Total No. of printed pages = 8

ME 131402

Roll No. of candidate | | | | | | | | | | |

2017

B. Tech 4th Semester End-Term Examination

APPLIED THERMODYNAMICS

Full Marks–100 Pass Marks–35 Time–Three hours

The figures in the margin indicate full marks for the questions.

1. Answer any *ten* of the following questions : 3×10=30

(a) Mention three accessories and three mountings of a boiler. State the function of each.

(b) Define and explain the term 'Equivalent evaporation.'

(c) What is the effect of friction on flow of steam through a nozzle ? Explain with the help of h-s diagram.

(d) Define critical pressure ratio for a nozzle. Give its values for wet, saturated and superheated steam.

[Turn over

(e) When is a convergent nozzle used ? For a convergent-divergent nozzle, why should the angle of divergence be small ?

(f) Draw a freehand sketch of Mollier diagram and show on it

(i) isentropic expansion

(ii) polytropic expansion

(iii) constant pressure expansion

(iv) isenthalpic expansion.

Use different colours for clarity of the graph.

(g) Define the term 'Slip factor.' What is its significance ? What causes slip ?

(h) What are intercoolers and aftercoolers ?

(i) Differentiate between open and closed feed-water regenerative systems.

(j) Explain with examples positive-displacement type compressors and steady flow compressors.

(k) Define compressor efficiency and turbine efficiency for a gas turbine plant.

(l) In a boiler test, 1250 kg of coal are consumed in 24 hours. The mass of water evaporated is 13000 kg and the mean effective pressure is 7 bar. The feed water temperature is 35°C, heating value of coal is 30000 kJ/kg. If the enthalpy of 1 kg of steam at 7 bar is 2570·7 kJ/kg, determine the equivalent evaporation per kg of coal.

2. Answer any *eight* of the following : 5×8=40

(a) What is binary vapour cycle ? Explain with neat diagram the working of a binary vapour cycle.

(b) Derive $P_{intermediate} = \sqrt{P_{final} \cdot P_{initial}}$ for a 2-stage single acting reciprocating compressor. Hence prove that for a three-stage compressor, the pressure ratio is $\left(\frac{P_{final}}{P_{initial}}\right)^{\frac{1}{3}}$, for ideal intermediate pressure and perfect intercooling.

(c) What do you mean by super saturated flow in steam nozzles ? Explain in detail with the help of h-s diagram.

(d) Derive an expression for maximum mass flow rate per unit area of flow through a convergent-divergent nozzle when steam expands isentropically from rest.

(e) Derive the expression of optimum pressure ratio for maximum network output in ideal Brayton cycle. What is the corresponding cycle efficiency ?

(f) In a gas turbine plant working on Brayton cycle with a regenerator of 75% effectiveness, the air at inlet to the compressor is at 0·1 MPa and 30°C, the pressure ratio is 6 and the maximum cycle temperature is 900°C. If the turbine and compressor have each an efficiency of 80%, find the percentage increase in the cycle efficiency due to regeneration.

(g) Air at temperature of 17°C flows in a centrifugal compressor running at 20,000 rpm. The other data given is as follows :

Slip factor = 0·80, isentropic total head efficiency = 0·75, outer diameter of blade = 500 mm.

Assume the absolute velocities of air at inlet and exit of the compressor to be same. Calculate :

(i) The temperature rise of air passing through the compressor.

(ii) The static pressure ratio.

Take C_p =1·00035 kJ/kg K.

(h) A steam power station uses the following cycle :

Steam at boiler outlet : 150 bar, 550°C

Reheat at 40 bar to 550°C

Condenser at 0·1 bar.

Using Mollier chart and assuming ideal processes, find the

(i) quality at turbine exhaust

(ii) cycle efficiency and

(iii) steam rate.

(i) For a Root blower, the inlet pressure is 1·013 bar and the pressure ratio is 2 to 1. The induced volume of air is 0·03 m^3/rev. Estimate the work input. What would be the work input for a vane-type compressor, if the internal compression takes place through half the pressure range ?

(j) Steam expands from 4 bar to 1 bar in a nozzle. Initial velocity is 90 m/s, initial temperature is 150°C. The nozzle efficiency is 0·85. Determine the exit velocity of steam from nozzle.

3. Answer any *three* questions : 3×10=30

(a) Write short notes on any *two* :

(i) Surging and choking in centrifugal compressors

(ii) Axial flow compressor with proper diagram

(iii) Vane-type compressor.

(b) The intake conditions of a single acting 2-stage air compressor running at 300 rpm are 0·98 bar and 300 K, the delivery presure is 20 bar. The intermediate pressure is 5 bar and the clearance volume of the low pressure compressor is 4% of the stroke volume. The compressor delivers $3m^3$/min at 1 bar, 25°C. Determine :

(i) Power required to drive the compressor

(ii) Low pressure cylinder dimensions, if L = D.

(iii) Isothermal efficiency, when intercooling is perfect and n = 1·2 for compression and expansion in both the cylinders.

(c) In a Rankine cycle, the steam at inlet to the turbine is superheated to 360°C at 20 bar. The exhaust pressure is 0·08 bar. It then enters a condenser, where it is condensed to saturated water. The pump feeds the water back into the boiler.

Determine for per kg of steam :

(i) The pump work

(ii) The turbine work

(iii) The Rankine efficiency

(iv) The condenser heat flow

(v) Dryness fraction at the end of expansion.

(d) The following observations were recorded during a boiler trial :

Mass of feed water and its temperature = 640 kg/hr and 50°C, steam pressure = 11 bar (gauge), quality of steam leaving the boiler is 98% dry, coal fired = 55 kg/hr, H.C.V of coal used = 44100 kJ/kg, flue gas temperature = 300°C, boiler house temperature = 30°C, mass of dry flue gas is 15 kg/kg of fuel.

The flue gas analysis by volume is : CO_2 = 12·5% , CO = 1·5%, carbon present in fuel is 85% by mass.

C_p (dry flue gases) = 1 kJ/kg°C, C_p(superheated steam) = 2·2 kJ/kg°C.

The fuel contains no moisture at the time of feeding into the boiler.

Find

(i) Efficiency of the boiler

(ii) Draw up the heat balance sheet on the basis of 1 kg of coal fed.