higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

NOVEMBER EXAMINATION

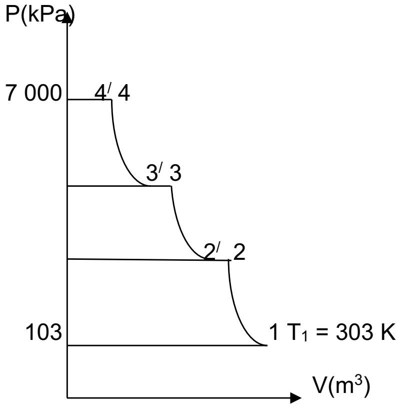
POWER MACHINES N6

18 NOVEMBER 2016

This marking guideline consists of 11 pages.

QUESTION 1

1.1



$$k = \sqrt[3]{\frac{P_4}{P_1}} = \sqrt[3]{\frac{7000}{103}} = 4{,}08$$

$$P_2 = kP_1 = 4{,}08x103 = 420{,}24kPa$$

$$P_3 = kP_2 = 4{,}08x420{,}24 = 1714{,}58.kPa$$

(6)

1.2

$$T_2 = T_1\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}}$$

$$= 303\left(\frac{420{,}24}{103}\right)^{\frac{0{,}3}{1{,}3}}$$

$$= 419{,}14.K$$

(3)

1.3

$$Q_{\text{int}} = mCp(T_2 - T_2')$$

$$= 1x1{,}005(419{,}14 - 303)$$

$$= 116{,}72kJ/kg$$

(3)

1.4

$$WD_{actual}/kg = RT_1\frac{xn}{n-1}\left[\left(\frac{P_4}{P_1}\right)^{\frac{n-1}{xn}} - 1\right]$$

$$= 0{,}287x303x\frac{3x1{,}3}{0{,}3}\left[\left(\frac{7000}{103}\right)^{\frac{0{,}3}{3x1{,}3}} - 1\right]$$

$$= 433{,}41KJ/kg$$

(4)

1.5

$$WD_{iso}/kg = RT_1 \ln\left(\frac{P_4}{P_1}\right)$$

$$= 0{,}287x303\ln\left(\frac{7000}{103}\right)$$

$$= 366{,}88.kJ/kg$$ (2)

$$\therefore \eta_{iso} = \frac{WD_{iso}}{WD_{act}} \times 100\%$$

$$= \frac{366{,}88}{433{,}41} x100\%$$

$$= 84{,}65\%$$ (2)

[20]

QUESTION 2

2.1 At 54°C : h_1 = 226 kJ/kg
[At superheat steam tables,1500 kPa and 350 °C] ; h_4 = 3 148 kJ/kg

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$$\eta = \frac{m_s(h_4 - h_1)}{m_f \times HV} x100\%$$

$$69{,}95 = \frac{m_s(3148 - 226)}{m_f \times 31000} x100$$

$$\frac{m_s}{m_f} = 7{,}421kg..steam/kg..fuel$$

$$EE = \frac{m_s(h_4 - h_1)}{m_f \times 2257}$$

$$= \frac{7{,}421(3148 - 226)}{2\,257}$$

$$= 9{,}608kg..steam/kg..fuel$$ (5)

2.2 $hfc = Cp_w.x.ta$

$= 4,2.x.29$

$= 121,8kJ/kg$

At P_{chim} = 100 kPa

$h_{suc} = hg + Cp_{suc}(t_{su} - t_s)$

$= 2676 + 2,75(260 - 99,6)$

$= 3117,1kJ/kg$

$Q_{moist} = m_m(h_{suc} - h_{fc})$

$= m_m(3117,1 - 121,8)$

$\therefore m_m = 0,577kg$ (7)

2.3 $Q_{dry} = m_{dry}.Cp_{ex}(T_{exh} - T_a)$

$5321 = m_{dry}x1,005(260 - 29)$

$\therefore m_{dry} = 22,92kg$

$m_{dry} = m_a + m_{combst} - m_m$

$22,92 = m_a + 0,92 - 0,577$

$\therefore m_a \quad 22,577kg$ (6)

2.4 $m_m = 9..x.\%.H_2$

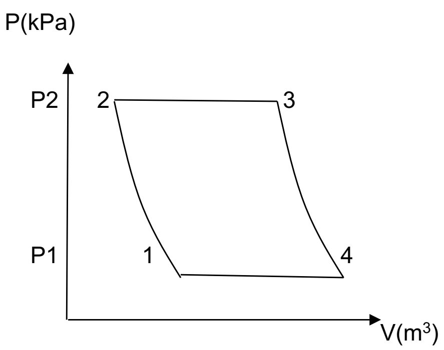
$0,577 = 9..x.\%H_2$

$\therefore H_2 = 6,4\%$ (2)

[20]

QUESTION 3

3.1



$$T_2' = T_1\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$$

$$= 299\left(\frac{830}{102}\right)^{\frac{0,4}{1,4}}$$

$$= 544,26.K$$

$$\eta_{comp} = \frac{T_2' - .T_1}{T_2 - T_1} x100\%$$

$$0,86 = \frac{544,26 - 299}{T_2 - 299}$$

$$\therefore T_2 = 584,19K$$

$$T_4' = T_3\left(\frac{P_4}{P_3}\right)^{\frac{\gamma-1}{\gamma}}$$

$$= 1097\left(\frac{102}{830}\right)^{\frac{0,4}{1,4}}$$

$$= 602,66K$$

$$\eta_{Turb} = \frac{T_3 - .T_4}{T_3 - T_4'} x100\%$$

$$0,79 = \frac{1097 - T_4}{1097 \quad - 602,66}$$

$$\therefore T_4 = 706,47K$$

(10)

3.2 $Q_{2-3} = mCp.(T_3 - T_2)$
$= 55x1,005(1097 - 584,19)$
$= 28345,57kJ/s$ (2)

3.3 $Q_{2-3} = m_f xHV$
$28345,57 = m_f x474000$
$\therefore m_f = 0,598kg/s$ (2)

3.4 $Q_{4-1} = mCp.(T_1 - T_4)$
$= 55x1,005(102 - 706,47)$
$= -33412,08kJ/s$ (2)

3.5
$$P = mR\left[(T_3 - T_2) - (T_4 - T_1) + \left(\frac{T_3 - T_4 - T_2 + T_1}{nc - 1}\right)\right]$$
$$= 55x0,288\left[(1097 - 584,19) - (706,47 - 299) + \left(\frac{1097 - 706,47 - 584,19 + 299}{0,4}\right)\right]$$
$$= 15,84[105,34 + 263,35]$$
$$= 5840,05kW$$
(4)
[20]

QUESTION 4

4.1 At superheated steam tables: 900 kPa and 200 °C : hsup = 2 835 kJ/kg = h1

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$$V_1 = \frac{n-1}{n}\left(\frac{h_1 - 1941}{P_1}\right)$$
$$= \frac{0,3}{1,3}\left(\frac{2835 - 1941}{900}\right)$$
$$\therefore V_1 = 0,2292m^3$$

$$A_1 = \frac{mV_1}{C_1}$$
$$400x10^{-6} = \frac{0,225x0,2292}{C_1}$$
$$\therefore C_1 = 128,93m/s$$
(4)

4.2

$$h_c = h_f . + x_c .hfg..@..450kPa$$
$$= 624 + 0,98x2120$$
$$\therefore h_c = 2701,6kJ/kg$$

$$Cc = \sqrt{2000(h_1 - hc)}$$
$$= \sqrt{2000(2835 - 2701,6)}. = 516,53m/s$$
$$V_C = \frac{n-1}{n}\left(\frac{hc \quad -1941}{P_C}\right)$$
$$= \frac{0,3}{1,3}\left(\frac{2701,6 - 1941}{450}\right)$$
$$\therefore V_C = 0,39005m^3$$
$$A_C = \frac{mV_C}{C_C}$$
$$= \frac{0,225x0,39005x10^6}{516,53}$$
$$\therefore A_C = 169,91mm^2$$

(6)
[20]

QUESTION 5

5.1

$$I.P = \frac{P_{IM} .LACE}{60}$$
$$120 = \frac{P_{IM} x0,09\left(\frac{\pi}{4}\right)x(0,095)^2 x2750x4}{60}$$
$$\therefore P_{IM} = 1026,03kPa$$
$$\eta_{mech} = \frac{BP}{IP}.x.100\%$$
$$= \frac{100}{120}x.100\%$$
$$= 83,33\%$$

(5)

5.2

$$Vs/\min = L.A.C.E$$
$$= 0,09x\frac{\pi}{4}(0,095).^2 x\frac{5500}{2}x4$$
$$\therefore Vs/\min = 7,0169m^3$$

$$Va/\min = \frac{m_a RT_a}{P_a} x.m_f/\min$$

$$= \frac{21x0,288x288}{101,3} x \frac{20}{60}$$

$$\therefore Va/\min = 5,7316m^3$$

$$\eta_{vol} = \frac{Va/\min}{Vs/\min}.x100\%$$

$$= \frac{5,7316}{7,0169} x100\%$$

$$= 81,68\%$$ (7)

5.3

$$F.P = mf/s.x.H.V$$

$$= \frac{20}{3600} x39000$$

$$= 216,84kW$$

$$\eta_{BT} = \frac{BP}{FP}.x100\%$$

$$= \frac{100}{216,84} x100\%$$

$$= 46,12\%$$ (4)

5.4

$$ASE = \left[1 - \left(\frac{1}{\Gamma}\right)^{\gamma-1}\right] x100\%$$

$$= \left[1 - \left(\frac{1}{9}\right)^{0,41}\right] x100\%$$

$$= 59,38\%$$ (2)

5.5

$$\eta_{Brake.eff.ratio} = \frac{\eta_{B.T}}{A.S.E}.x.100\%$$

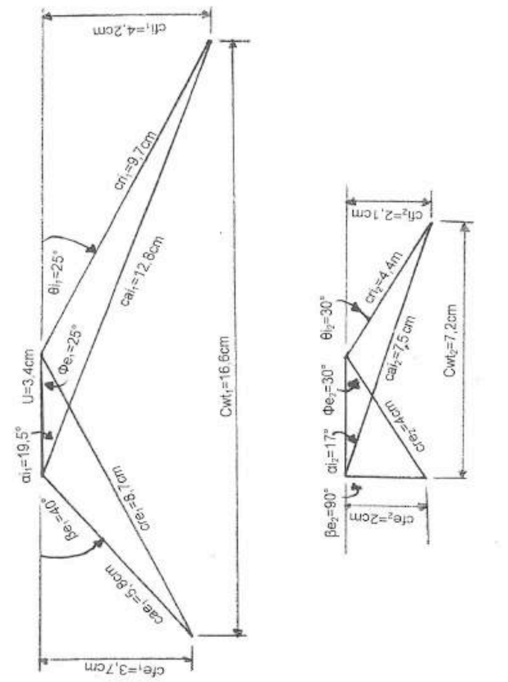
$$= \frac{46,12}{59,38} x.100\%$$

$$= 77,67\%$$ (2)

[20]

QUESTION 6

6.1



(14)

6.2 6.2.1

$$P = mu(.CwT_1 + CwT_2)$$
$$= \frac{2700}{60} x170(16{,}6 + 7{,}2)50$$
$$= 9{,}104 MW$$

(3)

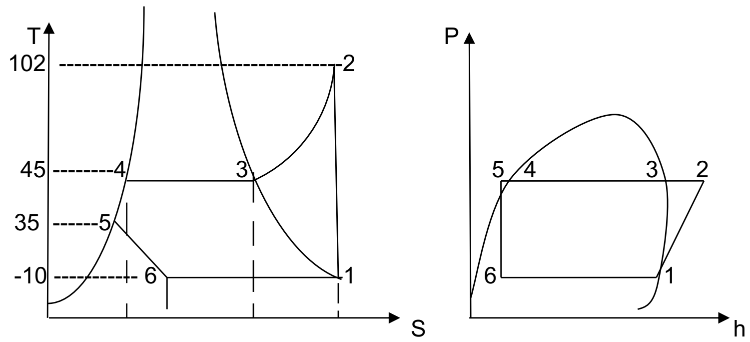
6.2.2

$$F_{axial} = m\Delta Cf_T$$
$$= \frac{2700}{60}\left[(4{,}2 - 3{,}7)50 + (2{,}1 - 2)50\right]$$
$$= 1350N$$

(3)
[20]

QUESTION 7

7.1



$S_2 = S_3 + C_P \ln\frac{T_2}{T_3}$

$1{,}762 = 1{,}587 + C_p \ln\frac{375}{318}$

$\therefore Cp = 1{,}061 kJ/kg.K$ (4)

7.2 $h_2 = h_3 + C_P(T_2 - T_3)$

$= 483{,}6 + 1{,}061(375 - 318)$

$\therefore h_2 = 544{,}1 kJ/kg.$

$h_5 = h_4 - C_{Pc}(T_4 - T_3)$

$= 133 - 1{,}62(318 - 308)$

$\therefore h_5 = 116{,}8 kJ/kg = h_6$

$C.O.P = \frac{h_1 - h_6}{h_2 - h_1}$

$= \frac{460{,}7 - 116{,}8}{544{,}1 - 460{,}7}$

$= 4{,}12$ (7)

7.3 $Ve = Vs x N x \eta_{vol}$

$= \frac{0{,}075\pi(0{,}08)^2 x.(500x60)x0{,}8}{4}$

$\therefore Ve = 9{,}0478 m^3/h$ (3)

7.4 $Mass.of.refrigerating.effect = \frac{.effective.volume}{Vg(at.177kPa)}$

$= \frac{9{,}0478}{0{,}233}$

$= 38{,}83 kg/h$ (3)

7.5 $Q_{water.refri} = m_{refri}.Cp_w.\Delta T$

$16592,63 = m_{refri}.x.4,187x15$

$\therefore m_{refri} = 264,19kg/h$

(3)

[20]

TOTAL: 100