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Study of mechanical, thermal and volumetric efficiencies.



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Volumetric Efficiency

Volumetric efficiency of an engine is an indication of the measure of the degree to which the engine fills its swept volume.

It is defined as the ratio of the mass of air inducted into the engine cylinder during the suction stroke to the mass of the air corresponding to the swept volume of the engine at atmospheric pressure and temperature.

Alternatively, it can be defined as the ratio of the actual volume inhaled during suction stroke measured at intake conditions to the swept volume of the piston.



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Volumetric Efficiency (Contd.)

Volumetric efficiency, η_v

$$= \frac{\text{Mass of charge actually sucked in}}{\text{Mass of charge corresponding to the cylinder intake } P \text{ and } T \text{ conditions}}$$

- The amount of air taken inside the cylinder is dependent on the volumetric efficiency of an engine and hence puts a limit on the amount of fuel which can be efficiently burned and the power output.
- For supercharged engine the volumetric efficiency has no meaning as it comes out to be more than unity.



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Fuel-Air Ratio (F/A) IC Engine Testing

Fuel-air ratio (F/A) is the ratio of the mass of fuel to the mass of air in the fuel-air mixture. Fuel-air ratio of the mixture affects the combustion phenomenon.

- It determines the flame propagation velocity, the heat release in the combustion chamber, the maximum temperature and the completeness of combustion.
- Relative fuel-air ratio is defined as the ratio of the actual fuel-air ratio to that of the stoichiometric fuel-air ratio required to burn the fuel supplied.
- Stoichiometric fuel-air ratio is the ratio of fuel to air is one in which case fuel is completely burned due to minimum quantity of air supplied.



Relative fuel-air ratio, $F_R = \frac{\text{Actual fuel - Air ratio}}{\text{Stoichiometric fuel - Air ratio}}$

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Brake Specific Fuel Consumption

Specific fuel consumption is defined as the amount of fuel consumed for each unit of brake power evolved per hour. It is a clear indication of the efficiency with which the engine develops power from fuel.

Brake specific fuel consumption (*bsfc*) = $\frac{\text{Actual fuel - Air ratio}}{\text{Stoichiometric fuel - Air ratio}}$



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Thermal Efficiency and Heat Balance

Thermal efficiency of an engine is defined as the ratio of the output to that of the chemical energy input in the form of fuel supply.

It may be based on brake or indicated output.

It is the true indication of the efficiency with which the chemical energy of fuel (input) is converted into mechanical work.

Thermal efficiency also accounts for combustion efficiency, i.e., for the fact that whole of the chemical energy of the fuel is not converted into heat energy during combustion.



$$\text{Brake thermal efficiency} = \frac{bp}{m_f \times C_v}$$

where, C_v = Calorific value of fuel, kJ/kg, and

m_f = Mass of fuel supplied, kg/sec.

- The energy input to the engine goes out in various forms – a part is in the form of brake output, a part into exhaust, and the rest is taken by cooling water and the lubricating oil.
- The break-up of the total energy input into these different parts is called the heat balance.
- The main components in a heat balance are brake output, coolant losses, heat going to exhaust, radiation and other losses.
- Preparation of heat balance sheet gives us an idea about the amount of energy wasted in various parts and allows us to think of methods to reduce the losses so incurred.