higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

NOVEMBER EXAMINATION

POWER MACHINES N5

15 NOVEMBER 2013

This marking guideline consists of 9 pages.

QUESTION 1

1.1
- When the user of a boiler permanently ceases to use a boiler. ✓
- When the user transfers ownership of the boiler to any other person. ✓
- When a person acquires a boiler. ✓
- The user shall notify the inspector when a boiler is damaged. ✓
- A user who proposes to execute repairs to a boiler. ✓
- No repairs are to be executed on a boiler without the prior written approval of the inspector. ✓
- No modifications are to be effected to a boiler without prior written approval of the inspector. ✓ (Any FIVE) (5)

1.2
- The stoker grate is self cleaning. ✓
- Labour costs are reduced. ✓
- Poor quality coal can be used. ✓
- The even feeding of coal prevents smoke. ✓
- The correct stoker speed improves the efficiency of the boiler. ✓ (5)

[10]

QUESTION 2

Given:

$T_1 (T_2) = 299\,K$ $\quad M = 2{,}732\,kg$ $\quad P_2 = 4000\,kPa$

$P_1 = 140\,kPa$ $\quad R = 0{,}3\,kJ/kg.K$

2.1
$$P_1V_1 = MRT_1$$
$$V_1 = \frac{MRT_1}{P_1} \quad ✓$$
$$= \frac{2{,}732 \times 0{,}3 \times 299}{140} \quad ✓$$
$$= \underline{1{,}75\,m^3} \quad ✓$$ (3)

2.2
$$P_2V_2 = MRT_2$$
$$V_2 = \frac{MRT_2}{P_2} \quad ✓$$
$$= \frac{2{,}732 \times 0{,}3 \times 299}{4000} \quad ✓$$
$$= \underline{0{,}06127\,m^3} \quad ✓$$ (3)

2.3

$$WD = P_1V_1 \ln\left(\frac{V_2}{V_1}\right) \quad \checkmark \qquad or \qquad WD = MRT_1 \ln\left(\frac{P_1}{P_2}\right) \quad \checkmark$$

$$= (140\times1,75)\ln\left(\frac{0,06127}{1,75}\right) \checkmark \qquad = (2,732\times0,3\times299)\ln\left(\frac{140}{4000}\right) \checkmark$$

$$= \underline{-821,26\ kJ} \quad \checkmark \qquad = \underline{-821,542\ kJ} \checkmark$$

(3)

2.4

$$Q = WD + \Delta U \quad \checkmark$$
$$= -821 + 0 \ (T_1 = T_2) \quad \checkmark$$
$$= \underline{-821\ kJ\ (\text{Re}jected)} \quad \checkmark$$

(3)

2.5

$$S_2 - S_1 = M\left[\left\{R\ln\left(\frac{P_1}{P_2}\right)\right\}+0\right] \quad \checkmark$$

$$= 2,732\left[\left\{0,3\ln\left(\frac{140}{4000}\right)\right\}+0\right] \quad \checkmark$$

$$= 2,732\times(-1,00572)$$

$$= \underline{-2,74762\ kJ/K} \quad \checkmark$$

(3)
[15]

QUESTION 3

Given:

$M = 8,5kg$ $\qquad t_{fw} = 40,3°C$ $\qquad P = 980kPa$

$C_p = 2,1kJ/kg°C$ $\qquad t_{su} = 214°C$

3.1

$$h_{sensible} = M(hf - h_{fw}) \quad \checkmark$$
$$= 8,5(759-169) \quad \checkmark$$
$$= \underline{5015kJ} \quad \checkmark$$

(4)

3.2

$$h_{latent} = M\times hfg \quad \checkmark$$
$$= 8,5\times2017 \quad \checkmark$$
$$= \underline{17144,5kJ} \quad \checkmark$$

(3)

3.3

$$h_{su} = M\{C_p(t_{su}-t_s)\} \quad \checkmark$$
$$= 8,5\{2,1(2,4-179)\} \quad \checkmark$$
$$= \underline{624,75kJ} \quad \checkmark$$

(4)

3.4

$$h_{total} = M\{hg + C_p(t_{su}-t_s) - h_{fw}\} \quad \checkmark$$
$$= 8,5\{2017+2,1(214-179)-169\}$$
$$= \underline{16332,75kJ} \quad \checkmark$$

(4)
[15]

QUESTION 4

4.1 Given:

$V_m = 689,3 mm\,Hg$ $B_m = 757 mm\,Hg$ $x = 0,93$

$M_s = 3450 kg/h$ $t_{wi} = 20,5°C$ $t_{wo} = 32,4°C$

$t_c = 31°C$ $SHC_w = 4187 J/kg.°C$

4.1.1 $P = (B_m - V_m) \times \frac{101,3}{760}$ ✓

$= (757 - 689,3) \times \frac{101,3}{760}$ ✓

$= 9 kPa$ ✓ (3)

4.1.2 $hf = 183 kJ/kg \quad (@ 9 kPa)$ ✓

$hfg = 2398 kJ/kg \quad (@ 9 kPa)$ ✓

$h_c = 130 kJ/kg \quad (@ 31°C)$ ✓

$Heat\,Gained\,(Water) = Heat\,Lost\,(Steam)$

$M_w \times SHC_w \times \Delta t_w = M_s(hf + xhfg - h_c)$ ✓

$M_w \times 4,187 \times (32,4 - 20,5) = 3450\{183 + (0,93 \times 2398) - 130\}$

$M_w = \frac{7876833}{49,8253}$ ✓

$= 158089,023\ kg/hour$ ✓

$\therefore Mass\ of\ water\ reqd.\ per\ minute = 158089,023 \div 60$ ✓

$= 2634,82 kg$ ✓ (8)

4.2 Given:

$M_c = 1,9 kg$ $M_w = 0,36 kg$

$x = \frac{M_c}{M_c + M_w}$ ✓

$= \frac{1,9}{1,9 + 0,36}$ ✓

$= 0,84$ ✓

$\therefore \%\ of\ vapour\ in\ the\ steam = (1 - 0,84) \times 100$ ✓

$= 16\%$ (4)

[15]

QUESTION 5

Given:

$S = 3\%$	$H_2 = 1$	M_{coal}
$O_2 = 6\%$	$C = 12$	
$C = 84\%$	$O_2 = 16$	
$H_2 = 7\%$	$S = 32$	

5.1

$3\%S = 0{,}03\,kg\,S$ ✓
$6\%O_2 = 0{,}06\,kg\,O_2$ ✓
$84\%C = 0{,}84\,kg\,C$ ✓
$7\%H_2 = 0{,}07\,kg\,H_2$ ✓
$100\% = 1\,kg\,Coal$ (4)

5.2

$C + O_2 = CO_2$
$12 + (16\times2) = [12+(16\times2)]$
$12 + 32 = 44$
$(\div12)\,1kg + 2{,}667\,kg = 3{,}667\,kg$ ✓

$\therefore Mass\ of\ Oxygen\ \text{Re}qd.to\ Burn\ Carbon = 0{,}84\times2{,}667$
$= \underline{2{,}24\,kg\,O_2}$ ✓ (2)

5.3

$H_2 + O_2 = H_2O$
$2(H_2) + O_2 = 2(H_2O)$ ✓
$(2\times1\times2)+(16\times2) = 2[(1\times2)+16]$
$4 + 32 = 36$ ✓
$(\div4)\ 1kg + 8kg = 9\,kg$

$\ni Mass\ of\ Oxygen\ \text{Re}qd.\ to\ Burn\ Hydrogen = 0{,}07\times8$
$= \underline{0{,}56kg\,O_2}$ ✓ (3)

5.4

$S + O_2 = SO_2$
$32 + (16\times2) = [32+(16\times2)]$ ✓
$(\div32)\ 1kg + 1kg = 2\,kg$

$\therefore Mass\ of\ Oxygen\ reqd.to\ Burn\ Sulphur = 0{,}03\times1$
$= \underline{0{,}03\,kg\,O_2}$ ✓ (2)

5.5 $Total\ mass\ of\ Oxygen\ reqd. = O_2c + O_2h_2 + O_2s - O_2 fuel$ ✓

$= 2{,}24 + 0{,}56 + 0{,}03 - 0{,}06$

$= \underline{2{,}77\,kg\,O_2}$ ✓ (2)

5.6 $Theoritical\ mass\ of\ air\ reqd. = \frac{100}{23} \times 2{,}77$ ✓

$= \underline{12{,}043\,kg}$ ✓ (2)

[15]

QUESTION 6

Given:

$V = 1{,}05\,m^3/\min$ $T_1 = 289{,}5\,K$ $P_1 = 102\,kPa$

$P_2 = 720\,kPa$ $n = 1{,}35$ $N = 325\,r/\min$

$Stroke\ to\ Bore\ Ratio = 1{,}45:1$ $\eta = 90{,}5\%$ $R = 0{,}287\,kJ/kg.K$

6.1 $V_s = \frac{Vol/\min}{N}$ ✓

$= \frac{1{,}05}{325}$ ✓

$0{,}00323\,m^3/stroke$ ✓

$V_s = Area \times Stroke\ Length$

$0{,}00323 = \frac{\pi}{4} \times D^2 \times 1{,}45D$ ✓

$D = \sqrt[3]{\frac{0{,}00323 \times 4}{\pi \times 1{,}45}}$ ✓

$= 0{,}14155\,m$

$= \underline{141{,}55\,mm}$ ✓ (6)

6.2 $Stroke\ Length = 1{,}45\,D$

$= 1{,}45 \times 141{,}55$ ✓

$= \underline{205{,}248\,mm}$ ✓ (2)

6.3

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

$$T_2 = T_1\left[\frac{P_2}{P_1}\right]^{\frac{n-1}{n}} \quad \checkmark$$

$$= 289{,}5\left[\frac{720}{102}\right]^{\frac{1{,}35-1}{1{,}35}} \quad \checkmark$$

$$= 480{,}497\,K$$

$$= 480{,}497 - 273$$

$$= \underline{207{,}5°C} \quad \checkmark \qquad (3)$$

6.4

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

$$= 102 \times \frac{1{,}05}{60}\left(\frac{1{,}35}{1{,}35-1}\right)\left[\left(\frac{720}{102}\right)^{\frac{1{,}35-1}{1{,}35}} - 1\right] \quad \checkmark$$

$$= 4{,}542\,kW$$

$$\therefore P_{in} = \frac{P_{out}}{\eta} \quad \checkmark$$

$$= \frac{4{,}542}{0{,}905}$$

$$= \underline{5\,kW} \quad \checkmark \qquad (4)$$

[15]

QUESTION 7

7.1

$$U = \pi Dn \quad \checkmark$$

$$= \pi \times 0{,}668 \times 50 \quad \checkmark$$

$$= \underline{105\ m/s} \quad \checkmark \qquad (3)$$

7.2

$$V_2 = \frac{V_3}{K}$$

$$= \frac{610}{678\,m/s} \quad \checkmark$$

See last page for velocity diagram. (9)

7.3 $P = M \times U \times C_w$ ✓

$M = \frac{P}{U \times C_w} \times 60$

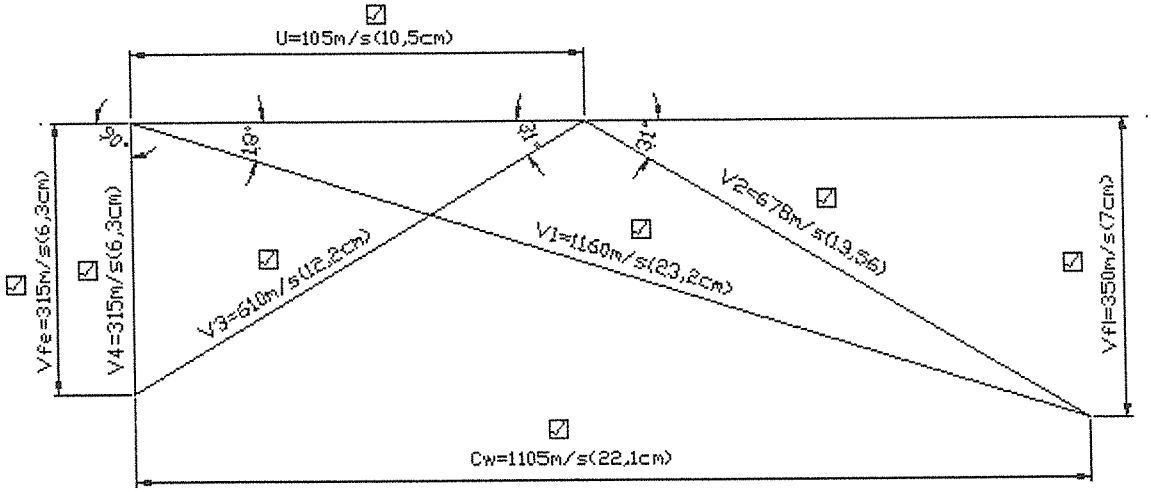
$= \frac{120 \times 10^3}{105 \times} \times 60$ ✓

$= \xrightarrow{kg/\min}$ ✓ (3)

[15]

TOTAL: 100

QUESTION 7.2



VELOCITY DIAGRAM