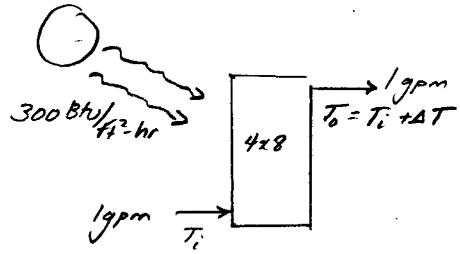
## Problem 1.16

50% of sunlight is captured and heats water in solar collector. What is $\Delta T$ in solar panel?



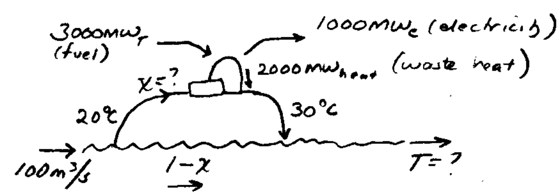

$$E = \frac{1\ Btu}{lb \cdot {}^\circ F}\ \Delta T\ {}^\circ F$$

$$0.5 \times 300 \frac{Btu}{ft^2\text{-}hr} \cdot 32 ft^2 \cdot \frac{1 hr}{60 min} = \frac{80 Btu}{min}$$

$$\frac{1 gal}{min} \cdot \frac{8.34 lbs}{1 gal} \cdot \frac{1 Btu}{lb \cdot {}^\circ F} \cdot \Delta T\ {}^\circ F = \frac{80 Btu}{min} \quad \text{Solve for } \Delta T$$

$$\Delta T\ {}^\circ F = \frac{80 Btu}{min} \cdot \frac{1 gal}{8.34 lbs} \cdot \frac{lb \cdot {}^\circ F}{1 Btu} \cdot \frac{1 min}{1 gal} = \underline{\underline{9.59 {}^\circ F}}$$ ← $\Delta T$

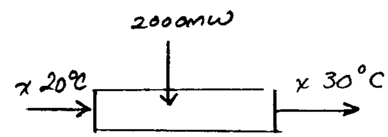
## Problem 1.18




2/3 energy into $1000 MW_e$ power plant is cooled by condenser that takes water from river. River has $Q = 100 m^3/s$, $T = 20°C$

a) If $\Delta T$ is 10°C, how much Q from river

b) What is $\Delta T$ of river?




a) $x \cdot 4.184 kJ/kg°C \cdot 10°C = 2000 \cdot 10^3 kJ/s$ Solve for $x$

$x = 47.8 \cdot 10^3 kg/sec$

$= 47.8 \cdot 10^3 \frac{kg}{sec} \cdot \frac{1 m^3}{1000 kg} = \underline{\underline{47.8 m^3/sec}}$ ← $Q_{plant}$

b) $\frac{(47.8 m^3/sec)(30°C) + (52.2 m^3/s)(20°C)}{100 m^3/s}$

$= 24.78°C$

$\therefore \Delta T_{river} = \underline{\underline{4.78°C}}$ ← $\Delta T_{river}$

## Problem 1-20

Energy to evaporate 1kg water at 15°C

① 15°C − 100°C heating $E = (85°C)(4.184 kJ/kg) = 355.64 kJ$

② Vaporize at 100°C heat $E = 2257 kJ/kg$ $= 2257 kJ$

$2612.64 kJ$

Energy to raise 1 kg water 3 km

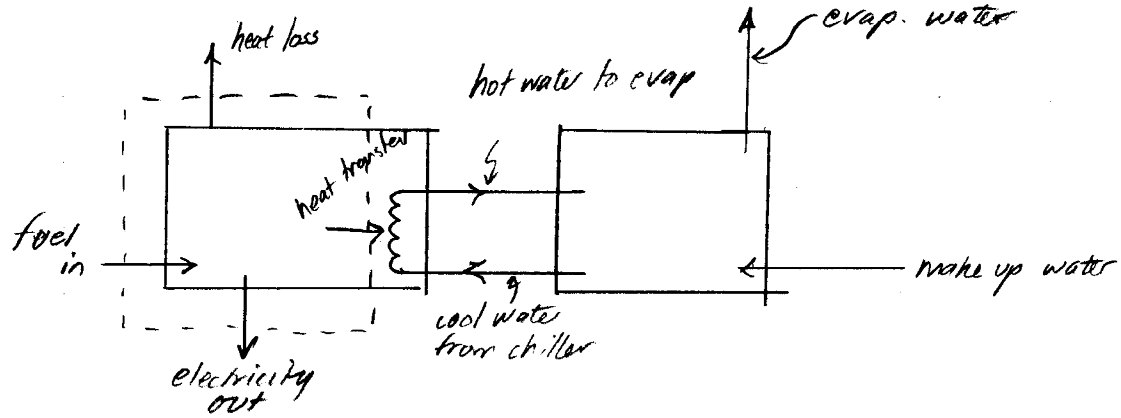
$E = mgy = (1 kg)(9.8 m/s^2)(3 \cdot 10^3 m) = (9.8 N)(3 \cdot 10^3 m)$

$= 29400\ J$

$= 29.4\ kJ$

∴ It takes nearly 100x more energy to boil water at surface of earth than to raise 1 kg of water 3 kilometers (~1.8 miles)

600 MW powerplant is 36% efficient with 15% waste heat released to atm., remainder in cooling water that is evaporated. Make-up water at 15°C is drawn from a river. How makeup water is needed?




Energy and mass balances

Energy balance for power plant

Energy IN + Heat transfer IN − ENERGY out = Δ Energy stored (= 0 steady state)

fuel in − heat loss − heat transfer − electricity out = 0

fuel in − 0.15 fuel in − 0.49 fuel in − .36 fuel in = 0 (.36 fuel in = 600 MW)

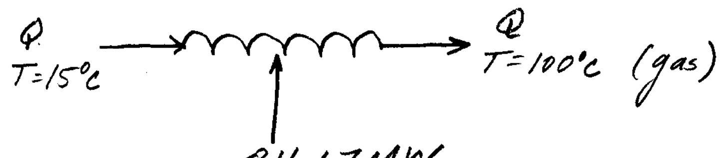
1666.67 MW − 250 MW − 816.67 MW − 600 MW = 0

Two ways

All heat transfer is 1666.67 − 600 MW

How 15% up stack
85% to exchanger

Mass & Energy Balance for heat exchanger




Water is heated from 15°C to 100°C, then vaporized. Table 1.4 gives $c_{v(15°)} = 2465\,kJ/kg$ – the amount of heat required to vaporize 1 kg of water initially at 15°C.

$$\text{Energy}_{IN} + \text{Heat transfer}_{IN} - \text{Energy}_{out} = \frac{dE_{sys}}{dt} = 0 \quad \text{steady state}$$

$$-\rho Q c T_{IN} + \rho Q c T_{out} = \text{Heat transfer in}$$

$$\rho Q c \Delta T = \text{Heat transfer}_{IN}$$

$$Q\,(1000\,kg/m^3)(2465\,kJ/kg) = 816.67 \cdot 10^3\,kW$$

$$Q = \frac{816.67 \cdot 10^6\,J/sec}{(1000)(2465 \cdot 10^3)\,J/m} = 0.331 \quad m^3/s$$

Alternate solution

$$\rho Q c_o \Delta T + \rho Q L = 816.67 \cdot 10^3\,kW$$

$$Q = \frac{816.67 \cdot 10^3\,kW}{(1000\,kg/m^3)(4.184 \cdot 85°C + 2257\,kJ/kg)} = 0.312 \quad m^3/s$$