MODULE – 5

IC Engines: Components and working principle of Four stroke SI Engine, Applications- Power generation, Agriculture, Marine, Automobiles and Aircraft propulsion, Performance of IC engines (numerical problems on IP, BP, Mechanical Efficiency and Thermal Efficiency)
Electric Vehicle: Components & working principle of EV, Advantages and disadvantages.

Introduction to IC Engines

What is an ENGINE???

- It is a device which converts heat energy liberated by combustion of fuel into mechanical energy.

Types of engines

- Internal combustion engine
- External combustion engine

Internal combustion engine

- Internal Combustion Engine (IC engine) is basically a **heat engine** in which **combustion take place inside engine**.

OR

- The fuel supplies **the thermal energy when burns inside**, which means **combustion of fuel takes place inside the engine** and thus it is called Internal Combustion Engine .
- **Ex**: *Petrol engine*, *diesel engine, etc.*

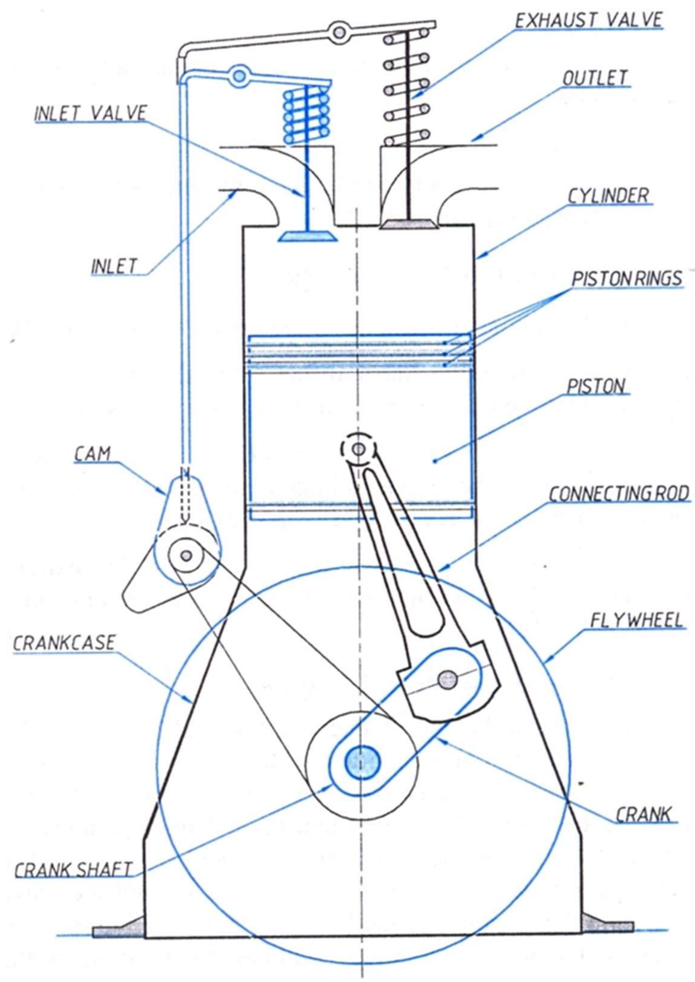
External combustion engine

- An engine in which fuel burns outside the engine, that is, combustion of fuel takes place outside the engine, is called external combustion engine
- Ex: Steam turbine

COMPONENTS OF I.C. ENGINE

The components of I.C. Engine are as follows,

1. Cylinder
2. Piston
3. Piston Rings
4. Connecting Rod
5. Crank and Crankshaft
6. Valves
7. Flywheel



Parts of I.C.Engine

1). Cylinder:
- Heart of the engine.
- Fuel is burnt and power is developed.
- Inside diameter is called "***bore***".

2). Piston:
- Is a close fitting hollow-cylindrical plunger.
- It reciprocates inside the cylinder.
- Power developed by combustion of fuel is transmitted by piston to crank-shaft through connecting rod.

3). Piston Rings:
- Metallic rings inserted into the circumferential grooves at top of the piston.
- These rings maintain gas tight joint between piston and cylinder.
- Also help in conducting heat from piston to cylinder.

4). Connecting Rod:
- Link that connects piston and crankshaft by means of pin joints.
- Converts rectilinear motion of piston into rotary motion of the crankshaft.

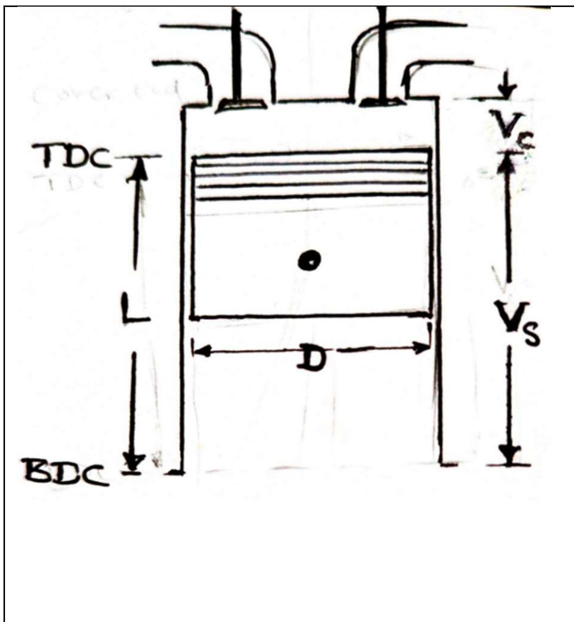
5). Crank and Crankshaft:
- *Crank* is the lever connecting to end of connecting rod by pin joint
- Other end of crank is connected rigidly to a shaft called *crankshaft*

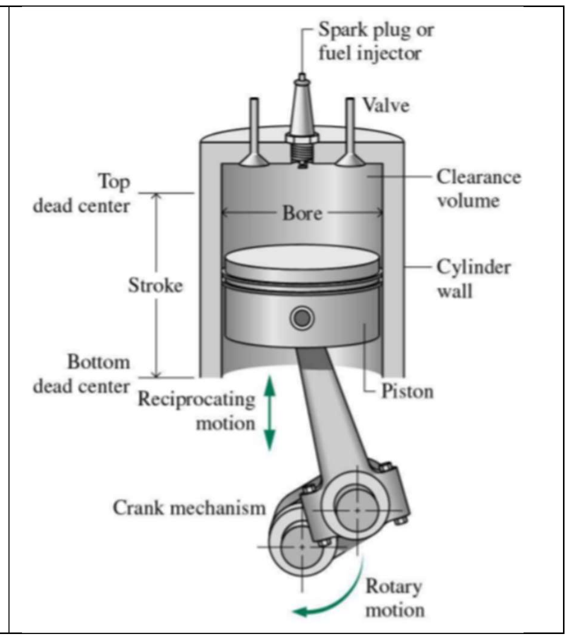
6. Valves:
- Devices which control flow of intake and exhaust gases to and from engine cylinder
- Also called poppet valves
- These valves are operated by means of cams driven by crankshaft through a timing gear or chain.

7. Flywheel:
- Heavy wheel mounted on crankshaft of the engine
- Helps in maintaining uniform rotation of the crankshaft

8. Crankcase:
- Lower part of the engine serving an enclosure for crankshaft
- Also a sump for lubricating oil

I. C. ENGINE TERMINOLOGY





Bore (D): Inner diameter of the engine

Stroke (L) : It is the linear distance travelled by the piston when it moves from one end of the cylinder to the other end. ***Stroke is equal to twice the radius of the crank***

Cover End or Top Dead Centre (TDC):
The extreme position near to the cover or cylinder head of the engine is called **cover end**. In vertical engines, this extreme position of the piston is called **Top Dead Centre (TDC).**

Crank End or Bottom Dead Centre (BDC):
The extreme position near to the crank is called **crank end**.

In vertical engines, this extreme position of the piston is called the **Bottom Dead Centre (BDC)**.

Swept volume (Vs):

- It is the volume covered by the piston when the piston moves from TDC to BDC.
- It is denoted by **Vs** and is given by,

$$V_S = \frac{(\pi D^2)}{4} * L$$

Clearance volume (V_C):

- It is the volume occupied by the charge at the end of compression stroke when the piston is at TDC.

Compression ratio (C.R):

- It is the ratio of total volume of the cylinder to the clearance volume.
- Compression ratio (C.R): $r = \frac{\text{Total volume}}{\text{Clearance volume}}$

$$r = \frac{V_T}{V_C} = \frac{(V_S + V_C)}{V_C}$$

FOUR STROKE PETROL ENGINE (SPARK IGNITION)

(THEORETICAL OTTO CYCLE OR Constant volume heat addition cycle)

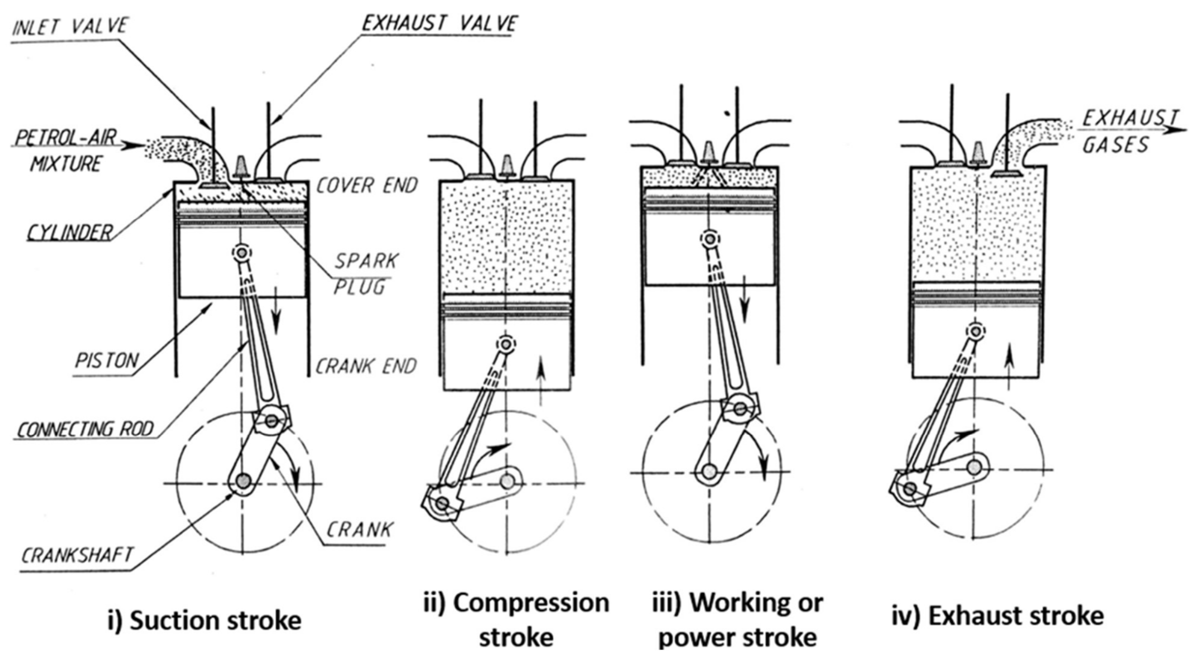


Fig. Different Strokes in Petrol Engine

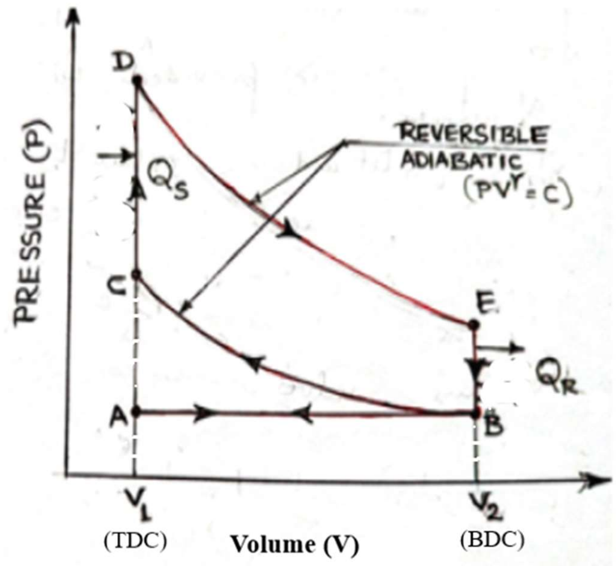


Fig. Theoretical Otto cycle
(P-V diagram of FOUR STROKE PETROL ENGINE)

Features:

- It consists of a cylinder with its **one end fitted a cover** and the **other end open**.
- **The cover is provided with inlet and exhaust apertures** which are mechanically operated by valves called inlet and exhaust valve respectively.
- **The spark plug fitted at the top of the cover initiates the ignition of the petrol**, hence the name **spark ignition engine**.
- **A freely moving piston reciprocates inside the cylinder**.
- The **connecting rod** and the **crank** convert the **reciprocating motion of the piston into the rotary motion.**
- The petrol engines work on the principle of **theoretical OTTO cycle**, also known as **constant volume heat addition cycle**.
- The piston performs **4 strokes to complete one working cycle**, hence the name 4S engine.
- The four different strokes are,

  i) Suction stroke

  ii) Compression stroke

  iii) Working or power stroke

  iv) Exhaust stroke.

1. SUCTION STROKE:

- **Inlet valve is open** and the **exhaust valve is closed**.
- The piston moves from the cover end **(TDC)** to the crank end **(BDC)**.
- Crankshaft revolves by **half rotation**.
- The volume in the cylinder increases, the pressure decreases.

- This sets up a pressure differential between the atmosphere and the inside of the cylinder.
- Due to this pressure differential the petrol & air mixture will be drawn into the cylinder through the **carburetor.**
- This stroke is represented by the horizontal line **AB on the** PV diagram.

2. COMPRESSION STROKE:

- Both the **inlet valve and exhaust valve are closed**.
- Piston moves from crank end (BDC) to cover end (TDC).
- Crankshaft revolves next half revolution.
- The petrol and air mixture contained in the cylinder is compressed.
- The **compression ratio** of petrol engine varies from **7:1 to 11:1**
- The process of compression is **reversible adiabatic or isentropic**.
- The process is represented by **curve BC** on PV diagram.
- **At the end of the stroke** the high temperature and pressure petrol-air mixture is ignited by electric spark produced by spark plug.
- The **constant volume** combustion is theoretically represented by **vertical line CD** on PV diagram.

3. WORKING / POWER / EXPANSION STROKE:

- Both **inlet valve** and **exhaust valve** are **closed**.
- The piston moves from the cover end (TDC) to the crank end (BDC).
- Crank revolves by **half revolution.**
- The high pressure of the **burnt gases forces the piston downwards performing power stroke**.
- The **linear motion of the piston is converted to rotary motion** of the crankshaft by connecting rod.
- The **theoretical expansion process** of burnt gases is considered as Reversible Adiabatic or isentropic and represented by **curve on DE** on PV diagram.
- At the **end of the stroke exhaust valve opens**.
- **This brings down pressure** in the cylinder to that of atmosphere. **The drop in pressure** takes place at constant volume theoretically and is represented by **vertical line EB on PV diagram.**

4. EXHAUST STROKE:

- **Exhaust valve is open** and **inlet valve is closed.**
- Piston moves from crank end (BDC) to cover end (TDC).
- **Crank revolves** by **half rotation**.
- The burnt gases are expelled from cylinder at atmospheric pressure.
- The process is represented by horizontal line **BA** on PV diagram.

APPLICATION OF IC ENGINES

- Power generation,
- Agriculture,
- Marine,
- Aircraft propulsion and
- Automobile

POWER GENERATION

- A diesel generator is the **combination of a diesel engine with an electric generator (often an alternator) to generate electrical energy**.
- This is a specific case of engine-generator.
- **A diesel compression-ignition engine** is usually designed to run on diesel fuel, but some types are adapted for other liquid fuels or natural gas.
- Diesel **generating sets are used in places without connection to a power grid, or as emergency power-supply if the grid fails**, as well as for more complex applications such as peak-lopping, grid support and export to the power grid.

Figure. Diesel generator for backup power

AGRICULTURE

- IC Engine pump is used for irrigation purpose
- IC Engine used for soil digging
- IC Engine used for crop cutting
- IC Engine used for seed sowing
- IC Engine used for heavy machinery's. (Ex. Tractors)

Farm Equipment

- Farm equipment and machinery are at the heart of the agricultural industry. Tractors, planters, and combines are all powered with engines to plant and harvest crops.

Trucks for Transportation

- Along with the farm machinery that is needed to grow and harvest crops, trucks are required to transport these products.

- Trucks and tractor trailers are also used to transport fertilizer, herbicides and pesticides, and even water to fields to help prepare them for planting and keeping the crop healthy while it is growing.

MARINE

- IC engine used for drive the propeller.
- IC engine used to operate auxiliary system.
- IC engine used to run compressor to store compressed air.
- Marine engines on ships are responsible for propulsion of the vessel from one port to another.
- Whether it's of a small ship working in the coastal areas or of a massive one travelling international waters, a marine engine of either 4-stroke or 2-stroke is fitted onboard ship for the propulsion purpose.

AIRCRAFT PROPULSION

- An aircraft engine, or power plant, **produces thrust to propel an aircraft.**
- Reciprocating engines and turboprop engines work in **combination with a propeller to produce thrust.**
- Turbojet and turbofan engines produce thrust by increasing the velocity of air flowing through the engine.
- An internal combustion engine works on the principle of converting reciprocating motion (pistons moving up and down) **into a rotational motion** (crankshaft turning) **which is used to drive the propeller.**

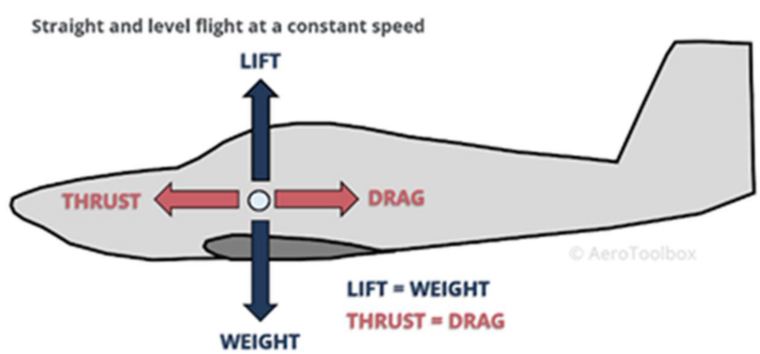


Figure. Straight and level flight at a constant speed

- An aircraft in straight and level flight is subjected to four fundamental forces which must be balanced for the aircraft to remain in equilibrium.
- The weight of the aircraft is balanced by the lift produced by the wing and horizontal stabilizer in the vertical direction.
- As the airplane moves through the air, a resistance or drag force is produced which must be counteracted to maintain the forward flying speed.
- This counterbalance to drag ***is termed the thrust force and is generated by the engine-propeller combination.***

Automobile.

- IC engine used in two wheelers, motor cycle
- IC engine used in three wheelers like auto rickshaw, light goods vehicle.
- IC engine used in four wheels like cars, mini goods vehicle.
- IC engine used in trucks, earth moving equipment.
- IC engine used in Railway.

PERFORMANCE OF IC ENGINES

- Mean effective pressure (p_m)
- Indicated power (IP)
- Brake power or Output power (BP)
- Frictional power (FP)
- Engine efficiencies. (η_{Mech}, $\eta_{B\ Thermal}$, $\eta_{I\ Thermal}$)
- Specific fuel consumption (W_{sfc})

Indicated Power (IP)

It is the power produced inside the cylinder and calculated by finding the actual mean effective pressure.

(a) Indicated Power of a Four–Stroke Engine

Let p_m = Mean Effective Pressure, N/m^2

L = Length of Stroke, m

A = Area of Cross section of the Cylinder, sq m

N = RPM of the Crankshaft.

n = Number of cycles per minute.

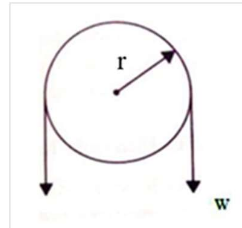
$$\text{Indicated power, } IP = \frac{p_m LAn}{60} \quad Nm/sec$$

- In four stroke I.C. engines, one cycle will be completed in two *revolutions* of the crank shaft.
- Therefore the work will be produced in every *alternate revolutions of* the crankshaft.
- Thus the ***number of cycles per minute will be equal to half the number of revolutions per minute.***

$$\text{For 4-stroke IC Engine, } n = N/2$$

Brake Power (BP) or Output power

- The indicated power produced inside the IC engine cylinder will be transmitted through the piston, connecting rod and crank.



The brake power is calculated as follows :

Let W = Net load acting on the brake drum, **kg**

r = Radius of the brake drum, **m**

N = R.P.M. of the crankshaft

T = Torque applied due to the net load W on the brake drum, **Nm**

$= W \times r$

$$\textbf{Brake Power} = \frac{2\pi NT}{60} \ \text{W}$$

FRICTION POWER (FP)

- "The amount of the power lost in friction is called friction power.
- The friction power is the difference between the indicated power and the brake power.

$$\textit{Friction Power} = \textit{Indicated Power} - \textit{Brake Power}$$

$$FP = IP - BP$$

ENGINE EFFICIENCIES. (η_{Mech}, $\eta_{B\ thermal}$, $\eta_{I\ thermal}$)

Mechanical efficiency (η_{Mech})

It is the efficiency of the moving parts of the mechanism transmitting the indicated power to the crankshaft. Therefore it is *defined as the ratio of the brake power and the indicated power.* It is expressed in percentage.

$$\therefore \quad \eta_{Mech} = \frac{\textit{Brake Power}}{\textit{Indicated Power}} \times 100$$

Thermal efficiency ($\eta_{Thermal}$)

It is the efficiency of conversion of the heat energy produced by the actual combustion of the fuel into the power output of the engine. Therefore *it is defined as the ratio of the power developed by the engine to the heat supplied by the fuel in the same interval of time.* It is expressed in percentage

$$\therefore \quad \eta_{Thermal} = \frac{Power\ Output}{Heat\ Energy\ Supplied\ by\ the\ Fuel} \times 100$$

Brake Thermal efficiency ($\eta_{B\ Thermal}$)

*The **brake thermal efficiency** is defined as the ratio of brake power to the heat supplied by the fuel.* It is expressed in percentage.

$$\therefore \quad \eta_{B\ Thermal} = \frac{Brake\ Power}{Heat\ Energy\ Supplied\ by\ the\ Fuel} \times 100$$

i.e.,

$$\boxed{\eta_{B\ Thermal} = \frac{B\ P}{CV \times \dot{m}} \times 100}$$

Where, m = Mass of the fuel supplied, **kg/s**
CV = Calorific Value of the fuel, **kJ/kg**
BP = Brake Power, **kW**

Indicated Thermal efficiency ($\eta_{I\ Thermal}$)

*The **indicated thermal efficiency** is defined as the ratio of indicated power to the heat supplied by the fuel.* It is expressed in percentage.

$$\eta_{I\ Thermal} = \frac{Indicated\ Power}{Heat\ Energy\ Supplied\ by\ the\ Fuel} \times 100$$

i.e.,

$$\boxed{\eta_{I\ Thermal} = \frac{I\ P}{CV \times m} \times 100}$$

PISTON SPEED

- <u>Piston speed</u>: The total linear distance travelled by the piston per unit time is called piston speed. It is expressed in m/min and is given by,

Piston speed = 2LN (m/min)

L= length of stroke in m
N= speed of the engine in rpm.

Simple Numerical on I.C. Engine

EXAMPLE 1:

A four-stroke I.C. Engine running at 450 rpm has a bore diameter of 100mm and stroke length 120mm. The mean effective pressure 6.15 bar. Calculate the indicated power of the engine.

Given data: A four-stroke I.C. Engine running N = 450 rpm

Bore diameter $\boldsymbol{D} = 100 \text{ mm} = \boldsymbol{0.1\ m}$

Stroke length $\boldsymbol{L} = 120 \text{ mm} = \boldsymbol{0.12\ m}$

Mean Effective pressure $\boldsymbol{p_m = 6.15\ bar}$

$$\boldsymbol{p_m = 6.15 \times 10^5\ \frac{N}{m^2}}$$

To find : Indicated power $\boldsymbol{IP}$ =?; $\boldsymbol{IP = \frac{p_m LAn}{60}\left(\frac{Nm}{sec}\right)}$

Solution:

Indicated power $\boldsymbol{IP = \frac{p_m LAn}{60}\ \left(\frac{Nm}{sec}\right)}$

- $\boldsymbol{IP = \frac{p_m \times L \times \left(\frac{\pi \times D^2}{4}\right) \times \left(\frac{N}{2}\right)}{60}}$
- $\boldsymbol{IP = \frac{(6.15 \times 105) \times (0.12) \times \left(\frac{\pi \times 0.1^2}{4}\right) \times \left(\frac{450}{2}\right)}{60}}$
- $\boldsymbol{IP = 2.17 \times 10^3\ \frac{Nm}{sec}}$
- $\boldsymbol{IP = 2.17\ \times 10^3\ W}$

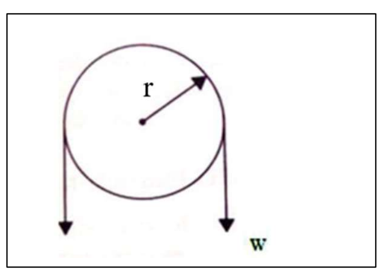
EXAMPLE 2: A single cylinder 4 stroke IC engine runs at 1000rpm and has a bore of 115mm and has a stroke of 140mm. The brake load is 6kg at 600mm radius and the mechanical efficiency is 80%. Calculate Brake Power and Mean Effective Pressure

Given data: A single cylinder four-stroke diesel Engine ;
Engine Speed N = 1000rpm
Bore diameter $\boldsymbol{D} = 115 \text{ mm} = \boldsymbol{0.115\ m}$
Stroke length $\boldsymbol{L} = 140 \text{ mm} = \boldsymbol{0.14\ m}$

Brake load is W= 6kg = (6 × 9.81)N

Brake drum radius **r = 600mm = 0.6m**

Mechanical Efficiency $\eta_{Mech} = 80\% = \boldsymbol{\frac{BP}{IP}} \times \mathbf{100}$



To find :

- Brake power ***BP = ?***; $\boldsymbol{BP = \frac{2\pi NT}{60}\ \left(\frac{Nm}{sec}\right)}$
- Mean Effective pressure $\boldsymbol{p_m}$ =?

Indicated power $\boldsymbol{IP}$ =?; $\boldsymbol{IP = \frac{p_m LAn}{60}} \quad \left(\frac{Nm}{sec}\right)$

<u>Solution:</u> (Refer your FME class note Book)

EXAMPLE 3: A four stroke petrol engine has a piston diameter 250mm & stroke 400mm. The mean effective pressure is 4bar and the speed is 500rpm. The diameter of the brake drum is **1**m and the effective brake load is 400N. Find Indicated power, Brake power, Friction power and Mechanical efficiency

<u>Given data:</u> A four-stroke diesel engine

Bore or Piston diameter $\boldsymbol{D}$ = 250 mm = ***0.25 m***
Stroke length $\boldsymbol{L}$ = *4*00 mm = ***0.4m***

Engine speed N = 500 rpm

Mean Effective pressure p_m = 4bar = $\mathbf{4 \times 10^5} \frac{N}{m^2}$

Engine Speed N = 500rpm

Brake drum diameter **d = 1m ;** Brake drum radius **r = 0.5m**

Effective brake load is **W= 400N**

<u>To find :</u>

- Indicated power $\boldsymbol{IP}$ =?; $\boldsymbol{IP = \frac{p_m LAn}{60}} \quad \left(\frac{Nm}{sec}\right)$
- Brake power ***BP = ?***; $\boldsymbol{BP = \frac{2\pi NT}{60}} \left(\frac{Nm}{sec}\right)$; $\boldsymbol{Torque\ applied,\ T = W \times r}$
- Friction power ***FP = ? ; FP = IP − BP*** ;
- Mechanical efficiency $\eta_{Mech} = \frac{BP}{IP} \times 100$

<u>Solution:</u> (Refer your FME class note Book)

EXAMPLE 4: A Single cylinder 4 Stroke IC engine has bore of 180mm, stroke length of 200mm & a rated speed of 300rpm. Torque on the brake drum is 200Nm and mean effective pressure is 6 bar. It consumes 4kg of fuel per hour. The CV of fuel is 42000kJ/kg. Determine BP, IP, Thermal efficiency.

<u>Given data:</u> A four-stroke I.C. Engine

Bore diameter $\boldsymbol{D}$ = 180 mm = ***0.18 m***

Stroke length $\boldsymbol{L}$ = 200 mm = ***0.2 m***

Crankshaft speed or Engine speed *N* = **300 rpm**

Torque on the brake drum is $\boldsymbol{T = W \times r}$ = **200Nm**

Mean Effective pressure p_m= **6 bar** = $\mathbf{6 \times 10^5} \frac{N}{m^2}$

Mass of fuel consumes, $\boldsymbol{m} = 4\ \frac{\textbf{kg}}{\boldsymbol{hour}} = \frac{\textbf{4 kg}}{(\textbf{60}\times\textbf{60})\boldsymbol{sec}}$

Calorific value of the fuel is CV = 42000kJ/kg = **42000×10³ N-m/kg**

To find :

Brake power ***BP = ?***; $\boldsymbol{BP} = \frac{2\pi NT}{60}\ \left(\frac{Nm}{sec}\right)$; $\boldsymbol{Torque\ applied,\ T = W \times r}$

Indicated power $\boldsymbol{IP} = \frac{p_m LAn}{60}\ \left(\frac{Nm}{sec}\right)$

Indicated Thermal efficiency $\eta_{I\ Thermal} = \frac{IP}{CV\times m}\times 100$

Brake Thermal efficiency $\eta_{B\ Thermal} = \frac{BP}{CV\times m}\times 100$

Solution: (Refer your FME class note Book)

EXAMPLE 5: The following observations were recorded during a test on Four-Stroke Petrol engine. Bore = 200mm, L = 250mm, p_m = 0.6MPa, Brake drum diameter = 1.2m, Net brake load = 500N, Speed of crank shaft = 600rpm. Find: IP, BP, FP, Mechanical efficiency.

Given data: A four-stroke I.C. Engine

Bore diameter $\boldsymbol{D}$ = 200 mm = ***0.2 m***

Stroke length $\boldsymbol{L}$ = 250 mm = ***0.25 m***

Mean Effective pressure $\boldsymbol{p_m}$**= 0.6 MPa** $= \mathbf{0.6 \times 10^6}\ \frac{\boldsymbol{N}}{\boldsymbol{m^2}}$

Brake drum diameter d = 1.2m ; Brake drum radius r = 0.6m

Effective brake load is W= 500N

Crankshaft speed or Engine speed *N* = **600 rpm**

To find :

Indicated power $\boldsymbol{IP} = \frac{p_m LAn}{60}\ \left(\frac{Nm}{sec}\right)$

Brake power ***BP = ?***; $\boldsymbol{BP} = \frac{2\pi NT}{60}\ \left(\frac{Nm}{sec}\right)$; $\boldsymbol{Torque\ applied,\ T = W \times r}$

Mechanical efficiency $\eta_{Mech} = \frac{BP}{IP}\times 100$

Solution: (Refer your FME class note Book)

EXAMPLE 6: Following data are collected from a 4S engine. D= 200mm, L=280mm, Speed=300 rpm, Mean Effective pressure p_m = 5.6bar, Torque = 250N-m, Fuel consumed = 4.2 kg/hr, CV = 41x10^3 kJ/kg. **Find**: Mechanical efficiency, Brake thermal efficiency, Indicated thermal efficiency.

Given data: A four-stroke I.C. Engine

Bore diameter D =200 mm = ***0.2 m***

Stroke length L =280 mm =***0.28 m***

Crankshaft speed or Engine speed N = **300 rpm**

Torque on the brake drum is ***T= W ×r = 250 Nm***

Mean Effective pressure p_m= **5.6 bar** $= \mathbf{5.6 \times 10^5}\ \frac{N}{m^2}$

Mass of fuel consumes, $m = 4.2\ \frac{kg}{hour} = \frac{4.2\ kg}{(60\times60)sec}$

Calorific value of the fuel is CV = 41x10^3 kJ/kg = **41×10^6 N-m/kg**

To find :

Mechanical efficiency $\eta_{Mech} = \frac{BP}{IP} \times 100$

Brake power ***BP = ?***; $BP = \frac{2\pi NT}{60}\ \left(\frac{Nm}{sec}\right)$; ***Torque applied***, $T = W \times r$

Indicated power $IP = \frac{p_m LAn}{60}\ \left(\frac{Nm}{sec}\right)$

Brake Thermal efficiency $\eta_{B\ Thermal} = \frac{BP}{CV\times m} \times 100$

Indicated Thermal efficiency $\eta_{I\ Thermal} = \frac{IP}{CV\times m} \times 100$

Solution: (Refer your FME class note Book)

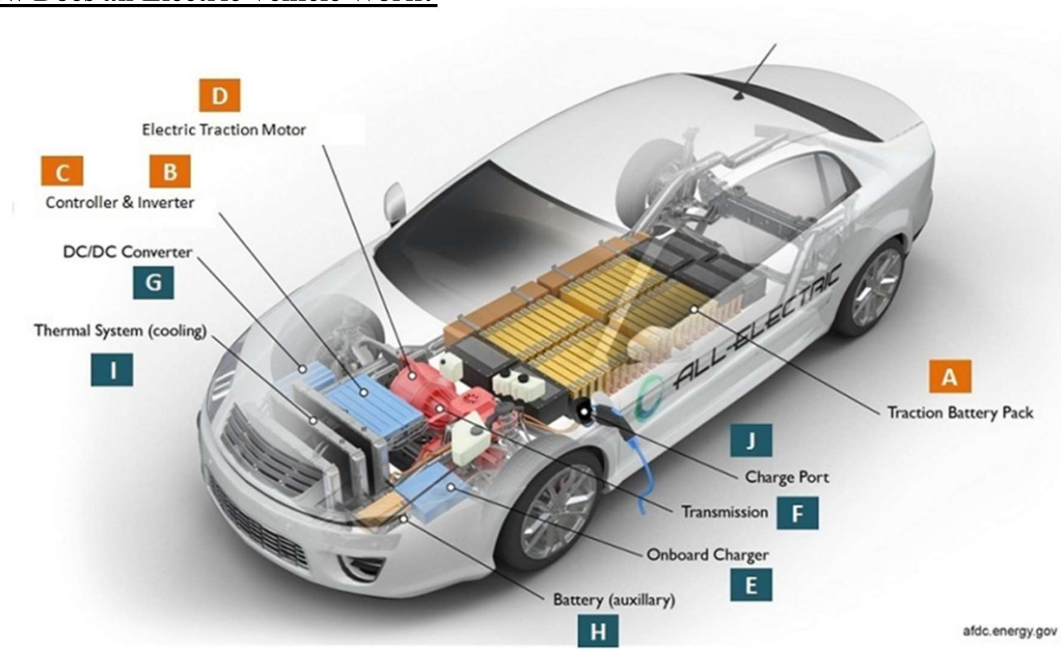
INSIGHT INTO FUTURE MOBILITY TECHNOLOGY

- A 'EV' is defined as a vehicle that can be powered by an electric motor that draws electricity from a battery and is capable of being charged from an external source.
- An EV includes both a vehicle that can only be powered by an electric motor that draws electricity from a battery (all-electric vehicle) and a vehicle that can be powered by an electric motor that draws electricity from a battery and by an internal combustion engine (plug-in hybrid electric vehicle).

ELECTRIC VEHICLES (EV)

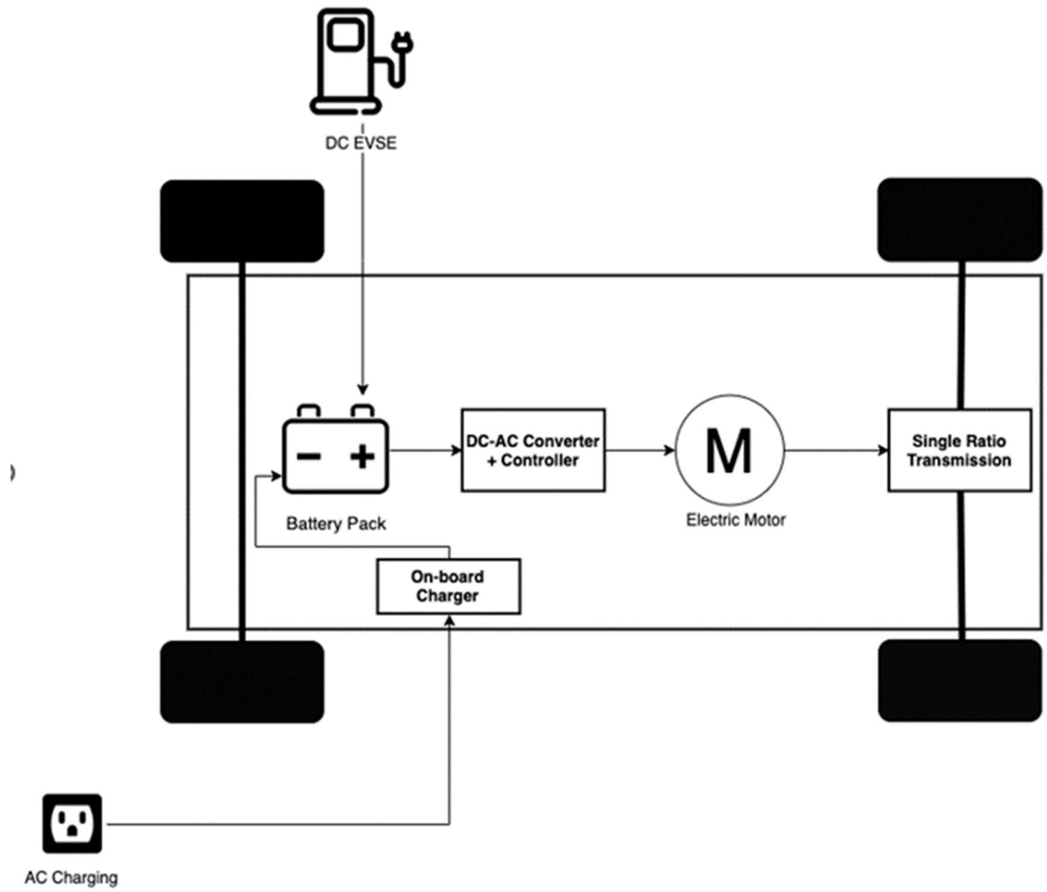
- An 'EV' is defined as a vehicle that can be powered by an electric motor that draws electricity from a battery and is capable of being charged from an external source.
- A 'EV' is a shortened acronym for an Electric Vehicle.
- EVs are vehicles that are either partially or fully powered on electric power.
- Electric vehicles have low running costs as they have less moving parts for maintaining and also very environmentally friendly as they use little or no fossil fuels (petrol or diesel).

<u>How Does an Electric Vehicle Work?</u>



- When the car pedal is pressed, then:
- Controller [C] takes and regulates electrical energy from batteries [A] and inverters [B]
- With the controller set, the inverter then sends a certain amount of electrical energy to the motor (according to the depth of pressure on the pedal)
- Electric motor [D] converts electrical energy into mechanical energy (rotation)
- Rotation of the motor rotor rotates the transmission so the wheels turn and then the car moves.

LINE OR BLOCK DIAGRAM OF ELECTRIC VEHICLES



Components of Electric Vehicles

- Traction Battery Pack (A)
- Power Inverter (B)
- Controller (C)
- Electric Traction Motor (D)
- Other Electric Car Components
  - ✓ Charger (E)
  - ✓ Transmission (F)
  - ✓ DC/DC Converter (G)
  - ✓ Battery (H)
  - ✓ Thermal System – Cooling (I)
  - ✓ Charge Port (J)

Traction Battery Pack (A)

- The function of the battery in an electric car is as an electrical energy storage system in the form of direct-current electricity (DC).
- If it gets a signal from the controller, the battery will flow DC electrical energy to the inverter to **then be used to drive the motor.**

- **The type of battery used is a rechargeable battery** that is arranged in such a way as to form what is called a **traction battery pack**.
- There are various types of electric car batteries.
- The most widely used is the type of **lithium-ion batteries.**

Power Inverter (B)

- The inverter functions to change the **direct current (DC) on the battery into an alternating current (AC)** and **then this alternating current is used by an electric motor.**
- In addition, the inverter on an electric car also has a function to change the AC current when regenerative braking to DC current and then used to recharge the battery.
- The type of inverter used in some electric car models is the bi-directional inverter category.

Controller (C)

- The main function of the controller is as a regulator of electrical energy from batteries and inverters that will be distributed to electric motors.
- While the controller itself gets the main input from the car pedal (which is set by the driver).
- **This pedal setting will determine the frequency variation or voltage variation** that will enter the motor, and at the same time determine the car's speed.
- In brief, this unit manages the flow of electrical energy delivered by the traction battery, controlling the speed of the electric traction motor and the torque it produces.
- This component will determine how electric car work.

Electric Traction Motor (D)

- Because the controller provides electrical power from the traction battery, the electric traction motors will work turning the transmission and wheels.
- Some hybrid electric cars use a type of generator-motor that performs the functions of propulsion and regeneration.

Other Electric Car Components

Charger (E)

- Charger (E) is a battery charging device.
- Chargers get electricity from outside sources, such as the utility grid or solar power plants.
- AC electricity is converted into DC electricity and then stored in the battery.
- There are 2 types of electric car chargers:
    - On-board charger: the charger is located and installed in the car
    - Off-board charger: the charger is not located or not installed in the car.

Transmission (F):

- The transmission transfers mechanical power from the electric traction motor to drive the wheels.

DC/DC Converter (G):

- This one of electric car parts that to converts higher-voltage DC power from the traction battery pack to the lower-voltage DC power needed to run vehicle accessories and recharge the auxiliary battery.

Battery (H):

- In an electric drive vehicle, the auxiliary battery provides electricity to power vehicle accessories.

Thermal System – Cooling (I):

- This system maintains a proper operating temperature range of the engine, electric motor, power electronics, and other components.

Charge Port (J):

- The charge port allows the vehicle to connect to an external power supply in order to charge the traction battery pack.

ADVANTAGES OF ELECTRIC VEHICLES

Electric vehicles (EVs) offer several advantages compared to traditional internal combustion engine (ICE) vehicles.

1. **Zero Emissions:** EVs produce zero tailpipe emissions, which means they do not release harmful pollutants like carbon dioxide (CO2), nitrogen oxides (NOx), particulate matter, and volatile organic compounds (VOCs). This significantly reduces air pollution and contributes to combating climate change.
2. **Reduced Greenhouse Gas Emissions:** EVs can be powered by electricity from renewable sources like solar, wind, or hydroelectric power, which can further reduce greenhouse gas emissions, making them more environmentally friendly.
3. **Energy Efficiency:** Electric motors are inherently more efficient than internal combustion engines. EVs convert a higher percentage of energy from the grid into usable power at the wheels, resulting in reduced energy waste compared to ICE vehicles.
4. **Lower Operating Costs:** Electric vehicles have fewer moving parts and require less maintenance than ICE vehicles. There are no oil changes, and brake wear is often reduced due to regenerative braking, which converts kinetic energy back into electricity. Over the vehicle's lifetime, this can lead to lower operating costs.
5. **Quiet and Smooth Operation:** EVs operate more quietly than traditional vehicles, which helps reduce noise pollution. They also provide smoother acceleration due to the instant torque provided by electric motors.
6. **Energy Independence:** EVs can be powered by locally generated electricity, reducing dependence on imported fossil fuels and enhancing energy security.
7. **Incentives and Rebates:** Many governments offer incentives, tax credits, and rebates to encourage the adoption of electric vehicles. These financial benefits can make EVs more affordable for consumers.
8. **Advancements in Battery Technology:** The continuous development of battery technology has led to improved energy density, longer range, and faster charging times for EVs, addressing some of the initial limitations of early electric vehicles.

9. **Health Benefits:** By reducing tailpipe emissions, EVs contribute to improved air quality, which has positive impacts on public health, reducing respiratory and cardiovascular illnesses associated with air pollution.
10. **Future Scalability and Grid Integration:** As renewable energy sources become more prevalent, EVs can play a vital role in energy storage and grid balancing. They can charge when there's excess renewable energy and discharge power back to the grid when needed, helping to create a more sustainable energy ecosystem.

DISADVANTAGES OF ELECTRIC VEHICLES

Here are some of the key disadvantages of electric vehicles:

1. **Limited Driving Range:** Compared to traditional internal combustion engine (ICE) vehicles, EVs often have a limited driving range on a single charge. Although this has been improving with advancements in battery technology, some EVs may still not have the same range as their gasoline-powered counterparts.
2. **Charging Infrastructure:** The availability of charging infrastructure can vary significantly depending on the region. In some areas, charging stations may be scarce, which can cause "range anxiety" for EV owners, making long-distance travel less convenient.
3. **Charging Time:** Charging an EV takes longer than refueling a conventional car. Even with fast-charging options, it can take considerable time to recharge the battery fully. This can be a drawback for people with busy schedules or those who need to cover long distances regularly.
4. **Upfront Cost:** Electric vehicles tend to have a higher upfront cost compared to traditional ICE vehicles. Although this cost is gradually decreasing as battery technology advances, it remains a barrier for some potential buyers.
5. **Battery Life and Replacement Cost:** EV batteries have a limited lifespan, and over time, their capacity to hold a charge decreases. While advancements have been made to improve battery longevity, eventual replacement can still be a significant expense.
6. **Weight and Performance:** The batteries used in EVs can be heavy, affecting the overall weight and performance of the vehicle. While electric motors provide instant torque, some EVs may have reduced acceleration or handling capabilities due to their weight distribution.
7. **Dependency on Electricity Grid:** Charging an EV relies on access to electricity. In regions where the electricity grid is unreliable or experiences frequent power outages, charging an EV could be challenging.
8. **Environmental Impact of Battery Production:** The manufacturing process of batteries for EVs can have a significant environmental impact, including carbon emissions and resource extraction. Proper recycling and disposal of batteries are also critical to mitigate environmental concerns.

9. **Limited Model Variety:** While the availability of electric vehicle models is increasing, it may still be challenging to find specific types of EVs, such as larger SUVs or trucks, which might limit consumer choices.

10. **Perceived Performance and Driving Range:** Some consumers may still be hesitant to switch to EVs due to concerns about perceived performance, range, and the overall driving experience compared to traditional vehicles.

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