higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T1790**(E)**(A11)T

NATIONAL CERTIFICATE

POWER MACHINES N5

(8190035)

11 August 2017 (X-Paper)
09:00–12:00

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

Candidates need drawing instruments.

Nonprogrammable 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 State the function of each of the following devices:

1.1.1 The Orstat apparatus (2)

1.1.2 The bomb calorimeter (3)

1.2 State the function of governors. (2)

1.3 Name THREE types of governors. (3)
[10]

QUESTION 2

A mass of gas occupies 1,2 m^3 at 72 °C and at a pressure of 92 kPa. The gas is compressed to a volume of 0,16 m^3, according to the law $PV^{1,374} = C$. Take C_v = 0,719 kJ/kg.K and R = 0,269 kJ/kg.K.

Calculate:

2.1 The mass of the gas (3)

2.2 The final temperature (6)

2.3 The change in internal energy (3)

2.4 The work done (3)
[15]

QUESTION 3

Feedwater with a temperature of 40,3 °C enters a boiler which is producing steam with a dryness fraction of 94% at a pressure of 2 350 kPa. The steam flows through a superheater at a constant pressure while the temperature increases to 260 °C.

The steam delivery is 8,5 kg/kg fuel.
The coal has a calorific value of 33 MJ/kg.
The specific heat capacity for superheated steam is 2,14 kJ/kg.K.

Calculate:

3.1 The heat absorbed by the coal in kJ/kg of fuel by the evaporator (4)

3.2 The heat absorbed by the superheater per kg of fuel (4)

3.3 The equivalent evaporation from and at 100 °C (3)

3.4 The efficiency of the installation (4)
[15]

QUESTION 4

4.1 A 100 m^3 volume of air at an absolute pressure of 200 kPa is saturated with a steam vapour at 54°C in a container.

Calculate:

4.1.1 The mass of the air in the container (5)

4.1.2 The mass of the steam vapour in the container (3)

4.2 The arms of a simple watt governor are 250 mm long. At an average speed of 70 r/min the arms form an angle of 30° with the vertical spindle. The bores each have a mass of 1,5 kg.

Calculate the centrifugal force acting on the governor. (7)

[15]

QUESTION 5

The analysis of a fuel according to the mass, is as follows:

Carbon (C) = 84% energy value = 34 MJ/kg
Hydrogen (H_2) = 6% energy value = 142 MJ/kg
Sulphur (S) = 7% energy value = 9 MJ/kg
Oxygen (O_2) = 3%

Take the latent heat of steam formed in the exhaust gas to be 2 433 kJ/kg.
The air temperature = 38 °C
The dry exhaust gas temperature = 210 °C

Calculate:

5.1 The higher heat energy value (6)

5.2 The lower heat energy value (5)

5.3 The mass of air required (4)

[15]

QUESTION 6

A single-stage, single-stroke reciprocal air compressor has a bore diameter of 200 mm and a stroke length of 300 mm. The crankshaft turns at 450 r/min. The free volume is 5% of the stroke volume. Assume N is 1,28 for compression and expansion. Air is sucked in at a pressure of 97 kPa and a temperature of 21 °C. The delivery pressure is 600 kPa.

Calculate:

6.1 The free air delivery in m^3/min (8)

6.2 The volumetric efficiency (2)

6.3 The delivery temperature (2)

6.4 Power required to drive the compressor (3)
[15]

QUESTION 7

The nozzle of a simple impulse gas turbine is positioned at an angle of 25° with the plane of the moving blades. Gas leaves the nozzle at a velocity of 850 m/s and the average blade velocity is 300 m/s. The inlet and the outlet angles of the moving blades are equal. There is a 10% loss in the velocity of the gas while it flows over the blades.

7.1 Construct a velocity diagram in the ANSWER BOOK (landscape) and indicate the values of ALL velocity (m/s) on the diagram.

Use the scale 1 mm : 5 m/s

NOTE: No marks will be given if the values are not indicated on the diagram and if the diagram is not constructed to scale. (8)

7.2 Determine the following from the diagram in QUESTION 7.1

7.2.1 The inlet and outlet angles of the moving blades (2)

7.2.2 The mass of gas used in kg/s when the turbine generates a power of 150 kW (2)

7.2.3 The diagram efficiency (3)
[15]

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