Study of Supercritical Coal Fired Power Plant Dynamic Responses for Grid Code Compliance

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Abstract

Coal is still a dominant energy source for power generation in the world and will not be replaced by clean energy sources soon [1]. In cleaner coal technologies, improving energy conversion efficiency has been one of the most important technology development directions in addition to carbon capture and storage. Compared to the traditional subcritical power plants, pressure-increased supercritical power plants will improve the plant energy efficiency from 35% to 45-50%. This work presents a study of the thermodynamic behavior of the water cycle in coal-fired boilers in response to the changes in electrical energy demands.

To date it is not known whether the supercritical power plant dynamic responses can satisfy the GB Grid Code requirement [2], therefore simulation-based research using COMSOL Multiphysics® will be focused specifically on the forced convection of pseudo-critical water inside a heated pipe (figure 1). The heat transfer coefficient will be evaluated in response to sudden changes in water conditions such as pressure, heat flux or mass flux, and thermal efficiencies. These results will be then verified by designing and constructing an experimental apparatus based on initial calculations. The apparatus consists of a test element wherein water will be pumped and heated through the critical point, in order to recreate the conditions experienced in supercritical water cycle. Subsequently, energy calculations based on real data will be conducted. In addition, a novel approach to energy storage as an alternative to the drum in conventional power plants will be investigated in an attempt to adhere to the constraints of the GB Code.

As a result, the best working conditions from a thermodynamic point of view will be identified, and more accurate control models and efficient boiler designs will be possibly produced.

Reference

[1]. J. T. McMullan et al. Energy Policy, Vol. 29, 2001, p. 441.
[2] R.J. Nicholls, C. Maxim. E.ON UK. 2008.

Figures used in the abstract

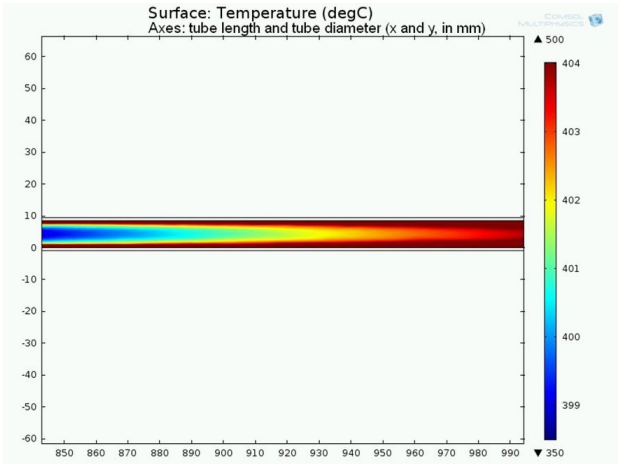

Figure 1: Temperature profile of a supercritical water flow at 300 bar and a mass flux of 100 kg/m^2s.