Heat Transfer Analysis with Critical Radius

Key Analysis

Heat Transfer Mechanism:
- Conduction through insulation (radial direction).
- Convection from the insulation's outer surface to the surroundings.

Thermal Resistances:

Conduction Resistance (insulation):
R_cond = ln(r2 / r1) / (2pikL)

Convection Resistance:
R_conv = 1 / (h 2pir2L)

Total Resistance:
R_total = R_cond + R_conv

Heat Transfer Rate:
Q = (T1 - T) / R_total

For simplicity, assume L = 1m:

Q = (2pi (T1 - T)) / [ln(r2 / r1) / k + 1 / (h r2)]

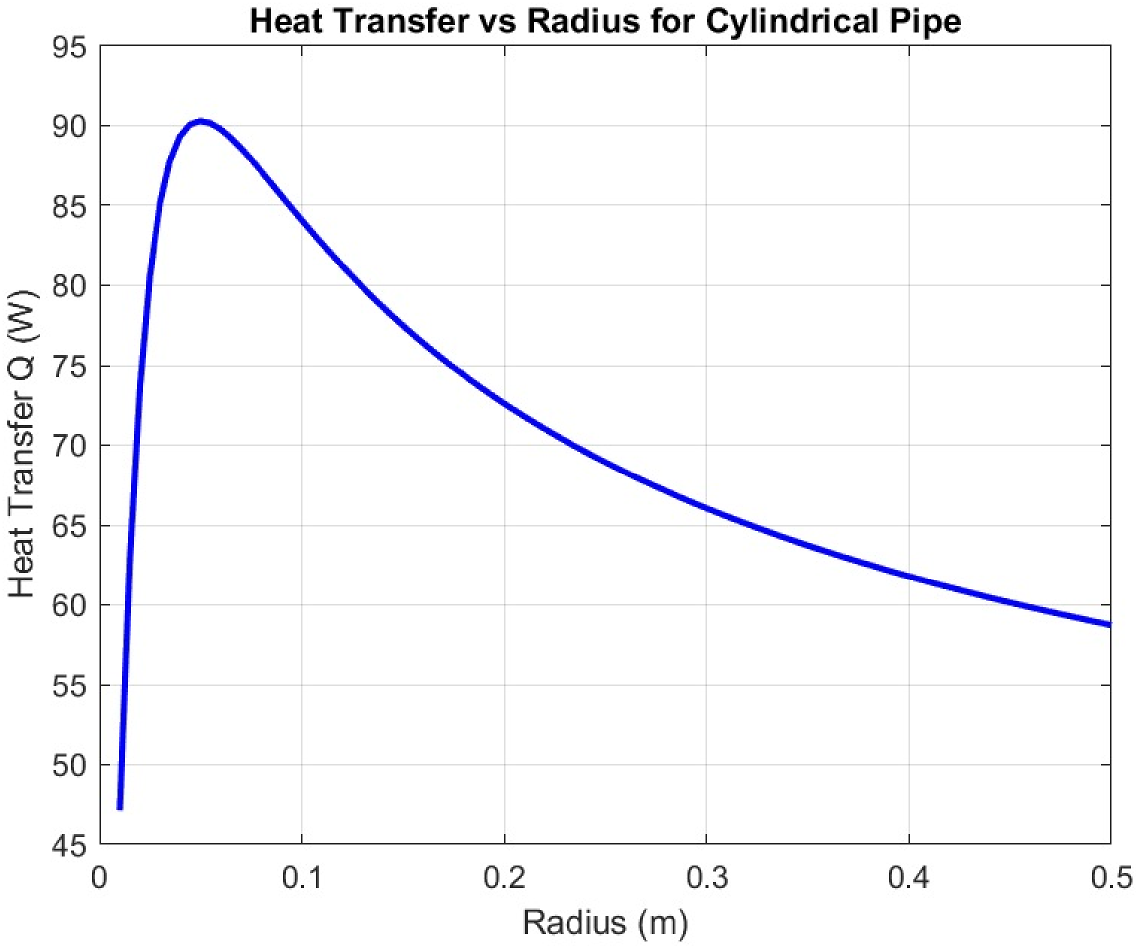
Critical Radius of Insulation:
For cylinders, critical radius rc = k / h

- If r2 < rc: Adding insulation increases heat loss.
- If r2 > rc: Adding insulation decreases heat loss.

Plotting Q vs r (for r2):

Behavior:
- Q initially decreases until r2 = rc.
- Q then increases for r2 > rc.

Conclusion:
The plot shows a U-shaped curve due to the critical radius effect. Insulation is only beneficial when r2 > rc.



Heat Transfer vs Radius for Cylindrical Pipe
Heat Transfer Q (W)
Radius (m)
95
90
85
80
75
70
65
60
55
50
45
0
0.1
0.2
0.3
0.4
0.5