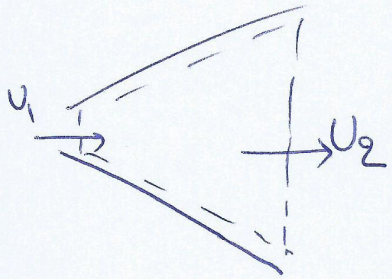
ΘΕΜΑ 4 (Ιούνιος 2015)



α) $\dot{m}$
β) T_2

$R = 0.287 \frac{kPa \cdot m^3}{kg \cdot K}$

α) $\dot{m} = \frac{1}{v} U A$

$\frac{PV}{m} = \frac{m R T}{m}$

$Pv = RT$

$T_1 = 27°C = 300K$

$P_1 = 100kPa$

$A_1 = 0.5m^2$

$U_1 = 200 m/s$

$v = \frac{RT}{P} \Rightarrow V_1 = \frac{RT_1}{P_1}$

$V_1 = \frac{0.287 \frac{kPa \cdot m^3}{kg \cdot K} \cdot 300K}{100kPa}$

$V_1 = 0.861 \ m^3/kg$

$\dot{m} = \frac{1}{V_1} U_1 A_1 = \frac{1}{0.861 \frac{m^3}{kg}} (200 \frac{m}{s})(0.5 m^2)$

$\dot{m} = 116.14 \ kg/s$

β) Ενεργειακό ισοζύγιο $\dot{E}_{in} = \dot{E}_{out}$

$\dot{m}(h_1 + \frac{U_1^2}{2}) = \dot{m}(h_2 + \frac{U_2^2}{2})$ ($U_2 << U_1$, $U_2 \cong 0$)

$h_2 = h_1 + \frac{U_1^2}{2}$

$T_1 = 300K \xrightarrow[(A-17)]{\text{Πίνακας}} h_1 = 300.19 kJ/kg$

$h_2 = 300.19 \frac{kJ}{kg} + \frac{(200 m/s)^2}{2}$

$h_2 = 300.19 \frac{kJ}{kg} + 20000 \frac{m^2}{s^2}$

$1 \frac{m^2}{s^2} = 1 \frac{J}{kg}$

$$h_2 = 300.19 \frac{kJ}{kg} + 20000 \frac{J}{kg}$$

$$h_2 = 300.19 \frac{kJ}{kg} + 20 \frac{kJ}{kg}$$

$$h_2 = 320.19 \frac{kJ}{kg} \xrightarrow{\text{Πίνακας}} T_2$$

Γραμμική Παρεμβολή

$T(K)$	$h(kJ/kg)$
310	310.00
T_2	320.19
730	745.62

$$\frac{T_2 - 310}{730 - 310} = \frac{320.19 - 310.00}{745.62 - 310.00} \Rightarrow T_2 = 319.82K$$

Παράδειγμα 5-5 (σελ. 250 - 251)

Ατμός $\longrightarrow$ Υπέρθερμος ατμός $\xrightarrow{\text{Πιν.}}$ Υπέρθερμου Νερού (Α-6)

$P_1 = 1.8MPa$, $T_1 = 400°C$ $\xrightarrow{\text{Α-6}}$ $h_1 = 3251.6 kJ/kg$, $v_1 = 0.16849 m^3/kg$

$\dot{m} = 5kg/s$

$A_1 = 0.02m^2$

$P_2 = 1.4MPa$

$V_2 = 275 m/s$

$q_{out} = 2.8 kJ/kg$

a) V_1

b) T_2

a) $\dot{m} = \frac{1}{v_1} U_1 A_1 \Rightarrow U_1 = \frac{\dot{m} v_1}{A_1}$

$$U_1 = \frac{5\frac{kg}{s} \cdot 0.16849 \frac{m^3}{kg}}{0.02 m^2} \Rightarrow U_1 = 42.12 \frac{m}{s}$$

b) Ενεργειακό ισοζύγιο $\dot{E}_{in} = \dot{E}_{out}$

$$\dot{m}\left(h_1 + \frac{U_1^2}{2}\right) = \dot{m}\left(h_2 + \frac{U_2^2}{2}\right) + \dot{Q}_{out}$$

$$\dot{Q}_{out} = \dot{m} q_{out}$$

$(\div \dot{m})$

$$h_1 + \frac{U_1^2}{2} = h_2 + \frac{U_2^2}{2} + q_{out}$$

$$h_2 = h_1 - q_{out} + \frac{U_1^2 - U_2^2}{2}$$

$$h_2 = 3251.6 \frac{kJ}{kg} - 2.8 \frac{kJ}{kg} + \frac{(42.12 m/s)^2 - (275 m/s)^2}{2} \; \text{J/kg}$$

$$h_2 = 3248.8 \frac{kJ}{kg} - 36925 \frac{m^2}{s^2}$$

$$h_2 = (3248.8 - 36.925) \frac{kJ}{kg}$$

$$h_2 = 3211.875 \frac{kJ}{kg} \Big\} \longrightarrow T_2$$

$$P_2 = 1.4 MPa$$

T[°C]	h [kJ/kg]
350	3150,1
T_2	3211,875
400	3258,1

$$\frac{T_2 - 350}{400 - 350} = \frac{3211,875 - 3150,1}{3258,1 - 3150,1} \Rightarrow$$

$$\frac{T_2 - 350}{50} = \frac{61,775}{108} \Rightarrow T_2 = 378,599537$$

Παράδειγμα 5-7 (σελ. 252-253)

Αδιαβατικός $\longrightarrow \dot{Q} = 0$

$\dot{W}_{out} = 5\,MW$

a) $\Delta e_{κιν} = \frac{U_2^2 - U_1^2}{2} = \frac{(180\,m/s)^2 - (50\,m/s)^2}{2} \Rightarrow$

$\Delta e_{κιν} = 14950 \frac{m^2}{s^2} = 14950 \frac{J}{kg}$

$\Delta e_{κιν} = 14.95 \frac{kJ}{kg}$

$\Delta e_{δυν} = g(z_2 - z_1) = 9.81 \frac{m}{s^2}(6m - 10m)$

$\Delta e_{δυν} = -39 \frac{m^2}{s^2} = -0.039 \frac{kJ}{kg}$

$$\Delta h = h_2 - h_1$$

$$\left.\begin{matrix} P_1 = 2\,MPa \\ T_1 = 400^\circ C \end{matrix}\right\} \xrightarrow{A\text{-}6} h_1 = 3248.4\,kJ/kg$$

$$\left.\begin{matrix} x_2 = 90\% = 0.9 \\ h_2 = h_f + x_2 h_{fg} \\ \text{A-5} \\ h_f = h_{f@15kPa} = 225.94\,kJ/kg \\ h_{fg} = h_{fg@15kPa} = 2372.3\,kJ/kg \end{matrix}\right\} h_2 = 2361.01\,\frac{kJ}{kg}$$

$$\Delta h = h_2 - h_1 = -887.39\,kJ/kg$$

β) w_{out} (kJ/kg)

Ενεργειακο Ισοζυγιο $\quad \dot{E}_{in} = \dot{E}_{out}$

$$\dot{m}\left(h_1 + \frac{U_1^2}{2} + g z_1\right) = \dot{W}_{out} + \dot{m}\left(h_2 + \frac{U_2^2}{2} + g z_2\right)$$

$$\dot{W}_{out} = \dot{m} w_{out}$$

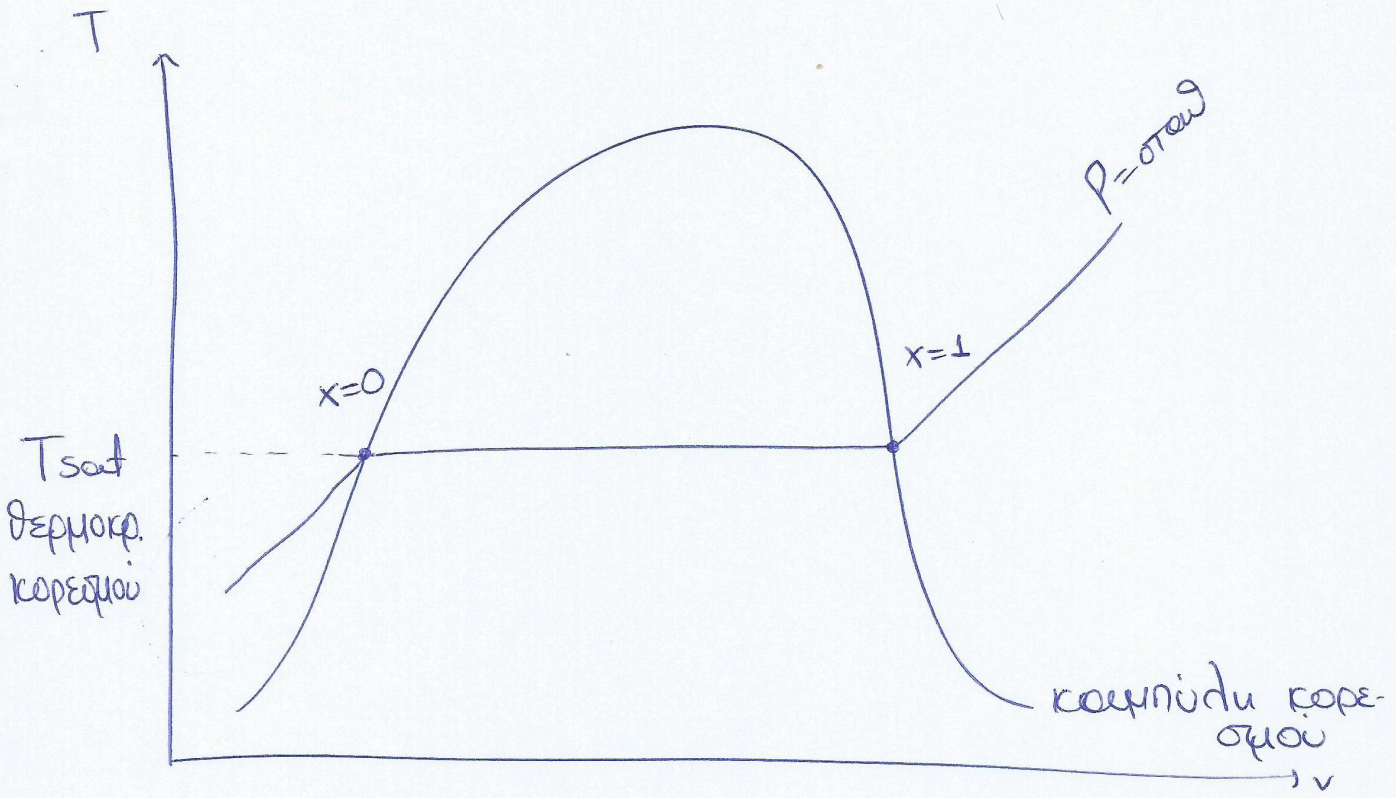
$$h_1 + \frac{U_1^2}{2} + g z_1 = w_{out} + h_2 + \frac{U_2^2}{2} + g z_2$$

$$w_{out} = -\Delta h - \Delta e_{κιν} - \Delta e_{συν}$$

$$w_{out} = 872.479\,kJ/kg$$

γ) $\dot{W}_{out} = \dot{m} w_{out} \Rightarrow \dot{m} = \frac{\dot{W}_{out}}{w_{out}} = \frac{5000\,\frac{kJ}{s}}{872.479\,\frac{kJ}{kg}} \Rightarrow \dot{m} = 5.73\,\frac{kg}{s}$

$\dot{W}_{out} = 5\,MW = 5000\,kW = 5000\,\frac{kJ}{s}$



$T < T_{sat}$: συμπιεσμένο υγρό (Α-4 / Α-5)

$T = T_{sat}$: κορεσμένο μίγμα (Α-4 / Α-5)

$T > T_{sat}$: υπέρθερμος ατμός (Α-6)

Μίγμα Ποιότητα $x = \dfrac{m_g}{m_f + m_g}$

fg : $g - f$
πχ. $h_{fg} = h_g - h_f$

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

$s = s_f + x\, s_{fg}$

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

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