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higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T1380(E)(M27)T
APRIL EXAMINATION

NATIONAL CERTIFICATE

POWER MACHINES N5

(8190035)

27 March 2013 (X-Paper)
09:00–12:00

REQUIREMENTS: **Steam Tables (BOE 173)**
Superheated Steam Tables (Appendix to BOE 173)
Candidates will require drawing instruments, pens and a ruler.

Calculators may be used.

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

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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.

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QUESTION 1

1.1 Name any THREE auxiliaries in a steam plant and state the function of each auxiliary. (6)

1.2 State FOUR disadvantages of hand stoking in coal-fired boilers. (4)
[10]

QUESTION 2

3,145 kg of gas is compressed from 103,9 kPa and a volume of 2,006 m^3 to a pressure of 3 117 kPa and a volume of 0,118 m^3, according to the law $PV^n = C$. The specific heat capacity of the gas at constant volume is 0,67 kJ/kg.K and the gas constant is 0,288 kJ/kg.K.

Calculate each of the following:

2.1 The index of compression (3)

2.2 The initial thermodynamic temperature (3)

2.3 The final thermodynamic temperature (2)

2.4 The work done during the compression in kilojoules (3)

2.5 The change in internal energy which takes place during compression in kilojoules (2)

2.6 The heat exchanged during compression in kilojoules (2)
[15]

QUESTION 3

A dryness fraction test was conducted using a combined separating and throttling calorimeter. The steam main line had a pressure of 600 kPa. 0,18 kg of water was collected in the separating calorimeter and the following data was recorded at the throttling calorimeter:

- Steam condensed at exit: 9 kg
- Temperature: 115 °C
- Pressure: 95 kPa

The specific heat capacity for superheated steam is 2 kJ/kg.K.

Calculate each of the following:

3.1 The dryness fraction of the steam in the separating calorimeter (3)

3.2 The dryness fraction of the steam in the throttling calorimeter (8)

3.3 The dryness fraction of the steam in the main line (4)
[15]

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QUESTION 4

A surface condenser receives 14% wet steam at a rate of 5 940 kg/hour. The readings on the manometer and barometer were 670 mm Hg and 760 mm Hg respectively. 0,85 kg of air leaks into the condenser with every 950 kg of steam. The air pump inlet and the condensate are at a temperature of 44,3 °C each and the cooling water enters the condenser at 24 °C and leaves at 41 °C. The specific heat capacity of water is 4,2 kJ/kg.K and the gas constant for air is 0,287 kJ/kg.K.

Calculate each of the following:

4.1 The mass of cooling water required by the condenser in kg/min (10)

4.2 The required capacity of the air pump in m^3/min (5)
[15]

QUESTION 5

5.1 A mass of coal was tested and the following analyses were recorded:

- Hydrogen 6,5%
- Oxygen 2,8%
- Sulphur 7,3%
- Carbon 83,4%

The calorific values of sulphur, carbon and hydrogen are 9 MJ/kg, 34 MJ/kg and 142 MJ/kg respectively.

Calculate each of the following:

5.1.1 The mass of air required for complete combustion of 1 kg of coal when there is 28% excess air supplied (7)

5.1.2 The calorific value of the coal (4)

5.2 A bomb calorimeter was used to test the heat value of a fuel. The following results were recorded:

- Mass of fuel burnt 0,497 g
- Mass of water used in the test 2,4 kg
- Water equivalent of the calorimeter 1 kg
- Change in temperature 1,082 °C
- Specific heat capacity of water 4,187 kJ/kg. °C

Calculate the calorific value of the fuel. (4)
[15]

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QUESTION 6

A double-acting, single-stage air compressor must supply 13,8 m^3/min of air at a pressure of 755 kPa to a pneumatic cylinder. The compressor has a clearance volume of 4,5% of the swept volume and it rotates at 325 r/min. The compressor receives the air at 105 kPa and 18 °C and the index of compression is 1,3.

Calculate each of the following:

6.1 The swept volume of the cylinder (9)

6.2 The power required to drive the compressor (3)

6.3 The temperature of the air supplied to the pneumatic cylinder (3)
[15]

QUESTION 7

The nozzles of an impulse turbine are inclined at an angle of 20° to the plane of rotation of the wheel and steam enters the blades of the wheel at a velocity of 535 m/s. The nominal diameter of the moving blades is 474 mm and the steam exits them at an angle of 22°. Tests conducted on the steam turbine indicate that for a speed of 9 872 r/min, the steam consumption is 45 kg/min and the power developed is 84,6 kW.

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

7.2 Calculate the total whirl velocity of the turbine. (3)

7.3 Construct a velocity diagram in the ANSWER BOOK (landscape) and enter ALL the values (m/s) onto the diagram. Use scale 1 cm : 50 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)

7.4 Use the data from the diagram and calculate the velocity coefficient of friction of the moving blades. (1)
[15]

TOTAL: 100

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

6. $\Delta S = m\left(C_v \ln \frac{T_2}{T_1} + R \ln \frac{V_2}{V_1} \right)$

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. $R = C_p - C_v$

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

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

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

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

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

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