Radiative Heating of Supercritical Carbon Dioxide Flowing through Tubes (CSP-1)

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Scientific Achievement:

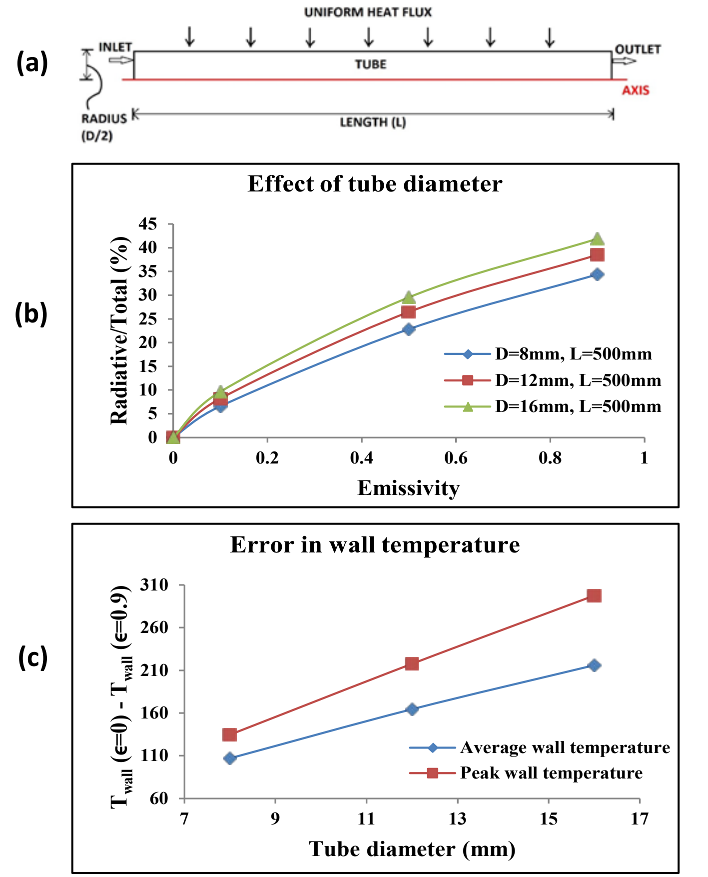
We characterized convection and radiation heat transfer in simultaneously developing laminar flow of s-CO_2 in tubes. This study showed that for certain physical and geometric conditions, neglecting radiative heat transfer—particularly the participation of s-CO_2 in thermal transport—can lead to large errors in predicting wall temperature, which affects lifetime and cost.

Significance and Impact:

Use of relatively less expensive materials or a comparatively lower heat-transfer area may be feasible. Tube geometry, optical properties of the tube, and radiation optical thickness can be optimized to use minimum heat-transfer area and minimum temperature differential between the surface and s-CO_2.

Research Details:

- A 2-D axisymmetric model was developed in ANSYS Fluent, and radiation absorption data for s-CO_2 were obtained by numerical averaging from HITEMP.
- ANSYS Fluent was coupled to REFPROP for accurate modeling of thermo-physical properties of s-CO_2.
- In general, the effect of participation can be expected to be significant at low Reynolds numbers, large tube diameters and lengths, and at high values of wall heat fluxes.



(a) Model geometry, (b) Fraction of radiation in total heat transfer to fluid, (c) Error in wall temperatures if radiation is neglected.

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