

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-CO₂ in tubes. This study showed that for certain physical and geometric conditions, neglecting radiative heat transfer—particularly the participation of s-CO₂ in thermal transport—can lead to large errors in predicting wall temperature, which affects lifetime and cost.

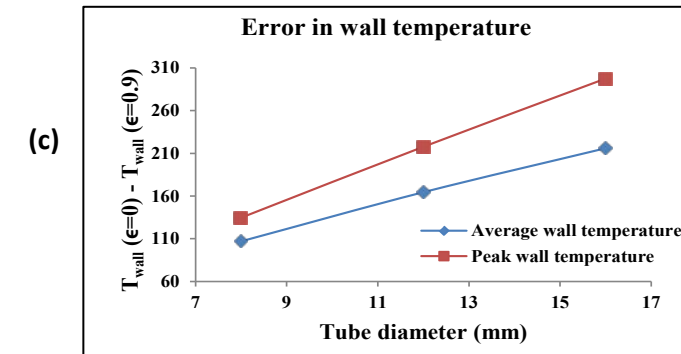
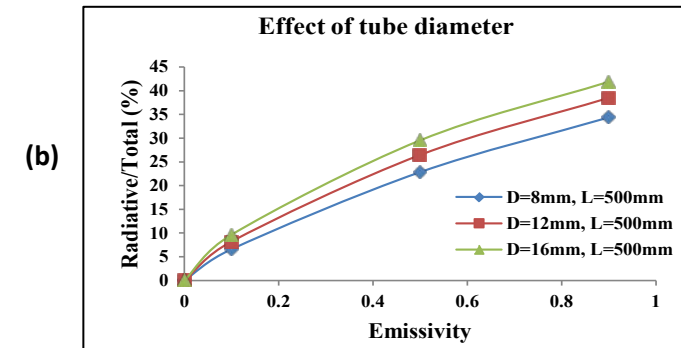
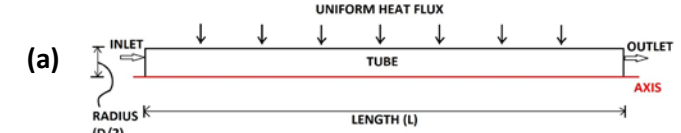
Significance and Impact:

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-CO₂.

Research Details:

- A 2-D axisymmetric model was developed in ANSYS Fluent, and radiation absorption data for s-CO₂ were obtained by numerical averaging from HITEMP.
- ANSYS Fluent was coupled to REFPROP for accurate modeling of thermo-physical properties of s-CO₂.
- 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.

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

Contact(s): Sagar Khivarsa (sagardk@mecheng.iisc.ernet.in)
Pradip Dutta (pradip@mecheng.iisc.ernet.in)
Vinod Srinivasan (vinods@mecheng.iisc.ernet.in)

