BENGAL ENGINEERING AND SCIENCE UNIVERSITY, SHIBPUR
B.E. 5th SEMESTER (M.E) EXAMINATION, 2012
Internal Combustion Engine (ME-502)

Full Marks: 70 **Time: 3 hrs**

i) **Use SINGLE ANSWERCRIPT covering both sections.**

ii) **All questions carry equal marks.**

iii) **Attempt six questions taking three from each section.**

iv) **Assume suitable data where necessary.**

SECTION A

1. a) A simple jet carburetor is required to supply 6 kg of air per minute and 0.45 kg/min of fuel having density of 740 kg/m^3. The air is initially at a pressure of 1.013 bar and temperature of 27^{0}C. Calculate the throat diameter of the choke tube for a flow velocity of 92 m/s considering the velocity coefficient to be 0.8. If the pressure drop across the fuel metering orifice is 0.75 of that at the choke, calculate the orifice diameter assuming the coefficient of discharge (C_d) to be 0.60.
   b) What are the major limitations of a simple carburetor? Derive an expression for the air fuel ratio in a simple carburetor considering the effect of compressibility of air into account.
2. a) Describe with pressure-crank angle (p-θ) diagram the various stages of combustion in spark ignition engine with special emphasis on flame front propagation.
   b) Explain in brief the phenomenon of knocking in CI engines.
3. a) State the different losses considered in actual cycle analysis.
   b) The following data were collected during the trial on a single cylinder four stroke oil engine:
   Diameter of the cylinder: 250mm
   Stroke of the piston: 600mm
   Area of the indicator diagram: 4.5 cm^2
   Length of the indicator diagram: 7.1 cm
   Spring constant: 8.5 bar/cm
   Engine speed: 350 rpm
   Load on hydraulic diameter: 955.5 N
   Dynamometer Constant: 9333
   Fuel consumption: 11.1 kg/h

Calorific value of fuel: 41840 kJ/kg
Mass flow rate of cooling water: 18.3 kg/min
Rise in temperature of cooling water: 25^0C
Mass analysis of fuel C=85% and H_2= 15%
Volumetric analysis of exhaust gases: CO_2=8%, O_2=11% and N_2=81%
Temperature of exhaust gases: 400^0C
Ambient temperature: 25^0C
Specific heat of exhaust gases: 1.005 kJ/kgK
Specific heat of superheated steam: 2.008 kJ/kgK
Partial pressure of steam in exhaust gases: 0.036 bar
Draw heat balance sheet on minute and percentage basis. Consider the value of specific heat of liquid water to at room temperature (25^0C) to be 104.8 kJ/Kg.

4. a) What are the different components of a battery ignition system? Describe with a simple circuit diagram the operation of a battery ignition system.
   b) Explain the effect of supercharging on the performance of an engine with respect to the following:
   i) Power output ii) Mechanical efficiency iii) Fuel consumption

5. Write short notes on the following (any three):
   a) Rating of SI and CI engine fuels b) Valve timing diagram for high speed SI engine iii) Exhaust blowdown loss iv) Function of idling system in SI engine

SECTION B

6. The following data apply to gas turbine set employing a separate power turbine, regenerator and intercooler between two stage compressions:
Isentropic efficiency of compression of each stage: 80%
Isentropic efficiency of both compressor and power turbines: 88%
Turbine to compressor transmission efficiency: 98%
Pressure ratio in each stage of compression: 3:1
Temperature after intercooler: 297K
Air mass flow rate: 15kg/s
Regenerator effectiveness: 80%
Regenerator gas side pressure loss: 0.1 bar
Maximum turbine temperature: 1000K
Ambient temperature: 327K
Ambient pressure: 1 bar
Calorific value of fuel: 43.1 MJ/kg

Calculate the net power output, specific fuel consumption and overall thermal efficiency. Assume that the pressure losses in the air side of the regenerator and combustion chamber are accounted for in the compressor efficiency.
Assume, C_{pa}=1.005 kJ/kg K, C_{pg}=1.147 kJ/kg K, γ_a=1.4, γ_g=1.33.

7 a) Define the term "critical pressure ratio" in a nozzle. Prove that when a nozzle is subjected to critical pressure ratio the velocity of the fluid flowing through it is equal to the velocity of sound under that condition.

b) Gases expand in a propulsion nozzle from 3.5 bar and 425^{0}C down to a back pressure of 0.97 bar at the rate of 18 kg/s. Taking a coefficient of discharge of 0.99 and a nozzle efficiency of 0.94, calculate the required throat and exit areas of the nozzle. For the gases take adiabatic index γ=1.333 and C_p=1.11 kJ/kg K. Assume that the inlet velocity is negligible.

8 a) Explain the working of turbo jet engine in PV and T S diagram with advantages and disadvantages.

b) Explain the following terminologies with respect to jet propulsion:

i) Propulsive efficiency ii) thrust specific fuel consumption iii) Thermal efficiency of a turbojet engine

9. A simple jet engine has compressor directly coupled to the turbine mounted in an aircraft with forward facing intake and rearward convergent propelling nozzle. Calculate the total thrust when the aircraft flies at true air speed of 300 m/s in the ambient conditions of temperature -10^{0}C and pressure 0.58 bar. Consider the following data:
Air mass flow rate: 39 kg/s
Compressor stagnation pressure ratio: 7.5:1
Turbine inlet stagnation temperature: 650^{0}C
Combustion chamber pressure loss in stagnation: 4%
Compressor stage efficiency: 82%
Turbine stage efficiency: 85%
Ram efficiency: 90%
Consider the nozzle efficiency, mechanical efficiency and combustion efficiency each to be 100 %.

10. Write short notes on the following

i) Off design performance of a convergent divergent nozzle ii) Purpose of providing afterburners in jet engines iii) Advantages of ramjet engine

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