higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NASIONALE SERTIFIKAAT

KOELERVAKTEORIE N3

(11041583)

5 Augustus 2019 (X-Vraestel)

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Hierdie eksamenvraestel bestaan uit 7 bladsye en 'n formuleblad van 8 bladsye

Kopiereg voorbehou

DEPARTEMENT VAN HOËR ONDERWYS EN OPLEIDING
REPUBLIEK VAN SUID-AFRIKA

NASIONALE SERTIFIKAAT
KOELERVAKTEORIE
TYD: 3 UUR
PUNTE: 1

INSTRUKSIES EN INLIGTING

1. Beantwoord AL die vrae.

2. Lees AL die vrae aandagtig deur.

3. Nommer die antwoorde volgens die nommeringstelsel wat in hierdie vraestel gebruik is.

4. Skryf netjies en leesbaar.

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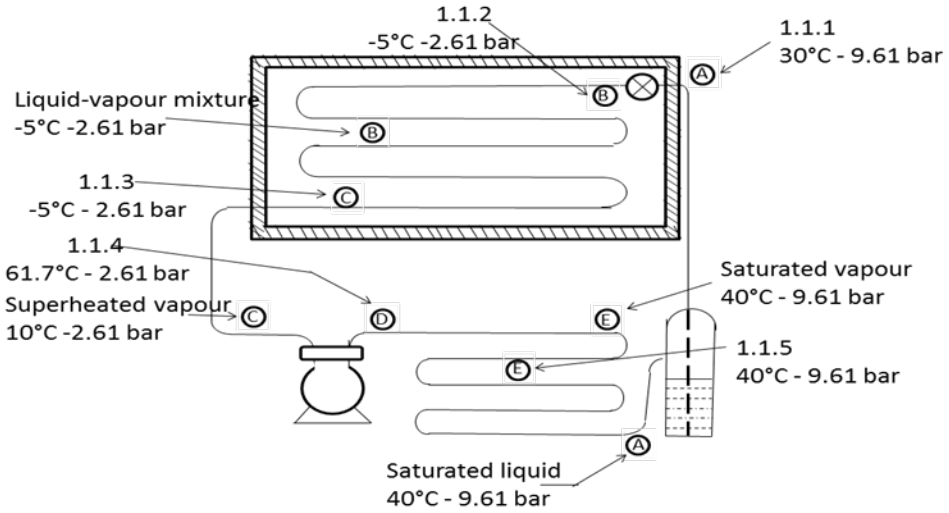
VRAAG 1

1.1 FIGUUR 1.1 toon 'n eenvoudige meganiese koelersiklus. Bestudeer die skets en noem die kondisie van die koelmiddel soos deur die pyltjies op die skets aangedui is. Skryf slegs dieantwoord langs die nommer (1.1.1–1.1.5) in die ANTWOORDBOEK neer.



FIGUUR 1.1 (5)

1.2 Met verwysing na FIGUUR 1.1 hier bo beskryf die volgende terme:

1.2.1 Oorverhitte verdamping('Super-heated vapour')

1.2.2 Versadigde damp ('Saturated vapour')

(2 × 3) (6)

1.3 Die lesing op 'n gewone drukmeter ('pressure gauge') is 725 K Pa.

Wat is die gewone absolute druk? (1)

1.4 Die absolute druk is 850 K Pa.

Wat is die gewone drukmeter lesing? (1)

1.5 Die temperatuur lesing is 330 K. Wat is die temperatuur lesing in ℃? (1)

1.6 Die temperatuur lesing is -270 ℃. Wat is die temperatuur lesing in Kelvin? (1)

1.7 Die temperatuur lesing is 88℉. Wat is die temperatuur lesing in ℃? (1)

1.8 Noem VIER faktore wat 'n invloed op hitteverlies ('heat leakage) het. (4)

[20]

VRAAG 2

2.1 Noem die VYF hooftipes koelerbeheer ('refrigerant controls'). (5)

2.2 Maak 'n netjiese. benoemde skets van 'n termostatiese verlengingsklep ('thermostatic expansion valve') (7)

2.3 Noem DRIE faktore wat die deltreffendheid van 'n kompressor bepaal. (6)

2.4 Verduidelik die doel van 'n koelmiddelolie. (2)

[20]

VRAAG 3

3.1 Beskryf kortliks die volgende beheerterms wat in koelerstelsels gebruik word:

3.1.1 Beheerpunt ('Control point') (2)

3.1.2 Sensor (2)

3.2 Maak 'n netjiese, benoemde skets van 'n bolvormige soort temperatuursensitiewe element en meganisme ('bulb type temperature sensing element'). Dui die volgende dele/komponente op die skets aan:

- Beweegbare kontak
- Stilstaande kontak
- Veer ('Spring')
- Bol ('Bulb')
- Diafragma verstelbare skroef
- Blaasbalk ('Bellow')

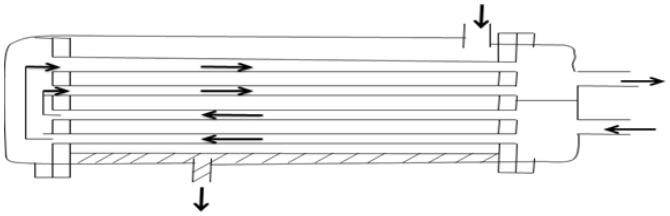
(6)

3.3 'n Agtsilinder kompressor roteer teen 20 revolusies per sekond en het 'n boor van 80 mm en 'n slag ('stroke') van 88mm. Hierdie kompressor is getoets en daar is gevind dat dit 'n koelmiddel lewer teen 'n tempo van 0.0225 m^3/s.

Bereken die volumetriese rendement van die kompressor. (5)

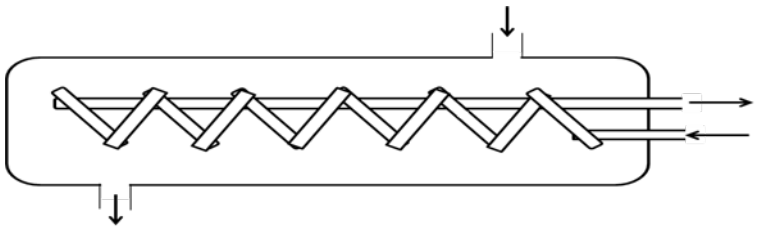
3.4 Identifiseer die soorte kondensators hier onder en skryf slegs die antwoord langs die nommers (3.3.1–3.3.2) in die ANTWOORDBOEK neer.

3.4 1



(1)

3.4.2



(1)

3.5 Verduidelik kortliks die werking van die kondensator by VRAAG 3.4.2. (3)
[20]

VRAAG 4

4.1 Verduidelik kortliks die volgende verdampers:

4.1.1 Ontvriesing (3)

4.1.2 Nie-Bevriesing ('Non-frosting') (3)

4.2 Maak 'n netjiese, benoemde skets van 'n oorstroomde verdamper ('flooded evaporator'). (6)

4.3 Noem VIER eienskappe van 'n doeltreffende klepsamestelling. (4 × 2) (8)
[20]

VRAAG 5

5.1 Definieer die term *werksverrigtingskoëffisiënt* ('COP'). (2)

5.2 Die verkoelingskapasiteit van 'n koeleraanleg is 30 kW. Die werksverrigtingskoëffisiënt van die aanleg is 4,9. Die entalpievermeerdering van die koelmiddel in die verdamper is 145 kJ/kg.

Bereken die volgende:

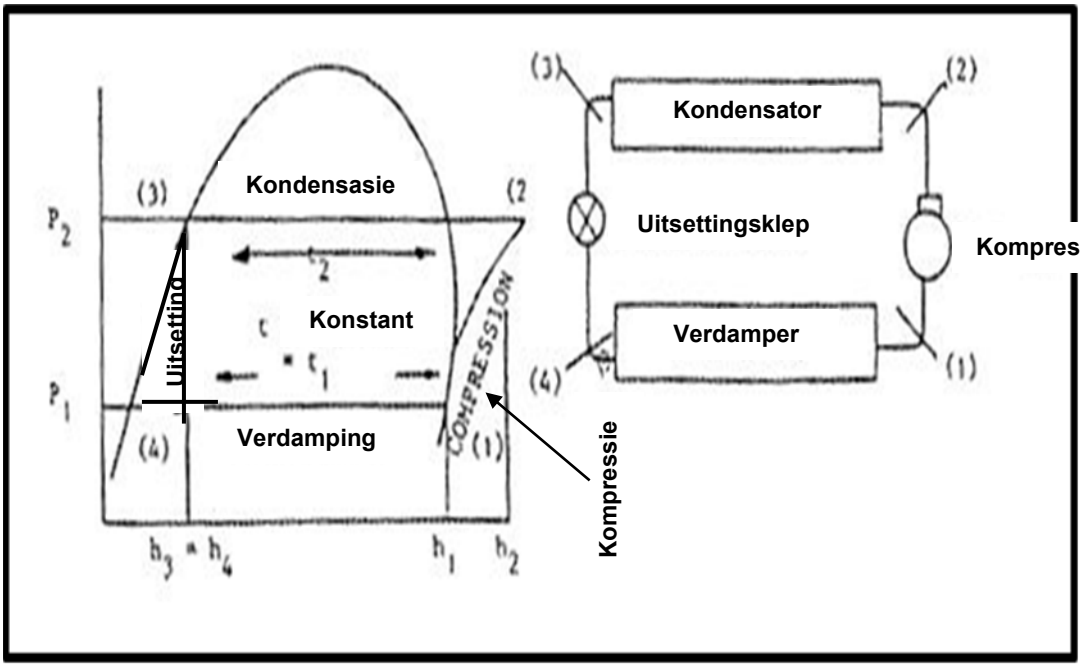
5.2.1 Die koelmiddel se massa vloeitempo.

5.2.2 Die werking van kompressie ('work of compression')

5.2.3 Die krag wat by die kompressormotor benodig word indien die rendement 90% is.

(3 × 2) (6)

5.3 FIGUUR 5.3 hier onder toon 'n P-H diagram vir die koelersiklus. Bestudeer die diagram en beantwoord die vrae.



FIGUUR 5.3

Beskryf die prosesse tussen die volgende nommers:

5.3.1 Proses 1 tot 2

5.3.2 Proses 2 tot 3

5.3.3 Proses 3 tot 4

5.3.4 Proses 4 tot 1

(4 × 2) (8)

5.4 Identifiseer die soorte beheerinstrumente hier onder en skryf die antwoord langs die nommers (5.4.1–5.4.2) in die ANTWOORDBOEK neer.

5.4.1



(1)

5.4.2



(1)

5.5 Noem die doel van die beheerinstrument in VRAAG 5.4.2. (2)

[20]

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FORMULEBLAD

KOELERVAKTEORIE N3

1. $Density = \frac{mass}{volume} \quad \therefore \rho = \frac{m}{v}\ kg/m^3$

   also $\rho = \frac{1}{v}\ kg/m^3 \quad (v = specific\ volume)$

2. $Specific\ volume\ (v) = \frac{1}{density} = \frac{1}{p}\ m^3/kg$

3. Greek symbols: $\eta = efficiency\ (neta)$
   $\rho = density\ (rho)$

4. $Mass\ flow\ rate: \left(\dot{m}\right)$

   $\dot{m} = \dot{V} \times \rho \quad Kg/S$

   $OR\ \dot{m} = \dot{V} \times \frac{1}{v} \quad \therefore \dot{m} = \frac{\dot{V}}{v}\ kg/s$

5. $(Quantity\ of\ heat\ (Q) for\ a\ change\ in\ temperature)$

   $Q = mC\Delta T\ \ kJ$

   $For\ a\ chnge\ of\ phase)$

   $Q = m.hfg$

   $(hfg\ = latent\ heat\ required\ )$

   $when\ the\ heat\ transfered\ reteis\ required\ the\ formula\ changes\ to:$

   $\dot{Q} = \dot{m}\ .\ hfg\ KJ/s\ or\ KW$

6. $Specific\ enthalphy\ (h)$

   To calculate the total energy transfer

   $\dot{Q} = \dot{Q}.\Delta h\ \ kJ/s\ or\ kW$

7. *Boyle's law*:

$$P_1V_1 = P_2V_2 \ (at\ constan\ temperature)$$

8. *Charles's law*:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

9. *ideal gas law*:

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

10. *The gas constant* (R)

$$R = \frac{Pv}{T} \ J/Kg.K$$

11. $Comperssor\ efficiency = \frac{Actual\ displacement(V)}{Thermal\ displacement(V\rho)}$

$$\eta = \frac{V}{V\rho} \times \frac{100}{1} = \%$$

12. *Theoretical displacement*:

$$V\rho = \frac{\pi \times D^2 \times L \times n \times N}{4} \ m^3/min$$

$$OR = \frac{\pi \times D^2 \times s \times N \times R}{4} \ m^3/min$$

$NOTE: (\pi = 3.142)$

13. *Evaporator capacity*:

(a) *The quantity of sensible heat transferred in watts*

(*evaporator sensible capacity*) $\left(\overset{\circ}{Q}\right)$

$$\overset{\circ}{Q} = U.A.\Delta t \ watts$$

(b) *Overall heat transfer coefficient* $('U' - factor)$

$$U = \frac{1}{R} \ W/m^2.℃$$

(c) *Resistance of surface to heat flow* (R)

$$R = \frac{1}{U} = \frac{1}{h_0} + \frac{x}{k} + \left(\frac{Ao}{A_1} + \frac{1}{h_1}\right) \quad m^2.℃/W$$

(d) *Log mean temperature diferrence (LMTD)*

$$LMTD = \frac{(te-tr)-(t\ell-tr)}{\log n\left(\frac{te-tr}{t\ell-tr}\right)} \quad ℃$$

14. *Condenser load*:

(a) *Total heat rejected of condenser in KW(THR)*

$$THR = \overset{\circ}{Qe} + \overset{\circ}{Q}i \quad \text{KW}$$

Also $THR = refrigeration\ capacity \times heat\ rejected\ factor$

(b) *Condenser capacity* $\left(\overset{\circ}{Q}\right)$

$$\overset{\circ}{Q} = U.A.\Delta t \quad kW$$

(c) $$LMTD = \frac{(tr-t\ell)-(tr-te)}{log\, n\left(\frac{tr-t\ell}{tr-te}\right)}$$

15. *The pressure enthalphy diagram:*

(a) *Refrigeration effect (Re)*

$$Re = h_1 - h_4 \quad kJ/kg$$

(b) *Heat of compression (WD)*

$$WD = h_2 - h_1 \quad kJ/kg$$

(c) *Heat rejection (THR)*

$$THR = h_2 - h_3 \quad kJ/kg$$

(d) *Coefficient of performance (COP)*:

$$COP = \frac{Re}{WD} \ (cooling)$$

$$COP = \frac{THR}{WD} \ \text{(heat pump)}$$

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(e) *Refrigerant mass flow* $\left(\dot{m}\right)$

$$\dot{m} = \frac{Load}{Re} \; kg/s$$

(f) *Plant capacity* $= \dot{m} \times Re \quad kW$

(g) *Theoretical power* $= \dot{m} \times WD \quad kW$

(h) *Actual power* $= \frac{\dot{m} \times WD}{\eta} \quad kW$

(i) *Total heat rejected in kW* (THR)

$$THR \text{ in } kW = \dot{m} \times THR \text{ in } kJ/kg \; kW$$

(j) *The efficiency of a comressor*:

$$\% = \frac{Theoretical\ power\ input}{Actual\ power\ input} \times 100$$

OR

$$\% = \frac{h_2 - h_1}{h_{1_2} - h_1} \times 100$$

16. *Cooling load calculations*:

(a) *Basic heat transfer formula*

$$Q = U \,.A\,.\Delta T \text{ watts } (J/S)$$

(b) *To calculate total resistance against heat flow*

$$Rt = \frac{1}{h_0} + \frac{d_1}{k_1} + \frac{d_2}{k_2} \cdots + \frac{1}{h_1} \quad m^2.℃/W$$

(c) *heat transfer coefficient* (U)

$$U = \frac{1}{R_1} \quad W/m^2.℃$$

(d) *Resistance against heat flow* (R)

$$R = \frac{d}{k} \quad m^2.℃/W$$

(e) *Total air change in cold room* $\left(\dot{V}\right)$

$$\dot{V} = \frac{V \times f}{86400} \quad m^3/s$$

(f) *Total air change load* $\left(\dot{Q}\right)$

(i) $\dot{Q} = \dot{V} \times \rho \times (h_2 - h_1) \times 1000$ *watts*

or when using the table for the number of air changes:

(ii) $\dot{Q} = \frac{V \times f \times \rho \times \Delta h}{86.4}$ *watts*

The above formula is the combination of the 2 formulae given in (e)and (f)(i)

(g) *The product load:*

(i) *Sensible heat:*

$$\dot{Q} = \frac{\dot{m} \cdot C \cdot \Delta t}{86.4} \text{ watts}$$

(ii) *Latent heat:*

$$\dot{Q} = \frac{\dot{m} \ \Delta h}{86.4} \text{ watts}$$

(iii) *Heat respiration:*

$\dot{Q} = \dot{m} \cdot \Delta h$ *Watts*

(h) *Miscellaneous loads:*

(i) $\text{Eqiupment load} = \frac{\text{Equipment output} \times \text{hours of operation}}{24}$ *watts*

NB: Loadand output must be given in watts

(ii) $\text{Lighting load} = \frac{\text{Wattage of lighting} \times \text{hours of operation}}{24}$ *watts*

NB: When lighting is by means of fluorescent light, add 25% to the Lighting load.

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(iii) *Occupancy load:*

$$\dot{Q} = \frac{\text{Heat equivalent per person} \times \text{number of persons} \times \text{hours}}{24} \text{ watts}$$

17. Ventilation and air conditioning:

(a) Removal of latent heat:

$$\dot{Q} = \dot{Q} \times \Delta g \times hfg \quad kW$$

$$\dot{m} = \frac{\dot{V}}{v} \quad kg/s$$

$$\therefore \dot{Q} = \frac{\dot{V} \times \Delta g \times hfg}{v}$$

(b) Room sensible heat factor (RSHF):

$$RSHF = \frac{RSH}{RSH+RLH} = \frac{RSH}{RTH}$$

(c) Efficiency of an evaporative cooler:

$$\eta = \frac{ta-tc}{ta-tb}$$

(d) Cooling and dehumidification:

$$\dot{Q} = \dot{m} \quad [\Delta h - hfg(\Delta g)] \quad kW$$

(e) $\dot{V}$ of the return air

$$\dot{V}ra = \dot{V}ra - \dot{V}fa \quad m^3/s$$

(f) Air temperature of mixture in the front of coil

$$T = \frac{\left(\dot{V}fa \times tdbfa\right) + \left(\dot{V}ra \times tdbra\right)}{\dot{V}sa} \quad ℃$$

(g) Quantity of air:

$$\dot{V} = \frac{\dot{Q}}{C \times \rho \times \Delta t} \quad m^3/s$$

(h) Amount of air forced through an opening by wind:

$$\dot{V} = E \times A \times v \quad m^3/s$$

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(i) *Volume flow due to temperature difference:*

$$\dot{V} = kA\sqrt{h(\Delta t)} \ m^3/s$$

(j) *Air changes per hour (f):*

$$f = \frac{\dot{V} \times 3600}{V} \ changes/hour$$

(k) *Volume air low per m^2 opening:*

$$\dot{V} = \frac{\dot{V}}{A} \ m^3/s/m^2$$

(l) *Free area of an opening (A):*

$$A = total\ area \times \eta\, m^2$$

(m) *Louvre size for given air speed:*

$$= \frac{\dot{V} \times 100}{Number\ of\ inlets \times inlet\ speed \times \%\ A} m^2$$

18. *Fans:*

(a) *Fan total pressure (Pt)*

$$Pt = Ps + Pv \ kPa$$

(b) *Theoretical power of the fan :*

$$= \dot{V} \times Pt \ \ kW$$

(c) *True power of the fan:*

$$= \frac{\dot{V} \times Pt}{\eta} \ kW$$

(d) *Air power (Ap)*

$$Ap = \frac{\dot{Q} \times Pt}{N} \ kW$$

(e) *Brake power (Bp)*

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$$Bp = \frac{\dot{Q} \times pt}{\eta t} = \frac{\dot{Q} \times ps}{\eta t}$$

$$\therefore Bp = \frac{Pt}{\eta t} = \frac{Ps}{\eta s} \quad (for\ the\ same\ volume)$$

19. Fan laws:

$$(a)\ \frac{VOL_1}{VOL_2} = \frac{N_1}{N_2} \times \frac{(DIA_1)^3}{(DIA_2)^3}$$

$$(b)\ \frac{P_1}{P_2} = \frac{(N_1)^2}{(N_2)^2} \times \frac{(DIA_1)^2}{(DIA_2)^2} \times \frac{\rho_1}{\rho_2}$$

$$(c)\ \frac{kW_1}{kW_2} = \frac{(N_1)^3}{(N_2)^3} \times \frac{(DIA_1)^5}{(DIA_2)^5} \times \frac{\rho_1}{\rho_2}$$

$$\frac{DIA_1}{DIA_2} = \frac{N_1}{N_2}$$

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