithm. Since it uses the function values and their derivatives thus
it works extremely well for smooth unimodal problems. Nevertheless, if there is some discontinuity in the objective function, it does not go well.

For stochastic algorithms, in general, there are two types of stochastic algorithm: heuristic and metaheuristic though their difference is minor. Generally, heuristic optimization gives quality solutions to a tough optimization problem and can be found in a reasonable amount of time, but there is no guarantee that optimal results are achieved (Xin-she Yang, 2010). Further development over the heuristic algorithms is the so-called meta-heuristic algorithms. Here, the meta- means ‘beyond’ or ‘higher level’, and they generally perform better than simple heuristics (Xin-she Yang, 2010). Recently, researchers tend to name the entire stochastic algorithm with local search and randomization as metaheuristic. Grey Wolf Optimizer (GWO) is one of the most developed and important paradigm of the meta-heuristic computation (Mirjalili and Lewis, 2014a). This thesis investigates the application of the GWO independently for the solution of the economic dispatch problem. GWO was expected to give the optimal result for ED in this research compared to recent literature reviews.

1.2 Problem Statement

Traditionally, in the ED computation, the cost function for each generator is represented by a quadratic function which is convex in nature, as well as increasing monotonically with linear constraints. Linear constraints can be listed down as follows (M. Vanitha, 2012):

i. Generation capacity constraints

ii. Power balance constraint

The actual characteristics of generators are drawn by considering the inequality constraints and ramp rate limit. Ramp rate or power response rate is described as the power response capability of the unit in terms of accommodating power changes in specified time interval. The operating range of all on-line units is restricted by their ramp rate limits. These characteristics exhibit higher order non-linearity and discontinuities.
Nowadays, a non-convexity appears in the characteristic curves. The major non-convex economic dispatch problems can be listed as follows (Malik, 2009):

i. Economic dispatch with piecewise quadratic cost function (EDPQ)
   - Piecewise quadratic cost function due to the valve point effect
   - Piecewise quadratic cost function due to the multiple fuel mix

ii. Economic dispatch with Prohibited Operating Zones (POZ).

One way to solve the ED problems with quadratic cost functions is by gradient-based optimization methods. For example, Newton-type methods which are only suitable for the fuel-cost curve with linear and monotonically increasing functions. However, ED problems with multiple-unit and piecewise quadratic cost functions will occur many local extreme points and resulting in huge revenue losses over the time.

As a result, conventional optimization techniques are no longer the finest choice since they may fail to locate the optimal solution and result in considerable errors. Thus, the non-convex nature of the ED problem requires accurate, robust and fast solution optimization techniques to avoid getting stuck in local optima. In this respect, stochastic search algorithms like Genetic Algorithm (GA), Evolutionary Search (ES), Particle Swarm Optimization (PSO) and etc. may prove to be very efficient in solving highly non-linear ED problem without any restrictions on the shape of cost curves.

Although these metaheuristic methods do not always guarantee the global optimal solution, they generally provide a reasonable solution (sub-optimal or near global optimal). These bring the motivation to solve highly non-linear ED problems by applying the stochastic search algorithms, GWO.

1.3 Objectives

The primary objective of this research is to incorporate the alternative metaheuristic technique, namely Grey Wolf Optimizer (GWO) in solving the practical