The local conductive and radiative heat transfer to a horizontal tube immersed in a fluidized bed combustor are investigated both analytically and experimentally. As the fluidization around the tube surface is not uniform due to its hydrodynamic character, an unique analytical solution for all angular positions along the circumference cannot be evolved. Hence in the present analysis, the zone around a horizontal tube surface is assumed to consist of three regions; namely defluidized, fluidized and stagnation regions.

In the analysis of heat transfer in the defluidized region, the particles are assumed to be in a packed bed condition and the heat is transferred to the tube surface by a steady-state process. The heat transfer rates are calculated by considering effective thermal conductivities of the defluidized particles and the gas film near the tube surface. The defluidized particles cap at the top of the tube is assumed to be parabolic and its local voidage is also assumed to vary with gas velocity.

The heat transfer from the fluidized bed to the fluidized region of the tube is assumed to be an unsteady process. The analysis is based on gas film-emulsion packet model. The gas film is assumed to be the boundary
layer thickness. The local velocity is assumed to be the
turbulent flow velocity over the tube surface and the
local voidage is assumed to vary with velocity. As a
simplification, the problem is formulated in terms of a
non-linear partial differential equation assuming the
boundary layer to be radiatively transparent and the
emulsion packet to radiate as layers of black bodies.
The conductive and radiative specific heat fluxes and
heat transfer coefficients are calculated for the locations
along the tube circumference in this region.

In the stagnation region the resistance to heat flow
is assumed to consist of two components, one due to the
gas film adjoining the tube surface and the other due to
the emulsion and bubble phases of the bed. The thickness
of the gas film layer is assumed to be 0.5 mm. The heat
transfer in this region is calculated by using the
expressions developed for the fluidized region.

The results of the experimental investigations
carried out for heat transfer rates to a horizontal tube
embedded in a 300 mm square water jacketed fluidized bed
combustor are also reported. The local total heat flux
at the tube surface was measured by a flux meter, employing
a steel plug, fixed with a differential thermocouple as
the sensing element and the radiative flux by a radiometer
employing a thermistor as the sensing element. The local
heat transfer rates were measured by indexing the horizontal tube in steps of 30° along the circumference. The experiments were conducted for fluidizing velocities of 0.6 to 1.4 m/s, bed temperatures of 700 to 900°C, particle sizes of 3-0 to 6-0 mm, and tube sizes of 32 to 60 mm outer diameter.

The experimental results indicated that local heat transfer coefficients are significantly influenced by angular position, fluidizing velocity, bed temperature, particle size and tube size. The comparison of these results shows a close agreement between the analytically predicted and experimentally observed values in the fluidized and stagnation regions. However, the deviation of experimental value from the analytical value is much wider in the defluidized region. This is mainly due to the restrictive assumptions made in the analysis. The contribution of radiation to the total heat transfer is of the order of 20 to 40 percent.