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Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T1450(E)(N15)T
NOVEMBER EXAMINATION

NATIONAL CERTIFICATE

POWER MACHINES N5

(8190035)

15 November 2013 (X-Paper)
09:00–12:00

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

Calculators and drawing instruments may be used.

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

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
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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 Regulation C99 of the Factories Act, refers to the returns of boilers.

State FIVE different occasions when a written notification and/or approval must be sought from the inspector for such return. (5)

1.2 State FIVE advantages of a mechanical stoker in coal-fired boilers. (5)

[10]

QUESTION 2

A certain gas at a temperature of 26 °C has a mass of 2,732 kg. This gas is compressed, isothermally, to 4 000 kPa from 140 kPa. The gas constant for this gas is 0,3 kJ/kg.K.

Calculate the following:

2.1 The volume before compression (3)

2.2 The volume after compression (3)

2.3 The work done in kilojoules (3)

2.4 The heat gained or lost in kilojoules (3)

2.5 The change in entropy $(S_2 - S_1)$ (3)

[15]

QUESTION 3

Water which has a mass of 8,5 kg and a temperature of 40,3 °C is used to form steam at a pressure of 980 kPa. The steam is then superheated to a temperature of 214 °C. The specific heat capacity of superheated steam is 2,1 kJ/kg.°C.

Calculate the following, with the aid of steam tables:

3.1 The sensible heat/enthalpy (4)

3.2 The latent heat/enthalpy of evaporation (3)

3.3 The superheat (4)

3.4 The total heat required to superheat the steam (4)

[15]

QUESTION 4

4.1 A surface condenser has a vacuum-meter reading of 689,3 mm mercury and a barometer reading of 757 mm mercury. Wet steam with a dryness fraction of 0,93 is supplied to this condenser at a rate of 3 450 kg/h. The cooling water enters the condenser at 20,5 °C and leaves at 32,4 °C and the condensate has a temperature of 31 °C. The specific heat capacity of the cooling water is 4 187 J/kg. °C.

Calculate the following:

4.1.1 The pressure in the condenser (3)

4.1.2 The mass of cooling water required by the condenser every minute (8)

4.2 The dryness fraction of wet steam is determined by using a separating calorimeter. For every 1,9 kg condensate which passes through the calorimeter, 0,36 kg of water is collected in the separator.

Calculate the percentage of vapour in the steam. (4)

[15]

QUESTION 5

A sample of coal has the following analysis by mass:

- Sulphur: 3%
- Oxygen: 6%
- Carbon: 84%
- Hydrogen: 7%

The atomic masses of the elements are as follows:

- Hydrogen: 1
- Carbon: 12
- Oxygen: 16
- Sulphur: 32

Calculate the following for one kilogram of coal, from first principles:

5.1 The mass of each element (4)

5.2 The theoretical mass of oxygen required to burn the carbon (2)

5.3 The theoretical mass of oxygen required to burn the hydrogen (3)

5.4 The theoretical mass of oxygen required to burn the sulphur (2)

5.5 The total mass of oxygen required for complete combustion (2)

5.6 The theoretical mass of air required for complete combustion (2)
[15]

QUESTION 6

A single-acting, single-cylinder air compressor takes in 1,05 m^3 of air, with a temperature of 16,5 °C, every minute. The air is received at a pressure of 102 kPa and delivered at a pressure of 720 kPa. The index of compression is 1,35 and the compressor does not have a clearance volume. The compressor operates at a speed of 325 r/min and it has a stroke-to-bore ratio of 1,45 : 1. The mechanical efficiency of the compressor is 90,5% and the gas constant for air is 0,287 kJ/kg.K.

Calculate the following:

6.1 The cylinder diameter in mm (6)

6.2 The stroke length in mm (2)

6.3 The delivery temperature in °C (3)

6.4 The power required to drive the compressor in kW (4)
[15]

QUESTION 7

An impulse turbine rotates at a speed of 50 r/s and it has a nominal-blade diameter of 668 mm. The outlet and inlet blade angles are 31° each and the turbine develops 120 kW of power. The gas is discharged in an axial direction and the loss in velocity due to friction is 9%.

7.1 Calculate the blade velocity of the turbine, in m/s. (3)

7.2 Construct a velocity diagram in the ANSWER BOOK (landscape) and enter ALL the values (m/s) onto the diagram.

Use the scale 1 cm : 10 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. (9)

7.3 Determine the mass of the gas which flows through the turbine every minute. (3)
[15]

TOTAL: 100

POWER MACHINES N5

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

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

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

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

11. $R = C_p - C_v$

12. $\gamma = \dfrac{C_p}{C_v}$

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

14. $PV = mRT$

15. $P_1 V_1 = P_2 V_2$

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

17. $\dfrac{T_2}{T_1} = \left(\dfrac{P_2}{P_1} \right)^{\frac{n-1}{n}} = \left(\dfrac{V_1}{V_2} \right)^{n-1}$

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

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

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