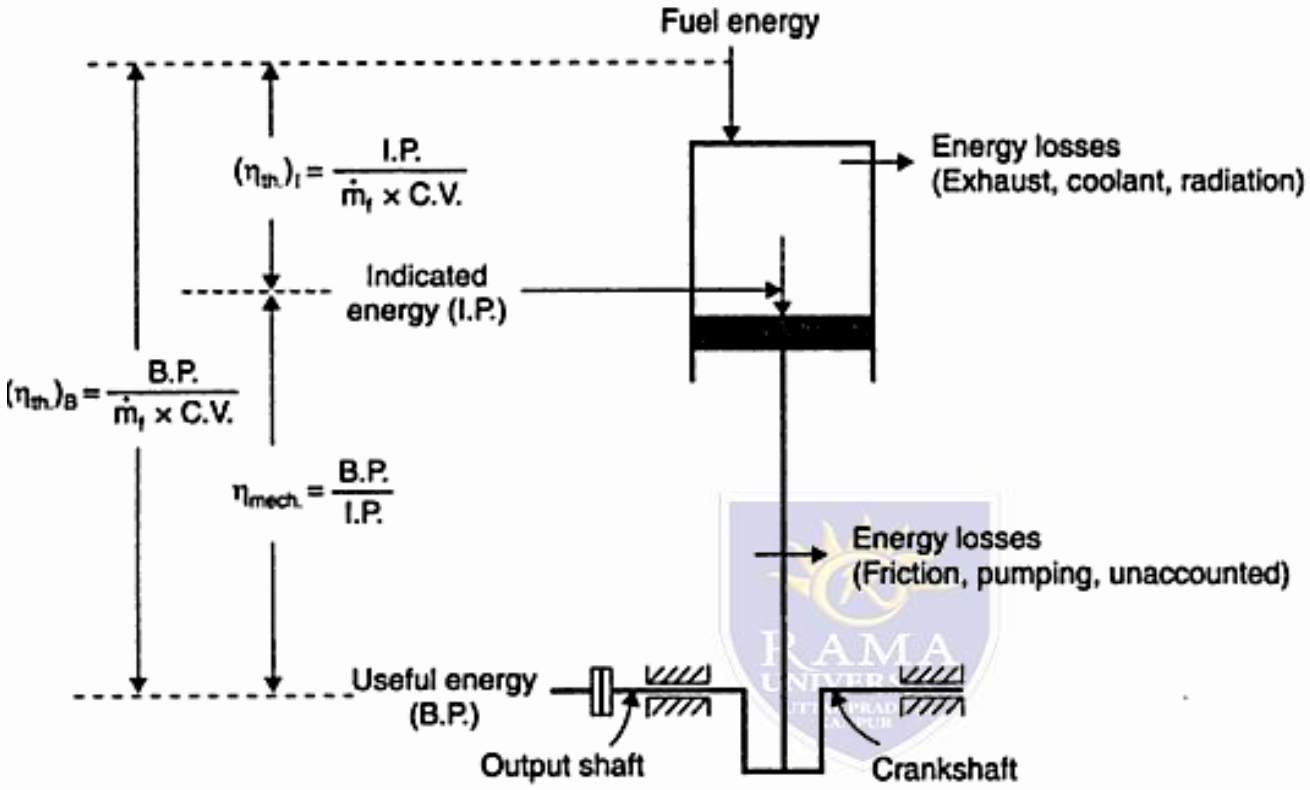

I.P. = Indicated power

B.P. = Brake power

$(\eta_{th.})_I$ = Indicated thermal efficiency = $\frac{I.P.}{\dot{m}_f \times C.V.}$

(where $\dot{m}_f$ = mass of fuel in kg/s and C.V. = calorific value)

$(\eta_{th.})_B$ = Brake thermal efficiency.

Fig. 2.3. The energy flow through the reciprocating engine.

- The energy available at the piston passes through the connecting rod to the crankshaft. In this transmission of energy/power there are losses due to friction, pumping, etc. The sum of all these losses, converted to power, is termed as **Friction Power (F.P.)**. The remaining energy is the *useful mechanical energy and is termed as* **shaft energy** or **Brake Power (B.P.)**. The *ratio of energy at shaft to fuel input energy is called* **brake thermal efficiency** $[\eta_{th.(B)}]$.
- The *ratio of shaft energy to the energy available at the piston is called* **mechanical efficiency** $(\eta_{mech.})$.

- Resistances to Motion
- A moving vehicle has to overcome the following resistances.
- 1. Air resistance:
- It is the resistance offered by air to the vehicle motion. It depends on the following factors.
- (l) Size of vehicle
- (2) Shape of vehicle
- (3) Speed of vehicle, and
- (4) Wind velocity.
- 2. Gradient resistances:
- It is the component of the vehicle's weight which is parallel to the plane of the road. This component remains constant but independent of the vehicle's speed.
- 3. Miscellaneous resistance:
- Other resistances such as rolling resistances depend on the following parameters.
- (1) Road characteristics
- (2) Tyre characteristics
- (3) Weight of the vehicle
- (4) Vehicle speed.
- Resistances to Vehicle Motion
- The fundamentals of vehicle design involve the basic principles of Newton's second law of motion. According to Newton's second law the acceleration of an object is proportional to the net force exerted on it. Hence, an object accelerates when the net force acting on it is not zero. In a vehicle, several forces act on it and the net or resultant force governs the motion according to the Newton's second law. The propulsion unit of the vehicle delivers the force necessary to move the vehicle forward. This force of the propulsion unit helps the vehicle to overcome the resisting forces due to gravity, air and tire resistance. The acceleration of the vehicle depends on.

- • the power delivered by the propulsion unit
- • the road conditions
- • the aerodynamics of the vehicle
- • the composite mass of the vehicle.
- Broadly the resistances can be categorized into the following categories.
- (i) Air resistance or Aerodynamic drag
- (ii) Gradient resistance
- (iii) Rolling resistance
- (iv) Inertia force.
- All the above produce a restraining force working against the tractive force. The tractive force must be greater than or equal to the resistive forces in order to maintain a sustainable motion.
- 1. Air resistance / Aerodynamic drag:
- A vehicle traveling at a particular speed in air encounters a force resistmg its motion. This force is known as aerodynamic drag. Simply speaking, it is the resistance offered by air to the vehicle motion. It depends upon the following factors.
- (1) Size of the vehicle
- (2) Shape of the vehicle
- (3) Speed of the vehicle
- (4) Wind velocity.
- 2. Gradient resistance:
- It is the component of the vehicle's weight which is parallel to the plane of the road. When a vehicle goes up or down a slope, its weight produces a component of force that is always directed downwards. If the vehicle travels uphill, a component of its weight works in a direction opposite to its motion. If some energy is not supplied to overcome this backward force, then the vehicle would slow down, stall and roll backwards. If the vehicle is trading uphill at. a slope of 8, then the weight of the vehicle. W has two components. One perpendicular to the road surface (with a value W x Cos 8) and the other along the road
- surface (with a value W x Sin 8). The component along the road surface is the one that tries to restrict the motion.
- The gradient resistance is given by. FG = W x Sinθ

- 3. Rolling resistance:
- The rolling resistance of tyres on hard surfaces is due to hysteresis it. the tyre material.
- When a vehicle rolls, it rolls with its tyres in contact with the road surface.
- The relative motion of two hard surfaces produces a friction. Further, neither the road, nor the tyre is perfectly rigid. Hence, both flex under the load slightly.
- As there is a gradual deformation at the contact between the road and the tyre, greatest at the bottom most point and least at the entry and exit points, the slip of the tyre with respect to the road produces another type of loss of energy which results in a resistance.
- Rolling resistance is the sum of the following components.
  - Tyre Rolling resistance: Resistance from tyre deformation
  - Road rolling resistance: Resistance from tyre penetration and surface compression.
  - Resistance due to tyre slip angle: Resistance from tyre slippage and air circulation around wheel.
  - Resistance due to bearing friction and residual braking.
- 4. Inertiaforce:
- In addition to the driving resistance occurring in steady state motion, inertia forces also occur during acceleration and braking.
- The total mass of the vehicle and the inertia mass of those rotating parts of the drive accelerated or braked are the factors influencing the resistance to acceleration.
- The rotational component is a function of the gear ratio.
- The moment of inertia of the rotating drive elements of engine, clutch, gearbox, drive shaft, etc., including all the road wheels are reduced to the driving axle.