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DBSSP—A computer program for simulation of controlled circulation boiler and natural circulation boiler start up behavior

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Abstract

In this paper, a computer program, Drum Boiler Start-up Simulation Program (DBSSP), is developed for simulating the start up behavior of controlled circulation and natural circulation boilers. The mathematical model developed here is based on the first principles of mass, energy and momentum conservations. In the boiler model, heat transfer in the waterwall, the superheater, the reheater and the economizer is simulated by the distributing parameter method, while heat transfer in the drum and the downcomer is simulated by lumped parameter analysis. The program can provide detailed flow and thermodynamic characteristics of the boiler components. The development of this program is based only on design data, so it can be used for any subcritical, controlled or natural circulation boiler. The simulation results were compared with experimental measurements, and good agreements between them were found. This program is expected to be useful for predicting the characteristics and the performance of controlled circulation and natural circulation boilers during the start up process. It also can be used to optimize a start up system for minimum start up time.

Keywords: Boiler; Controlled circulation; Natural circulation; Modeling and simulation

1. Introduction

With the economic development in China, the demand for electricity has increased rapidly in recent years. The disparity between on-peak loads and off-peak loads of the electric utility grids is

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Nomenclature

AT	attemperator
BP	bypass valve
CP	circulation pump
CV	control valve
EC	economizer
GE	generator
HP	high pressure turbine
HRH	high temperature reheater
HSH	high temperature superheater
IP	intermediate pressure turbine
ICV	intercept valve
LP	low pressure turbine
LSH	low temperature superheater
MRH	intermediate temperature reheater
MSH	intermediate temperature superheater
PSH	divided panels surperheater
WRH	wall reheater

increasing by about 30–40%. Operating utilities are under greater financial and operational constraints in generation of electricity. To solve these constraints, both new and existing plants are expected to operate under more flexible and exacting regimes. Since the peak load regulating capacity of hydroelectric power plants is very limited and nuclear power plants are only suitable for base load operation, the existing fossil fired plants have to operate under two shift cycles and are subject to rapid start up processes. Presently, in China, the bulk of the load swings is expected to be provided by 300 and 600 MW fossil fired power plants.

In order to use the 300 and 600 MW power plants for peak load regulating, the following characteristics have to be considered to meet the requirements of large load swings in power demand:

- Minimizing the time required for cold, warm and hot start ups without shortening the lifetime of the boiler and turbine. For hot start up, the boiler has been out of operation less than 8 h, and the start up time should be from 1 to 2 h. For warm start up, the boiler has been out of operation between 8 and 36 h, and the start up time should be from 2 to 3 h. For cold start up, the boiler has been out of operation over 36 h and the start up time should be from 2 to 5 h.
- Providing stable operations during sharp load decreases/increases and severe load fluctuations.
- Handling load variations quickly at a minimum rate of about 5% of the normal rating per minute.
- Maintaining high boiler efficiency not only at the base load but also at the fractional load.