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Exchange market algorithm for multi-objective economic emission dispatch and reliability

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Abstract

This paper proposes exchange market algorithm (EMA) to solve economic emission dispatch and reliability (EEDR) problem in thermal power plants. The aim of EMA, inspired by the method of selling and purchasing of shares by elite stockholders, is to solve the optimization problems. The EMA is a new, robust and efficient algorithm to exploit the global optimum point in optimization problems. Existence of two seeking operators in EMA provides a high ability in exploiting global optimum point. In economic emission dispatch and reliability, it is tried to utilize generating units in a way that we have high reliability in supplying the system load demand as well as the minimum fuel costs. In this paper, the EMA is successfully implemented on two systems with 6 and 26 generating units considering economic and emission dispatch and system reliability. The obtained results are compared with other advanced techniques. The results well demonstrate the practical advantage of the exchange market algorithm over the other approaches.

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Keywords: Economic dispatch; reliability; exchange market algorithm; emission; robust.

1. Introduction

Exchange market algorithm is inspired by stock market in which the shareholders try to buy and sell variety of shares under different market conditions. Here, it is assumed that the shareholders compete to mark themselves as the most successful members of the market in the ranking list. In this market, members with low ranks tend to

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accomplish logical risks to gain more profit and it is generally assumed that the shareholders are intelligent and perform as the same as the elite members of the real stock market. In EMA, each member is an answer of the problem. There exists certain number of shares (variables of optimization problem) each member intelligently buys a number of them (variables initialization) and conducts his intelligent proceedings at the end of each period calculating the validity of total share amounts to gain the maximum possible profit in market (Ghorbani & Babaei, 2014; 2016).

EMA has two search operators (members of group 2 and group 3 in oscillation mode) results in simultaneously exploration in two limited and wide search domains. Searching in limited domain leads to exploration of points adjacent to the optimum point and searching in wide domain results in exploiting unknown points as well as two absorbent operators for individuals to be absorbed to the elite person (members of group 2 and group 3 in non-oscillation mode), which leads to create and organize the random numbers in the most appropriate manner. They enable the EMA to overcome the limitations of other algorithms such as trapping in local points and consequently premature convergence (exploration problem), non-sufficient ability in finding out the adjacent points of the optimum point (exploitation problem), and convergence to non-similar points in every program implementation (Ghorbani, 2016).

In order to optimize the multi-object function of problem which aims to decrease the fuel cost and greenhouse gases (GHGs) emission costs with system reliability increase, the EMA algorithm is applied.

The economic dispatch (ED) in thermal plants aims to minimize the plants fuel costs. This is accomplished in a system by determining the output power of the plants in a way that the total network power is supplied with the minimum cost amount and constraints satisfaction. For simplicity, the cost function of each power plant is specified by a quadratic function (Barisal, 2013).

Reliability is always one of the major aims in power systems and is one of the most important factors in power systems planning, design, maintenance, and operation (Ghorbani &Babaei, 2015). The reliability of a system is generally represented by its indices. Recent outages in power systems depict that the reliability indices should be more under attention in supplying consumers with uninterrupted power. The reliability parameters such as, loss of load probability (LOLP), expected energy not supplied (EENS) and forced outage rate (FOR) are defined and explained in (Billinton, &Allan, 1996; Qin, 2011).

In order to examine EMA's capability and extracting optimum point of convex and non-convex EEDR problem, the EMA is implemented on two systems with 6 and 26 units, aiming to decrease the system fuel cost, emission cost, and to increase the system reliability.

2. Formulation of the problem

2.1. Objective function in EEDR problem

In solving the EEDR, it is aimed to decrease the plants fuel and emission cost, and at the same time to increase the system reliability by applying system reliability in solution process. Therefore, the objective function of the problem is consists of three independent functions. The variables of the problem are the generated powers of plants defined as follows (Ghorbani &Babaei, 2015):

$$[P_G] = [P_1, P_2, ... P_n]^T$$

minimizing:

$$F = [F_{FC}, F_{GHG}, EENS] \tag{1}$$

where P_n is the real power generated by the n^{th} generator. F is the multivariable objective function that should be minimized. The parameter F_{FC} is the fuel cost of the units and F_{GHG} shows the greenhouse gases emission costs. In continuous the functions are separately investigated before combining them in the objective function.

2.2. Economic dispatch formulation

Aim of ED problem is minimizing the cost function of the system considering the system constraints. The more details have been presented in (Ghorbani & Babaei, 2014; 2016).