higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T1270(E)(A5)T
AUGUST EXAMINATION

NATIONAL CERTIFICATE

POWER MACHINES N5

(8190035)

5 August 2014 (Y-Paper)
13:00–16:00

REQUIREMENTS: **Steam Tables (BOE 173)**
Superheated Steam Tables (Appendix to BOE 173)

Drawing instruments are required.
Calculators may be used.

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

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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. Write neatly and legibly.

QUESTION 1

1.1 The blades of a single-stage, impulse turbine has a mean diameter of 960 mm. 100 kW of power develops at a speed of 4 755 r/min. The gas discharges in an axial direction and the coefficient of friction is 0,87. Both blade angles are 30° each to the plane of rotation.

1.1.1 Calculate the blade velocity in m/s (3)

1.1.2 Use a scale of 1 cm = 50 m/s and construct a velocity diagram in the ANSWER BOOK. Enter ALL the values (m/s) onto the diagram.

HINT: Use the answer page in the landscape format to construct the diagram.

NOTE: NO marks will be awarded if the values (m/s) are NOT entered onto the diagram and if the diagram is NOT constructed to the given scale. (8)

1.1.3 Determine the following from the diagram:

(a) The nozzle angle (1)
(b) The mass flow of gas in kg/s (3)
(c) The diagram efficiency (3)

1.2 State the volume and enthalpy of 1 kg of steam which has a temperature of 500 °C and a pressure of 0,5 MPa. (2)

[20]

QUESTION 2

2.1 With the aid of steam tables, calculate the following:

2.1.1 The enthalpy found in 2 kg of steam which has a pressure of 480 kPa and is 7,3% wet. (3)

2.1.2 The enthalpy of a kilogram of steam which has a pressure of 1,5 MPa, a temperature of 396 °C and a specific heat capacity of 2,1 kJ/kg.K. (3)

2.1.3 The dryness fraction of wet steam which has an enthalpy of 2 650 kJ/kg at a pressure of 1,3 MPa. (3)

2.1.4 The heat required to change 2,3 kg of water from a temperature of 31 °C to dry saturated steam at a pressure of 1 000 kPa. (3)

2.2 Name THREE apparatus used to determine the dryness fraction of steam. (3)

 Please turn over

2.3 A boiler plant supplies 5 600 kg of wet steam every hour at a pressure of 800 kPa. The steam is 9,5% wet and the supply water enters the boiler at 29 °C. The boiler consumes 11 kg of coal every minute, which has a heat value of 35 MJ/kg.

Calculate the efficiency of the boiler. (5)

[20]

QUESTION 3

1 kg of fuel oil which has the formula $C_{12}\,H_4$ completely burnt with the aid of 40% excess air. The atomic mass of carbon, oxygen and hydrogen is 12,16 and 1, respectively.

Calculate the following:

3.1 The theoretical mass of air required to burn the fuel (8)

3.2 The actual mass of air used to burn the fuel (2)

3.3 The mass of each product of combustion (6)

3.4 The percentage analysis, by mass, of the combustion products (4)

[20]

QUESTION 4

A single cylinder, single-acting compressor takes in 56,4 m^3 of air every hour. The air is delivered at a pressure of 900 kPa after it is received at a pressure of 103 kPa and 22 °C. The compressor does not have a clearance volume and the law of compression is $PV^{1,35} = C$. The stroke to bore ratio is 1,6 to 1 and the speed is 350 r/min. The electric motor experiences a power loss of 10% and the compressor experiences a power loss of 12%. Air has a specific heat capacity of 0,287 kJ/kg.K.

Calculate the following:

4.1 The indicated power of the compressor (4)

4.2 The bore diameter in mm (8)

4.3 The stroke length in mm (2)

4.4 The power rating of the motor used to drive the compressor in kW (6)

[20]

QUESTION 5

5.1 Name TWO types of compressors. (2)

5.2 State Boyle's law. (4)

5.3 State Charles' law. (5)

5.4 A constant volume process was used to heat 3,3 kg of gas from a temperature of 21 °C and 0,87 m^3 to a temperature of 137 °C. The specific heat capacity of the gas at constant volume is 0,718 kJ/kg.K and the gas constant is 0,289 kJ/kg.K.

Calculate the following:

5.4.1 The quantity of heat transferred in kJ (3)

5.4.2 The final pressure of the gas after heating (6)
[20]

TOTAL: 100

FORMULA SHEET

1. $Q = W + \Delta U$
2. $\Delta U = mC_v \Delta T$
3. $Q = mC_v \Delta T$
4. $Q = mC_p \Delta T$
5. $Q = P_1V_1 \ln \dfrac{V_2}{V_1}$
6. $\Delta S = m\left(C_v \ln \dfrac{T_2}{T_1} + R \ln \dfrac{V_2}{V_1} \right)$
7. $W = P_1 \Delta V$
8. $W = P_1V_1 \ln \dfrac{V_2}{V_1}$
9. $W = \dfrac{P_1V_1 - P_2V_2}{n - 1}$
10. $W = \dfrac{P_1V_1 - P_2V_2}{\gamma - 1}$
11. $R = C_p - C_v$
12. $\gamma = \dfrac{C_p}{C_v}$
13. $\dfrac{P_1V_1}{T_1} = \dfrac{P_2V_2}{T_2}$
14. $PV = mRT$
15. $P_1V_1 = P_2V_2$
16. $P_1V_1^n = P_2V_2^n$
17. $\dfrac{T_2}{T_1} = \left(\dfrac{P_2}{P_1} \right)^{\frac{n-1}{n}} = \left(\dfrac{V_1}{V_2} \right)^{n-1}$
18. $\dfrac{T_2}{T_1} = \left(\dfrac{P_2}{P_1} \right)^{\frac{\gamma-1}{\gamma}} = \left(\dfrac{V_1}{V_2} \right)^{\gamma-1}$
19. $h = h_f + \chi h_{fg}$
20. $h = h_g + C_p \Delta T$
21. $h = h_f + h_{fg} = h_g$
22. $V_{sup} = \dfrac{n-1}{n} \left(\dfrac{h_{sup} - 1\,941}{P} \right)$
23. $\chi = \dfrac{V_m}{V_g}$
24. $\chi = \dfrac{M}{M + m}$
25. $U = H - PV$
26. $gZ_1 + U_1 + P_1V_1 + \dfrac{1}{2}C_1^2 + Q = gZ_2 + U_2 + P_2V_2 + \dfrac{1}{2}C_2{}^2 + W$
27. $\eta = \dfrac{\dot{m}_s (h_2 - h_1)}{\dot{m}_f CV}$
28. $EE = \dfrac{\dot{m}_s (h_2 - h_1)}{\dot{m}_f \; 2\,257}$
29. $p = (B_m \pm M_m) \dfrac{101{,}325}{760}$

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. $\theta_1 = t_c - twi$

46. $\theta_2 = t_c - two$

47. $$Log.temp.d\ iff. = \frac{\theta_1 - \theta_2}{\ell n\ \dfrac{\theta_1}{\theta_2}}$$

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

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

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