higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

# NASIENRIGLYN

## NASIONALE SERTIFIKAAT

## KRAGMASJIENE

## 9 APRIL 2018

**Hierdie nasienriglyn bestaan uit 9 bladsye.**

Kopiereg voorbehou

## VRAAG 1

1.1
- Koolstofdioksied ($CO_2$)
- Swaweldioksied ($SO_2$)
- Water(vogtigheid) ($H_2O$)

(3 × 2) (6)

1.2
- Dit omskep stoom in kondensaat teen dieselfde temperatuur.
- Dit skep 'n preserverende vakuum.
- Dit skep 'n streek van lae druk waarin stoom uitgelaat word
- Dit bespaar water vir hersirkulering.

(Enige 2 × 2) (4)
**[10]**

## VRAAG 2

Gegewe:

$P_1$ = 95 kPa $P_2$ = 650 kPa R = 0,287 kJ/kg.K
$V_1$ = 1,25 $m^3$ $T_1 = (38 + 273) = 311\ K$

2.1 *Mass of air*

$$P_1V_1 = mRT_1 \quad \checkmark$$
$$m = \frac{P_1V_1}{RT_1} \quad \checkmark$$
$$= \frac{95 \times 1{,}25}{0{,}287 \times 311} \quad \checkmark$$
$$= 1{,}33 \ kg \quad \checkmark$$

(4)

2.2
$$\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} = \left(\frac{V_1}{V_2}\right)^{n-1}$$

$P_1V_1^{1,24} = P_2V_2^{1,24}$ *or* $\left(\frac{P_2}{P_1}\right)^{\frac{1}{n}} = \frac{V_1}{V_2}$

$V_2 = \left(\frac{P_1}{P_2}\right)^{1/1,24} V_1$

$= 1{,}25\left(\frac{95}{650}\right)^{1/1,24}$

$= 0{,}265\ m^3$ ✓

$V_2 = \frac{1{,}25}{\left(\frac{650}{95}\right)^{\frac{1}{1,24}}}$ ✓

$= \frac{1{,}25}{4{,}716}$ ✓

$= 0{,}265\ m^3$ ✓

(3)

2.3 $P_2V_2 = mRT_2$ ✓

$T_2 = \frac{P_2V_2}{mR}$ ✓

$= \frac{650 \times 0,265}{1,33 \times 0,287}$ ✓

$= 451,26\ K$ ✓ (4)

2.4 *Work done during compression*

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

$= \frac{(95 \times 1,25) - (650 \times 0,265)}{1,24 - 1}$

$= \frac{118,75 - 172,25}{0,24}$

$= -223kJ$ (*negative sign indicates compression work done*) (4)

**[15]**

## VRAAG 3

Gegewe:

P = 2 500 kPa $t_{in}$ = 32,9 °C $t_{out}$ = 90 °C
Cv = 33 MJ/kg x = 0,95

3.1

$Q = \frac{m_s}{m_f}(h_2 - h_1)$ ✓

$= \frac{5000}{650}(377 - 138)$ ✓✓

$= 1838,462\ kJ/kg$ ✓

*From S.T*
*at* $32,9^oC$
$h_1 = 138kJ/kg$
*at* $90^oC$
$h_2 = 377kJ/kg$ (4)

3.2 *At* $2500kPa$
$h_f = 962\ kJ/kg$
$h_{fg} = 1839\ kJ/kg$

$h_3 = h_f + xh_{fg}$

$= 962$ ✓$+(0,95 \times 1839)$ ✓

$= 2709,05kJ/kg$ ✓

$\eta = \frac{\dot{m}_s(h_3 - h_1)}{\dot{m}_f \times CV} \times 100$ ✓

$= \frac{5000}{650} \frac{(2709,05 - 138)}{\times\ 33000} \times 100$ ✓

$= 59,93\%$ ✓ (7)

3.3 *The equivalent evaporator (EE) at 100 °C*

$$EE = \frac{\dot{m}_s(h_3 - h_1)}{\dot{m}_f \times 2257}$$ ✓ ✓

$$= \frac{5\,000(2709{,}05 - 138)}{650 \times 2257}$$ ✓ ✓

$$= 8{,}763\ kg/kg$$

(4)
**[15]**

## VRAAG 4

Gegewe:

$B_m$ = 755 mmHg $SHC_w$ = 4,187 kJ/kg.K $t_{wi}$ = 15 °C $m_s$ = 200 kg
$M_m$ = 650 mmHg $t_c$= 45,8 °C $t_{wo}$ = 23 °C

4.1 *Absolute pressure*

$$p = (B_m - M_m)\frac{101{,}325}{760}$$

$$= (755 - 650)\frac{101{,}325}{760}$$ ✓

$$= 14\ kPa$$ ✓

(3)

4.2 $h_s = xh_{fg}$ *From S.T at* $14kPa$ ✓

$= 0{,}9 \times 2377$ $h_{fg} = 2377\ kJ/kg$

$= 2139{,}3\ kJ/kg$ ✓ $x = (1 - 0{,}1) = 0{,}9$

$h_c = 4{,}187(ts - tc)$ ✓ ✓

$= 4{,}187(52{,}6 - 45{,}8)$

$= 28{,}472 kJ/kg$ ✓

*heat lost by steam and condensate = heat gained by the cooling water*

$$m_s(h_s + h_c) = mC_P(t_{out} - t_{in})$$ ✓

$$200(2139{,}3 + 28{,}472) = m \times 4{,}187 \times (23 - 15)$$ ✓

$$\frac{200 \times 2167{,}772}{4{,}187 \times 8} = m$$

$$m = 12943{,}47\ kg/\min$$ ✓

(9)

4.3 $\log temperature\ difference$

$$\log temp\ diff = \frac{\theta_1 - \theta_2}{\ln\frac{\theta_1}{\theta_2}}$$

$$= \frac{30,8 - 22,8}{\ln\frac{30,8}{22,8}}$$

$$= 26,6\ ^{\circ}C$$

$\theta_1 = t_c - twi$

$\theta_1 = 45,8 - 15 = 30,8$ ✓

$\theta_2 = t_c - t_{wo}$

$\theta_2 = 45,8 - 23 = 22,8$ ✓

(3)

**[15]**

## VRAAG 5

5.1

$$C_xH_y + \left(x + \frac{y}{4}\right)O_2 = xCO_2 + \frac{y}{2}H_2O$$

$$x = 7 \quad y = 18$$

$$C_7H_{18} + \left(7 + \frac{18}{4}\right)O_2 = 7CO_2 + \frac{18}{2}H_2O$$

$$[(12 \times 7) + (1 \times 18)] + (11,5 \times 2 \times 16) = 7[(12 + 2 \times 16)] + 9[(1 \times 2) + 16]$$ ✓

$$(84 + 18) + 368 = 308 + 162$$ ✓

$$102 + 368 = 308 + 162\ (divide\ through\ by\ 102)$$

$$1 + 3,608 = 3,02 + 1,588$$ ✓

$$Theorectical\ mass\ of\ air\ required = \frac{100}{23} \times mass\ O_2$$

$$= \frac{100}{23} \times 3,608$$ ✓

$$= 15,687\ kg$$ ✓

(5)

5.2

$$Actual\ mass\ of\ air\ required = \frac{100 + x}{100} \times theorectical\ mass\ of\ air$$

$$= \left(\frac{100 + 40}{100}\right) \times 15,687\ kg$$ ✓

$$= 21,962\ kg$$ ✓

*OR*

$$(\%\ Excess\ air \times theorectical\ mass\ of\ air) + theorectical\ mass\ of\ air$$

$$= (0,4 \times 15,687) + 15,687$$ ✓

$$= 21,962\ kg/kg$$ ✓

(2)

5.3 Massa van elke produk van verbranding

| SIMBOOL | MASSA |
|---|---|
| $CO_2$ | $3{,}02\ kg$ ✓ |
| $H_2O$ | $1{,}588\ kg$ |
| Excess $O_2$ | $0{,}40 \times 3{,}608 = 1{,}443\ kg$ ✓ |
| $N_2$ | $0{,}77 \times 21{,}962 = 16{,}911\ kg$ ✓ |
| TOTAL | $\underline{22{,}962kg}$ ✓ |

(4)

5.4 % van elke massa van verbranding

| SIMBOOL | % BY MASSA |
|---|---|
| $CO_2$ | $\frac{3{,}02}{22{,}962} \times 100 = 13{,}31\%$ ✓ |
| $H_2O$ | $\frac{1{,}588}{22{,}962} \times 100 = 6{,}92$ ✓ |
| $O_2$ | $\frac{1{,}443}{22{,}986} \times 100 = 6{,}28$ ✓ |
| $N_2$ | $\frac{16{,}911}{22{,}962} \times 100 = 73{,}65$ ✓ |
| TOTAAL | $100\%$ |

(4)
**[15]**

**VRAAG 6**

Gegewe:

$P_1$ = 103 kPa $t_1$ = 22 °C + 273 = 295 K $V_2 = \frac{V_1}{6}$

$P_2$ = 900 kPa R = 0,287 kJ/kg.K

6.1
$$P_1V_1^n = P_2V_2^n$$
$$\frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^n$$
$$\log\frac{900}{103} = n \log\left(\frac{V_1}{\frac{1}{6}V_1}\right) \quad \text{or} \quad \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} = \left(\frac{V_1}{V_2}\right)^{n-1}$$
$$\left(\frac{P_2}{P_1}\right) = \left(\frac{V_1}{V_2}\right)^n$$
$$n = \frac{\log\frac{900}{103}}{\log 6} \checkmark$$
$$= 1{,}21 \checkmark$$

(5)

6.2

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

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

$$= 295\left(\frac{900}{103}\right)^{\frac{0,21}{1,21}}$$

$$= 429,7K \quad \checkmark$$

(3)

6.3 *Volume after compression*

$$P_2V_2 = mRT_2 \quad \checkmark$$

$$V_2 = \frac{mRT_2}{P_2}$$

$$= \frac{1 \times 0,287 \times 429,74}{900} \quad \checkmark$$

$$= 0,137\ m^3 \quad \checkmark$$

*OR*

$$P_1V_1 = mRT_1$$

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

$$= \frac{1 \times 0,287 \times 295}{103}$$

$$= 0,822\ m^3 \quad \checkmark$$

$$V_2 = \frac{V_1 1}{6} \quad \checkmark$$

$$= \frac{0,822}{6}$$

$$= 0,137\ m^3 \quad \checkmark$$

(3)

6.4 *Work done after compression*

$$Work\ done = \frac{n}{n-1}P_1V_1\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right]$$

$$= \left(\frac{1,21}{1,21-1}\right) \times 103 \times 0,822\left[\left(\frac{900}{103}\right)^{\frac{0,21}{1,21}} - 1\right] \quad \checkmark$$

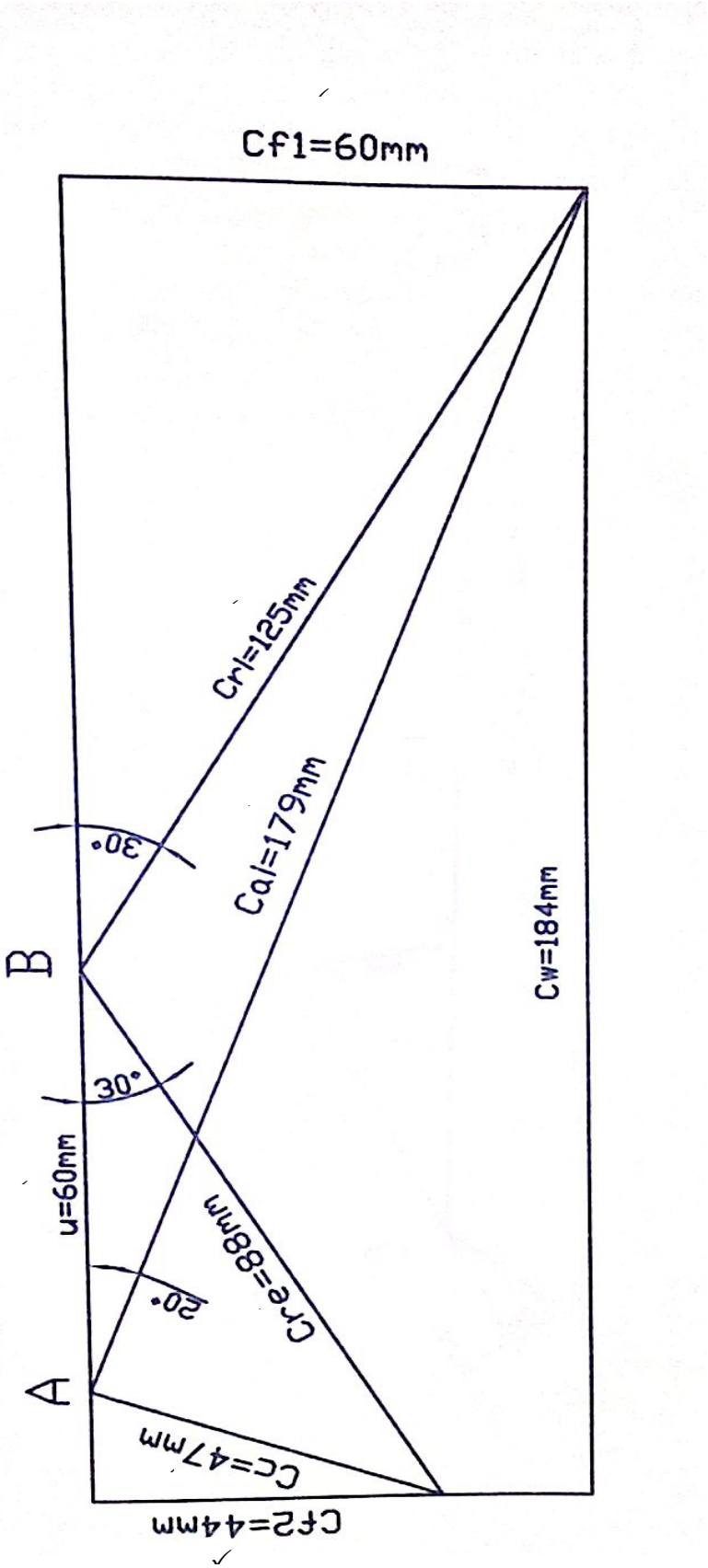
$$= 487,84 \times 0,822$$

$$= 222,82kJ \quad \checkmark$$

(4)

**[15]**

**VRAAG 7**
7.1


Cf1=60mm
Cr1=125mm
Ca1=179mm
Cw=184mm
30°
B
30°
u=60mm
Cre=88mm
20°
A
CC=47mm
Cf2=44mm

(8)

7.2 7.2.1 Cri = 125 × 5 = 625 m/s (1)

7.2.2 Cre = 88 × 5 = 440 m/s (1)

7.2.3 $$\begin{aligned} The\ axial\ thrust &= m(C_{f1} - C_{f2}) \\ &= 1 \times [(60 \times 5) - (44 \times 5)] \\ &= 1 \times (16 \times 5) \\ &= 80\ N \end{aligned}$$ (2)

7.2.4 $$\begin{aligned} \eta &= \frac{2U\ C_w}{C_{ai}^{\ 2}} \times 100 \\ &= \frac{2 \times 300 \times (184 \times 5)}{(179 \times 5)^2} \times 100 \\ &= \frac{2 \times 300 \times 920}{(895)^2} \times 100 \\ &= 68{,}9\% \end{aligned}$$ (3)

**[15]**

**TOTAAL: 100**

Kopiereg voorbehou