higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

POWER MACHINES N5

2 AUGUST 2018

This marking guideline consists of 10 pages.

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QUESTION 1

1.1 1.1.1 Function of an air pump is to remove unwanted air in a steam condenser to maintain the vacuum in the condenser

1.1.2
- The Edwards pump
- The Hamilton (rotating) pump

(2 x 2) (4)

1.2
- The impulse turbine
- The reaction turbine

(2)

1.3 Carbon monoxide (1)

1.4
- Mining industry
- Manufacturing industry
- Motor industry

(3)
[10]

QUESTION 2

Given:

T_1 = 250°C + 273 = 523 K
T_2 = 273 + 37°C = 310 K
V_2 = 2 m^3
R = 0,287 kJ/kg K
m = 1 kg

2.1
$$P_2V_2 = mRT_2$$
$$P_2 = \frac{mRT_2}{T_2} \quad \checkmark$$
$$= \frac{1 \times 0{,}287 \times 310}{2} \quad \checkmark$$
$$= 44{,}485kPa \quad \checkmark$$

(3)

2.2

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

$$\frac{310}{523} = \left(\frac{44,485}{1300}\right)^{\frac{n-1}{n}}$$

$$\log\frac{310}{523} = \frac{n-1}{n}\log\frac{44,485}{1300} \quad \checkmark$$

$$\frac{n-1}{n} = \frac{\log\frac{310}{523}}{\log\frac{44,485}{1300}} \quad \checkmark$$

$$\frac{n-1}{n} = 0,155$$

$$n - 1 = 0,155n$$

$$n(1 - 0,155) = 1$$

$$n = \frac{1}{0,845}$$

$$n = 1,18 \quad \checkmark$$

(5)

2.3

$$P_1V_1 = mRT_1$$

$$V_1 = \frac{mRT_1}{P_1} \quad \checkmark$$

$$= \frac{1 \times 0,287 \times 523}{1300} \quad \checkmark$$

$$= 0,115m^3 \quad \checkmark$$

(3)

2.4

$$Workdone = \frac{P_1V_1 - P_2V_2}{n - 1} \quad \checkmark$$

$$= \frac{(1300 \times 0,115) - (44,485 \times 2)}{1,18 - 1} \quad \checkmark$$

$$= \frac{149,5 - 88,97}{0,18} \quad \checkmark$$

$$= 336,28kJ \quad \checkmark$$

(4)
[15]

QUESTION 3

3.1

$$\eta = \frac{\dot{m}_s(h_2 - h_1)}{\dot{m}_f \times CV} \times 100$$ ✓

$$0{,}80 = \frac{6600}{600}\frac{(h_2 - 399)}{\times 32000} \times 100$$ ✓

$$(h_2 - 399) = \frac{0{,}80 \times 32000}{11}$$ ✓

$$(h_2 - 399) = 2327{,}27$$ ✓

$$h_2 = 2327{,}27 + 399$$ ✓

$$h_2 = 2726{,}27 kJ/kg$$ ✓

from S.T

at $95{,}2^{\circ}C$

$h_1 = 399\,kJ/kg$

(6)

3.2

Dryness factor

$h_2 = h_f + xh_{fg}$ ✓

$x = \frac{h_2 - h_f}{h_{fg}}$ ✓

$= \frac{2726{,}27 - 908}{1889}$ ✓

$= 0{,}963$ ✓

At $2000kPa$ *from S.T*

$h_f = 908\,kJ/kg$

$h_{fg} = 1889\,kJ/kg$

(5)

3.3

Heat absorbed by boiler

$Q = \frac{m_s}{m_f}(h_2 - h_1)$ ✓

$= \frac{6600}{600}(2726{,}27 - 399)$ ✓ ✓

$= 25599{,}97\,kJ/kg$ ✓

(4)

[15]

QUESTION 4

Given:

P	= 2500 kPa	P_{ss}	= 100 kPa
M_w	= 0,2 kg	t_{ss}	= 125°C
M_s	= 1,8 kg	Cp_{ss}	= 2,5 kJ/kg.K

4.1 *Separating calorimeter*

$$\chi_1 = \frac{M_s}{M_s + m_w} \checkmark$$

$$= \frac{1,8}{1,8 + 0,2} \checkmark$$

$$= 0.9 \checkmark$$

(3)

4.2 *Throttling calorimeter*

Enthalpy before throttling = *Enthalpy after throttling*

$$h_s \text{ at } 2500kPa = h_{ss} \text{ at } 100kPa \checkmark$$

$$h_f + x_2 h_{fg} = h_g + C_p(t_{ss} - t_s) \checkmark$$

$$962 + 1839x_2 = 2676 + 2,5(125 - 99,6)$$

at $2500kPa$: $h_f = 962kJ/kg$, $h_{fg} = 1839kJ/kg$

at $100kPa$: $h_g = 2676kJ/kg$, $t_s = 99,6^{\circ}C$

$$x_2 = \frac{2739,5 - 962}{1839} \checkmark$$

$$= 0,967 \checkmark$$

(8)

4.3 *dryness fraction of steam in the main line*

$$x = x_1 \times x_2 \checkmark$$

$$= 0,9 \times 0,967 \checkmark$$

$$= 0,87 \checkmark$$

(4)

[15]

QUESTION 5

5.1 5.1.1

$$\begin{aligned} Higher\ \ Calorific\ \ value\ \ (H.C.V) & \\ Heat\ \ emitted &= Heat\ \ absorbed\ \ by\ \ water \\ M_f \times HCV &= (M_w + M_e)C_w\Delta t \quad \checkmark \\ HCV &= \frac{(2{,}42+0{,}390)\times 4{,}187\times(14{,}9-13)}{0{,}000515} \quad \checkmark \\ &= 43406 kJ/kg \\ &= 43{,}41 MJ/kg \quad \checkmark \end{aligned}$$

(4)

5.1.2

$$\begin{aligned} L.C.V. &= H.C.V. - h_{fg} \times (9H_2) \\ &= 43406 - (2453\times 9\times 0{,}15) \quad \checkmark \\ &= 43406 - 3311{,}55 \quad \checkmark \\ &= 40094\ kJ/kg \\ &= 40{,}1 MJ/kg \quad \checkmark \end{aligned}$$

(3)

5.2

Gas symbol	(a) %volume	(b) Molecular Mass	(a)×(b) M	% Mass
CO_2	8,7	12+32= 44	3,828✓	$\frac{3{,}828}{29{,}612}\times 100 = 12{,}93\%$ ✓
O_2	5,5	2×16 = 32	1,76✓	$\frac{1{,}76}{29{,}612}\times 100 = 5{,}94\%$ ✓
CO	6,3	12+16= 28	1,764✓	$\frac{1{,}764}{29{,}612}\times 100 = 5{,}96\%$ ✓
N_2	79,5	14×2 = 28	22,26✓	$\frac{22{,}26}{29{,}612}\times 100 = 75{,}17\%$ ✓
TOTAL:	100		22,612	100%

(8)
[15]

QUESTION 6

Given:

P_1 = 98 kPa T_1 = 15+273=288 K N = 540 r/min D =150 mm
P_2 = 600 kPa R = 0,287 kJ/kg.K L = 160 mm V_c =0,06 V_s

6.1

$$Stroke\ volume(V_s) = \frac{\pi d^2}{4} \times L$$
$$= \frac{\pi \times 0{,}15^2}{4} \times 0{,}16 \quad \checkmark$$
$$= 0{,}002827 m^3/stroke \quad \checkmark$$

$$Clearance\ volume(Vc) = 0{,}06 V_s$$
$$= 0{,}06 \times 0{,}002827$$
$$= 0{,}0001696 m^3/stroke \quad \checkmark$$

$$P_3 V_3^n = P_4 V_4^n$$
$$V_4 = \left(\frac{P_3}{P_4}\right)^{1/n} V_3 \quad \checkmark$$
$$= 0{,}0001696\left(\frac{600}{98}\right)^{1/1{,}32} \quad \checkmark$$
$$= 0{,}0006692 m^3/stroke \quad \checkmark$$

$$Cylinder\ volume(V_1) = V_s + V_c$$
$$= 0{,}002827 + 0{,}0001696$$
$$= 0{,}002997 m^3/stroke \quad \checkmark$$

$$Effective\ volume(V_{e1})\ at\ inlet = V_1 - V_4$$
$$= 2{,}997\times10^{-3} - 6{,}692\times10^{-4}$$
$$= 0{,}002328 m^3/stroke \quad \checkmark$$

$$Effective\ volume/s = V_{e1} \times \frac{N}{60}$$
$$= 0{,}002328 \times \frac{540}{60} \quad \checkmark$$
$$= 0{,}021 m^3/s \quad \checkmark \qquad (10)$$

6.2 *Volumetric efficiency*

$$\eta = \frac{V_1 - V_4}{V_s} \times 100$$

$$= \frac{2{,}997\times10^{-3} - 6{,}692\times10^{-4}}{2{,}827\times10^{-3}} \times 100 \checkmark$$

$$= 82{,}34\% \checkmark$$ (2)

6.3

$$\text{Power required} = \frac{n}{n-1} P_1 V_{e1}\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right] \times \frac{N}{60}$$

$$= \frac{1{,}32}{0{,}32}\times98\times0{,}002328\left[\left(\frac{600}{98}\right)^{\frac{1{,}32-1}{1{,}32}} - 1\right] \times \frac{540}{60} \checkmark$$

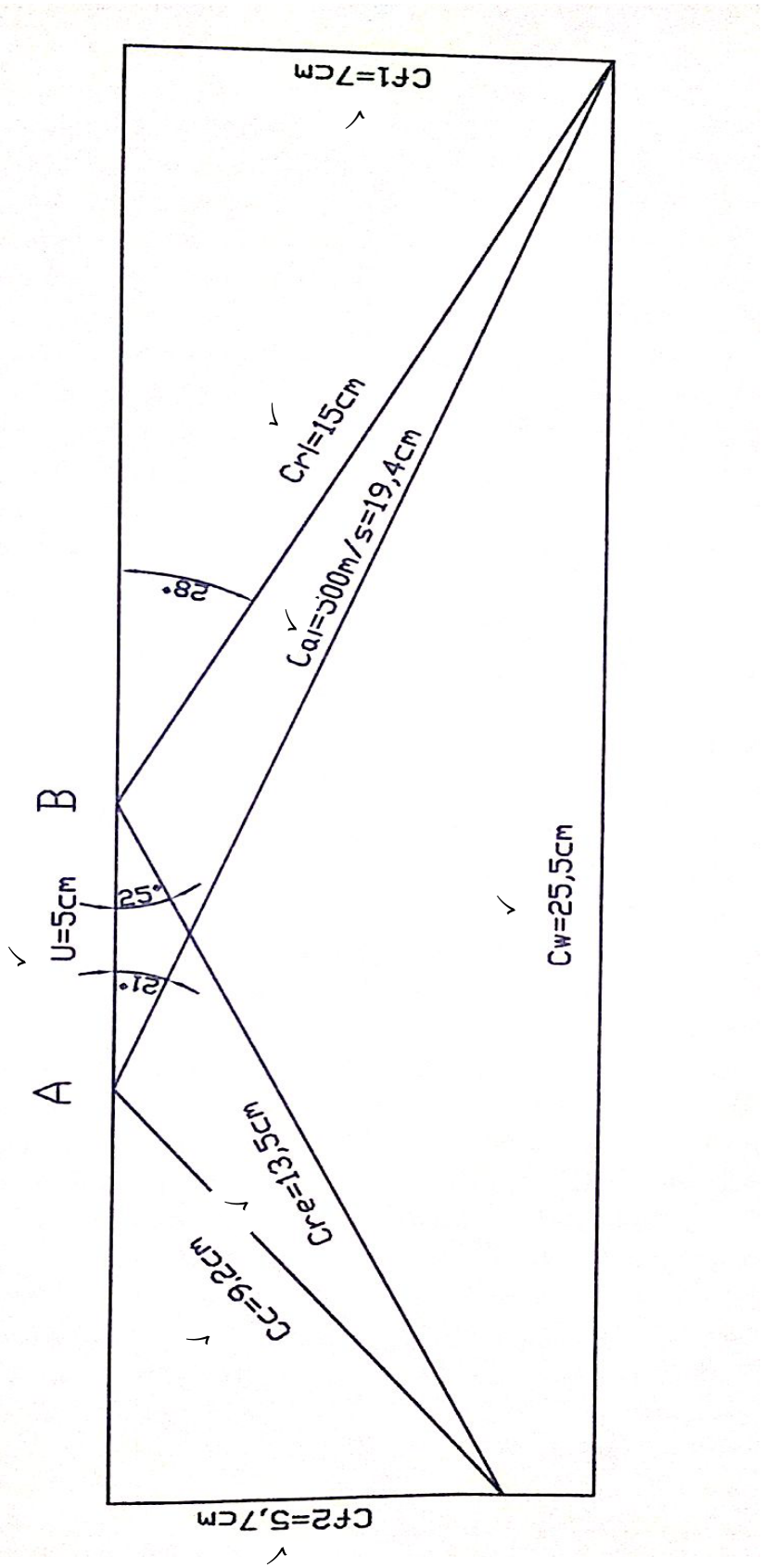
$$= 0{,}941\times0{,}552\times\frac{540}{60} \checkmark$$

$$= 4{,}67kW \checkmark$$ (3)

[15]

QUESTION 7

7.1



$$Scale \quad : \quad \frac{500}{19,4} \quad = \quad 25,77 m/s \quad \checkmark$$

$$\therefore \quad 1cm \quad = \quad 25,77 m/s \quad \checkmark$$

(10)

7.2 7.2.1 Blade velocity U = 5 × 25,77 = 128,85 m/s (1)

7.2.2 Inlet velocity Cri = 15 × 25,77 = 386,55 m/s (1)

7.2.3 Discharge velocity Ce = 9,2 × 25,77 = 237,08 m/s (1)

7.2.4 $Power \quad developed \quad = \quad mUC_w$

$= \quad 1 \times 128,85(25,5 \times 25,77) \checkmark$

$= \quad 84671,84 kW \quad \checkmark$

(2)

[15]

TOTAL: 100

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