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A Model of Dynamic Characteristics of Water-cooled Wall in (Ultra) Supercritical Once-through Boiler Based on Moving Boundary Method

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Extended Abstract

The sustained and rapid economic development puts higher requirements on the national power supply, thus the development of technologies related to supercritical and ultra-supercritical thermal power units should be accelerated[1]. A study on dynamic characteristics is required for the start-up and regulation of the boiler itself. At present, the increasing proportion of renewable sources such as wind and solar, as well as the intermittent operation of renewable sources, make the regulation and start-stop of thermal power more frequent, requiring flexible regulation and understanding and mastering dynamic characteristics. To prejudge the boiler's operation and control performances, and to predict whether its thermal parameters exceed the specified limits and the operating economy meets the predetermined targets in these states, the process of the boiler's variable conditions needs to be investigated. In the case of (ultra) supercritical boilers, owing to the small inner diameter of the water-cooled wall tubes, low water capacity, and its corresponding heat storage capacity, the wall temperature of the evaporation heating surface may change violently when the load changes or thermal disturbances occur in the furnace, resulting in the tube rupture of the water-cooled wall.

Most existing supercritical once-through boiler water-cooled wall dynamic characteristic models can not realize the full working condition simulation. And due to the use of a special static approximation method for the model switching, there is still a certain degree of error and other problems compared with the actual switching process. In this paper, the basic model of the water-cooled wall of a supercritical once-through boiler is firstly established based on the basic physical law; then the moving boundary theory is introduced into the basic model, and the moving boundary model with clear physical meaning and unified description of the water-cooled wall of supercritical boiler with various work quality states is obtained. Based on the pressure correction method, the solution scheme of the model established in this paper and its computational steps are presented. The Thomas algorithm[2] based on the Gaussian elimination method is chosen to solve the discrete equations in a three-point scheme. The required boundary conditions and the computational models of the friction and heat transfer source terms are introduced. The corresponding program flow framework is designed, and the simulation program for the dynamic characteristics of the water wall of the (ultra) supercritical once-through boiler is compiled accordingly. Based on the experimental data in the literature[3], the dynamic characteristics of the water-cooled wall of a supercritical once-through boiler are calculated using this program. The calculation results are compared with the experimental data, and the results show that the values obtained from the model calculation are in good conformity with the experimental values. Therefore, it can be assumed that the model established in this paper is correct and reliable. Then the moving boundary model established in this paper can describe the water-cooled wall of a supercritical boiler in a unified way, which simplifies the calculations to a certain extent because it is not necessary to model and solve the problems separately for various states. Moreover, the grid moving scheme proposed in this paper can realize the tracking of the phase change point and the critical pressure point, which reduces the error compared with the actual switching process to a certain extent compared with the static approximation calculation method. And it can solve the mutual switching problem between various work states more easily and reasonably, and then realize the full working condition simulation.

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