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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.

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

(3)

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

(3)

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2.3 $WD = P_1V_1 \ln\left(\frac{V_2}{V_1}\right)$ ✓ *or* $WD = MRT_1 \ln\left(\frac{P_1}{P_2}\right)$ ✓

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

$= \underline{-821,26\ kJ}$ ✓ $= \underline{-821,542\ kJ}$ ✓ (3)

2.4 $Q = WD + \Delta U$ ✓

$= -821 + 0 \quad (T_1 = T_2)$ ✓

$= \underline{-821\ kJ \ (Rejected)}$ ✓ (3)

2.5 $S_2 - S_1 = M\left[\left\{R\ln\left(\frac{P_1}{P_2}\right)\right\}+0\right]$ ✓

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

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

$= \underline{-2,74762\ kJ/K}$ ✓ (3)

[15]

QUESTION 3

Given:

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

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

3.1 $h_{sensible} = M(hf - h_{fw})$ ✓

$= 8,5(759-169)$ ✓

$= \underline{5015\,kJ}$ ✓ (4)

3.2 $h_{latent} = M \times hfg$ ✓

$= 8,5\times2017$ ✓

$= \underline{17144,5\,kJ}$ ✓ (3)

3.3 $h_{su} = M\{C_p(t_{su} - t_s)\}$ ✓

$= 8,5\{2,1(2,4-179)\}$ ✓

$= \underline{624,75\,kJ}$ ✓ (4)

3.4 $h_{total} = M\{hg + C_p(t_{su} - t_s) - h_{fw}\}$ ✓

$= 8,5\{2017 + 2,1(214-179) - 169\}$

$= \underline{16332,75\,kJ}$ ✓ (4)

[15]

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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

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

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

$$= 9\,kPa \quad \checkmark$$ (3)

4.1.2

$hf = 183\,kJ/kg \quad (@\,9\,kPa)$ ✓

$hfg = 2398\,kJ/kg \quad (@\,9kPa)$ ✓

$h_c = 130\,kJ/kg \quad (@\,31°C)$ ✓

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

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

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

$$M_w = \frac{7876833}{49,8253} \quad \checkmark$$

$$= 158089,023\ kg/hour \quad \checkmark$$

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

$$= 2634,82\,kg \quad \checkmark$$ (8)

4.2 Given:

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

$$x = \frac{M_c}{M_c + M_w} \quad \checkmark$$

$$= \frac{1,9}{1,9 + 0,36} \quad \checkmark$$

$$= 0,84 \quad \checkmark$$

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

$$= 16\%$$ (4)

[15]

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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

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

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

5.3

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

$\therefore Mass\ of\ Oxygen\ Req d.\ to\ Burn\ Hydrogen = 0{,}07\times8$
$= 0{,}56kg\,O_2$ ✓ (3)

5.4

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

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

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

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

$= 2,77\,kg\,O_2$ ✓ (2)

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

$= 12,043\,kg$ ✓ (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 $V_s = \frac{Vol/\min}{N}$ ✓

$= \frac{1,05}{325}$ ✓

$0,00323\,m^3/stroke$ ✓

$V_s = Area \times Stroke\ Length$

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

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

$= 0,14155\,m$

$= 141,55\,mm$ ✓ (6)

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

$= 1,45 \times 141,55$ ✓

$= 205,248\,mm$ ✓ (2)

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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)

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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

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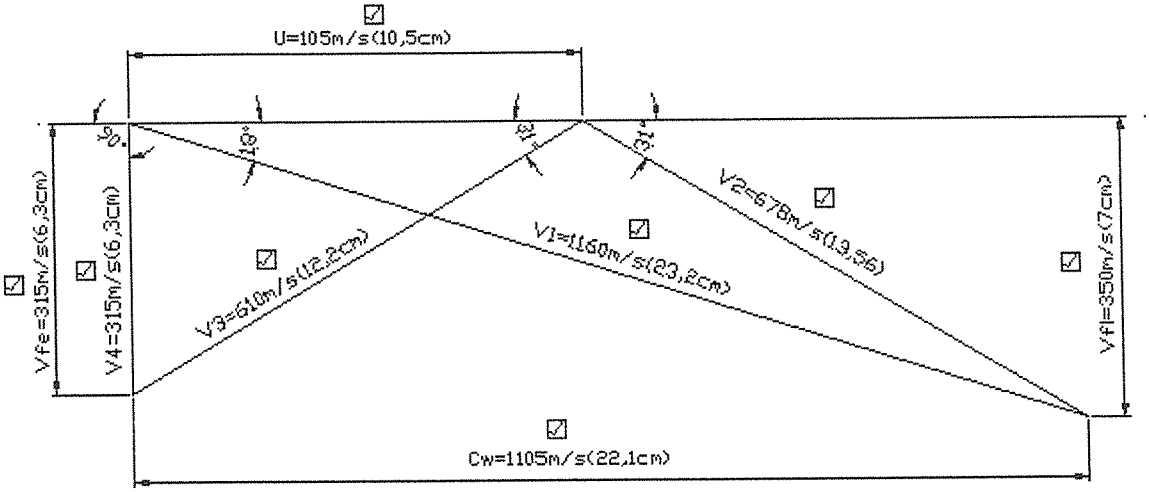
QUESTION 7.2



VELOCITY DIAGRAM

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