# Hydraulic Development Length and Boundary Condition Effects on Local $sCO_2$ Heat Transfer Coefficients


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## INTRODUCTION

### Entrance Length

- Many $sCO_2$ pipe flow simulations utilize fixed-length adiabatic entrance sections.
- It is assumed the adiabatic entrance sections are long enough to generate hydraulically fully-developed flow before entering the heat transfer test section.

### Boundary Conditions

- $sCO_2$ single-pipe flow cases utilize constant heat flux or temperature boundary conditions.
- These are often treated as simplifications of double-pipe heat exchangers with a conjugate boundary.

## OBJECTIVES

- Evaluate hydraulic entrance length criteria for $sCO_2$ numerically. Results will help determine appropriate hydraulically developed conditions.
- Demonstrate the differences in local heat transfer trends of $sCO_2$ under conjugate and corresponding constant heat flux or temperature boundary conditions to illustrate that the latter are not appropriate simplifications of the former.

## CONCLUSIONS

- The generally accepted adiabatic development length criteria may not be appropriate for $sCO_2$.
- Constant heat flux and temperature boundary conditions are not appropriate simplifications of conjugate $sCO_2$ problems.

## ENTRANCE LENGTH RESULTS

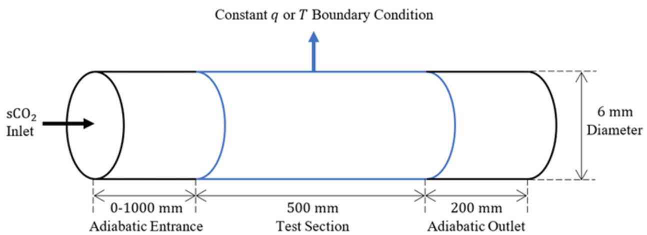


*Figure 1: Single pipe geometry with varying adiabatic entrance lengths*

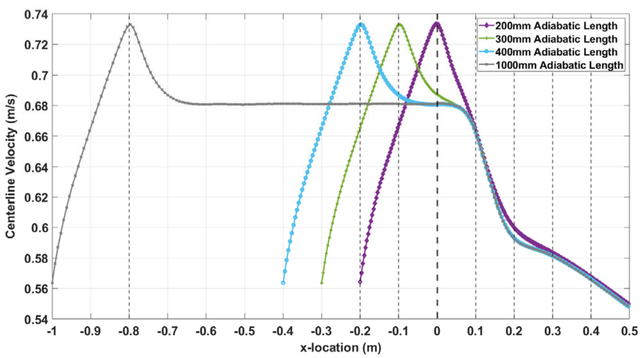


*Figure 2: Centerline velocity with varying adiabatic entrance lengths. Cooling starts at $x = 0\ m$, $T_{b,in} = 36°C$*

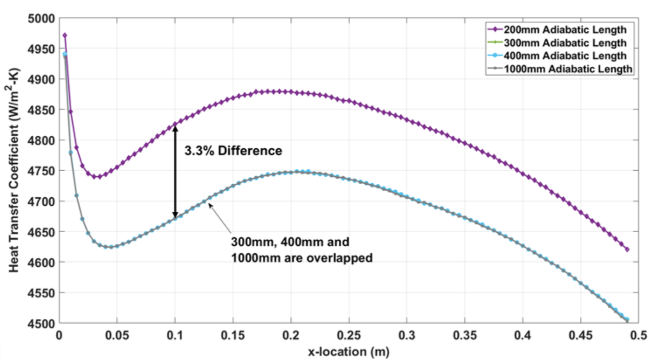


*Figure 3: Heat transfer coefficients with varying adiabatic entrance lengths. Cooling starts at $x = 0\ m$, $T_{b,in} = 36°C$*

## BOUNDARY CONDITION RESULTS

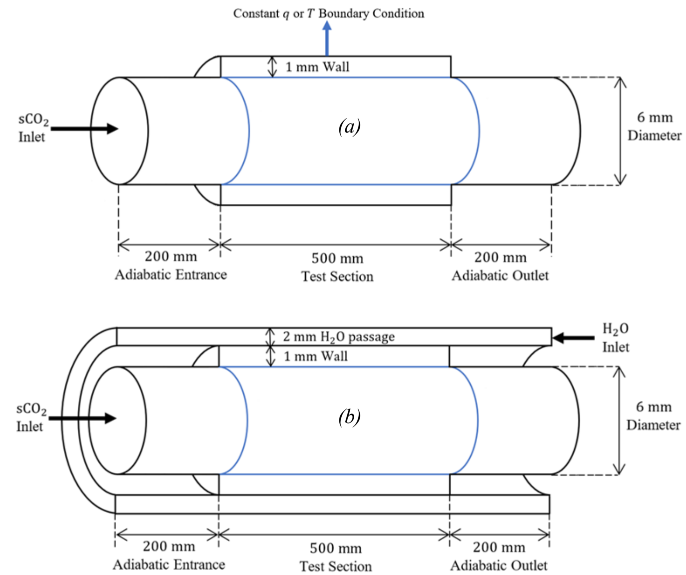


*Figure 4: (a) single pipe with a wall and (b) counterflow double-pipe HX geometry*

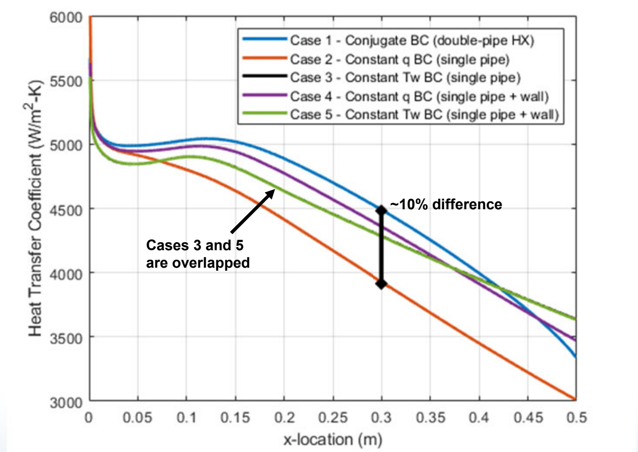


*Figure 5: Comparison of boundary conditions. Cooling starts at $x = 0\ m$. $sCO_2 : T_{b,in} = 36°C$, and $G = 200\ kg/m^2s$. $H_2O : T_{b,in} = 14°C$, and $G = 200\ kg/m^2s$*


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