higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

APRIL EXAMINATION

POWER MACHINES N5

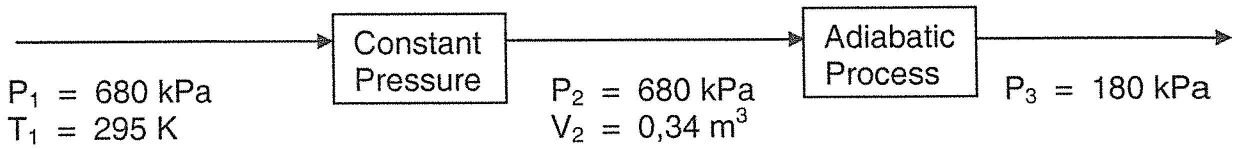
8 APRIL 2014

This marking guideline consists of 9 pages.

QUESTION 1

Given:

$m = 2{,}682\ kg$ $C_p = 1{,}05\ kJ/kg.K$ $C_v = 0{,}779\ kJ/kg.K$



1.1

$$R = C_p - C_v \quad ✓$$
$$= 1{,}05 - 0{,}779 \quad ✓$$
$$= 0{,}271\, kJ/kg.K$$

$$P_1V_1 = MRT_1$$
$$V_1 = \frac{MRT_1}{P} \quad ✓$$
$$= \frac{2{,}682 \times 0{,}271 \times 295}{680} \quad ✓$$
$$= 0{,}31531\, m^3 \quad ✓$$

$$\gamma = \frac{C_p}{C_v} \quad ✓$$
$$= \frac{1{,}05}{0{,}779}$$
$$= 1{,}35 \quad ✓$$

$$P_2V_2^{\gamma} = P_3V_3^{\gamma}$$
$$V_3^{\gamma} = V_2^{\gamma} \times \frac{P_2}{P_3} \quad ✓$$
$$V_3 = V_1\left(\frac{P_2}{P_3}\right)^{\frac{1}{\gamma}}$$
$$= 0{,}31531\left(\frac{680}{180}\right)^{\frac{1}{1{,}35}} \quad ✓$$
$$= 0{,}84396\, m^3 \quad ✓$$

(10)

1.2

$$P_2V_2 = MRT_2$$

$$T_2 = \frac{P_2V_2}{MR} \checkmark$$

$$= \frac{680 \times 0{,}34}{2{,}682 \times 0{,}271} \checkmark$$

$$= 318{,}1\,K \checkmark$$

or

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \checkmark$$

$$T_2 = \frac{V_2 \times T_1}{V_1}$$

$$= \frac{0{,}34 \times 295}{0{,}31531} \checkmark$$

$$= 318{,}1\,K \checkmark$$

$$P_3V_3 = MRT_3$$

$$T_3 = \frac{P_3V_3}{MR} \checkmark$$

$$= \frac{180 \times 0{,}84396}{2{,}682 \times 0{,}271} \checkmark \checkmark$$

$$= 209\,K$$

or

$$\frac{P_2V_2}{T_2} = \frac{P_3V_3}{T_3} \checkmark$$

$$T_3 = \frac{P_3V_3T_2}{P_2V_2}$$

$$= \frac{180 \times 0{,}84396 \times 318{,}1}{680 \times 0{,}34} \checkmark$$

$$= 209\,K \checkmark$$

(6)

1.3

$$WD = P_1(V_2 - V_1) + \frac{P_2V_2 - P_3V_3}{\gamma - 1} \checkmark \checkmark$$

$$= \{680(0{,}34 - 0{,}31531)\} + \left\{\frac{(680 \times 0{,}34) - (180 \times 0{,}84396)}{1{,}35 - 1}\right\} \checkmark$$

$$= 16{,}7892 + 226{,}53486$$

$$= 243{,}324\,kJ \checkmark$$

(4)

[20]

QUESTION 2

Given:

V_c = 6,5% | P_1 = 100 kPa | T_1 = 296 K
P_2 = 778 kPa | N = 300 r/min | Stroke:Dia = 1,6
M = 46 kg/min | η = 75% | R = 0,286 kJ/kg.K
n = 1,37

2.1

$$V_1 = V_s + 0{,}065V_s$$
$$= 1{,}065V_s \checkmark$$

$$V_3 = 0{,}065V_s \checkmark$$

$$V_4 = V_3\left(\frac{P_3}{P_4}\right)^{\frac{1}{1,37}} \quad OR \quad \eta_{vol} = \checkmark 1-\alpha\left[\left(\frac{P_2}{P_1}\right)^{\frac{1}{n}} -1\right]\times\frac{100}{1} \checkmark$$

$$= 0{,}065V_s\left(\frac{778}{100}\right)^{\frac{1}{1,37}} \quad = 1-\overset{\checkmark}{0{,}065}\left[\left(\frac{778}{100}\right)^{\frac{1}{1,37}} \overset{\checkmark}{-1}\right]\times\frac{100}{1} \checkmark$$

$$= 0{,}2906V_s \checkmark \quad = 77{,}44\% \checkmark$$

$$\eta_{vol} = \frac{V_1 - V_4}{V_1 - V_3}\times\frac{100}{1} \checkmark$$

$$= \frac{1{,}065V_s - 0{,}2906V_s}{1{,}065V_s - 0{,}065V_s}\times\frac{100}{1} \checkmark$$

$$= 77{,}44\% \checkmark$$

(6)

2.2

$$P_1V_1 = MRT_1$$

$$V_1 = \frac{MRT_1}{P_1} \checkmark$$

$$= \frac{46 \times 0{,}286 \times 296}{100} \checkmark$$

$$= 38{,}942\, m^3 / \text{min} \checkmark$$

$$Vol/\text{min} = V_1 - V_4 \checkmark$$

$$\frac{38{,}942}{300} = 1{,}065V_s - 0{,}2906V_s$$

$$0{,}7744V_s = 0{,}1298 \checkmark$$

$$V_s = \frac{0{,}1298}{0{,}7744}$$

$$= 0{,}16761 m^3 \checkmark$$

$$V_s = \frac{\pi}{4} \times D^2 \times 1{,}6D \checkmark$$

$$D = \sqrt[3]{\frac{0{,}16761 \times 4}{\pi \times 1{,}6}} \checkmark$$

$$= 0{,}511 M$$

$$= 511 mm \checkmark$$

$$\therefore Stroke = 1{,}6 \times 511$$

$$= 817{,}6 mm \checkmark$$

(10)

2.3

$$P = P_1V_e\left(\frac{n}{n-1}\right)\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right] \checkmark$$

$$= 100 \times 0{,}1298\left(\frac{1{,}37}{1{,}37-1}\right)\left[\left(\frac{778}{100}\right)^{\frac{1{,}37-1}{1{,}37}} - 1\right] \checkmark$$

$$= 35{,}58 \times \frac{300}{60} \times \frac{100}{75} \checkmark$$

$$= 237{,}2\, kW \checkmark$$

(4)

[20]

QUESTION 3

3.1 Given:

Excess Air = 50% N_2 = 12% V = 1 m^3

H_2 = 43% CH_4 = 23% C_o = 22%

3.1.1

SYMBOL	%	Vol in m^3	Formula	O_2 Reqd in m^3 ✓ ✓	CO_2 Produced
H_2	43	0,43	$2H_2+O_2=2H_2O$	0,43x0,5=0,215 ✓	nil ✓
CH_4	23	0,23	$CH_4+2O_2=CO_2+2H_2O$	0,23x2=0,46 ✓	0,23x1=0,23 ✓
CO	22	0,22	$2CO+O_2=2CO_2$	0,22x0,5=0,11 ✓	0,22x1=0,22 ✓
N_2	12	0,12	nil	nil	nil
TOTAL	100	1 m^3		0,785 ✓	0,45

Volume of oxygen reqd. = 0,785 m^3 (From Table Above) (6)

3.1.2

$$Vol\ of\ air\ reqd\ with\ 50\%\ excess\ air = 0{,}785\times\frac{100}{21}\times\frac{150}{100} \checkmark$$
$$= 5{,}607\,m^3 \checkmark$$

(2)

3.1.3 Volume of dry products of combustion:

$$CO_2 = 0{,}45\,m^3\ (From\ Tables) \checkmark$$

$$Excess\ O_2 = 5{,}607\times\frac{21}{100} - O_2\ in\ Fuel \checkmark$$
$$= \left(5{,}607\times\frac{21}{100}\right) - 0{,}785 \checkmark$$
$$= 0{,}392\,m^3 \checkmark$$

$$N_2 = 5{,}607\times\frac{79}{100} + N_2\ in\ Fuel \checkmark$$
$$= 4{,}43 + 0{,}12 \checkmark$$
$$= 4{,}55\,m^3 \checkmark$$

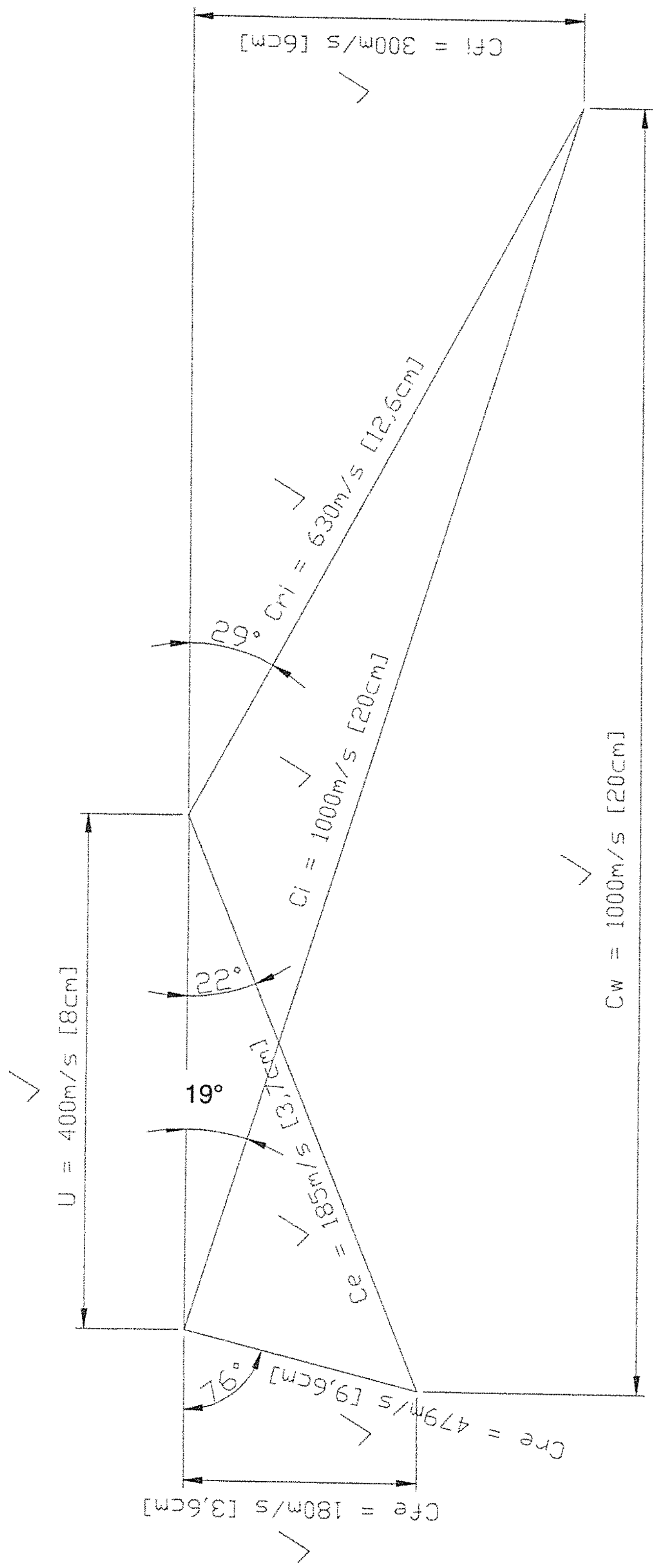
(10)

3.2 The Edwards air pump ✓
The Rotary air pump ✓

(2)
[20]

QUESTION 4

4.1 4.1.1



(8)

4.1.2 A 29° ✓ (1)

B $P = M \times V_w \times U$ ✓
$= 5 \times 1\,000 \times 400$ ✓
$= 2$ MW ✓ (3)

C
$$\eta = \frac{2 \times U \times V_w}{V_1^2} \times \frac{100}{1} \checkmark$$
$$= \frac{2 \times 400 \times 1000}{1000^2} \times \frac{100}{1} \checkmark$$
$$= 80\,\% \checkmark$$
(3)

D 76° ✓ (1)

4.2
- Fuel is expensive, and inefficient combustion means expensive wastage. ✓
- Inefficient combustion results in pollution of the atmosphere with noxious gases.✓ (2)

4.3
- Watt Governor ✓
- Porter Governor ✓
- Proell Governor ✓

(Any 2 × 1) (2)
[20]

QUESTION 5

5.1
$$\textit{Enthalpy before Throttling } (@\ 2000\ kPa) \checkmark = \textit{Enthalpy after Throttling } (@\ 200\ kPa) \checkmark$$
$$hf + x_2 hfg = hg + C_p(t_{su} - t_s)$$
$$x_2 = \frac{hg + C_p(t_{su} - t_s) - hf}{hfg} \checkmark$$
$$= \frac{2707 + 2{,}09(140 - 120{,}2) - 908}{1889} \checkmark$$
$$x_2 = 0{,}974 \checkmark$$

$$x = x_1 \times x_2$$
$$x_1 = \frac{x}{x_2} \checkmark$$
$$= \frac{0{,}958}{0{,}974} \checkmark$$
$$= 0{,}984 \checkmark$$
(8)

5.2 Given:

$\eta = 73\%$ $M_s = 5500\,kg/hour$

$t_{su} = 350^o C$ $P = 4000\,kPa$

$t_w = 39^o C$ $C_v = 35\,MJ/kg$

5.2.1

$h_1 = 163\,kJ\,(@\,39^o C)$ ✓

$h_2 = 3094\,kJ/kg\,(@\,350^o C\,\&\,4000\,kPa)$ ✓

$$\eta = \frac{M_s(h_2 - h_1)}{mf \times Cv} \times \frac{100}{1} \quad ✓$$

$$mf = \frac{M_s(h_2 - h_1)}{Cv \times \eta} \times \frac{100}{1}$$

$$= \frac{5500(3094 - 163)}{35 \times 10^3 \times 73} \times \frac{100}{1} \quad ✓$$

$$= 630{,}94\,kg/hour \quad ✓$$

$$\therefore mf/\min = \frac{630{,}94}{60} \quad ✓$$

$$= 10{,}52\,kg/\min \quad ✓$$

(7)

5.2.2

$$EE = \frac{M_s(h_2 - h_1)}{mf \times 2257} \quad ✓$$

$$= \frac{5500(3094 - 163)}{630{,}94 \times 2257} \quad ✓$$

$$= 11{,}32 \quad ✓$$

(3)

5.3
- A higher calorific value ✓
- A lower calorific value ✓

(2)
[20]

TOTAL: 100