higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

POWER MACHINES N5

12 AUGUST 2019

This marking guideline consists of 8 pages.

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NOTE: √ = ½ mark
✓ = 1 mark

QUESTION 1

1.1
- Oil firing
- Gas firing
- Coal/pulverised coal (3)

1.2
- The Edwards air pump
- The Hamilton pump OR rotary air pump OR rotating air pump (2)

1.3 The relationship between temperature and volume is directly proportional. (1)

1.4 Isochronism is the maintenance✓ of the equilibrium speed of a governor for every radius of ball rotation.✓

OR

A governor is isochronous if the equilibrium✓ speed is the same for every radius of ball rotation✓ (2)

Hunting means a governor cannot√ maintain√ a constant√ speed√. (2)
[10]

QUESTION 2

Adiabatic P_1 = 150 kPa

m = 0,245 kg R = 0,293 kJ/kg.K

P_2 = 800 kPa Cp = 1,005 kJ/kg.K

Density = 1,2 kg/m^3

2.1
$$R = C_p - C_V V$$
$$C_V = C_p - R$$
$$C_V = 1{,}005 - 0{,}293 \ \surd$$
$$C_V = 0{,}712 kJ/kg.K \surd$$
$$\gamma = \frac{C_p}{C_V}$$
$$\gamma = \frac{1{,}005}{0{,}712} \ \surd$$
$$\gamma = 1{,}4 \quad \checkmark$$
(3)

2.2

$$\rho = \frac{m}{V}$$

$$V_1 = \frac{m}{\rho} \checkmark$$

$$V_1 = \frac{0,245}{1,2} \quad \surd \quad \surd$$

$$V_1 = 0,204 m^3 \checkmark$$

$$P_1 V_1 = mRT_1$$

$$T_1 = \frac{P_1 V_1}{mR} \checkmark$$

$$T_1 = \frac{150 \times 0,204}{0,245 \times 0,293} \surd \surd$$

$$T_1 = 426,273 K \checkmark$$

(6)

2.3

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

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

$$= (426.,273)\left(\frac{800}{150}\right)^{\frac{1.4-1}{1.4}} \checkmark \checkmark$$

$$= 687,704 K \checkmark$$

(4)

2.4

$$W = \frac{mR(T_1 - T_2)}{\gamma - 1}$$

$$W = \frac{0,245 \times 0,293 (426,273 - 687,704)}{1,4 - 1} \checkmark \surd \surd$$

$$W = -46,917\ kJ \checkmark$$

OR

$$V_2 = \frac{mRT_2}{P_2}$$

$$V_2 = \frac{0,245 \times 0,293 \times 687,704}{800} \surd$$

$$V_2 = 0,0617 m^3 \surd$$

$$W = \frac{P_1 V_1 - P_2 V_2}{n - 1}$$

$$= \frac{(150 \times 0,204) - (800 \times 0,0617)}{1,4 - 1} \checkmark \checkmark$$

$$= -46,9\ kJ \checkmark$$

(4)

2.5 $\Delta U = -WD$
$= -(-46{,}917)$ ✓ ✓
$= 46{,}917\ kJ$ ✓

OR

$\Delta U = -WD$
$= -(-46{,}9)$ ✓ ✓
$= 46{,}9\ kJ$ ✓

OR

$\Delta U = mC_V(T_1 - T_2)$
$\Delta U = 0{,}245 \times 0{,}712(687{,}704 - 426{,}273)$ √ √ √
$= 45{,}6kJ$ ✓ (3)

[20]

QUESTION 3

3.1 $h_1 = 188\ kJ/kg$ ✓
$h_2 = h_f + xh_{fg}$
$= 885 + (0{,}85 \times 1910)$ √ √
$= 2508{,}5\ kJ/kg$ √
$h_3 = h_g + c_p(t_{ss} - t_s)$
$= 2795 + 2{,}1(250 - 207)$ √ √
$= 2885{,}3\ kJ/kg$ √
$EE = \dfrac{m_s(h_3 - h_1)}{m_f \times 2257}$
$\dfrac{m_s}{m_f} = \dfrac{EE \times 2257}{(h_3 - h_1)}$ ✓
$= \dfrac{12 \times 2257}{(2885{,}3 - 188)}$ √ √
$= 10{,}041 \dfrac{kg\ steam}{kg\ coal}$ ✓ (7)

3.2 $\eta = \dfrac{\dot{m}_s(h_3 - h_1)}{\dot{m}_f\, CV} \times 100$
$= \dfrac{10.041(2885.3 - 188)}{1 \times 32000} \times 100$ ✓ √ √ ✓
$= 84.67\%$ ✓ (5)

3.3

$$heat\ transferred_{economiser} = \frac{m_s}{m_f}(h_2 - h_1)$$
$$= \frac{10{,}041}{1}(2508{,}5 - 188)$$
$$= 23300{,}141\ kJ/kg$$

(4)

3.4

$$heat\ transferred_{superheater} = \frac{m_s}{m_f}(h_3 - h_2)$$
$$= \frac{10{,}041}{1}(2885{,}3 - 2508{,}3)$$
$$= 3785{,}457\ kJ/kg$$

(4)
[20]

QUESTION 4

4.1

$$P = (B_m - M_m)\frac{101{,}325}{760}$$
$$= (760 - 670)\frac{101{,}325}{760}$$
$$= 11{,}999\ kPa$$
$$\approx 12\ kPa$$

(2)

4.2

$h_c = 179\ kJ/kg\ at\ 42{,}7^oC$
$At\ P = 12\ kPa:$
$h_f = 207\ kJ/kg$
$h_{fg} = 2384\ kJ/kg$

heat emitted by steam = heat absorbed by water

$$h_1\ at\ 12\ kPa = h_2$$
$$100[207 + (0{,}95 \times 2384) - 179] = m \times 4{,}187 \times (40 - 21{,}1)$$
$$m = 2897{,}353\frac{kg}{\min} \times \frac{1\min}{60s}$$
$$m = 48{,}289\frac{kg}{s}$$

OR

Alternative Method :

$h_c = c_p(t_s - t_c)$ √

$= 4{,}187(49{,}5 - 42{,}7)$ √ ✓

$h_c = 28{,}472\ kJ/kg\ at\ 42{,}7^oC$

At $P = 12\ kPa$:

$h_{fg} = 2384 kJ/kg$ ✓

heat emitted by steam = heat absorbed by water

$h_1\ at\ 12\ kPa = h_2$

$100[(0{,}95 \times 2384) + 28{,}472] = m \times 4{,}187 \times (40 - 21{,}1)$ √ ✓ √ √

$m = 2897.949\ \frac{kg}{\min} \times \frac{1\min}{60s}$ √ √

$m = 48{,}299\ \frac{kg}{s}$ ✓ (7)

4.3 $At\ t_c = 42{,}7^oC,\ P_s = 8{,}5\ kPa$

$P_T = P_a + P_s$ √

$P_a = 11{,}999 - 8{,}5$

$P_a = 3{,}499\ kPa$ ✓

$T_a = 273 + 38$

$T_a = 311\ K$ √

$P_aV_a = mRT_a$

$m_a = \frac{P_qV_a}{RT_a}$ ✓

$m_a = \frac{3{,}499 \times 2}{0{,}287 \times 311}$ √ √

$m_a = 0{,}078\ kg$ ✓ (5)

4.4 $P_aV_a = mRT_a$

$m_a = \frac{P_aV_a}{RT_a}$ ✓

$m_a = \frac{3{,}499 \times 2{,}5}{0{,}287 \times 311}$ ✓ √ √

$m_a = 0{,}098\ kg$ ✓ (4)

4.5 $\Delta m = 0{,}098 - 0{,}078$

$m_a = 0{,}02\ kg$ ✓ ✓ (2)

[20]

QUESTION 5

5.1
$$U = \pi DN$$
$$= \pi \times 0.445 \times \frac{6500}{60}$$
$$= 151,45\ m/s$$
(3)

5.2 See ANSWER SHEET (attached). (10)

5.3 5.3.1 $Cae = 105\ m/s$

5.3.2 $\phi = 35^{o}$

(2 × 1) (2)
[15]

QUESTION 6

6.1
$$C_xH_y + \left(x + \frac{y}{4}\right)O_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$$
$$C_4H_{10} + (4 + \frac{10}{4})\,O_2 \rightarrow 4\,CO_2 + 5\,H_2O$$
$$[(12 \times 4) + (10 \times 1)] + [(6.5 \times 2 \times 16)] \rightarrow [(4 \times 12) + (4 \times 2 \times 16)] + [(5 \times 2 \times 1) + (5 \times 16)]$$
$$58 + 208 \rightarrow 176 + 90$$
$$\frac{58}{58} + \frac{208}{58} \rightarrow \frac{176}{58} + \frac{90}{58}$$
$$1 + 3,586 \rightarrow 3,034 + 1,552$$

$$m = \frac{100}{23}[3,586]$$
$$= 15,591\ kg\ air/kg\ fuel$$
$$= 15,591 \times \frac{135}{100}$$
$$= 21,048\ kg\ air/kg\ fuel$$
(7)

6.2 *Mass of the products*:

$CO_2 = 3,034\ kg\ CO_2/kg\ fuel$

$H_2O = 1,552\ kg\ H_2O/kg\ fuel$

$O_2 = \frac{35}{100} \times 3,586$

$= 1,255\ kg\ O_2/kg\ fuel$

$Or\ O_2 = \left(\frac{23}{100} \times 21,048\right) - 3,586$

$= 1,255\ kg\ O_2/kg\ fuel$

$N_2 = \frac{77}{100} \times 21,048$

$= 16,207\ kg\ N_2/kg\ fuel$

$Total = 22,048\ kg\ products/kg\ fuel$

Percentages of the products:

$CO_2 = \frac{3,034}{22,048} \times 100 = 13.8\ \%$

$H_2O = \frac{1,552}{22,048} \times 100 = 7\ \%$

$O_2 = \frac{1,255}{22,048} \times 100 = 5,7\ \%$

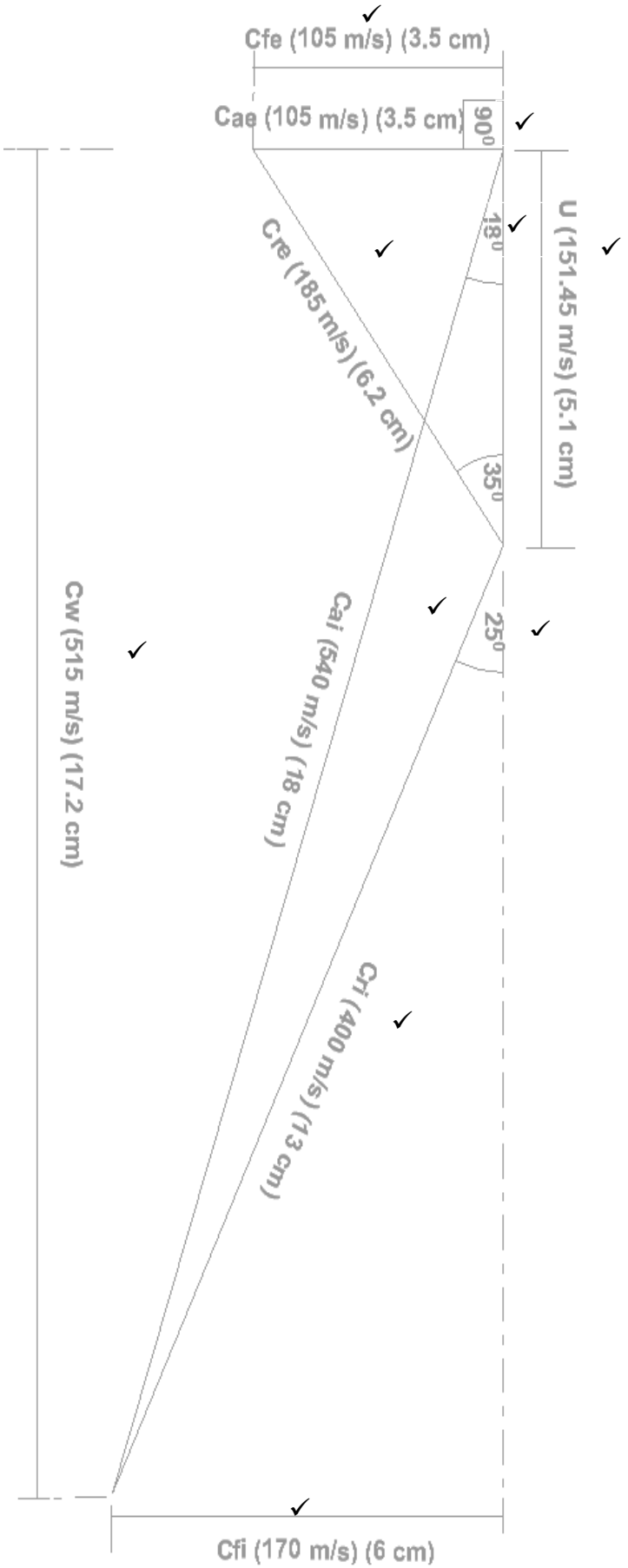
$N_2 = \frac{16,207}{22,048} \times 100 = 73,5\ \%$

$Total = 100\ \%$

(8)
[15]

ANSWER SHEET

QUESTION 5.2



TOTAL: 100

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