Comparison of particle swarm optimization and dynamic programming for large scale hydro unit load dispatch

Chun-tian Cheng\textsuperscript{a,}\textsuperscript{*}, Sheng-li Liao\textsuperscript{a}, Zi-Tian Tang\textsuperscript{a}, Ming-yan Zhao\textsuperscript{b}

\textsuperscript{a}Department of Civil and Hydraulic Engineering, Dalian University of Technology, 116024 Dalian, People's Republic of China
\textsuperscript{b}Department of Environmental Science and Engineering, Tsinghua University, 100084 Beijing, People's Republic of China

\section*{Abstract}
Dynamic programming (DP) is one of classic and sophisticated optimization methods that have successfully been applied to solve the problem of hydro unit load dispatch (HULD). However, DP will be faced with the curse of dimensionality with the increase of unit number and installed generating capacity of hydropower station. With the appearance of the huge hydropower station similar to the Three George with 26 generators of 700 MW, it is hard to apply the DP to large scale HULD problem. It is crucial to seek for other optimization techniques in order to improve the operation quality and efficiency. Different with the most of literature about power generation scheduling that focused on the comparisons of novel PSO algorithms with other techniques, the paper will pay emphasis on comparison study of PSO with DP based on a case hydropower station. The objective of study is to seek for an effective and feasible method for the large scale of hydropower station of the current and future in China. This paper first compares the performance of PSO and DP using a sample load curve of the Wujiangdu hydropower plant located in the upper stream of the Yangtze River in China and contained five units with the installed capacity of 1250 MW. Next, the effect of different load interval and unit number on the optimal results and efficiency of two methods has also been implemented. The comparison results show that the PSO is feasible for HULD. Furthermore, we simulated the effect of the magnitude of unit number and load capacity on the optimal results and time cost. The simulation comparisons show that PSO has a great advantage over DP in the efficiency and will be one of effective methods for HULD problem of huge hydropower stations.

Crown Copyright © 2009 Published by Elsevier Ltd. All rights reserved.

1. Introduction
China is endowed with large hydro potential. China's hydropower and hydropower system, the hydro unit load dispatch (HULD) problem is one of hydropower scheduling problems. Essentially, the principal objective of HULD is to schedule the turbine-generating units in order to meet the given load demand at the maximum hydropower operating efficiency while satisfying water demands, operational restrictions, reliability constraints, and security requirements. Over many years, plenty of works and researches by means of various mathematical programming and optimization techniques, considering different kinds of constraints or multiple objectives, have been used to solve this problem featuring by non-linear, non-convex, and large-scaled characteristics. The relative methods included branch and bound algorithm [7], mixed integer linear programming (MILP) [22], decomposition...
approach [3], and Lagrangian relaxation [6,11,23]. Especially, as a classic and sophisticated optimization method, dynamic programming (DP) [1,9,14,25,26] has been applied widely and was found to be an effective technique for the hydroelectric generating stations with the small numbers of hydropower units and the low installed capacity. However, these methods based on mathematical computation become helpless and cannot be implemented for scheduling power systems with large numbers of hydropower units and huge installed capacity in real time because of requiring extensive computational resources and much cost time. DP will be faced with the curse of dimensionality for the optimal operation of hydropower units when the scale is huge, such as the number of units is more than 10 or the installed capacity is over 10,000 MW, and this problem has restricted its application to large-scale systems. Therefore, it is crucial to seek for other optimization techniques in order to improve the operation quality and efficiency.

In recent years, particle swarm optimization (PSO) algorithm [15], a population based and self-adaptive search optimization technique, has aroused intense interest due to its flexibility, versatility and robustness in seeking the global optimal solution. It has been increasingly applied to hydropower system such as parameters estimation for hydrological forecasting [5,12], hydrological models [10], water resources management [2], water supply planning [13,24] and multi-reservoir operation [16]. PSO has also been utilized to solve the power generation scheduling problems [4,8,17–21]. However, these methods based on mathematical computing (DP) has been applied widely and was found to be a classic and sophisticated optimization method, dynamic programming [3], and Lagrangian relaxation [6,11,23]. Especially, as a population based and self-adaptive search optimization technique, PSO has been utilized to solve the power generation scheduling problems [4,8,17–21]. However, these methods based on mathematical computing (DP) has been applied widely and was found to be a classic and sophisticated optimization method, dynamic programming [3], and Lagrangian relaxation [6,11,23]. Especially, as a population based and self-adaptive search optimization technique, PSO has also been utilized to solve the power generation scheduling problems [4,8,17–21]. However, these methods based on mathematical computing (DP) has been applied widely and was found to be a classic and sophisticated optimization method, dynamic programming [3], and Lagrangian relaxation [6,11,23].

In PSO, each individual searches space by adjusting its flying trajectory towards its own personal best position and the best location of its neighbor at each time step. Suppose that the search efficiency and optimization results between PSO and DP. The results show that PSO has a great advantage over DP in the efficiency and will be one of effective methods to solve the problem of optimal operation for the huge hydropower units.

This paper is structured as follows. In Section 2, we present the mathematical formulations for scheduling of hydro units with emission constraints, modeled as a dynamic, mixed-integer nonlinear constrained optimization problem. In Section 3, the flow chart and calculation steps of PSO to solve HULD problem are shown. In Section 4, we present the case study of Wujiangdu hydropower plant with 1250 MW of installed capacity and five units, is used to compare the performance of optimal operation from calculating time, calculation efficiency and optimization results between PSO and DP. The results show that PSO has a great advantage over DP in the efficiency and will be one of effective methods to solve the problem of optimal operation for the huge hydropower units.

This paper is structured as follows. In Section 2, we present the mathematical formulations for scheduling of hydro units with emission constraints, modeled as a dynamic, mixed-integer nonlinear constrained optimization problem. In Section 3, the flow chart and calculation steps of PSO to solve HULD problem are shown. In Section 4, we present the case study of Wujiangdu hydropower plant with 1250 MW of installed capacity and five units, is used to compare the performance of optimal operation from calculating time, calculation efficiency and optimization results between PSO and DP. The results show that PSO has a great advantage over DP in the efficiency and will be one of effective methods to solve the problem of optimal operation for the huge hydropower units.

This paper is structured as follows. In Section 2, we present the mathematical formulations for scheduling of hydro units with emission constraints, modeled as a dynamic, mixed-integer nonlinear constrained optimization problem. In Section 3, the flow chart and calculation steps of PSO to solve HULD problem are shown. In Section 4, we present the case study of Wujiangdu hydropower plant with 1250 MW of installed capacity and five units, is used to compare the performance of optimal operation from calculating time, calculation efficiency and optimization results between PSO and DP. The results show that PSO has a great advantage over DP in the efficiency and will be one of effective methods to solve the problem of optimal operation for the huge hydropower units.
دریافت فوری متن کامل مقاله

امکان دانلود نسخه تمام متن مقالات انگلیسی
امکان دانلود نسخه ترجمه شده مقالات
پذیرش سفارش ترجمه تخصصی
امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
امکان دانلود رایگان ۲ صفحه اول هر مقاله
امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
دانلود فوری مقاله پس از پرداخت آنلاین
پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات