higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T1340**(E)**(A11)T
APRIL EXAMINATION

NATIONAL CERTIFICATE

POWER MACHINES N5

(8190035)

11 April 2016 (X-Paper)
09:00–12:00

REQUIREMENTS: **Steam Tables (BOE 173)**
Superheated Steam Tables (Appendix to BOE 173)
Drawing instruments, pens and a ruler

Calculators may be used.

This question paper consists of 5 pages, and 1 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

The mean blade diameter of a single-stage impulse turbine is 1 960 mm and it rotates at a speed of 3 898 r/min. The blade speed is 0,4 of the speed of the gas velocity leaving the nozzles. The nozzles are inclined at an angle of 22° to the plane of the wheel and the blading is symmetrical. The gas loses 12% velocity, due to friction, as it moves over the blades. The turbine uses 100 kg of gas every minute.

1.1 Calculate the peripheral speed of the blade (3)

1.2 Calculate the nozzle velocity of the gas (3)

1.3 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.

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.

HINT: Use the ANSWER PAGE in the LANDSCAPE FORMAT to construct the diagram. (8)

1.4 Determine the following from the diagram:

1.4.1 The relative velocity of the gas at the inlet of the moving blade (1)

1.4.2 The relative velocity of the gas at the outlet of the moving blade (1)

1.4.3 The velocity of the gas leaving the turbine (1)

1.4.4 The end thrust developed (3)

[20]

QUESTION 2

2.1 Define *boiler efficiency*. (4)

2.2 A boiler produces 18 000 kg steam every hour at a pressure of 2,5 MPa. The feed water to the boiler has a temperature of 37,7 °C. Fuel, which has a calorific value of 30 MJ/kg, is consumed at a rate of 1 775 kg every hour. The equivalent evaporation of the boiler from and at 100 °C is 11,2 kg steam/kg fuel.

Calculate the following:

2.2.1 The efficiency of the boiler. (6)

2.2.2 The condition of the steam produced and state a reason based on the calculations. (6)

2.2.3 The dryness percentage of the steam. (4)
[20]

QUESTION 3

The density of a certain gas is 1,75 kg/m^3 at a pressure of 115 kPa and 20 °C. 80 kJ of heat is used to heat 0,75 kg of this gas at constant pressure to a temperature of 126 °C.

Calculate the following:

3.1 The characteristic gas constant (3)

3.2 The specific heat capacity of the gas at constant pressure (3)

3.3 The specific heat capacity of the gas at constant volume (3)

3.4 The change of internal energy (3)

3.5 The initial volume (2)

3.6 The final volume (3)

3.7 The work done during the heating process (3)
[20]

QUESTION 4

A single-acting, single-stage, reciprocating compressor runs at a speed of 650 r/min. The cylinder bore diameter is 220 mm and the piston stroke length is 310 mm. The clearance volume is 5,5 % of the swept volume and the compression index n = 1,35. Intake conditions are 98 kPa and 18 °C and the compression pressure is 650 kPa. The free air conditions are 101,325 kPa and 15 °C.

Calculate the following:

4.1 The swept volume (3)

4.2 The effective swept volume (9)

4.3 The free air delivered in m^3/min (5)

4.4 The volumetric efficiency (3)
[20]

QUESTION 5

A porter governor has a sleeve mass of 6 kg, whilst the rotating balls each have a mass of 1,8 kg. The arms of the governor are 330 mm long and they form an angle of 30° to the vertical. The coefficient of friction between the sleeve and its shaft is 0,33 and the minimum and maximum radii of rotation is 130 mm and 210 mm respectively.

Calculate the following:

5.1 The minimum speed limit in r/min (12)

5.2 The maximum speed limit in r/min (8)
[20]

TOTAL: 100

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. $Q = P_1 V_1 \ln \frac{V_2}{V_1}$

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. $W = P_1 V_1 \ln \frac{V_2}{V_1}$

9. $W = \frac{P_1 V_1 - P_2 V_2}{n - 1}$

10. $W = \frac{P_1 V_1 - P_2 V_2}{\gamma - 1}$

11. $R = C_p - C_\upsilon$

12. $\gamma = \frac{C_p}{C_\upsilon}$

13. $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

14. $PV = mRT$

15. $P_1 V_1 = P_2 V_2$

16. $P_1 V_1^n = P_2 V_2^n$

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. $gZ_1 + U_1 + P_1 V_1 + \frac{1}{2} C_1^2 + Q =$
$gZ_2 + U_2 + P_2 V_2 + \frac{1}{2} C_2{}^2 + W$

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

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

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