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higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T1310(E)(N26)N
NOVEMBER EXAMINATION

NATIONAL CERTIFICATE

POWER MACHINES N5

(8190035)

26 November 2014 (Y-Paper)
13:00–16:00

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

Calculators may be used.

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

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

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 THREE advantages of a condenser. (6)

1.2 Every hour a surface condenser processes 6 500 kg exhaust steam, which has a dryness fraction of 0,83. Air leakage into the condenser is at a rate of 1,2 kg/1 000 kg of steam. The air pump suction pipe and the condensate have a temperature of 31 ℃ each. The barometer and vacuum gauge reading is 760 mm Hg and 662 mm Hg respectively. The temperature of the cooling water is increased by 21 ℃ after it passes through the condenser. The specific heat capacity of the water is 4 187 kJ/kg.K and R for air is 0,288 kJ.kg.K.

Calculate the following:

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

1.2.2 The capacity of the air pump in m^3/min (6)

[20]

QUESTION 2

2.1 A certain gas has a density of 1,28 kg/m^3 at 200 kPa and 267 ℃. The law, $PV^{1,29} = C$, is used to expand 0,7 kg of this gas to 2,5 times its original volume, from 200 kPa and 267 ℃.

Calculate the following:

2.1.1 The characteristic gas constant (3)

2.1.2 The original and final volume of the gas (6)

2.1.3 The final pressure of the gas (3)

2.1.4 The final temperature of the gas (3)

2.1.5 The work done during the expansion (3)

2.2 State the function of a governor. (2)

[20]

QUESTION 3

Gas leaves a single-stage impulse turbine at an angle of 41°. Friction over the blading causes a 10% loss in velocity. The relative velocity of the gas at the inlet to the blades is 350 m/s at an angle of 30°. The blade experiences a peripheral velocity of 175 m/s, when 50 kg of gas flows through the turbine every second.

3.1 Use a scale of 1 cm = 25 m/s and construct a velocity diagram in the ANSWER BOOK. Enter ALL the values (m/s) onto the diagram.

NB: 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. (11)

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

3.2 Determine the following from the diagram:

3.2.1 The nozzle angle (1)

3.2.2 The nozzle velocity (1)

3.2.3 The exit angle of the moving blades (1)

3.2.4 The axial thrust (3)

3.2.5 The power developed (3)
[20]

QUESTION 4

4.1 18,04 kg of air is used for the complete combustion of a kilogram of fuel.

The fuel has the following composition:

Carbon = 87%
Hydrogen = 2,5%
Sulphur = 1%
The balance of the fuel is non-combustible.

Calculate the percentages of the products of combustion. (18)

4.2 Regulation C112 provides for the access and inspection openings of boilers.

Name TWO reasons for these openings. (2)
[20]

QUESTION 5

5.1 A single-stage, double-acting, compressor must deliver 16 m^3 of air every minute. The compressor receives the air at 101,3 kPa and 20 °C and delivers it at a pressure of 900 kPa. The effective volume is 0,94 of the swept volume, and the speed of the compressor is 375 r/min. The index of compression is 1,3 and the mechanical efficiency is 79%.

Calculate the following:

5.1.1 The volumetric efficiency (3)

5.1.2 The swept volume (4)

5.1. The temperature of the delivered air (3)

5.1.4 The power required to drive the compressor (6)

5.2 Regulation C97.7 refers.

State the hydraulic test pressure for the following boilers:

5.2.1 Boilers which do NOT exceed the working gauge pressure of 500 kPa.

5.2.2 Boilers which exceed the working gauge pressure of 500 kPa.

(2 x 2) (4)

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

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. $h = h_f + x h_{fg}$

20. $h = h_g + C_p \Delta T$

21. $h = h_f + h_{fg} = h_g$

22. $V_{\text{sup}} = \frac{n-1}{n} \left(\frac{h_{\text{sup}} - 1941}{P} \right)$

23. $x = \frac{V_m}{V_g}$

24. $x = \frac{M}{M + m}$

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. $EE = \frac{\dot{m}_s (h_2 - h_1)}{\dot{m}_f \, 2257}$

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. $C_x H_y + \left(x + \frac{y}{4} \right) O_2 = xCO_2 + \frac{y}{2} H_2O$

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. $$H.C.V. = \frac{(m_w + w_e)C_p \Delta T}{m_f}$$

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. $$\eta_c = \frac{V_e}{V_s}.100 = 1 - \frac{V_c}{V_s}\left[\left(\frac{P_2}{P_1}\right)^{\frac{1}{n}} - 1\right] = 1 + \alpha - \alpha(r_p)^{\frac{1}{n}}$$

37. $$\eta_a = \frac{V_a}{V_s}.100$$

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. $$KE = \frac{1}{2}mv^2$$

42. $$U = \pi DN$$

43. $$\dot{m}V = AC$$

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

45. $$V_s = \frac{\pi}{4}D^2L$$

46. $$\theta_1 = t_c - twi$$

47. $$\theta_2 = t_c - two$$

48. $\log.temp.diff.=\dfrac{\theta_1-\theta_2}{\ln\dfrac{\theta_1}{\theta_2}}$

48. $P_{iso}=P_1V_1\ln\left(\dfrac{P_2}{P_1}\right)$

49. $P_{act}=\dfrac{n}{n-1}P_1V_1\left[\left(\dfrac{P_2}{P_1}\right)^{\frac{n-1}{n}}-1\right]$

50. $\eta_{iso}=\dfrac{P_{iso}}{P_{act}}.100$