higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

APRIL EXAMINATION

POWER MACHINES N5

27 MARCH 2013

This marking guideline consists of 10 pages.

QUESTION 1

1.1 1.1.1 Economiser: ✓ To preheat the feed water which enters the evaporator. ✓ (2)

1.1.2 Evaporator / Boiler: ✓ To convert the feed water into steam. ✓ (2)

1.1.3 Superheater: ✓ To convert the steam into superheated steam. ✓ (2)

1.1.4 Air Preheater: ✓ To preheat the air supply for increased efficiency in combustion. ✓ (Any THREE) (2)

1.2 1.2.1 Hand stoking is an uneven process. ✓ (1)

1.2.2 There is a sudden evaporation of great amounts of hydrocarbons with each delivery. ✓ (1)

1.2.3 There is an uncontrolled amount of air flow every time the doors are opened. ✓ (1)

1.2.4 Unnecessary cooling of the boiler takes place when the doors are opened. ✓ (1)

[10]

QUESTION 2

Given:

$M = 3{,}145\,kg$

$R = 0{,}288\,kJ/kg.K$

$Cv = 0{,}67\,kJ/kg.K$

$P_1 = 103{,}9\ kPa$

$P_2 = 3117\ kPa$

$V_1 = 2{,}006\ m^3$

$V_2 = 0{,}118\ m^3$

2.1

$$P_1V_1^n = P_2V_2^n \quad ✓$$

$$\left(\frac{V_1}{V_2}\right)^n = \frac{P_2}{P_1}$$

$$\left(\frac{2{,}006}{0{,}118}\right)^n = \frac{3117}{103{,}9} \quad ✓$$

$$17^n = 30$$

$$n\ln 17 = \ln 30$$

$$\therefore n = \frac{\ln 30}{\ln 17}$$

$$= 1.2 \quad ✓$$

(3)

2.2

$$P_1V_1 = MRT_1 \checkmark$$

$$T_1 = \frac{P_1V_1}{MR}$$

$$= \frac{103{,}9 \times 2{,}006}{3{,}145 \times 0{,}288} \checkmark$$

$$= \underline{230{,}11\,K} \checkmark$$

(3)

2.3

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \checkmark$$

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

$$= \frac{3117 \times 0{,}118 \times 230{,}11}{103{,}9 \times 2{,}006}$$

$$= \underline{406{,}076\,K} \checkmark$$

or

$$P_2V_2 = MRT_2 \checkmark$$

$$T_2 = \frac{P_2V_2}{MR}$$

$$= \frac{3117 \times 0{,}118}{3{,}145 \times 0{,}288}$$

$$= \underline{406{,}074\,K} \checkmark$$

(2)

2.4

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

$$= \frac{(103{,}9 \times 2{,}006) - (3117 \times 0{,}118)}{1{,}2 - 1} \checkmark$$

$$= \underline{-797\,kJ} \checkmark$$

or

$$WD = \frac{MR(T_1 - T_2)}{n-1} \checkmark$$

$$= \frac{3{,}145 \times 0{,}288(230 - 406)}{1{,}2 - 1} \checkmark$$

$$= \underline{-797\,kJ} \checkmark$$

(3)

2.5

$$\Delta U = M \times Cv \times (T_2 - T_1) \checkmark$$

$$= 3{,}145 \times 0{,}67(406 - 230)$$

$$= \underline{370{,}858\,kJ} \checkmark$$

(2)

2.6

$$Q = W + \Delta U \checkmark$$

$$= -797 + 370{,}858$$

$$= \underline{-426{,}142\,kJ} \ (\text{Rejected}) \checkmark$$

(2)
[15]

QUESTION 3

Given:

P_s	=	$600\,kPa$	M_w	=	$0{,}18\,kg$
$P_{throttle}$	=	$95\,kPa$	M_s	=	$9\,kg$
Cp	=	$2\,kJ/kg.K$	$t_{throttle}$	=	$115\,°C$

3.1

$$x_1 = \frac{M_s}{M_s + M_w} \checkmark$$

$$= \frac{9}{9 + 0{,}18} \checkmark$$

$$= \underline{0{,}98} \checkmark$$

(3)

3.2

$$\text{Enthalpy before throttling @ } 600\,kPa \checkmark = \text{Enthalpy after throttling @ } 95\,kPa \checkmark$$

$$hf + x_2 hfg \checkmark = hg \checkmark + c_p(t_{su} - t_s) \checkmark$$

$$670 + x_2(2085) \checkmark = 2674 + 2(115 - 98{,}2) \checkmark$$

$$670 + 2085x_2 = 2707{,}6$$

$$x_2 = \underline{0{,}977} \checkmark$$

(8)

3.3

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

$$= 0{,}98 \times 0{,}977 \checkmark$$

$$= \underline{0{,}957} \checkmark$$

(4)

[15]

QUESTION 4

Given:

x	=	0,86	Ms	=	$5940\,kg/hour$
Mm	=	$670\,mm\,Hg$	Bm	=	$760\,mm\,Hg$
$Air\ Leakage$	=	$0,85\,kg/950\,kg\ of\ steam$			
t_c	=	$44,3\,°C$	t_{wi}	=	$24\,°C$
t_{wo}	=	$41\,°C$	shc_w	=	$4,2\ kg/kg.K$
R	=	$0,287\ kJ/kg.K$			

4.1

$$P = (Bm - Mm)\times\frac{101,325}{760} \checkmark$$

$$= (760-670)\times\frac{101,325}{760}$$

$$= 12\,kPa \checkmark$$

Interpolation

$hf = 183\,kJ\ @\ 43,8\,°C$ ✓

$hf = 188\,kJ\ @\ 44,8\,°C$

$$\therefore hf\ @\ 44,3\,°C = 183\left\{\frac{\left(\frac{188-183}{44,8-43,8}\right)}{2}\right\} \checkmark$$

$$= 185,5\ kJ \checkmark$$

For mass of cooling water required :

$$hf + xhfg - hc = Mw\times shc_w\times\Delta t_w \checkmark$$

$$207 + (0,86\times 2384) - 185,5 = Mw\times 4,2\times(41-24) \checkmark$$

$$2071,74 = 71,4\,Mw$$

$$Mw = 29\,kg/kg\ steam \checkmark$$

$$\therefore Mass\ of\ cooling\ water\ required\ every\ minute = 29\times\frac{5940}{60} \checkmark$$

$$= \underline{2871\ kg} \checkmark$$

(10)

4.2 *For air pump capacity:*

$$Ps \ @ 44{,}3\,°C = 9 + \left\{ \frac{\left(\frac{9{,}5 - 9}{44{,}8 - 43{,}8} \right)}{2} \right\} \checkmark$$

$$= 9 + 0{,}25$$

$$= 9{,}25 \ kPa \checkmark$$

$$\therefore Pa = P - Ps$$

$$= 12 - 9{,}25$$

$$= 2{,}75\,kPa \checkmark$$

$$\therefore Capacity\ of\ air\ pump\,(Va) = \frac{Ma \times R \times Ta}{Pa} \checkmark$$

$$= \frac{\frac{0{,}8}{950} \times \frac{5940}{60} \times 0{,}287 \times (44{,}3 + 273)}{2{,}75}$$

$$= 2{,}76\,m^3/\min \checkmark$$

(5)

[15]

QUESTION 5

5.1 Given:

H_2	=	6,5 %	HVs	=	9 MJ/kg
O_2	=	2,8 %	HVc	=	34 MJ/kg
S	=	7,3 %	HV_{H2}	=	142 MJ/kg
C	=	83,4 %			

5.1.1

$$H_2 = 0{,}065\,kg$$
$$O_2 = 0{,}028\,kg \checkmark$$
$$S = 0{,}073\,kg$$
$$C = 0{,}834\,kg \checkmark$$

$$Theoritical\ air\ required = \frac{100}{23}\left[\frac{8}{3}C + 8H + S - O_2\right] \checkmark$$

$$= \frac{100}{23}\left[\left(\frac{8}{3} \times 0{,}834\right) + (8 \times 0{,}065) + 0{,}073 - 0{,}028\right] \checkmark$$

$$= 12{,}23\,kg/kg\ fuel \checkmark$$

$$\therefore Actual\ Air\ Required = 12{,}23 \times 1{,}28 \checkmark$$

$$= 15{,}65\,kg/kg\ fuel \checkmark$$

(7)

5.1.2

$$Cv\,of\,Coal = (HVc \times C) + (HVs \times S) + \left\{HV_{H2}\left(H_2 - \frac{O_2}{8}\right)\right\} \checkmark$$

$$= (34 \times 0{,}834) + (9 \times 0{,}073) + \left\{9\left(0{,}065 - \frac{0{,}028}{8}\right)\right\} \checkmark \checkmark$$

$$= 63{,}19 + 0{,}657 + 0{,}5535$$

$$= 64{,}40\,MJ/kg \checkmark$$

(4)

5.2 Given:

$M_f = 0{,}497\,g = 0{,}497 \times 10^{-3}\,kg$

$M_w = 2{,}4\,kg$

$W_e = 1\,kg$

$\Delta t = 1{,}082\,°C$

$C_w = 4{,}187\,kJ/kg.°C$

$$Hv = \frac{(M_w + W_e) \times C_w \times \Delta t}{M_f} \checkmark$$

$$= \frac{(2.4 + 1) \times 4{,}187 \times 1{,}082 \checkmark}{0{,}497 \times 10^{-3} \checkmark}$$

$$= 30992\,kJ/kg$$

$$= 30{,}992\,MJ/kg \checkmark$$

(4)
[15]

QUESTION 6

Given:

Double – Acting			V_1	=	$13{,}8\, m^3/\min$
$P_2(P_3)$	=	$755\, kPa$	$V_c(V_3)$	=	$0{,}045\ V_s$
N	=	$325\ r/\min$	$P_1(P_4)$	=	$105\, kPa$
T_1	=	$291K$	n	=	$1{,}3$

6.1

$$V_s = V_1 - V_3 \quad ✓$$
$$V_1 - 0{,}045V_s = V_s$$
$$V_1 = V_s + 0{,}045V_s$$
$$= 1{,}045V_s \quad \text{-------------} 1 \quad ✓$$

$$P_3V_3^n = P_4V_4^n$$
$$V_4 = V_3\left(\frac{P_2}{P_4}\right)^{1/n} \quad ✓$$
$$= 0{,}045\ V_s\left(\frac{755}{105}\right)^{1/3}$$
$$= 0{,}20523\ V_s \quad \text{-------------} 2 \quad ✓$$

$$V_1 - V_4 = \frac{V_1}{N \times 2} \quad ✓$$
$$= \frac{13{,}8}{325 \times 2}$$
$$= 0{,}02123\, m^3/\min \quad ✓$$

Sub: 1 into 2

$$1{,}045V_s - 0{,}20523\ V_s = 0{,}02123 \quad ✓$$
$$0{,}83977\ V_s = 0{,}02123 \quad ✓$$
$$\therefore V_s = \underline{0{,}02528\ m^3} \quad ✓$$

(9)

6.2

$$P = P_1V_e\left(\frac{n}{n-1}\right)\left[\left(\frac{P_2}{P_1}\right)^{n-1/n} - 1\right] \quad ✓$$
$$= 110 \times \frac{0{,}02123 \times 325 \times 2}{60} \times \left(\frac{1{,}3}{1{,}3-1}\right)\left[\left(\frac{755}{105}\right)^{1{,}3-1/1{,}3} - 1\right] \quad ✓$$
$$= 63{,}21\ kW \quad ✓$$

(3)

6.3

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

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

$$= 291\left(\frac{755}{105}\right)^{1,3-1/1,3} \checkmark$$

$$= \underline{458,782\ K} \checkmark$$

(3)
[15]

QUESTION 7

7.1

$$U = \frac{\Pi DN}{60} \checkmark$$

$$= \frac{\Pi \times 0,474 \times 9872}{60} \checkmark$$

$$= \underline{245\, m/s} \checkmark$$

(3)

7.2

$$P = MUC_w$$

$$C_w = \frac{P}{MU} \checkmark$$

$$= \frac{84,6 \times 10^3 \times 60}{45 \times 245} \checkmark$$

$$= \underline{460,4\, m/s} \checkmark$$

(3)

7.3 See the last page for the velocity diagram. (8)

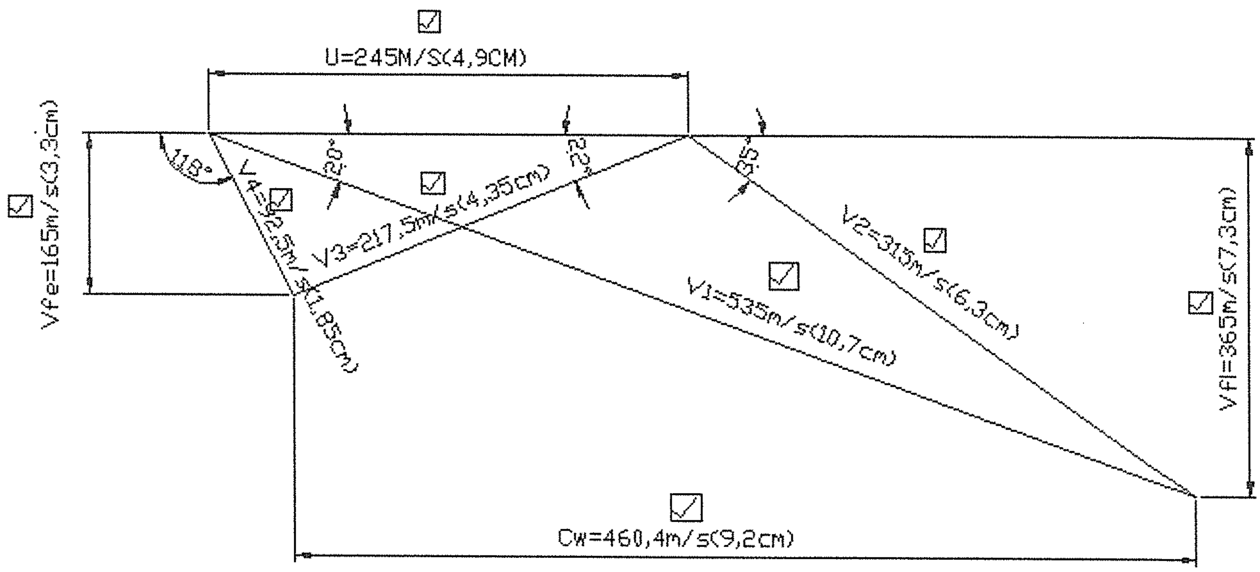
7.4

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

$$= -$$

$$= \underline{0,} \checkmark$$

(1)
[15]



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Q. 7.3