PART - A
Comprehensive Examination
First Semester 2023-2024

Name: Id:

Birla Institute of Technology and Science, Pilani
ME F317: Engines, Motors, and Mobility

Close Book 30 Marks 09:00-10:00 AM, 11/12/2023

Instructions: *1. Please write concisely and legibly. Final answers should be clearly marked.*
2. Draw neat labelled diagrams wherever necessary.
3. All parts of a question should be answered consecutively.
4. Assumptions made if any, should be stated clearly at the beginning of your answer.

Q1. Draw a representative P-V diagram of an SI engine and compare it with the corresponding Otto cycle P-V diagram. Explain the differences and underlying reasons for the same. **[6M]**

Q2. Why *hydrogen* is being considered an ideal fuel for IC engines? Write down four advantages and four disadvantages of hydrogen as a fuel in IC engines. **[6M]**

Q3. A random fuel is tested and found to have the Cetane number 36. What do you understand by Cetane number? What conclusions can you draw from the given information with reference to – (i) fuel quality, (ii) suitability in the engines (both SI and CI), (iii) fuel volatility **[6M]**

Q4. What do you understand by three-way catalytic converter? Explain its construction features using a simple diagram. Explain its suitability for gasoline and diesel engines. Draw a characteristic curve showing emission conversion efficiency with Air-fuel ratio. **[6M]**

Q6. An automobile has a 3.2-liter, five-cylinder, four-stroke diesel engine operating at 2400 rpm. Fuel injection occurs from 20° BTDC to 5° ATDC. The engine has a volumetric efficiency of 0.95 and operates with fuel equivalence ratio of 0.8. Calculate:

(i) Time for one injection

(ii) Fuel flow rate through an injector

(iii) What effect on knocking tendency if fuel injection occurs from 15° BTDC to 10° ATDC. Why?

Hint – take Stoichiometric A/F ratio – 14.5 **[6M]**

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PART - B
Comprehensive Examination
First Semester 2023-2024

Name: Id:

Birla Institute of Technology and Science, Pilani
ME F317: Engines, Motors, and Mobility

Open Book: 50 Marks 10:00-12:00 AM, 11/12/2023

Instructions: *1. Please write concisely and legibly. Final answers should be clearly marked.*
2. Draw neat labelled diagrams wherever necessary.
3. All parts of a question should be answered consecutively. Each answer should start from a fresh page.
4. Assumptions made if any, should be stated clearly at the beginning of your answer.

Q1. A four-stroke gasoline engine has six single-acting cylinders of 8 cm bore and 10 cm stroke. The engine is coupled to a brake having a torque radius of 40 cm. At 320 rpm, with all cylinders operating, the net brake load is 350 N. When each cylinder in turn is rendered inoperative, the average net brake load produced at the same speed by the remaining 5 cylinders is 250 N. With all cylinders operating, the fuel consumption is 0.33 kg/min; calorific value of fuel is 43 MJ/kg; the cooling water flow rate and temperature rise are 70 kg/min and 10°C respectively. On test, the engine is enclosed in a thermally and acoustically insulated box through which the output drive, water, fuel, air and exhaust connections pass. Ventilating air blown up through the box at the rate of 15 kg/min enters at 17°C and leaves at 62°C.

a) Estimate the indicated mean effective pressure of the engine **[3M]**
b) Draw a schematic diagram of the test engine **[3M]**
c) Draw up a heat balance of the engine stating the items as a percentage of the heat input. **[6 M]**

Q2. A person wants to buy an electric vehicle (EV) that is said to offer 450 km range and houses a battery pack of capacity 38.5 kWh. He gathers some details about the battery cells which are following: cell type – Li-ion cylindrical type (18650), cell weight – 76 g, cell capacity (at 0.5C rate) – 2.5 Ah, cell voltage (nominal) – 3.3 V, cell peak current (charging)– 10 A, cell peak current (discharging) – 20 A, cell life – >1000 cycles.

Following battery pack details are also available: pack voltage – 240 V, mass of pack – 1.2 times mass of total cell mass, volume of pack – 1.3 times volume of total cell volume.

The cost of this vehicle is 5 lakhs (in rupee) higher than the non-electric version. His average running distance per month is 2000 km. The charging cost – 12 ₹/unit whereas gasoline cost is 112 ₹/litre (vehicle mileage can be taken as 14 km/litre).

Determine:

(i) Cell volumetric and gravimetric energy densities. [**2M]**

(ii) Vehicle energy consumption per km (Wh/km). **[1M]**

(iii) Cell configuration of battery pack (number of cell in series and parallel). **[5M]**

(iv) Total mass and volume of battery pack. [**3M]**

(v) Peak power supply of the battery pack. [**3M]**

(vi) Schematic diagram of this battery pack with BMS. **[3M]**

(vii) Should he buy this vehicle? Give justification for your recommendation. **[3M]**

Hint: Your answers should be based on the given details only. Don't take any other assumptions.

Q3. (a) A turbocharged Diesel engine has an exhaust gas flow rate of 0.15 kg/s. The turbine entry conditions are 500°C at 1.5 bar, and the exit conditions are 450°C at 1.1 bar. Calculate the turbine isentropic efficiency and power output. Draw a schematic diagram of the turbocharged Diesel engine setup and P-T diagram for turbocharging process. **[6M]**

(b) The engine design is changed to reduce the heat transfer from the combustion chamber, and for the same operating conditions the exhaust temperature becomes 550°C. The pressure ratio remains the same, and assume the same turbine isentropic efficiency. Calculate the increase in power output from the turbine. How will the performance of the engine be changed by reducing the heat transfer, in terms of: economy, power output an emissions? **[6M]**

Assume: ratio of specific heat capacities = 1.3, and C_P = 1.15 k.J/kgK

Q4. (a) Methanol is burned with 20% excess air. Determine the stoichiometric air/fuel ratio and the actual air/fuel ratio. **[3M]**

(b) If the air is supplied at 1 bar and 27°C, calculate the volume of air supplied per kmole of the fuel. **[3M]**

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