Sept. 14/12
Thermal

Heating Value / Caloric Value

1. HHV → Gross
2. LHV → Net

Fuel → H_2, C + O_2 → H_2O + CO_2 ... (Steam) ... + heat → HHV

100°C
100°C
↑ latent heat 2257 kJ/kg
→ (heat)

$$\eta_{combustion} = \frac{Q}{HV} = \frac{\text{Amount of heat released during comb.}}{\text{Heating Value of Fuel Burned}}$$

(efficiency)

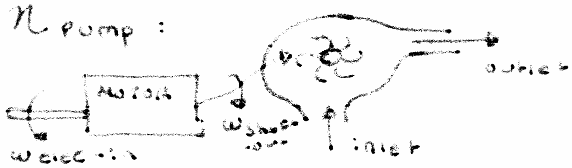
Overall efficiency of a power plant

$$\eta_{overall} = \eta_{combustion}\,\eta_{thermal}\,\eta_{generator} = \frac{W_{net,\,electric}}{HHV \times \dot{m}_{Fuel}}$$

$$\frac{Q}{HV} \times \frac{W_{shaft\,out}}{Q} \times \frac{W_{elec\,out}}{W_{shaft\,out}} = \frac{W_{elec\,out}}{HV}$$

where $HV = HHV \cdot \dot{m}_{Fuel}$

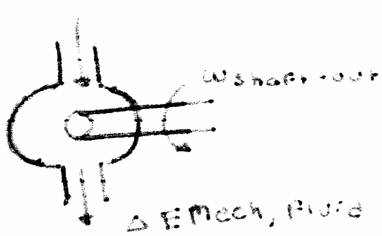
η_{pump} :



$\Delta E_{mech,\,fluid}$

$$\eta_{pump} = \frac{\Delta E_{mech,\,fluid}}{W_{shaft,\,in}}$$

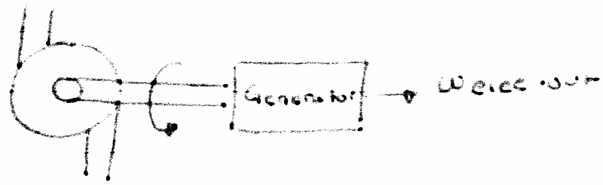
$\eta_{turbine}$:



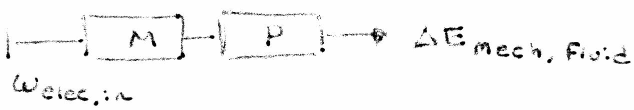
$$\eta_{turbine} = \frac{W_{shaft,\,out}}{\Delta E_{mech,\,fluid}}$$

$\eta_{motor} = \frac{W_{shaft,out}}{W_{elec,in}}$

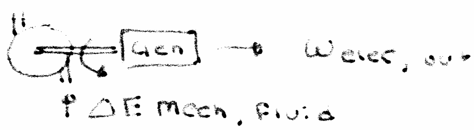
$\eta_{generator} = \frac{W_{elec,out}}{W_{shaft,in}}$



$\eta_{pump\text{-}motor} = \eta_{pump} \times \eta_{motor} = \frac{\Delta E_{mech,fluid}}{W_{elec,in}}$



$\eta_{turbine\text{-}generator} = \eta_{turbine} \times \eta_{generator} = \frac{W_{elec,out}}{\Delta E_{mech,fluid}}$



Energy + Environment:

Fuel + Air → CO_2 + H_2O + HC + CO + NO_x + PM + SO_2, etc.

(HC, CO, NO_x, PM) → main focus of EPA, etc.

Diesel: HC, NO_x, PM

Gasoline: CO, HC, NO_x

Ozone + Smog:

Smog: smoke + fog

↳ O_3, CO

Acid Rain: S + O_2 → SO_2

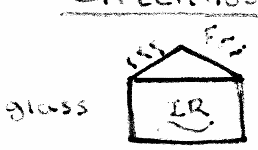
SO_2 + O_2 → SO_3

NO_x

$SO_3 + H_2O$: H_2SO_4 (sulfuric acid)

$NO_x + H_2O$ → HNO_3 (nitric acid)

Greenhouse Effect:

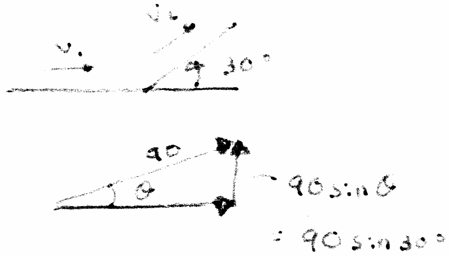


↳ small wavelengths (visible radiation)

(enter through micro pores)

- small wavelength during day
- become large wavelengths (too big too leave)

Example 2-8: (From textbook p. 69)



$\dot{W}_g = \frac{mg\Delta z}{\Delta t}$ → $V_{velocity}$

$= (1200\ kg)(9.81\ m/s^2)(90\ km/h) \cdots$

$\cdots (\sin 30°)\left(\frac{1000\ m}{1\ km}\right)\left(\frac{1\ hour}{3600\ s}\right)$

$= \frac{(\quad)}{1000}\ kW = 147\ kW$

$\Rightarrow \frac{147 \times 1000\ W}{746} \simeq 197\ hp$

Example 2-9: (From textbook)

$W_a = \frac{1}{2} m (V_2^2 - V_1^2)$

$= \frac{1}{2}(900)\left(\left[(80)\left(\frac{1000}{3600}\right)\right]^2 - 0\right)\ kJ$

$= 222\ kJ$

$\therefore \dot{W}_a = \frac{W_a}{\Delta t} = \frac{222\ kJ}{20\ sec} = 11.1\ kW$ or $14.9\ hp$

Example 2-15: (From textbook)

$\Delta \dot{E}_{mech,fluid} = \dot{m}(e_{mech,in} - e_{mech,out})$
→ (1) → (2)

$= 1500(0.687 - 0)$

$= 1031\ kW$

$Pe_1 = gz_1$

$= 9.81 \times 70$

$= 0.687\ kJ/kg$

$\eta_{turbine} = \frac{\dot{W}_{elec}}{\Delta \dot{E}_{mech}}$

$= \frac{750}{1031} \times 100$

$= 72.7\ \%$

$\eta_{turbine} = \frac{\dot{W}_{shaft}}{\Delta \dot{E}_{mech}}$

$= \frac{800}{1031} \times 100$

$= 77.6\ \%$

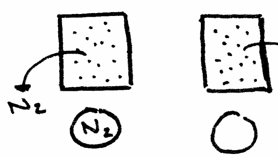
Sept. 21/17

THERMAL

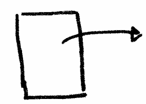
Thermo Chapter 3 : Properties of Pure Substances

Obj :
1) Introduce the concept of pure substance
2) Discuss phase change process
3) Illustrate P-V , T-V property diagram
4) Property table
5) Ideal gas equation
6) Compressibility Factor

Pure substance : → mixture



→ H_2O (2 parts H, 1 part O)

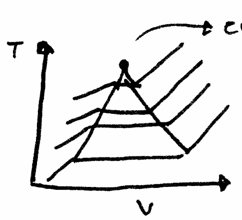


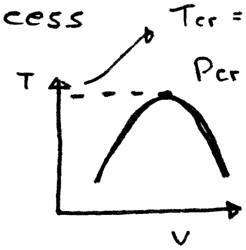
→ oil + water mixture

liquid air is not a pure substance

Phases of a pure substance :
1) Solid
2) Liquid
3) Gaseous

Phase Change Process





$T_{cr} = 374°C$

$P_{cr} = 22\,MPa$

H_2O → A-4, A-5 → Saturated

A-6 → Superheated

A-7 → compressed H_2O

@ 20°C ≅ @ 100°C

$v_{fg} = v_g - v_f$

$u_{fg} = u_g - u_f$

$h_{fg} = h_g - h_f$ ... etc.

(h_{fg}) → latent heat of vaporization

$h = u + (P\upsilon)$ → Flow energy

Example 3-1:

Saturated liquid temp is 90°c

Table A4 : $P = P_{sat@90°c} = 70.18$ kPa

1atm = 101 kPa

$v = v_{f@90°c} = 0.001036\ m^3/kg$

$v = \frac{V}{m}$ $\therefore$ $V = v \cdot m$

$V = (0.001036)(50)$

$V = 0.0518\ m^3$

Example 3-3:

$v_{fg} = v_g - v_f$

$= 1.6941 - 0.001043$

$\Delta V = m v_{fg}$

$= (0.2)(v_{fg})$

$= 0.3386\ m^3$

b) Energy transfer $= m h_{fg}$ ($\rightarrow h_{fg}$)

$= (0.2)(2257)$

$= 451.5$ kJ

$u = u_f + x\, u_{fg}$

$h = h_f + x\, h_{fg}$

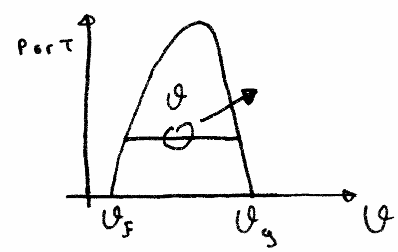
$v = v_f + x\, v_{fg}$

↓ Saturated mixture value

$x \rightarrow$ quality of steam

$x = \frac{m_{vapor}}{m_{total}}$

$= \frac{m_g}{m_f + m_g}$



Example 3-4: