higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE (VOCATIONAL)

APRIL EXAMINATION

POWER MACHINES N5

14 APRIL 2015

This marking guideline consists of 9 pages.

QUESTION 1

1.1 1.1.1

$$HCV = \frac{(M_w + W_e)C_p \times \Delta t}{M_f} \quad ✓$$

$$= \frac{(2{,}464 + 0{,}327)4{,}2 \times (20{,}69 - 18{,}5)}{7 \times 10^{-4}} \quad ✓$$

$$= 36673{,}74\, kJ/kg \quad ✓$$

$$= \boxed{36{,}67\, MJ/kg} \quad ✓$$

(4)

1.1.2

$$LCV = HCV \times (100\% - 13{,}7\%) \quad ✓$$

$$= 36{,}67 \times 86{,}3\% \quad ✓$$

$$= 31{,}646\, MJ/kg$$

$$= \boxed{31{,}65\, MJ/kg} \quad ✓$$

(3)

1.1.3

$$LCV = HCV - \left(hfg \times 9 \times \frac{H_2}{100}\right)$$

$$H_2 = \frac{HCV - LCV}{hfg \times 9} \times \frac{100}{1} \quad ✓$$

$$= \frac{36{,}67 - 31{,}65}{2{,}453 \times 9} \times \frac{100}{1} \quad ✓$$

$$= 0{,}22738 \times \frac{100}{1}$$

$$= \boxed{22{,}74\%} \quad ✓$$

(3)

1.2 1.2.1

$$Mass\ of\ air = \frac{100}{23}\left[\frac{8}{3}C + 8H_2 + S - O_2\right] \quad ✓$$

$$= \frac{100}{23}\left[\left(\frac{8}{3} \times 0{,}86\right) + (8 \times 0{,}07) - 0{,}07\right] \quad ✓$$

$$= 12{,}1\, kg/kg\ fuel \quad ✓$$

$$\therefore Total\ mass = 12{,}1 \times 12$$

$$= \boxed{145{,}2\, kg} \quad ✓$$

(4)

1.2.2

$$\text{HCV} = (\text{HV}_c \times \text{C}) + \ \text{HV}_{\text{H2}}\ \ \text{H}_2\ \ \frac{\text{O}_2}{8}\ \ + (\text{HV}_s \times \text{S}) \quad ✓$$

$$= (35 \times 0{,}86) + \ 144\ \ 0{,}07\ \ \frac{0{,}07}{8} \quad ✓$$

$$= \boxed{38{,}92\, \text{MJ}} \quad ✓$$

(3)

1.2.3

$$\begin{aligned} LCV &= HCV \quad (hfg \times 9 \times H_2) \quad \checkmark \\ &= 38{,}92 \quad (2{,}424 \times 9 \times 0{,}07) \quad \checkmark \\ &= \boxed{37{,}393\,MJ/kg} \quad \checkmark \end{aligned}$$

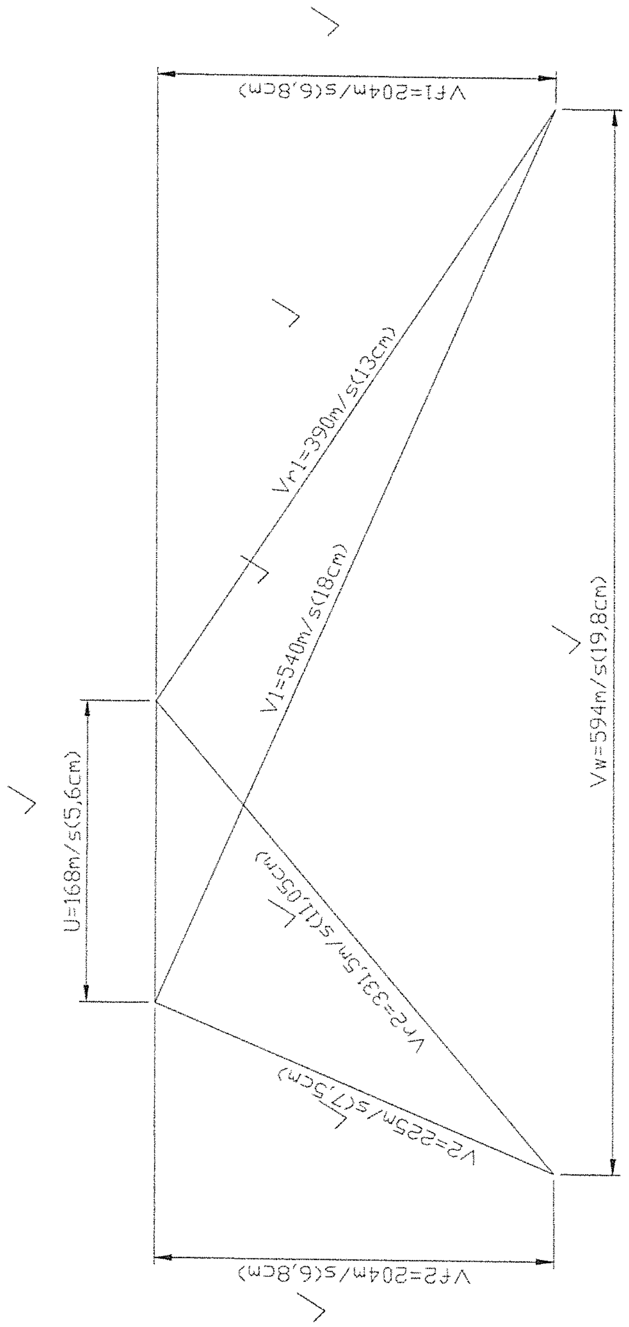
(3)
[20]

QUESTION 2

2.1

$$U = \pi \times D \times N \checkmark$$
$$= \frac{\pi \times 0{,}46 \times 6976}{60} \checkmark$$
$$= 168\,m/s \checkmark$$

$$Vr_2 = Vr_1 \times K \checkmark$$
$$= 390 \times 0.85 \checkmark$$
$$= 331{,}5\,m/s \checkmark$$



(14)

2.2 2.2.1

$$P = MUV_w \checkmark$$
$$= 1 \times 168 \times 594 \checkmark$$
$$= 99792\,W$$
$$= \boxed{99{,}792\,kW} \checkmark$$

(3)

2.2.2

$$KE = \frac{1}{2}MV^2 \checkmark$$
$$= 0{,}5 \times 1 \times 225^2 \checkmark$$
$$= 25312{,}5\,W/kg$$
$$= \boxed{25{,}313\,kW/kg} \checkmark$$

(3)
[20]

QUESTION 3

3.1 Given:

V_{air} = 18,5m³/min
P_1 = 110 kPa
N = 400 r/min
n = 1,35

Double-Acting
T_1 = 295K
P_2 = 820 kPa
V_c = $0{,}07S_v$

3.1.1

$$V_1 = V_3 + S_v \checkmark$$
$$= 0{,}07S_v + S_v$$
$$V_1 = 1{,}07S_v \quad \langle 1 \rangle \checkmark$$

$$V_4 = V_3 \left(\frac{P_2}{P_1}\right)^{\frac{1}{n}} \checkmark$$
$$= 0{,}07S_v \left(\frac{820}{110}\right)^{\frac{1}{1{,}35}}$$
$$= 0{,}31S_v \checkmark \langle 2 \rangle$$

$$V_1 \quad V_4 = 18{,}5\,m^3/min \checkmark$$
$$1{,}07S_v \quad 0{,}31S_v = 18{,}5 \checkmark$$
$$0{,}76S_v = 18{,}5 \checkmark$$
$$S_v/min = 24{,}3421\,m^3/min \checkmark$$
$$\therefore S_v = \frac{24{,}3421}{400 \times 2} \checkmark$$
$$= \boxed{0{,}030428\,m^3} \checkmark$$

(10)

3.1.2

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

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

$$= 295\left(\frac{820}{110}\right)^{\frac{1,35-1}{1,35}} \checkmark$$

$$= \boxed{496,6\,K} \checkmark$$

(3)

3.1.3

$$P = P_1V_1\frac{n}{n-1}\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right] \checkmark$$

$$= 110\times\frac{18,5}{60}\times\left(\frac{1,35}{1,35-1}\right)\times\left[\left(\frac{820}{110}\right)^{\frac{1,35-1}{1,35}} - 1\right] \checkmark$$

$$= \boxed{89,4\,kW} \checkmark$$

(3)

3.2 Dalton's law of partial pressure states that the pressure of a mixture of gases ✓ equals the sum of the partial pressures of each individual gas at the same temperature, in the container. ✓ (2)

3.3 Axial – flow turbines ✓

Radial – flow turbines ✓

(2)
[20]

QUESTION 4

Given:

$P_2 = 655\,kPa$ $PV^n = C$ $V_1 = 0{,}114\,m^3$

$P_1 = 110\,kPa$ $T_1 = 373K$ $V_2 = \frac{1}{4}\,of\,V_1$

$Cv = 0{,}754\,kJ/kg.K$ $Cp = 1{,}05\,kJ/kg.K$

4.1

$$R = Cp - Cv \checkmark$$
$$= 1{,}05 - 0{,}754 \checkmark$$
$$= 0{,}296\,kJ/kg.K \checkmark$$

$$P_1V_1 = MRT_1$$
$$M = \frac{P_1V_1}{RT_1} \checkmark$$
$$= \frac{110 \times 0{,}114}{0{,}296 \times 373} \checkmark$$
$$= \boxed{0{,}1136\,kg} \checkmark$$

(6)

4.2

$$V_2 = \frac{1}{4}\,of\,V_1 \checkmark$$
$$= 0{,}25 \times 0{,}114$$
$$= 0{,}0285\,m^3 \checkmark$$

$$P_1V_1^n = P_2V_2^n$$
$$\left(\frac{V_1}{V_2}\right)^n = \frac{P_2}{P_1} \checkmark$$
$$n\ln\frac{V_1}{V_2} = \ln\frac{P_2}{P_1} \checkmark$$
$$\therefore n = \frac{\ln\left(\frac{P_2}{P_1}\right)}{\ln\left(\frac{V_1}{V_2}\right)} \checkmark$$
$$= \frac{\ln\left(\frac{655}{110}\right)}{\ln\left(\frac{0{,}114}{0{,}0285}\right)} \checkmark$$
$$= \frac{1{,}78415}{1{,}38629}$$
$$= \boxed{1{,}287} \checkmark$$

(7)

4.3 $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ ✓

$T_2 = \frac{P_2V_2T_1}{P_1V_1}$

$= \frac{655\times0{,}0285\times373}{110\times0{,}114}$ ✓

$= \boxed{555{,}26\,K}$ ✓

or

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

$= 373\left(\frac{655}{110}\right)^{\frac{1{,}287-1}{1{,}287}}$ ✓

$= \boxed{555{,}26\,K}$ ✓

(3)

4.4 $S_1 - S_2 = m\left\{\left(Cv\ln\frac{T_2}{T_1}\right)+\left(R\ln\frac{V_2}{V_1}\right)\right\}$ ✓

$= 0{,}1136\left\{\left(0{,}754\ln\frac{555{,}26}{373}\right)+\left(0{,}296\ln\frac{0{,}0285}{0{,}114}\right)\right\}$ ✓ ✓

$= 0{,}1136\{0{,}29998+(-0{,}41034)\}$

$= \boxed{-0{,}01254\,kJ/K}$ ✓

(4)
[20]

QUESTION 5

5.1 <u>Given:</u>

$M = 3{,}5\,kg$ $\quad P_1 = 2000\,kPa$

$t_{su} = 300\,^oC$ $\quad x = 0{,}9$

$P_2 = 280\,kPa$ $\quad Cp = 2{,}1\,kJ/kg.K$

$$U_1 = h - P_1V_1 \qquad (@\,2000\,kPa \text{ and } 300^oC) \checkmark$$
$$= \{hg + Cp(t_{su} - t_s)\} - \left\{P_1 \times \left[\frac{0{,}231(h_{sup} - 1941)}{P_1}\right]\right\} \checkmark \checkmark$$
$$= \{2797 + 2{,}1(300 - 212{,}4)\} - \left\{2000 \times \left[\frac{0{,}231(3025 - 1941)}{2000}\right]\right\} \checkmark \checkmark$$
$$= 2980{,}96 - 250{,}404$$
$$= 2730{,}556\,kJ/kg \checkmark$$

$$U_2 = h - P_2V_2 \checkmark \qquad (@\,280\,kPa \text{ and } x = 0{,}9) \checkmark$$
$$= \{hf + xhfg\} - \{P_2 \times xVg_2\} \checkmark$$
$$= \{551 + (0{,}9 \times 2170)\} - \{280(0{,}9 \times 0{,}6460)\} \checkmark \checkmark$$
$$= 2504 - 162{,}792$$
$$= 2341{,}208\,kJ/kg \checkmark$$

$$U_2 - U_1 = 2341{,}208 - 2730{,}556 \checkmark$$
$$= -389{,}348\,kJ/kg \checkmark$$

$$\therefore \Delta U = 3{,}5(U_2 - U_1) \checkmark$$
$$= 3{,}5 \times (-389{,}348) \checkmark$$
$$= \boxed{-1362{,}718\,kJ} \checkmark$$

(17)

5.2 Solid – eg Ice
Liquid – eg Water
Gas – eg Steam

(3)
[20]

TOTAL: 100