Experiment 4
cross flow heat Exchanger

objectives

study cross flow heat exchanger
calculate h experimentally
calculate Nu

Calculations

- lumped capacitance method: $\ln\left(\frac{T-T_\infty}{T_o-T_\infty}\right) = -mt$

  T: Rod temperature, T_∞: ambient temperature, T_o: initial temperature

  $m = \frac{h}{\rho C L_s}$

  ρ: density of Rod, C: specific heat of Rod, L_s: characteristic length $= \frac{V}{A}$

- Biot number: $Bi = \frac{hL_e}{K}$

  L_e: equivalent length, K: Air thermal conductivity

Resistance to conduction within the solid is less resistance to convection, so uniform ↓

$Bi < 0.1$ to assure validation of lumped capacitance method

- Nusselt number: $Nu_{exp} = \frac{hd}{K}$ / $Nu_{Theo} = 0.24 \times Re^{0.6}$

  d: Rod diameter

- Air velocity: $V = 237.3\sqrt{\frac{H_1 T_\infty}{P_a}}$

  H_1 in cmH_2O, T_∞ in K, P_a in Pa

- Reynolds: $Re = \frac{Vd}{\upsilon}$

  υ: Air Kinematic viscosity

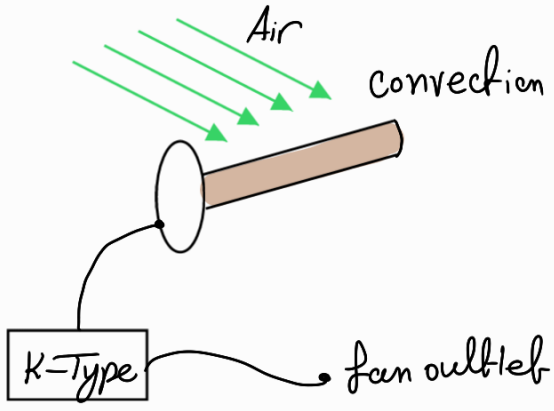
- Prandtl number: $Pr = \frac{C_p \mu}{K}$

  For air: C_p specific heat of air, μ dynamic viscosity, K Thermal conductivity of air

$Pr < 1$ for gases

- Heat transfer: $Q = Ah(T_{Rod} - T_{\infty})$

Theory and results explanation



- Air absorbs temperature of the rod and tempreture difference decrease
- More air → more absorbtion → less time to reach cooling
- Throttle opening ↓ → heat transfer ↓
- Throttle opening ↓ → m (represents temperature differenc) ↓
- h depends on 1. surface geometry
  2. Fluid motion
  3. Fluid properties
  4. Fluid quantity and velocity
- Fan was used and so forced convection → Air flow is turbulent

  Turbulent flow means: 1. Irregular movement of fluid particles
  2. fluctuating velocity of fluid particles and so particles always moves between layers

  → Better heat transfer
- Nusselt number is a measure of the heat transfer

  Better heat transfer → Nu ↑

$$Nu = \frac{\text{heat transferred to fluid}}{\text{heat transfer within the fluid}}$$