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LETTERS TO THE EDITORS

ON THE PAPER "AN ANALYSIS OF THE CONDUCTIVE AND RADIATIVE HEAT TRANSFER TO THE WALLS OF FLUIDISED BED COMBUSTOR"

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AN INTERESTING analysis of the heat-transfer mechanism in a fluidised bed combustor of coal and ash has been presented in [1]. But some important aspects of the coal fired fluidised bed combustor have missed the author's attention. In a fluidised bed the coal particles act as individual heat sources. While burning they generate heat. As the emulsion packet contains both ash and coal particles distributed uniformly over it one would expect a certain amount of heat generation in the packet as well. Hence the energy equation should be written as

$$\rho_e C_{Pe}\frac{\partial T}{\partial t} = K_e\frac{\partial^2 T}{\partial x^2}+\sigma F_e T^3\frac{\partial T}{\partial x}+Q(T)^* \qquad (1)$$

where, $Q(T)$ = heat generation rate per unit volume of the packet. This can be determined by knowing the burning rate of coal particle [2] and the fraction of coal in the bed. This equation, when solved, should render the specific heat flux decreasing much slower with the time of contact for $Q(T)$ is a positive quantity. Subsequently the average heat-transfer rate should also increase.

It has been shown by [3] that there exists a property boundary layer near the wall, i.e. the property values like voidage, conductivity, specific heat etc. of the emulsion phase varies with the distance from the wall. Therefore, the equation (1) could be further modified as

$$\rho_e(x)C_{Pe}(x)\frac{\partial T}{\partial t} = \frac{\partial}{\partial x}\left(K_e(x)\frac{\partial T}{\partial x}\right)+\sigma F_e T^3\frac{\partial T}{\partial x}+Q(T) \qquad (2)$$

$\rho_e(x)$, $C_{Pe}(x)$, $K_e(x)$ are the density, specific heat, thermal conductivity respectively of an emulsion packet at a distance x from the wall.

The authors have also failed to take note of the fact that the temperature of the burning coal particles is 200–300°C higher than the average bed temperature [4]. Hence the initial temperature of the packet should be higher than T_b, i.e. at $t = 0$; $T_{\text{eff}} = (1-\eta)T_b+\eta T_{\text{coal}}$, where η is the fraction of coal in the bed. The solution of equation (2) under this boundary condition obviously results in still higher heat flux to the wall.

The assumption of the uniform residence time seems to be a little oversimplification because it is most unlikely for each packet to have the same residence time on the wall. It has been shown [5, 6] that the average rate of heat flux should be found from the expression

$$\bar{q}_c = \int_0^\infty q_i(\tau)f(\tau)\,d\tau \qquad (3)$$

where $f(\tau)$ is the fraction of packets on the wall having ages between τ and $\tau+d\tau$. And this could be represented by a gamma function [6]. As $q_i(\tau)$ is a nonlinear function of τ, the simple arithmetic mean, as proposed in the paper [1], should not be the same as the mean temporal heat flux $\bar{q}_c$.

In addition to these there seems to be some typographical errors which might have crept in during proof reading. The equation for instantaneous heat flux given in (4) of [1] should be

$$q_e = (q_c+q_{re})(1-f_0)$$

instead of

$$q_e = (q_e+q_{re})(1-f_0).$$

Again the equation for minimum fluidization should have been

$$u_{mf} = \frac{\mu}{d_p\rho_g}\left\{(33{\cdot}7)^2+0{\cdot}0408\,\frac{d_p^3\rho_g(\rho_s-\rho_g)g}{\mu^2}\right\}^{1/2}-33{\cdot}7\,\frac{\mu}{d_p\rho_g}$$

instead of

$$u_{mf} = \frac{\mu}{d_p\rho_g}\left\{(33{\cdot}7)^2+\frac{0{\cdot}0408\,d_p^3\rho_g(\rho_s-\rho_g)g}{\mu^2}\right\}^{1/2}-33{\cdot}7.$$

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[*] See [1] for Nomenclature for the symbols not explained in this text.