higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T1390(**E**)(A2)T

NATIONAL CERTIFICATE

POWER MACHINES N5

(8190035)

2 August 2018 (X-Paper)
09:00–12:00

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

Nonprogrammable calculators and drawing instruments may be used.

This question paper consists of 6 pages and a formula sheet of 3 pages.

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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.

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QUESTION 1

1.1 1.1.1 State the function of an air pump in a steam condenser.

1.1.2 Name the TWO most common air pumps.

(2 × 2) (4)

1.2 Name TWO types of turbines used in a power station to generate electricity. (2)

1.3 State the toxic gas which is produced from incomplete combustion. (1)

1.4 State THREE industries where compressed air is used. (3)

[10]

QUESTION 2

A gas of 1 kg mass is expanded polytropically from an initial pressure of 1 300 kPa and a temperature of 250 °C until it occupies a volume of 2 m^3 and has a temperature of 37 °C. Take the gas constant R = 0,287 kJ/kg K.

Calculate the following:

2.1 The final pressure after expansion (3)

2.2 The index of expansion (5)

2.3 The initial volume (3)

2.4 The work done during expansion (4)

[15]

QUESTION 3

The following information were recorded during the testing of a steam boiler.

Mass of steam produced	= 6 600 kg/hr
Mass of coal used	= 600 kg/hr
Pressure of a steam boiler	= 2 000 kPa
Temperature of feedwater entering the boiler	= 95,2 °C
Calorific value of fuel	= 32 MJ/kg
Thermal efficiency of boiler	= 80%

Calculate the following using the steam tables:

3.1 The enthalpy of steam produced by the boiler (6)

3.2 The dryness fraction of steam produced (5)

3.3 The quantity of heat absorbed by steam in the boiler (4)

[15]

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QUESTION 4

A test for dryness fraction was conducted using a combined separating and throttling calorimeter.

The following information was recorded during the test:

The pressure of steam in main line	= 2500 kPa
Mass of water collected in separating calorimeter	= 0,2 kg
Mass of steam condensed after throttling	= 1,8 kg
Pressure after throttling	= 100 kPa
Temperature after throttling	= 125°C
Specific heat capacity of superheated steam	= 2,5 kJ/kg.K

Calculate the following:

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

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

4.3 The dryness fraction of the steam in the main line. (4)

[15]

QUESTION 5

5.1 During a test with a bomb calorimeter the following observations were recorded:

Mass of fuel burned	= 0,515 g
Mass of water in the calorimeter	= 2,42 kg
Water equivalent of the calorimeter	= 390 g
Initial temperature of water in the calorimeter	= 13 °C
Final temperature of water in the calorimeter	= 14,9 °C
Quantity of hydrogen in the fuel	= 15 %
Latent heat of moisture	= 2453 kJ/kg
Specific heat capacity of water	= 4,187 kJ/kg K

Calculate the following:

5.1.1. The highest calorific value of the fuel in MJ/kg (4)

5.1.2 The lowest calorific value of the fuel in MJ/kg (3)

5.2 The Orstat apparatus gave the following analysis of the dry products from an engine's exhaust gas by volume:

CO_2	= 8,7%
O_2	= 5,5%
CO	= 6,3%
Remainder N_2	= 79,5%

Calculate the percentage analysis according to the mass using the table method. (8)

[15]

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QUESTION 6

A single-stage, single-acting reciprocating air compressor has a piston diameter of 150 mm, a stroke length of 160 mm and runs at a speed of 540 r/min. Air enters at an initial pressure of 98 kPa and a temperature of 15 °C. The clearance volume is 6% of the stroke volume and the delivery pressure is 600 kPa. Compression and expansion is according to the law $PV^{1,32} = C$.

Take R as 0,287 kJ/kg K.

Calculate the following:

6.1 The effective stroke volume at inlet in m^3/s (10)

6.2 The volumetric efficiency at inlet (2)

6.3 The power required (3)
[15]

QUESTION 7

A single-stage impulse turbine discharges gas axially. The gas leaves the nozzle at a velocity of 500 m/s and at an angle of 22°. The inlet angle of the moving blade is 28° and the outlet angle of the moving blade is 25°.The coefficient of friction across the blade is 0,9.

7.1 Construct a velocity diagram in the ANSWER BOOK (landscape) and enter ALL the values (m/s) onto the diagram. Use a length of 5 cm for the blade velocity and calculate the scale.

NB: NO marks will be given if the values are not indicated on the diagram and if the diagram is not constructed to scale. (10)

7.2 Determine the following from the velocity diagram:

7.2.1 The blade velocity in m/s (1)

7.2.2 The inlet velocity of the moving blade in m/s (1)

7.2.3 The discharge velocity from the turbine in m/s (1)

7.2.4 The power developed per kg of gas per second in kW (2)
[15]

TOTAL: 100

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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. $Q = P_1V_1 \ln \frac{V_2}{V_1}$
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. $W = P_1V_1 \ln \frac{V_2}{V_1}$
9. $W = \frac{P_1V_1 - P_2V_2}{n-1}$
10. $W = \frac{P_1V_1 - P_2V_2}{\gamma - 1}$
11. $R = C_p - C_{\upsilon}$
12. $\gamma = \frac{C_p}{C_{\upsilon}}$
13. $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$
14. $PV = mRT$
15. $P_1V_1 = P_2V_2$
16. $P_1V_1^n = P_2V_2^n$
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. $V_{\text{sup}} = \frac{n-1}{n}\left(\frac{h_{\text{sup}} - 1\,941}{P}\right)$
23. $\chi = \frac{V_m}{V_g}$
24. $\chi = \frac{M}{M + m}$
25. $U = H - PV$
26. $gZ_1 + U_1 + P_1V_1 + \frac{1}{2}C_1^2 + Q =$

    $gZ_2 + U_2 + P_2V_2 + \frac{1}{2}C_2{}^2 + W$
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. $(m + M)g = m\omega^2 h$

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

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45. $\theta_1 = t_c - twi$

46. $\theta_2 = t_c - two$

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

48. $Piso = P_1 V_1 \ell n \left(\dfrac{P_2}{P_1} \right)$

49. $Pact = \dfrac{n}{n-1} P_1 V_1 \left[\left(\dfrac{P_2}{P_1} \right)^{\frac{n-1}{n}} - 1 \right]$

50. $Niso = \dfrac{Piso}{Pact} \bullet 100$

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