TEST 1

DR. ORLANDO AYALA

MET 350

CAMERON MORTON

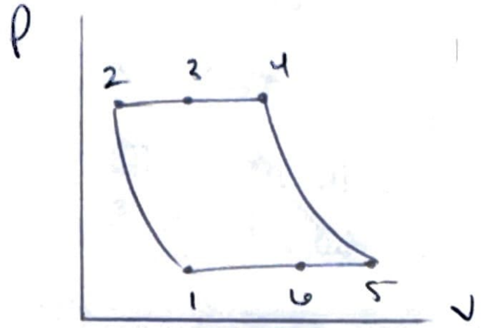
2/23/25

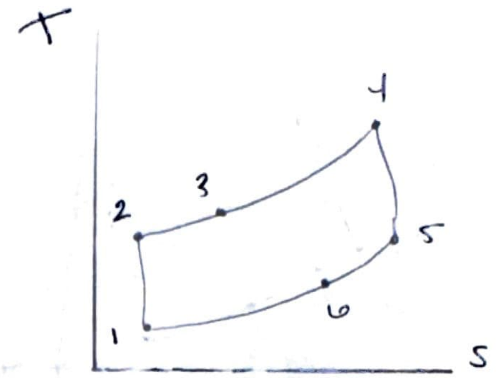
CMORT008@ODU.EDU

1. COLD AIR-STANDARD BRAYTON CYCLE $\quad \eta_T = 0.8 \quad k = 1.4$

$P_1 = 1\text{ BAR} \quad P_2 = 5\text{ BAR} \quad T_3 = 760K \quad T_4 = 1140K \quad P_5 = 1\text{ BAR}$

$T_1 = 310K$





$\xrightarrow{P = \text{CONST.}} 1 \xrightarrow{\text{ISENT.}} 2 \xrightarrow{P = \text{CONST}} 3 \xrightarrow{P = \text{CONST.}} 4 \xrightarrow{\text{ISENT.}} 5 \xrightarrow{P = \text{CONST.}} 6$

1	2	3	4	5	6
$P_1 = 100kPa$	$P_2 = 500kPa$	$P_3 = P_2$	$P_4 = P_3$	$P_5 = P_6$	$P_6 = 100kPa$
$T_1 = 310K$	$T_2 = $ —	$T_3 = 760K$	$T_4 = 1140K$	$T_5 = $ —	$T_6 = $ —
$h_1 = 310.24 \frac{kJ}{kg}$	$T_2 = T_1 \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}} = 490.98K$	$h_3 = 778.18$	$h_4 = 1207.57$		$h_6 = 538.962$
$P_{r_1} = 1.5546$	$h_2 = 493.747$	$P_{r3} = 39.27$	$P_{r4} = 193.1$		$P_{r6} = 10.721$
	$P_{r_2} = 7.882$				

$$\frac{T_4}{T_{5S}} = \left(\frac{P_4}{P_{5S}}\right)^{\frac{k-1}{k}} \rightarrow \frac{1140}{T_{5S}} = \left(\frac{5}{1}\right)^{\frac{k-1}{k}} = 719.78K$$

$h_{5S} = 734.583 \frac{kJ}{kg}$

$P_{r5S} = 31.984$

$$\eta_T = \frac{T_4 - T_5}{T_4 - T_{5S}} \rightarrow 0.8 = \frac{1140 - T_5}{1140 - 719.78}$$

$T_5 = 803.824K$

$h_5 = 826.162 \; kJ/kg$

$P_{r5} = 48.675$

$$(T_3 - T_2) = (T_5 - T_6) \rightarrow (760 - 490.98) = (803.824 - T_6)$$

$T_6 = 534.804K$

a) THERMAL EFFICIENCY

$\eta_{TH} = \frac{W_{NET}}{q_{IN}}$ $\rightarrow$ $q_{IN} = C_p(T_4 - T_3)$

$= 1.005(1140 - 760)$

$= 381.9 \text{ kJ/kg}$

$W_{NET} = W_T - W_C$

$= C_p(T_4 - T_5) - C_p(T_2 - T_1)$

$= 1.005(1140 - 803.824)$

$- 1.005(490.98 - 310)$

$W_{NET} = 155.97 \text{ kJ/kg}$

$= \frac{155.97}{381.9}$

$\boxed{\eta = 0.4084 \quad 40.84\%}$

EFFECTIVENESS, $\varepsilon = \frac{T_3 - T_2}{T_5 - T_2} = \frac{760 - 490.98}{803.824 - 490.98}$

$\boxed{= 0.8599 \quad 85.99\%}$

b) NET POWER (500W)

$\dot{m} \cdot W_{NET} = 500$

$\dot{m} = \frac{500}{W_{NET}} \rightarrow \frac{500}{155.97}$ $\boxed{3.206 \text{ kg/s}}$

c) EFFECTIVENESS @ 100%

$\frac{T_3 - T_2}{T_3 - T_2} = 1 \rightarrow T_3 = T_5 = 760K$

$\eta_{TH} = \frac{W_{NET}}{q_{IN}} = \frac{C_p(T_4 - T_5 - T_2 + T_1)}{C_p(T_4 - T_3)}$

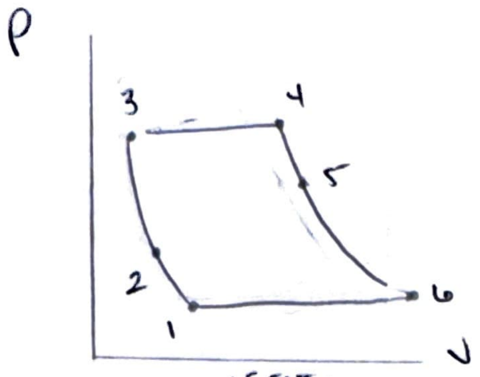
$\boxed{= 0.5237 \quad 52.37\%}$

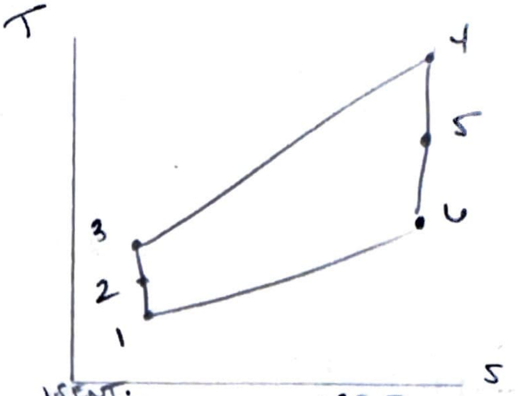
11. TURBOJET AIRCRAFT $\eta_c = 80\%$ $\quad W_{comp} = 500$ kJ/kg

$V = 900$ km/h $= 250$ m/s $\quad \eta_T = 90\%$ $\quad W_{TURB.} = 500$ kJ/kg

$T = -35°C \quad T_T = 950°C \quad v_1 = \dfrac{RT_1}{P_1} = 1.7077$ m³/kg

$P = 40$ kPa





P=CONST. → 1 $\xrightarrow{\text{ISENT.}}$ 2 $\xrightarrow{\eta_c = 0.8}$ 3 → P = CONST. → 3s → 4 $\xrightarrow{\eta_T = 0.95}$ 5 → 5s $\xrightarrow{\text{ISENT.}}$ 6

$V_1 = 900$ km/h	$P_3 = P_4$	$P_4 = P_3$		$P_6 = P_1$
$T_1 = 238$ K	$T_2 = 269.1$ K	$h_3 = 769.208$		$h_5 = 804.853$
$P_1 = 40$ kPa	$h_2 = 269.208$	$P_{r3} = 37.595$	$T_4 = 1223$ K	$T_5 = 784.401$ K
$h_1 = 238.02$	$P_{r2} = 0.948$	$T_3 = 751.788$	$h_4 = 1304.853$	$P_{r5} = 44.818$
$P_{r1} = 0.618$	$s_2 = 1.593$	$h_{3s} = 669.208$	$P_{r4} = 257.34$	$P_5 = \left(\dfrac{P_{r5}}{P_{r4}}\right) P_4$
$v_1 = 1.7077$ m³/kg		$P_{r3s} = 22.979$	$s_4 = 3.201$	$\boxed{= 256.174 \text{ kPa}}$
		$T_{3s} = 658.813$		

$$T_2 = T_1 + \frac{V_1^2}{2C_p}$$

$$238 + \frac{900}{2}\left|\frac{}{1.005}\right|\frac{1}{1}\left|\frac{1}{1000}\right|\frac{1000}{1}\left|\frac{1}{3600}\right|$$

$$= 269.1\text{K}$$

$$P_2 = \left(\frac{P_{r2}}{P_{r1}}\right) P_1 = \frac{0.948}{0.618}(40) = 61.36 \text{ kPa}$$

$W_{comp} = h_3 - h_2$

$h_3 = h_2 + W_{TURB.} \Rightarrow 500 + 269.208$
$= 769.208$

$$P_{3s} = \left(\frac{P_{r3s}}{P_{r2}}\right) P_2 \Rightarrow \left(\frac{22.979}{0.948}\right) 61.36 = 1487.33 \text{ kPa} = P_4 = P_3$$

$W_{TURB.} = h_4 - h_5 \Rightarrow 1304.853 - 500 = 804.853$

$\eta_T = \frac{h_4 - h_5}{h_4 - h_{5s}}$ $\rightarrow h_{5s} = \frac{-h_4 + h_5 + \eta_T (h_4)}{\eta_T}$

$h_{5s} = 749.3$

$T_{5s} = 727.85 K$

$P_{r5s} = 33.355$

$P_{r6} = \left(\frac{P_6}{P_5}\right) P_{r5} = 5.2082$

$T_6 = 437.03 K$

$h_6 = 438.588 \text{ kJ/kg}$

b) VELOCITY @ NOZZLE EXIT

$V_6 = \sqrt{2(h_5 - h_6)}$

$= 27.065 \text{ kJ/kg}$

$\rightarrow \boxed{855.893 \text{ m/s}}$

c) THRUST w/ 1.6m INLET

$F = \frac{V_1}{v_1}\left(\frac{\pi}{4}\right) D^2 (V_6 - V_1)$ $\rightarrow \frac{250}{1.7077}\left(\frac{\pi}{4}\right)(1.6m)^2 (V_6 - V_1)$

$\boxed{F = 178342.24 N}$

a) PRESSURE @ TURBINE EXIT

$\boxed{P_5 = 256.174 kPa}$