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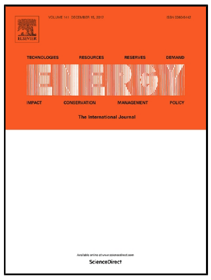

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Novel online simulation-ready models of conjugate heat transfer in combustion chamber waterwall tubes of supercritical power boilers

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ABSTRACT

This paper presents two models of fluid heating in waterwall tubes of supercritical steam boilers. The models are named 1D/2D and 1D/3D. The models are formulated and discussed in detail with an industrial application example. For the 1D/2D model, a two-dimensional (2D) transient heat conduction equation is solved for the tube wall with the fin domain, while one-dimensional (1D) mass, momentum, and energy equations are solved for the fluid domain. The 1D/3D model considers a three-dimensional tube wall domain (3D) and one-dimensional fluid domain. At the fluid-solid interface, a conjugate heat transfer model is applied. The model is based on convective flux between the fluid and solid domains. Nonlinear governing balance equations of mass, momentum, and energy for fluid are solved using the forward time backward space (FTBS) scheme. The proposed models allow incorporation of the effect of heat flux nonuniformities along the waterwall tube and on its outer circumference. Transient simulations are carried out to determine the temperature histories for both the fluid and the tube wall in the selected cross sections. The computations are performed using the finite volume method formulation. The results obtained from the 1D/2D model are nearly the same as those from the 1D/3D model; however, the computation time is more than five times shorter. Therefore, an efficient 1D/2D model can be used in power unit simulators.

Nomenclature

A	cross-sectional area, m^2
c	specific heat, J/(kg·K)
d	diameter, m
g	gravity acceleration, m/s^2
h	heat transfer coefficient, W/(m^2·K)
i	enthalpy, kJ/kg
k	thermal conductivity, W/(m·K)
L	length of the waterwall tube, m
$\dot{m}$	mass flow, kg/s
M	number of cross sections
p	pressure, bar, MPa
q	heat flux, W/m^2
r	radius, m