

The naive method for evaluating a microchannel cooling solution

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The Naive Method function allows the user to calculate the heat flux q , pressure loss dP , and outlet temperature T_{out} for a simple microchannel cooler which consists of straight rectangular channels.

1 Input

The Naive Method function takes the following input

1. Channel Length, L [m]
2. Channel Width, W [m]
3. Channel Depth, D [m]
4. Fluid Density, ρ [kg/m^3]
5. Fluid Viscosity, μ [$Pa \cdot s$]
6. Fluid Specific Heat, c_p [$J/(kg \cdot K)$]
7. Fluid Thermal Conductivity, k [$W/(m \cdot K)$]
8. Fluid Inlet Temperature, T_{in} [K]
9. Wall Temperature, T_w [K]
10. Flow Rate, Q [uL/min]

2 Describing the Flow

The cross-sectional area [m^2]

$$A = WD \tag{1}$$

The wetted perimeter [m]

$$P = 2(W + D) \tag{2}$$

The hydraulic diameter [m]

$$D_h = 4 \frac{A}{P} \tag{3}$$

The fluid velocity [m/s]

$$v = \frac{Q}{A} * 1.67 \times 10^{-11} \tag{4}$$

where the constant 1.67×10^{-11} ensures dimensional consistency.

2.1 Dimensionless Flow Parameters

The Reynolds number for the flow $[ul]$

$$Re = \frac{\rho v D_h}{\mu} \quad (5)$$

where ρ is the density of the fluid, v is the speed of the flow, D_h is the hydraulic diameter, and μ is the viscosity of the fluid.

The Prandtl number for the flow $[ul]$

$$Pr = \frac{c_p \mu}{k} \quad (6)$$

where c_p is the specific heat of the fluid, μ is the viscosity of the fluid, and k is the thermal conductivity of the fluid.

The Nusselt number for the flow $[ul]$ is calculated using the Reynolds number and the Prandtl number.

$$Nu = 0.023 * Re^{4/5} * Pr^{1/3} \quad (7)$$

2.2 Heat Transfer

The heat transfer coefficient, h $[W/(m^2 * K)]$

$$h = \frac{Nu * k}{D_h} \quad (8)$$

where Nu is the Nusselt number, k is the fluid thermal conductivity, and D_h is the hydraulic diameter.

The heat flux, q $[W/m^2]$

$$q = h * (T_w - T_{in}) \quad (9)$$

where h is the heat transfer coefficient, T_w is the wall temperature, and T_{in} is the inlet temperature.

2.3 Pressure Loss

The pressure loss, dP $[Pa]$

$$dP = \frac{f L \rho v^2}{2D} \quad (10)$$

where f is $64/Re$, L is the channel length, ρ is the fluid density, v is the fluid velocity, and D is the channel depth.

2.4 Outlet Temperature

The outlet temperature, T_{out} $[K]$

$$T_{out} = T_{in} + \frac{q}{Q \rho c_p * 1.67 \times 10^{-4}} \quad (11)$$

where T_{in} is the inlet temperature, q is the heat flux, Q is the flow rate, ρ is the fluid density, and c_p is the specific heat of the fluid. The constant 1.67×10^{-4} ensures dimensional consistency.