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higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

POWER MACHINES N5

(8190035)

29 November 2022 (X-paper)
09:00–12:00

REQUIREMENTS: Steam Tables (BOE 173)
Superheated-steam tables (Appendix to BOE 173)

Drawing instruments and nonprogrammable calculators may be used.

This question paper consists of 5 pages and a formula sheet of 3 pages.

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
POWER MACHINES N5
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer all the questions.
2. Read all the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Start each question on a new page.
5. Use only a black or blue pen.
6. Write neatly and legibly.

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QUESTION 1

1.1 Define the TWO laws of thermodynamics. (4)

1.2 State FOUR methods used to determine the dryness fraction of steam. (4)

1.3 What are the TWO types of air compressors? (2)

[10]

QUESTION 2

A gas with a mass of 1,32 kg at 20 °C is compressed from 105 kPa to 1 500 kPa according to the law PV^{γ} = constant. The specific heat capacity at constant pressure is 1,005 kJ/kg.K and the characteristic gas constant is 0,285 kJ/kg.K.

Calculate:

2.1 Gamma (4)

2.2 The initial volume (3)

2.3 The final volume (3)

2.4 The final temperature (3)

2.5 Change in internal energy in kJ (3)

2.6 Work done (4)

[20]

QUESTION 3

2,3 kg of steam at a pressure of 1 200 kPa and a temperature of 230 °C expands until the pressure is 500 kPa. The dryness fraction of steam after expansion is 0,8. The specific heat capacity of superheated steam is 2 kJ/kg.K and index n is 1,3.

Calculate:

3.1 The specific enthalpy of superheated steam in kJ/kg (3)

3.2 The volume of superheated steam in m^3/kg (4)

3.3 The internal energy of superheated steam in kJ/kg (3)

3.4 The specific enthalpy of wet steam in kJ/kg (3)

3.5 The volume of wet steam in m^3/kg (2)

3.6 The internal energy of wet steam in kJ/kg (3)

3.7 The change in internal energy in kJ (2)

[20]

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QUESTION 4

4.1 6 200 kg/h steam at 8,5 kPa condenses while 0,08 kg air leaks into the condenser per 100 kg steam. The air pump suction and condensate each has a temperature of 36,2 °C. The gas constant is 0,296 kJ/kg.K.

Calculate:

The air pump capacity in m^3/min. (8)

4.2 A single acting, single cylinder reciprocating compressor runs at 120 r/min and the volumetric efficiency is 76%. The diameter is 2 times stroke length. The air used is 12 m^3 per minute at a pressure of 104 kPa and a temperature of 28 °C. Air is delivered at 850 kPa according to the law PV 1,3 = constant. Clearance volume is negligible and the gas constant is 0,288 kJ.kg.K.

Calculate:

4.2.1 The stroke volume in m^3 and the diameter in m (5)

4.2.2 The delivery temperature (3)

4.2.3 The power required to drive the reciprocating compressor (4)

[20]

QUESTION 5

5.1 A gas consists of 25% CO_2, 20% CH_4, 50% N_2 and 5% O_2 by volume. Convert the given volume analysis of 1 m^3 fuel to mass analysis and determine the percentages. (8)

5.2 A porter type governor has arms that support rotating balls each with a mass of 2,1 kg. The equilibrium height (h) is 0,22 m. The central dead load has a mass of 15 kg. Calculate the speed of rotation in revolution per minute using the formula:

$$m\omega^2 h = g(M + m)$$ (7)

[15]

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QUESTION 6

The mean blade velocity of an impulse turbine is 150 m/s. The amount of gas entering is 2,3 kg. Gas leaves the turbine at an angle of 59° and a velocity of 200 m/s. The blade inlet angle is 32°. The coefficient of friction is 80,7%.

6.1 In landscape format, draw a velocity diagram by using a scale of 1 cm = 25 m/s. Label all angles and velocities in m/s. (10)

6.2 From the diagram determine:

6.2.1 The nozzle angle (1)

6.2.2 The relative inlet velocity in m/s (1)

6.3 By using a diagram, calculate:

The power required in kW. (3)

[15]

TOTAL: 100

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POWER MACHINES N5

FORMULA SHEET

1. $Q = W + \Delta U$
2. $\Delta U = mC_{\upsilon}\Delta T$
3. $Q = mC_{\upsilon}\Delta T$
4. $Q = mC_{p}\Delta T$
5. $Q = P_1V_1 \ln \frac{V_2}{V_1}$
6. $\Delta S = m\left(C_{\upsilon} \ln \frac{T_2}{T_1} + R \ln \frac{V_2}{V_1}\right)$
7. $W = P_1\Delta V$
8. $W = P_1V_1 \ln \frac{V_2}{V_1}$
9. $W = \frac{P_1V_1 - P_2V_2}{n-1}$
10. $W = \frac{P_1V_1 - P_2V_2}{\gamma - 1}$
11. $R = C_p - C_{\upsilon}$
12. $\gamma = \frac{C_p}{C_{\upsilon}}$
13. $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$
14. $PV = mRT$
15. $P_1V_1 = P_2V_2$
16. $P_1V_1^n = P_2V_2^n$
17. $\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} = \left(\frac{V_1}{V_2}\right)^{n-1}$
18. $\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} = \left(\frac{V_1}{V_2}\right)^{\gamma-1}$
19. $h = h_f + \chi h_{fg}$
20. $h = h_g + C_p\Delta T$
21. $h = h_f + h_{fg} = h_g$
22. $V_{sup} = \frac{n-1}{n}\left(\frac{h_{sup} - 1\,941}{P}\right)$
23. $\chi = \frac{V_m}{V_g}$
24. $\chi = \frac{M}{M + m}$
25. $U = H - PV$
26. $gZ_1 + U_1 + P_1V_1 + \frac{1}{2}C_1^2 + Q =$

    $gZ_2 + U_2 + P_2V_2 + \frac{1}{2}C_2{}^2 + W$
27. $\eta = \frac{\dot{m}_s(h_2 - h_1)}{\dot{m}_f\, CV}$
28. $EE = \frac{\dot{m}_s(h_2 - h_1)}{\dot{m}_f\ 2\,257}$
29. $p = (B_m \pm M_m)\frac{101{,}325}{760}$

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30. $$m = \frac{100}{23}\left[C\frac{8}{3} + 8H_2 + S - O_2\right]$$

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

32. $$H.C.V. = (CV_C.C) + CV_{H_2}\left(H_2 - \frac{O_2}{8}\right) + (CV_s.S)$$

33. $$L.C.V. = H.C.V. - h_{fg}\ (9H_2)$$

34. $$H.C.V. = \frac{(m_w + m_e)\,C_p\Delta T}{m_f}$$

35. $$W = P_1V_e\left(\frac{n}{n-1}\right)\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right] = mRT_1\left(\frac{n}{n-1}\right)\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right]$$

36. $$\eta_c = \frac{V_e}{V_s}.100 = 1 - \frac{Vc}{Vs}\left[\left(\frac{P_2}{P_1}\right)^{\frac{1}{n}} - 1\right] = 1 + \alpha - \alpha(r_p)^{\frac{1}{n}}$$

37. $$\eta_\alpha = \frac{V_\alpha}{V_s}.100$$

38. $$F_c = \dot{m}(C_{fe} - C_{fi})$$

39. $$P = \dot{m}U[C_{wi} - (-C_{we})]$$

40. $$\eta = \frac{2U[C_{wi} - (-C_{we})]}{C_{ai}{}^2}.100$$

41. $$U = \pi DN$$

42. $$\dot{m}V = AC$$

43. $$(m + M)\,g = m\omega^2 h$$

44. $$Vs = \frac{\pi}{4}D^2L$$

45. $$\theta_1 = t_c - twi$$

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46. $\theta_2 = t_c - two$

47. $Log.temp.diff. = \dfrac{\theta_1 - \theta_2}{\ell n \dfrac{\theta_1}{\theta_2}}$

48. $Piso = P_1 V_1 \ell n \left(\dfrac{P_2}{P_1} \right)$

49. $Pact = \dfrac{n}{n-1} P_1 V_1 \left[\left(\dfrac{P_2}{P_1} \right)^{\frac{n-1}{n}} - 1 \right]$

50. $Niso = \dfrac{Piso}{Pact} \bullet 100$

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