

## Questions

- (5.1) What is the significance of space velocity of a catalytic converter? A gasoline car powered by a 1.2 litre swept volume engine is fitted with a catalytic converter of 1.2 litre. The maximum speed of the engine is 5,500 rpm and when operating at maximum load it has volumetric efficiency of 0.8. Taking inlet conditions as 100 kPa, 300K and stoichiometric mixture, calculate the maximum space velocity encountered in the converter if the exhaust gas enters the catalyst at 500 K. Take gasoline as octane.
- (5.2) In the above converter, exhaust gas with 1.2% CO and 1000 ppmC1 HC enters. If conversion efficiency of the converter is 90 % for CO and HC, estimate increase in the gas temperature under steady state operation of the engine and converter. The LHV of gasoline is 44 MJ/kg and of CO is 10.1 MJ/kg. The specific heats of gases are:  $N_2 = 33.75$ ,  $O_2 = 35.59$ ,  $CO_2 = 55.37$ ,  $H_2O = 44.94$  kJ/kmol.K
- (5.3) In a gasoline car exhaust gas with 9.0, 0.8 and 0.6 g/km of CO, HC and  $NO_x$  enters the 3-way catalytic converter. During city trip of 15 km for the first 1.5 km the exhaust gas temperatures being low the catalyst has overall only 20% conversion efficiency. For the remaining trip, efficiency of conversion is 85%. Find the average vehicle emissions for the trip in g/km.
- (5.4) An inventor claims that he has developed a non-catalyst thermal reactor when fitted in the exhaust muffler converts HC and CO by 50%. Under the full engine load peak combustion pressure are about 40 bar and temperature is 2500 K. Under the other conditions the peak combustion temperatures and pressures would be lower than these. The exhaust blows down to 1.1 bar pressure. The polytropic index of expansion process is about 1.28. As the gas flows through the exhaust pipe its temperature falls by 50% when it reaches the exhaust muffler. The residence time for the exhaust gas in the muffler is 100 ms. In view of the above information verify the acceptability of these claims.
- (5.5) An engine misfires and HC concentration in the exhaust gas suddenly rises to 50,000 ppmC1. Estimate the extent of sudden increase in the gas and catalyst temperatures for a ceramic monolith converter. The converter volume is 0.85 litre, mass 340 g, specific heat is 0.9 kJ/kg. K.
- (5.6) If the engine in Problem 5.5 is fitted with metal monolith converter of the same size having mass of 680 g and specific heat of 0.5 kJ/kg.K what would be the maximum temperatures reached. Assume the unburned HC are like gasoline in composition and have the same LHV as given in Problem 5.2.
- (5.7) For cold start emission control discuss the advantages and disadvantages of the closed coupled catalysts, electric heated catalysts and HC traps.