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Cost Effective Integrated Maintenance Scheduling in Power Systems using Ant Lion Optimizer

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Abstract

Integrated system preventive maintenance is an exigent job in both regulated as well as deregulated utility systems that must be carried over by the utilities in order to extend their continuation and performance. The generator maintenance scheduling is commonly focused, but the line flow limits in the transmission lines, which are connected to the generating units may violate due to the outages. Thus, maintenance planning of generators and transmission lines has become indispensable and the Integrated Maintenance Scheduling (IMS) addresses alike. Inclusion of transmission lines and line flow constraints in generating unit maintenance will increase intricacy of the problem that enforces IMS for secure and economic operations. As an efficient optimization tool is necessary, the modern bio inspired algorithm, Ant Lion Optimizer (ALO) has been intended for the first time to address the IMS problem. The well-known / standard test systems are used for demonstration and the attained numerical results by simulation are compared with other meta-heuristic methods. The comparison reveals that the ALO is a positive choice for solving IMS problems.

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Keywords: Integrated maintenance scheduling; Ant lion optimizer; Security constrainted unit commitment

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1. Introduction

Nomenclature

d	duration of maintenance
e, l	earliest and latest period of equipment maintenance window
G, TL	generating units and transmission lines
i, j	generating units and transmission lines indices
I	set of indices of generator for maintenance scheduling
$IC(t)$	installed generation in the system at period t
$M_i(t)$	maintenance cost of unit i at period t
$M'_j(t)$	maintenance cost of transmission line j at period t
NG, NL	total number of generating units and transmission lines
NT	number of intervals under study
$P_i(t)$	generation capacity of unit i at period t
$P'_i(t)$	output power from unit i at period t
Pop	number of search agents
RTS	Reliability test system
T	set of indices of period in the planning horizon
T_i	set of indices of feasible maintenance starting period for unit i, $T_i = \{ t \in T: e_i \leq t \leq l_i - d_i +1\}$
$U_i(t)$	decision variable for generator maintenance at period t ($t \in T_i$)
$U_i(t)$=1	when unit i starts its maintenance at period t, otherwise $U_i(t) = 0$
$V_j(t)$	decision variable of transmission line maintenance at period t ($t \in T_j$)
$V_j(t)$=1	when transmission line j begins its maintenance at period t, otherwise $V_j(t) = 0$
$X_i(t)$ =1	when unit i is on its maintenance at period t, otherwise $X_i(t) = 0$
$X_i(t)$	state variable for generating unit maintenance at period t ($t \in T$)
$Y_j(t)$	state variable of transmission line maintenance at period t ($t \in T$)
$Y_j(t)$ =1	when transmission line j is in maintenance at period t, otherwise $Y_j(t) = 0$

1.1. Economic centered integrated maintenance scheduling

Preventive maintenance scheduling is the essential activity that is to be carried over a planning horizon on electric power components to increase their life time and reduce the probability of their failure. Generators and the transmission lines are vital components in power system, hence routine maintenance of generators and transmission lines must aim to reduce the failure rate for maintaining smooth operations of the power utility. Thus Integrated Maintenance Scheduling (IMS) problem is very important in a power system under economic considerations.

The solution methods available for solving Generator Maintenance Scheduling (GMS) problems can be grouped as analytical and meta-heuristic methods. The analytical methods include branch and bound [1], dynamic programming [2], integer programming [3] and Benders' decomposition [4]. The meta-heuristic search algorithms conquer the confines in the mathematical based optimization methods. The well known meta-heuristic approaches such as Simulated Annealing (SA), Genetic Algorithm (GA), Particle Swarm Optimization (PSO) and their modified versions have been addressed for solving the GMS problems [5-13]. A hybrid evolutionary approach has been reported for the feasible GMS solution [14]. Ekpenyong *et al.*, have applied PSO to determine the outage schedules using the robust GMS model [15]. The modified versions of SA and GA have also been addressed to GMS problems [16-18]. However, few reports in the literature deals with the IMS problem [19-25].

1.2. Research gap and motivation

In order to overcome the drawbacks of meta-heuristic techniques, it is of great significance to enhance the existing solution techniques or adopting new techniques to solve IMS problems. This motivates to contribute in this

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