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A genetic algorithm solution to the optimal short-term hydrothermal scheduling

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ABSTRACT

This paper presents an algorithm for solving the hydrothermal scheduling through the application of genetic algorithm (GA). The hydro subproblem is solved using GA and the thermal subproblem is solved using lambda iteration technique. Hydro and thermal subproblems are solved alternatively. GA based optimal power flow (OPF) including line losses and line flow constraints are applied for the best hydro-thermal schedule obtained from GA. A 9-bus system with four thermal plants and three hydro plants and a 66-bus system with 12 thermal plants and 11 hydro plants are taken for investigation. This proposed GA reduces the complexity, computation time and also gives near global optimum solution.

1. Introduction

Short-term hydrothermal scheduling of power systems aims at determining optimal hydro and thermal generations in order to meet the load demands over a scheduled horizon of one day or a week while satisfying the various constraints on the hydraulic and power system network. The goal is to minimize total operation costs of thermal plants. The problem is a complex mathematical optimization problem with a highly nonlinear and computational expensive environment.

Several methods have been developed to solve this problem, including dynamic programming (DP) [1–3], network flow programming (NFP) [4,5], Non-Linear Programming (NLP) technique in combination with NFP [6], Decomposition Approach (DA) and Linear Programming (LP) [7–9] method etc.

DP is a powerful mathematical tool, and it can handle the constraints directly [1–3]. However, DP needs to discrete reservoir levels as the determining state. When the system has more than one reservoir or has cascaded stations, the state space expands exponentially with problem size, DP is suffered from the "curse of dimensionality".

Network flow programming (NFP) is the most widely used method for hydropower scheduling since, comparing to other approaches, it is more effective in dealing with the water traveling time between stations in a river, especially when the river is branched. However, the computational efforts will drastically increase when there exist some convex branches in the flow network [4].

A realistic model of seasonal production planning in the Swedish State Power Board (SSPB) was developed using NEP [5]. This paper presented the latest developments in the area of network flow modeling for operations planning at the SSPB. Extensions and modifications to network flow theory were developed to incorporate the nonlinear constraints and functions of the type existing in the seasonal planning problem and state dependent constraints.

A seasonal and weekly planning process was developed using NLP techniques in combinations with NFP at SSPB [6]. This paper presents an effective modeling and formulation for optimal seasonal and weekly planning. The solution methodologies were integrated in a production optimizer of an information system for optimal operations planning of hydro and thermal energy resources.

Optimal short-term hydrothermal scheduling using decomposition approach (DA) and linear programming (LP) method presented an effective algorithm, which decomposes the problem into hydro and thermal subproblems and solves them alternatively [7–9]. Hydro subproblem is solved using a search procedure, the local variation method, the thermal subproblem is solved using the participation factors and LP method.

Heuristic search algorithms like tabu search (TS) [10], evolutionary strategy (ES) [11], ant colony systems (ACS) [12] and genetic algorithm (GA) [13–16] have been reported to have performed very efficiently in solving highly nonlinear hydrothermal scheduling problems since they do not place any restriction on the shape of the cost curves and other nonlinearity in model representation.

A diploid genetic approach is proposed to solve the short-term scheduling of hydrothermal system [14]. In this paper, a pair of binary strings of the same length is used to represent the solution to the problem. The diploid genotype structure along with the dominance mechanism showed a stronger ability to maintain the gene diversity in a limited population. Though the proposed method has the ability to determine the global optimum solution, the line flow constraints were not considered in this formulation.

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