Electric Power Systems Research 80 (2010) 975–986

Contents lists available at ScienceDirect

Electric Power Systems Research

journal homepage: www.elsevier.com/locate/epsr

Review

Optimal dynamic economic dispatch of generation: A review

X. Xia*, A.M. Elaiw[1]

Centre of New Energy Systems, Department of Electrical, Electronic and Computer Engineering, University of Pretoria, Pretoria 0002, South Africa

ARTICLE INFO

Article history:
Received 5 June 2009
Accepted 30 December 2009
Available online 4 February 2010

Keywords:
Dynamic economic dispatching
Power generation

ABSTRACT

This paper presents a review of the research of the optimal power dynamic dispatch problem. The dynamic dispatch problem differs from the static economic dispatch problem by incorporating generator ramp rate constraints. There are two different formulations of this problem in the literature. The first formulation is the optimal control dynamic dispatch (OCDD) where the power system generation has been modeled as a control system and optimization is done in the optimal control setting with respect to the ramp rates as input variables. The second one is a later formulation known as the dynamic economic dispatch (DED) where optimization is done with respect to the dispatchable powers of the committed generation units. In this paper we first outline the two formulations, then present an overview on the mathematical optimization methods, Artificial Intelligence (AI) techniques and hybrid methods used to solve the problem incorporating extended and complex objective functions or constraints. The DED problem in deregulated electricity markets is also reported.

1. Introduction

The problem of allocating the customers' load demands among the available thermal power generating units in an economic, secure and reliable way has received considerable attention since 1920 or even earlier (see the reviews in [1,2]). The problem has been formulated as a minimization problem of the fuel cost under load demand constraint and various other constraints at a certain time of interest. It has been frequently known as the static economic dispatch (SED) problem. SED can handle only a single load level at a particular time instant. However, SED may fail to deal with the large variations of the load demand due to the ramp rate limits of the generators, moreover, it does not have the look-ahead capability [3,4]. Owing to the large variation of the customers load demand and the dynamic nature of the power systems, it necessitated the investigation of optimal dynamic dispatch (ODD) problem. ODD is an extension of SED to determine the generation schedule of the committed units so as to meet the predicted load demand over a time horizon at minimum operating cost under ramp rate and other constraints. ODD has a look-ahead capability which is necessary to schedule the load beforehand so that the system can anticipate sudden changes in demand in the near future. The ramp rate constraint is a dynamic constraint which is important to maintain the life of the generators [5]. Some coupling constraints, especially ramp rate constraints, make the solution of the ODD problem more difficult than that of SED.

The first paper in the area of dynamic dispatching by Bechert and Kwatny [6] appeared in 1972 and was followed by [7–10]. In these papers the ODD problem was formulated as an optimal control problem. The optimal control dynamic dispatch (OCDD) formulation models the power system generation by means of state equations where the state variables are the electrical power outputs of the generators and the control inputs are the ramp rates of the generators. In OCDD the optimization is done with respect to the ramp rates and the solution produces an optimal output generator trajectory for a given initial generation.

Since the 1980s the ODD problem has been formulated as a minimization problem of the total cost over the dispatch period under some constraints and has been known as the dynamic economic dispatch (DED) problem [3–5,11–65]. The DED problem is normally solved by discretization of the entire dispatch period into a number of small time intervals, over which the load demand is assumed to be constant and the system is considered to be in a temporal steady state. Over each time interval a SED problem is solved under static constraints and the ramp rate constraints are enforced between the consecutive intervals [12]. In the DED problem the optimization is done with respect to the dispatchable powers of the units. Some researchers have considered the ramp rate constraints by solving SED problem interval by interval and enforcing the ramp rate constraints from one interval to the next. However, this approach can lead to suboptimal solutions [13]; moreover, it does not have the look-ahead capability.

In the ODD literature the OCDD and DED formulations have been regarded as the similar. Recently it has been shown in [66]

* Corresponding author. Tel.: +27 12 420 2165; fax: +27 12 362 5000.
E-mail addresses: xxia@postino.up.ac.za (X. Xia), a_m_elaiw@yahoo.com (A.M. Elaiw).
[1] Tel.: +27 12 420 2165; fax: +27 12 362 5000.

0378-7796/$ – see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.epsr.2009.12.012