higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

AUGUST EXAMINATION

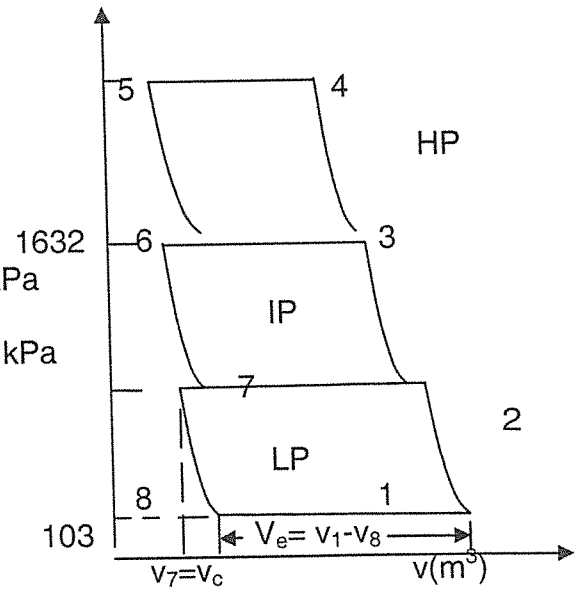
POWER MACHINES N6

28 July 2014

This marking guideline consists of 9 pages.

QUESTION 1

1.1.1 $k = \sqrt{\frac{P3}{P1}} = \sqrt{\frac{1632}{103}} = 3,98$



(3)

$P_2 = P_1 \times k = 103 \times 3,98 = 409,94$ kPa

$P_4 = P_3 \times k = 1632 \times 3,98 = 6495,36$ kPa

1.1.2 $V_1 = V_s + V_c = V_s + 0,04V_1$

$0,96\ V_1 = V_s$

$\therefore V_1 = \frac{0,0084}{0,96} = 0,00875\ m^3$

$V_C = 0,04\ V_1 = 0,04 \times 0,00875 = 0,00035\ m^3$

$V_8 = V_C(\frac{P7}{P8})^{\frac{1}{n}} = 0,00035(\frac{409,94}{103})^{\frac{1}{1,32}} = 0,00099\ m^3$

$\therefore V_e = V_1 - V_8 = 0,00875 - 0,00099 = 0,00776 m^3$ (6)

1.1.3 $P = \frac{xn}{n-1} P_1 V_e [(P_2/P_1)^{n-1/n} - 1] \times 2 \times \frac{N}{60}$

$= \frac{3 \times 1,32 \times 103 \times 0,00776}{0,32} [(\frac{409,94}{103})^{\frac{0,5}{1,32}} - 1] \times 2 \times \frac{340}{60}$

$= 44,586W$ (3)

1.1.4 $T_2 = T_1 (P_2/P_1)^{n-1/n} = 302\ (3,98)^{0,32/1,32} = 422,12\ K$ (2)

1.1.5 $Q_{intercooler} = mCp\ (T_2 - T_1) = \frac{336}{3600} \times 1,005\ (422,12 - 302)$

$= 11,267$ kJ/s (2)

1.1.6 $Q_{waterjacket} = \frac{P}{3} - Q_{intercooler} = \frac{41,34}{3} - 11,267 = 2,513$ kJ/s (2)

1.1.7 1.1.5 $\eta_{vol} = \frac{Ve}{Vs} \times 100\%$

$= \frac{0,00776}{0,0084} \times 100\%$

$= 92,4\ \%$ (2)
[20]

QUESTION 2

2.1.1 At 37, 7°C : $hfw1 = 158$ kJ/kg
At 99.6°C : $hfw_2 = 418$ kJ/kg

$Q_{econ} = \frac{ms}{mf}(hfw_2 - hfw_1) = \frac{7350}{750}(418 - 158) = 9,8\ (260)$
$= 2548$ kJ/kg (2)

2.1.2 At 3000 kPa : $hf = 1008$kJ/kg & $hfg = 1794$ kJ/kg

$Q_{evap} = \frac{ms}{mf}(hf - xhfg - hfw_2) = 9,8\ [1008 + 0,975\ (1794) - 418]$

$= 22923,67$kJ (2)

2.1.3 At 3000 kPa & 250°C: $hss = 2858$ kJ/kg

$Q_{sup} = \frac{ms}{mf}(hss - xhfg - hf) = 9,8\ [2858 - 0,975(1794) - 1008]$

$= 988,33$ kJ/kg (3)

2.1.4 $\eta = \frac{ms\ (hss - hfw1)}{mf \times Cv}$

$Cv = \frac{ms\ (hss - hfw_1)}{mf \times \eta} = \frac{9,8\ (2858 - 158)}{0,8} = \frac{9,8\ (2700)}{0,8}$

$= 33075$ kJ/kg (3)

2.1.5 $EE = \frac{ms(hss - hfw_1)}{mf \times 2257} = \frac{9,8\ (2858 - 158)}{2257} = \frac{9,8\ (2700)}{2257} = 11,724$ (2)

2.1.6 $Q_{econ} = mCp\ (t_{in} - t_{out})$

$t_{out} = t_{in} - \frac{Qecon}{mCp} = 353,33 - \frac{2548}{(18+1)1,045} = 353,33 - 128,33$

$= 225°C$ (3)

2.2

Q_{in} (kJ/kg)	Q_{out} (kJ/kg)		%
33 075	Economiser	2548	7,704
	Evaporator	22923,67	69,308
	Superheater	988,33	2,988
	Unaccounted	33075 – 26460 = 6615	20
33 075		33 075	100

(5)
[20]

QUESTION 3

3.1.1 $Vs = \frac{\pi}{4} D^2 L = \frac{\pi}{4} (0,07515)^2 \times 0,09018$

$= 0,0004\ m^3$

$BP = \frac{PLACE}{60} = \frac{1250 \times 0,0004 \times 4800 \times 4}{60 \times 2}$

$= 80\ kW$

$P_{im} = \frac{P_{bm}}{\eta} = \frac{1250}{0,8}$

$= 1562,5kPa$ (6)

3.1.2 $BP = \frac{2\pi TN}{60}$

$T = \frac{60 \times BP}{2\pi N} = \frac{60 \times 80 \times 10^3}{2 \times \pi \times 4800}$

$=159,155\ N.m$ (2)

3.1.3 $BSFC = \frac{mf/h}{BP}$

$mf/s = \frac{BSFC \times BP}{60 \times 60} = \frac{0,288 \times 80}{60 \times 60}$

$= 0,0064\ kg/s$

$\eta_B = \frac{BP}{mf/s \times CV} = \frac{80}{0,0064 \times 39062,5} \times 100\%$

$= 32\%$

$\eta_{IT} = \frac{\eta_{BT}}{\eta_m} = \frac{32}{0,8} = 40\%$ (6)

3.1.4 $r = \frac{vs+vc}{vc} = \frac{vs+0,05vs}{0,05vs} = \frac{1,05vs}{0,05vs} = 21$

$$A\,S\,E = [1 - (1/r)^{r-1}] \times 100\,\% = [1 - (1/21)^{0.41}] \times 100\%$$

$= 71{,}3\%$

$$\text{Ind. } \eta \text{ ratio} = \frac{\eta_{IT}}{ASE} \times 100\% = \frac{0{,}4}{0{,}713} \times 100\%$$

$= 56{,}1\ \%$ (6)
[20]

QUESTION 4

4.1.1 $Cc = \sqrt{2000\ Cp\ (T1 - T2)}$

$$T_1 = \frac{Cc2}{2000Cp} + Tc = \frac{398{,}801^{\ 2}}{2000X1{,}008} + 404,\ 11 = 78,\ 89 + 404,\ 11$$

$= 483K$

$$\frac{Pc}{p1} = \left(\frac{2}{\gamma+1}\right)^{\frac{\gamma}{\gamma-1}}$$

$$P_1 = P_c \left(\frac{\gamma+1}{2}\right)^{\frac{\gamma}{\gamma-1}} = 475{,}454\left(\frac{2{,}4}{2}\right)^{\frac{2{,}4}{0{,}4}} = 900kPa$$ (5)

4.1.2 $T'_c = T_1 \left(\frac{2}{\gamma+1}\right) = 483\left(\frac{2}{2{,}4}\right) = 402{,}5K$

$$A_c = \frac{mVc}{Cc}$$

$$V_c = \frac{Ac.Cc}{m} = \frac{1534{,}6 \times 10^{-6} x398{,}801x60}{150} = 0{,}2448\ m^3/kg$$

$$\eta = \left(1 - \frac{T1 - Tc}{T1 - T'c}\right) \times 100\%$$

$$= \left(1 - \frac{78{,}89}{80{,}5}\right) \times 100\% = 2\%$$ (6)

4.1.3 $$T2' = T_1\left(\frac{P2}{P1}\right)^{\frac{\gamma-1}{\gamma}} = 483\left(\frac{237{,}26}{900}\right)^{\frac{0{,}4}{1{,}4}} = 330K$$

$$T_2 = T_1 - \eta(T_1 - T2') = 483\text{-}0,\ 92(153)$$

$= 342{,}24K$

$$C_2 = \sqrt{2000\ Cp\ (T1 - T2)}$$

$$= \sqrt{2000x1{,}008\ (483 - 342{,}24)}$$

$= 532{,}703\ m/s$

$$A_2 = \frac{mV2}{C2} = \frac{150x0,4154x106}{60x532,703}$$

$$= 1949,492 \text{ mm}^2$$ (8)

4.1.4 $$\text{Mach no} = \frac{C2}{Cc} = \frac{532,703}{398,801} = 1,336$$ (1)

[20]

QUESTION 5

5.1.1 (5)

$V_S = \frac{\pi}{4} D^2 L = \frac{\pi}{4} (0, 187)^2 \times 0, 233$ $P_2=P_3$

$= 0, 0064 \text{ m}^3$

$V_s=V_1 - V_c = 17V_c - V_c$

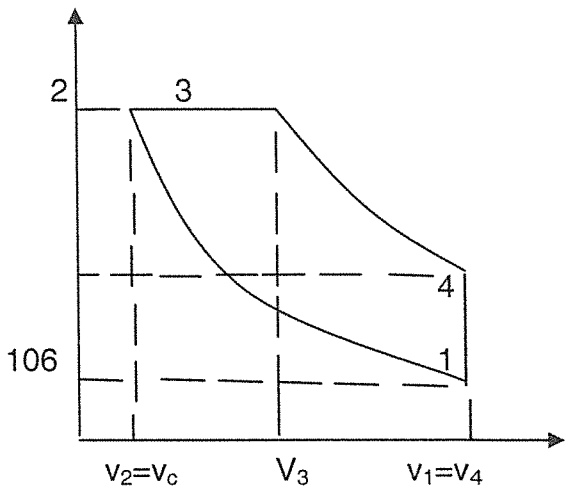
$V_s = 16V_c = 0, 0064$

$V_c=V_2= 0, 0064/16 = 0, 0004 \text{ m}^3$

$V_1=V_4 = 17V_c = 0, 0068 \text{ m}^3$

$V_3 = 10\%V_s + V_c$

$= 0, 1(0, 0064) + 0, 0004 = 0, 00104 \text{ m}^3$



5.1.2 $$P_2 = P_3 = P_1 \left(\frac{V1}{V2}\right)^n = 106(17)^{1,32} = 4461, 68 \text{ kPa}$$

$$T_2 = T_1\left(\frac{V1}{V2}\right)^{n-1} = 295,5(17)^{0,32} = 731,646 \text{ K}$$

$$T_3 = \frac{V3.T2}{V2} = \frac{0,00104x731,646}{0,0004} = 1902, 28 \text{ K}$$

$$P_4 = P_3\left(\frac{V3}{V4}\right)^n = 4461,68\left(\frac{0,00104}{0,0068}\right)^{1,32} = 374,171 \text{ kPa}$$

$$T_4 = T_3\left(\frac{V3}{V4}\right)^{n-1} = 1902, 28\left(\frac{0,00104}{0,0068}\right)^{0,32} = 1043,091 \text{ K}$$ (8)

5.1.3 $$m = \frac{P1.V1}{RT1} = \frac{106x0,0068}{0,287x295,5} = 0,0085 \text{ kg/cycle}$$

$$= 0, 0085 \times \frac{300}{60} = 0, 0425 \text{ kg/s}$$ (3)

5.1.4 $WD = mR[(T_3 - T_2) + \frac{T3-T4-T2+T1}{n-1}]$

$= 0,0425x0,287[(1902,28 - 731,646) + \frac{1902,28-1043,091-731,646+295,5}{0,32}]$

$= 0,0425x0,287[1170,634 + 1322,009]$

$= 30,404\ kW$ (4)

[20]

QUESTION 6

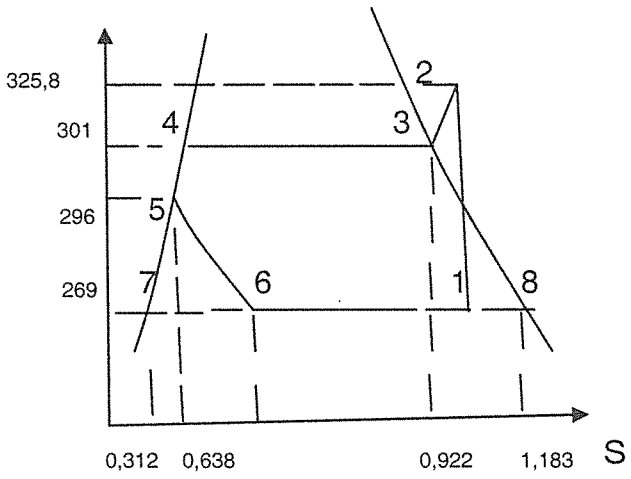
6.1.1 (5)

$S_2 = S_1 = S_3 + Cp.\ln\frac{T2}{T3}$

$= 0,922 + 2,5261.\ln\frac{325,8}{301}$

$= 1,122\ kJ/kg$

$x_1 = \frac{S1-S7}{S8-S7} = \frac{1,122-0,312}{1,183-0,312} = 0,93$



6.1.2 $h_1 = h_7 + x_1(h_8 - h_7)$

$= 81,4 + 0,93(318,6 - 81,4)$

$= 81,4 + 220,6$

$= 302\ kJ/kg$

$h_2 = hg + Cp(T_2 - T_3) = 263,8 + 2,5261(325,8 - 301)$

$= 263,8 + 62,447$

$= 326,447\ kJ/kg$

(6)

6.1.3 $h_6 = h_4 - Cp(T_4 - T_5) = 178,6 - 5,42(301 - 296)$

$= 178,6 - 27,1$

$= 151,5\ kJ/kg$

$RE = h_1 - h_6 = 302 - 151,5 = 150,5\ kJ/kg$

$WD = h_2 - h_1 = 326,447 - 302 = 24,447\ kJ/kg$

$COP = \frac{RE}{WD} = \frac{150,5}{24,447} = 6,156$

(7)

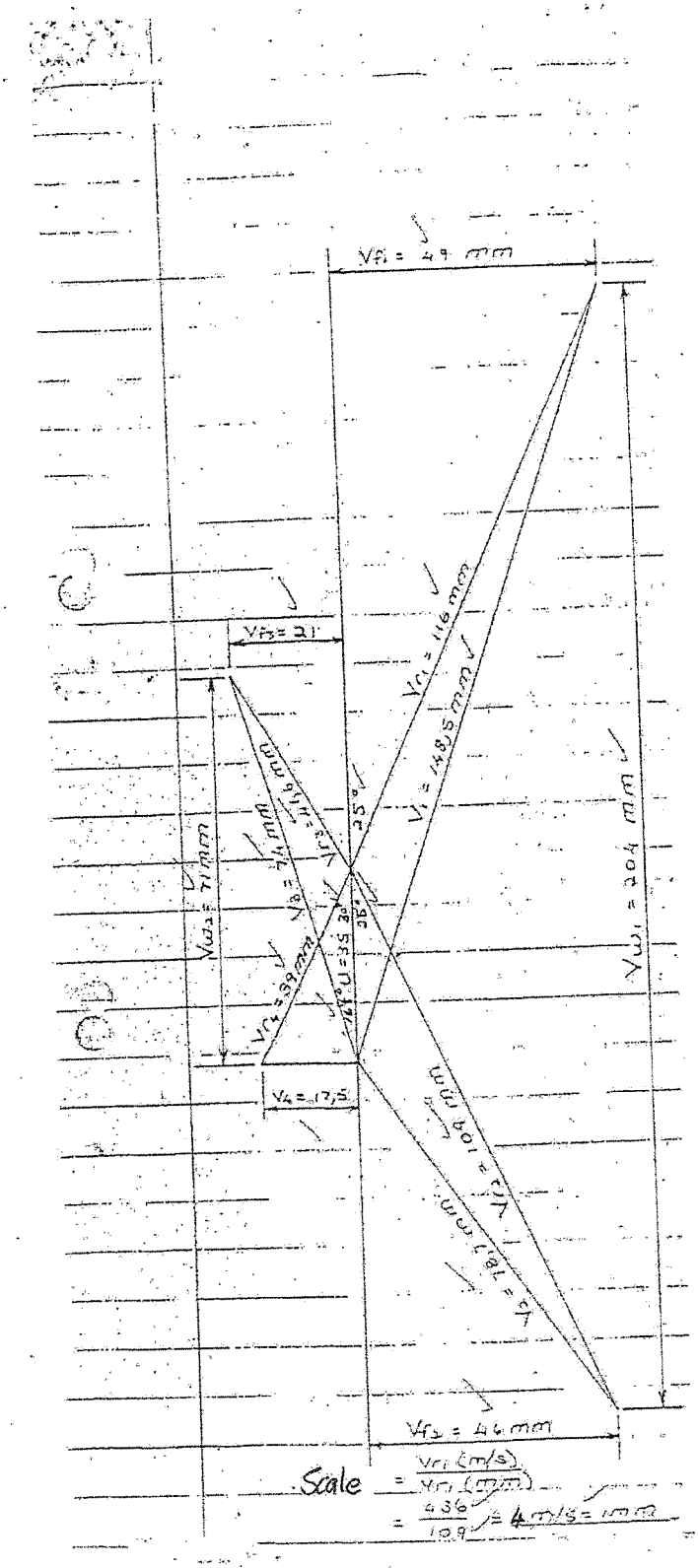
6.1.4 $Pm = \frac{mr(h2-h1)}{\eta}$

$= \frac{18(24,447)}{60x0,83}$

$= 8,836 \text{ kW}$ ⟶ (2)

[20]

QUESTION 7



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7.2 7.2.1 U = 35x4 = 140 m/s

7.2.2 V_1 = 148,5x4 = 594 m/s

7.2.3 V_2 = 78,7x4 = 314, 8 m/s

7.2.4 V_3 = 74x4 = 296 m/s

7.2.5 V_4 = 17,5x4 = 70 m/s

7.2.6 $\alpha 1$=19,3°

7.2.7 $P = mu (Vw_1 + Vw_2)$
$=1x140(204+71)\ x4$
$= 154$ kJ/kg

7.2.8 $\eta = 2UVw_T/V_1^2 \times 100\%$
$= 2x140x1100/594^2 \times 100\%$
$= 87,3\%$

(10)
[20]

TOTAL: 100