Indian Institute of Technology Kharagpur

Department of Mechanical Engineering

ATF-1 (Internal Combustion Engine) ME41001

Tutorial 3

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1. A compression-ignition engine has a volumetric compression ratio of 15. Find the thermal efficiency of the following air-standard cycles having the same volumetric compression ratio as the engine. The specific heat capacity ratio is 1.4.
   a) an Otto cycle

   (0.661)

   b) a Diesel cycle in which the temperature at the beginning of compression is 18^0C, and in which the heat supplied per unit mass of air is equal to the energy supplied by the fuel (in terms of its calorific value). The gravimetric air:fuel ratio is 28:1; the calorific value of the fuel is 44 MJ/kg; assume the specific heat of air at constant pressure is 1.01 kJ/kgK and is independent of temperature.

   (0.566)

2. A petrol engine of volumetric compression ratio 9 to 1 takes in a mixture of air and fuel in the ratio 17 to 1 by weight; the calorific value of the fuel is 44 MJ/kg. At the start of compression the temperature of the charge is 50^0C. Assume that compression and expansion are reversible with pv^n = constant, and n = 1.325 and 1.240 respectively, and that combustion occurs instantaneously at minimum volume. Combustion can be regarded as adding heat equal to the calorific value to the charge.

However, there is a finite combustion efficiency, and heat transfer from the combustion chamber. Combustion is thus equivalent to a net heat input that corresponds to 75% of the calorific value of the fuel being burnt.

Calculate the temperatures (in K): after compression, and at the start and end of expansion.

(T_2=660, T_3=2590, T_4=1529)

Calculate the net work produced by the cycle and thus calculate the indicated efficiency of the engine. (**1026 kJ/kg_mixture, 42%)**

Use the following thermodynamic data: c_v for heat release process = 0.95; molar mass (kg) for air-fuel mixture 30, for combustion products 28. Universal gas constant = 8.314 kJ/kmole.K.

3. A CI engine operating on the air-standard Diesel cycle has cylinder conditions at the start of compression of 65^0C and 130 kPa. Light diesel fuel is used at an equivalence ratio of φ=0.8 with a combustion efficiency η_c=0.98. Compression ratio is r_c=19. Take k=1.35. Q_{CV}=42.5 MJ/kg; stoichiometric AF= 14.5; gas constant R = 0.287 kJ/kg.K. Calculate:

- **a)** Temperature at each state of the cycle. [K] **(338, 946, 2914, 1544)**
- **b)** Pressure at each state of the cycle. [kPa] **(130, 6922, 6922, 595)**
- **c)** Cutoff ratio. **(3.08)**
- **d)** Indicated thermal efficiency. [%] **(54.6)**
- **e)** Heat lost in exhaust. [kJ/kg] **(989)**