Convection

Convection:

Convection-heat transfer between a solid surface and a fluid (air, gas, liquid)
Forced convection –moving fluid (pump water through a pipe)
Free (natural) convection- fluid circulating (a pipe subjected to outside ambient air with no wind)

Fluid properties are critical in determining heat transfer

- Laminar or turbulent flow (Reynolds number)
- Velocity
- Viscosity
- Density

$q_{cv} = hA(t_w - t_\infty)$ (flow over an external surface)

Where:

q_{cv}=heat transfer (convection)
h =convection heat transfer coefficient (different value for different substances and scenarios)
t_w= wall temperature
t_∞= fluid temperature

Flow through a pipe
$q_{cv} = hA\left(t_w - t_{fluid\ avg}\right)$

Where:
q_{cv}=heat transfer (convection)
h =convection heat transfer coefficient (different value for different substances and flow)
t_w= wall temperature
$t_{fluid\ avg}$= bulk or average energy temperatures

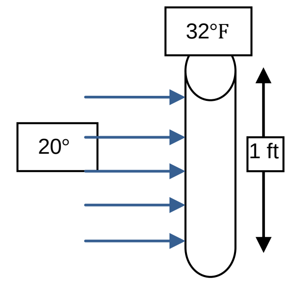
$q_{cv} = hA\left(t_w - t_{fluid\ avg}\right) = q_{cv} = m\dot{m}c_p(t_e - t_i)$

Where:
$\dot{m}m$ = mass flow rate of fluid
t_e= exit fluid temperature
t_i= inlet fluid temperature

Water at 20°F flows across a long cylinder (diameter = 3.5”). The cylinder surface is maintained at 32°F and h (convection heat transfer coefficient) for this type of flow is 1200 btu / (hr •ft^2 •°F). Calculate the heat transfer per foot of length.

$q_{cv} = hA(t_w - t_\infty)$
$q_{cv} = h(\pi dl)(t_w - t_\infty)$
$\frac{q_{cv}}{l} = h(\pi d)(t_w - t_\infty)$

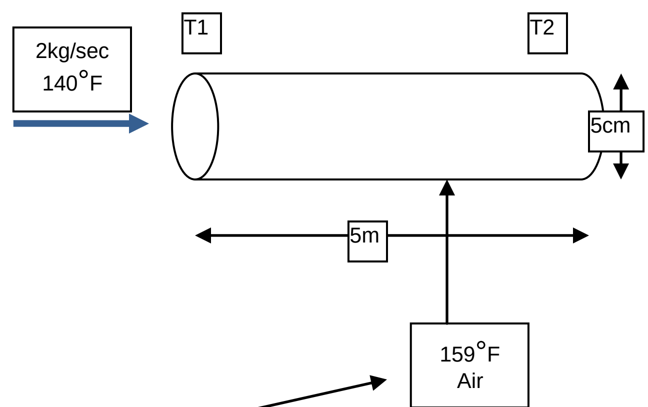
$= \frac{1200\ btu}{hr\ ft^2 °F}(3.14 * 3.5in)\frac{ft}{12in}(32°F - 20°F) = 13{,}188\frac{btu}{hr\ ft}$



5kg/sec of water is heated from 20°C to 45°C as it flows through a heat exchanger. How much heat is added?

Find c_p at average temp (45-20)/2 =12.5+20=32.5°C
$c_p = 4.178\frac{kJ}{kg\ °C}$ from reference chart 32.5°C
$q_{cv} = \dot{m}c\_p(t_e - t_i)$
$= \frac{5kg}{s} 4.178\frac{kJ}{kg\ °C}(45°C - 20°C) = 522\frac{kJ}{s} = 522kW$

Water flows at 2kg/sec at 140°F through a 5m long section of 4cm (1.57”) diameter tubing. The h value (convection heat transfer coefficient) is known to be 3500W/(m^2°C). What ΔT (change in temperature) is needed between the pipe wall and the flowing water to cause a 5°C increase in water temperature? c_p from table is 4180 J/(kg°C)



$q_{cv} = \dot{m}c_p(t_e - t_i)$

$q_{cv} = 2\frac{kg}{s} 4180\frac{J}{kg°C}(5°C) = 4.18x10^4\ \frac{J}{s}$

$q_{cv} = h(\pi dl)(t_w - t_\infty)$

$4.18x10^4\ \frac{J}{s} = 3500\frac{Watts}{m^2\ °C}(3.14 * .04m * 5m) * \Delta T$

$\Delta T = 19.02°C$

$140°C + 19.02°C = 159°C$