higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

POWER MACHINES N5

16 April 2020

This marking guideline consists of 9 pages.

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QUESTION 1

1.1 higher (1)

1.2 a) Separating calorimeter
b) Throttling calorimeter
c) Vessel meter (3)

1.3 1.3.1 C
1.3.2 C
1.3.3 A

(3 × 2) (6)
[10]

QUESTION 2

2.1
$$\frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^n \checkmark$$
$$P_2 = 1500\left(\frac{0,25}{0,3}\right)^{1,2} \checkmark$$
$$P_2 = 1205,241\ kPa \checkmark$$
(3)

2.2
$$WD = \frac{P_1V_1 - P_2V_2}{n-1} \checkmark$$
$$WD = \frac{(1500)(0,25) - (1205,241)(0,3)}{1,2-1} \checkmark \surd$$
$$WD = 67,139\ kJ \checkmark$$
(4)

2.3
$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{n-1}$$
$$\frac{T_2}{T_1} = \left(\frac{0,25}{0,3}\right)^{1,2-1} \checkmark$$
$$\frac{T_2}{T_1} = \frac{0,964}{1} \checkmark$$
(2)

2.4 2.4.1

$$WD = \frac{mR(T_1 - T_2)}{n-1} \quad \text{since } T_2 = 0{,}964T_1$$

$$67{,}139 = \frac{(1)(0{,}288)(T_1 - 0{,}964T_1)}{1{,}2-1} \checkmark\checkmark$$

$$0{,}036T_1 = 46{,}624$$

$$T_1 = 1295{,}111\ K \checkmark$$

$$T_2 = 0{,}964(1295{,}111) \checkmark$$

$$T_2 = 1248{,}487\ K \checkmark \quad (5)$$

2.4.2 $\Delta U = mc_V(T_2 - T_1)$ ✓

$$\Delta U = (1)(0{,}709)(1248{,}487 - 1295{,}111) \checkmark$$

$$\Delta U = -33{,}429\ kJ \checkmark \quad (3)$$

2.4.3 $Q = WD + \Delta U$ ✓

$$Q = 67{,}139 + (-33{,}429) \checkmark$$

$$Q = -33{,}709\ kJ \checkmark \quad (3)$$

[20]

QUESTION 3

3.1 3.1.1 $Enthalpy\ of\ sensible\ heat = h_f - c_p t$ ✓

$$= 962 - (4{,}187 \times 35)$$

$$= 815{,}455\ kJ/kg \checkmark \quad (3)$$

3.1.2 $Enthalpy\ of\ latent\ heat = [h_{fg}]$ ✓

$$= 1839\ kJ/kg \checkmark \quad (2)$$

3.1.3 $Enthalpy\ of\ superheat = c_p(t_{ss} - t_s)$ ✓

$$= (2)(350 - 223{,}9)$$

$$= 252{,}2\ kJ/kg \checkmark \quad (3)$$

3.2 3.2.1

$P = 3000\ kPa$

$t_{ss} = 350\ ^0C$

$h_{su} = 3117\ kJ/kg$ ✓

$\Delta h = h_4 - h_1$

$3016 = 3117 - h_1$ ✓

$h_1 = 3117 - 3016$ √

$h_1 = 101\ kJ/kg$ √ (3)



(3)

3.2.2

$$\eta = \frac{m_s(h_4 - h_1)}{m_f\ CV} \times 100\ \%$$

$$\eta = \frac{(4300)(3117 - 101)}{400 \times 41000} \times 100\%$$ √ √ √ √

$\eta = 79\%$ ✓ (3)

3.2.3

$$EE = \frac{m_s(h_4 - h_1)}{m_f\ 2257}$$

$$EE = \frac{(4300)(3117 - 101)}{400 \times 2257}$$ √ √ √ √

$EE = 14{,}365\ \frac{kg\ steam}{kg\ fuel}$ ✓ (3)

[20]

QUESTION 4

4.1 4.1.1

$$SV = \frac{\pi d^2 h}{4}$$ √

$$SV = \frac{\pi(0{,}18)^2(0{,}25)}{4}$$ ✓

$SV = 6{,}3617 \times 10^{-3} \times 3$ √ ✓

$SV = 0{,}0191\ m^3$ ✓ (4)

4.1.2 $V_C = 0,05 \times SV$

$= 0,05 \times 0,0191$ ✓

$= 9,55 \times 10^{-4}\ m^3$ ✓ (2)

$SV = V_1 - V_C$

$V_1 = 0,0191 + \left(9,55 \times 10^{-4}\right)$ ✓

$= 0,02005\ m^3$ ✓ (2)

$$V_4 = V_3\left(\frac{P_3}{P_4}\right)^{\frac{1}{n}}$$

$$V_4 = \left(9,55 \times 10^{-4}\right)\left(\frac{800}{101,325}\right)^{\frac{1}{1,2}}$$ ✓

$= 5,343 \times 10^{-3}\ m^3$ ✓ (2)

$V_e = V_1 - V_4$

$= (0,02005) - (0,005343)$ ✓

$= 0,0147\ m^3$ √

$= 0,0147 \times 240 \frac{rev}{\min}$ √

$= 3,528\ m^3 / \min$ ✓ (3)

4.1.3 $$\eta = \left[1 - \frac{0,05 \times SV}{SV}\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}}\right] \times 100\%$$

$$\eta = \left[1 - \frac{0,05 \times 0,0191}{0,0191}\left(\frac{800}{101,325}\right)^{\frac{1,2-1}{1,2}}\right] \times 100\%$$ √ √ √

$\eta = 79,444\%$ ✓ (2)

4.2

4.2 4.2.1 $heat\ emitted = heat\ absorbed$

$m_s(h_i + h_c) = mC_P(t_w - t_s)$

$2500\left[(0,7 \times 2384) + 4,187(49,5 - 34,6)\right] = (340 \times 60) \times 4,187 \times (58 - T_1)$ √ ✓ √ √

$$58 - T_1 = \frac{2500\left[(0,7 \times 2384) + 4,187(49,5 - 34,6)\right]}{340 \times 60 \times 4,187}$$ ✓

$T_1 = 7,33\ ^0C$ ✓

Alternative:

$$heat\ emitted = heat\ absorbed$$

$$m_s(h_f + xh_{fg} - h_c) = mC_P(t_w - t_s) \quad \surd$$

$$2500[207 + (0{,}7 \times 2384) - 145] = (340 \times 60) \times 4{,}187 \times (58 - T_1) \quad \surd \surd$$

$$58 - T_1 = \frac{2500[207 + (0{,}7 \times 2384) - 145]}{340 \times 60 \times 4{,}187} \checkmark$$

$$T_1 = 7{,}341\ ^0C \checkmark$$

(5)
[20]

QUESTION 5

5.1 *From the First principle* :

$$C + O_2 \rightarrow CO_2$$

$$12 + (16 \times 2) = (12) + (16 \times 2) \surd$$

$$12 + 32 = 44$$

$$\frac{12}{12} + \frac{32}{12} = \frac{44}{12} \surd$$

$$1 + 2{,}667 = 3{,}667 \checkmark$$

$$2H_2 + O_2 \rightarrow 2H_2O$$

$$(1 \times 2 \times 2) + (16 \times 2) = (1 \times 2 \times 2) + (16 \times 2) \surd$$

$$4 + 32 = 36$$

$$\frac{4}{4} + \frac{32}{4} = \frac{36}{4} \surd$$

$$1 + 8 = 9 \checkmark$$

$$S + O_2 \rightarrow SO_2$$

$$32 + (16 \times 2) = (32) + (16 \times 2) \surd$$

$$32 + 32 = 64$$

$$\frac{32}{32} + \frac{32}{32} = \frac{64}{32} \surd$$

$$1 + 1 = 2 \checkmark$$

$$Mass\ O_2\ /kg\ of\ of\ coal = (2{,}667 \times 0{,}751) + (8 \times 0{,}045) + (1 \times 0{,}05) - (0{,}059)$$
$$= 2{,}3539\ kg \quad \surd$$
$$Theoretical\ mass\ of\ air\ /\ kg\ of\ coal = \frac{100}{23}(2{,}3539)$$
$$= 10{,}2343\ kg \quad \surd$$
$$Actual\ mass\ of\ air = 10{,}2343 \times \frac{122}{100} \quad \checkmark$$
$$= 12{,}4858\ kg\ air\ /\ kg\ fuel \quad \checkmark$$ (9)

5.2 *mass of products per kg fuel and percentages*:

$CO_2 = 3{,}667 \times 0{,}751$
$\therefore CO_2 = 2{,}7539 \quad \surd$ $20{,}44 \surd$

$H_2O = 9 \times 0{,}405$
$\therefore H_2O = 0{,}405 \quad \surd$ $3{,}01 \quad \surd$

$SO_2 = 2 \times 0{,}05$
$\therefore SO_2 = 0{,}1 \quad \surd$ $0{,}74 \quad \surd$

$N_2 = 12{,}4858 \times \frac{77}{100}$
$\therefore N_2 = 9{,}614 \surd$ $71{,}37 \quad \surd$

$O_2 = 2{,}3539 \times \frac{22}{100}$
$\therefore O_2 = 0{,}5178 \surd$ $3{,}84 \quad \surd$

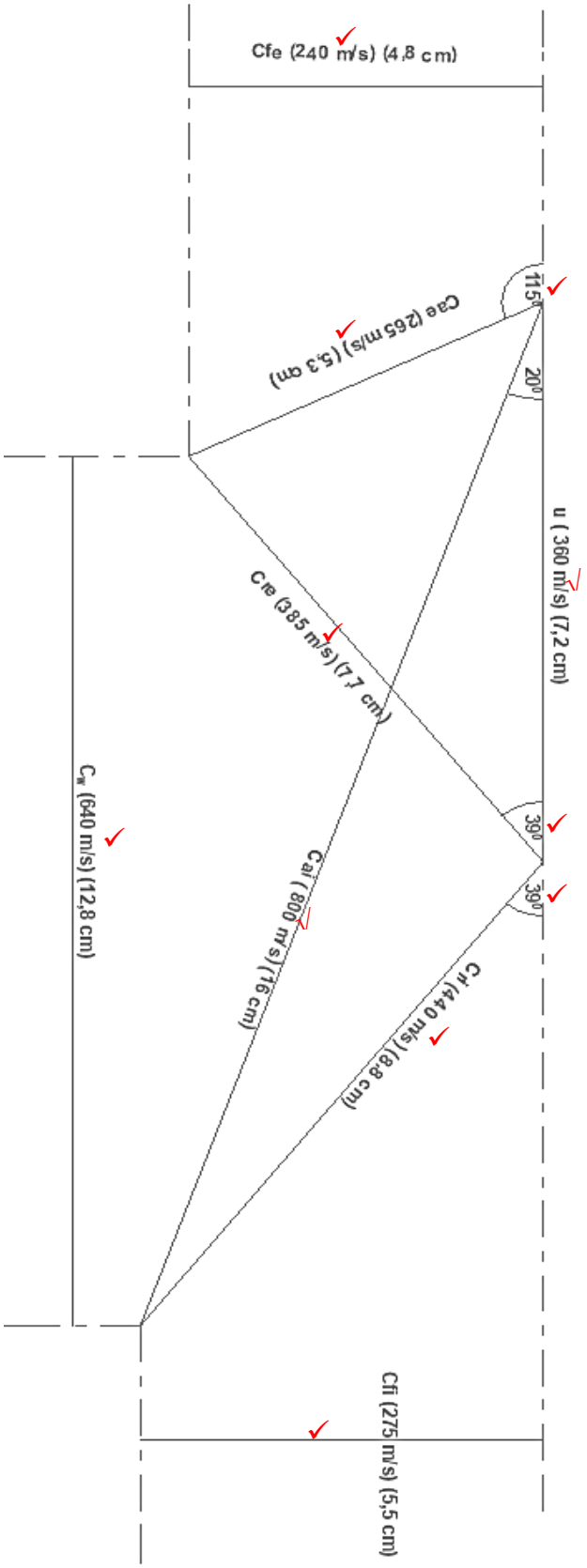
$Ash = 0{,}08 \quad \surd$ $0{,}59 \quad \surd$

$TOTAL = 13{,}4707$ 100

(6)
[15]

QUESTION 6

6.1



(10)

6.2 6.2.1 $\theta = 39^0$

$\phi = 39^0$ ✓✓ (2)

6.2.2 $F_c = m(Cfe - Cfi)$ ✓

$F_c = 2(240 - 275)$ ✓

$F_c = 70\ N$ ✓ (3)

[15]

TOTAL: 100

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