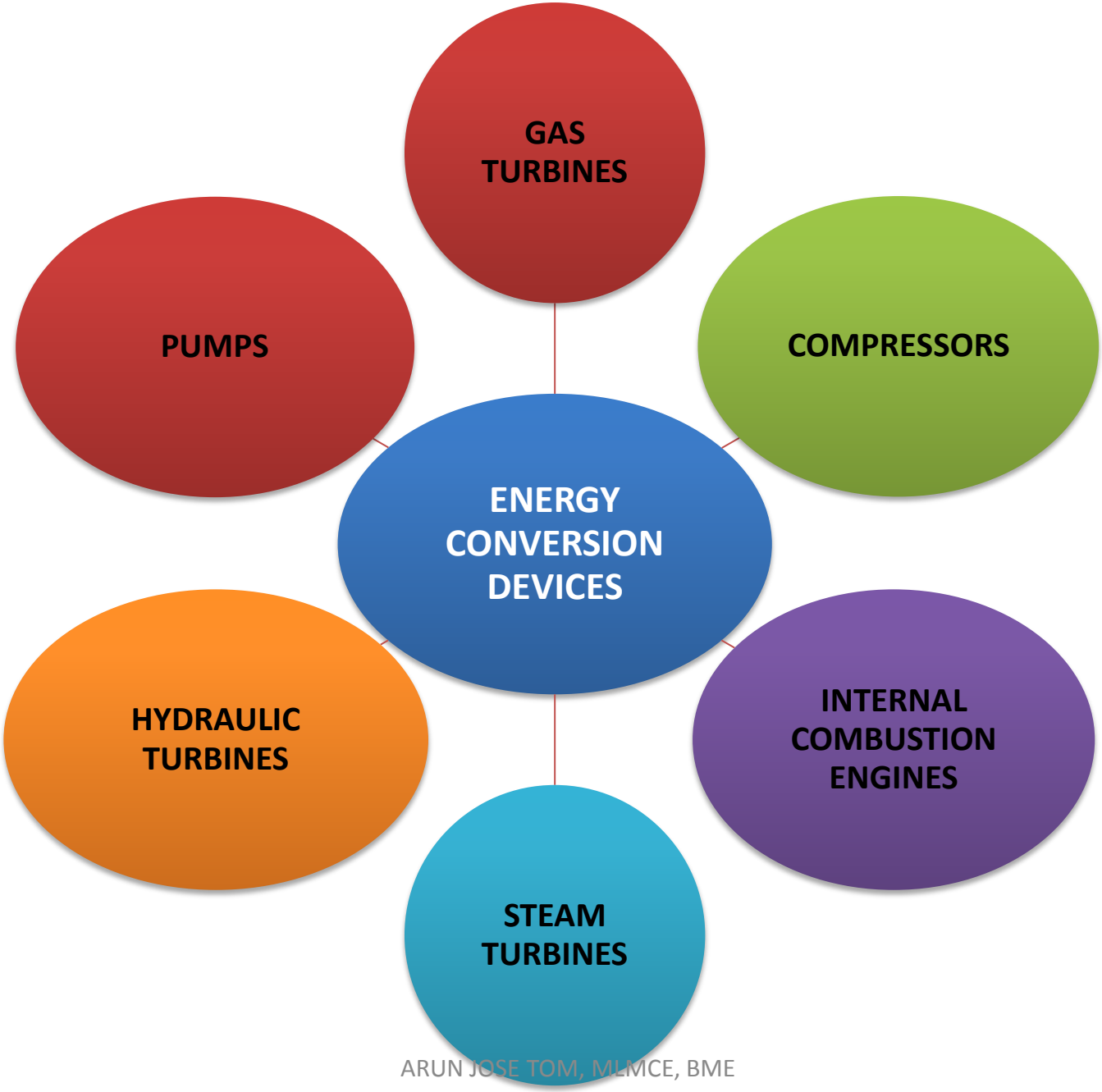
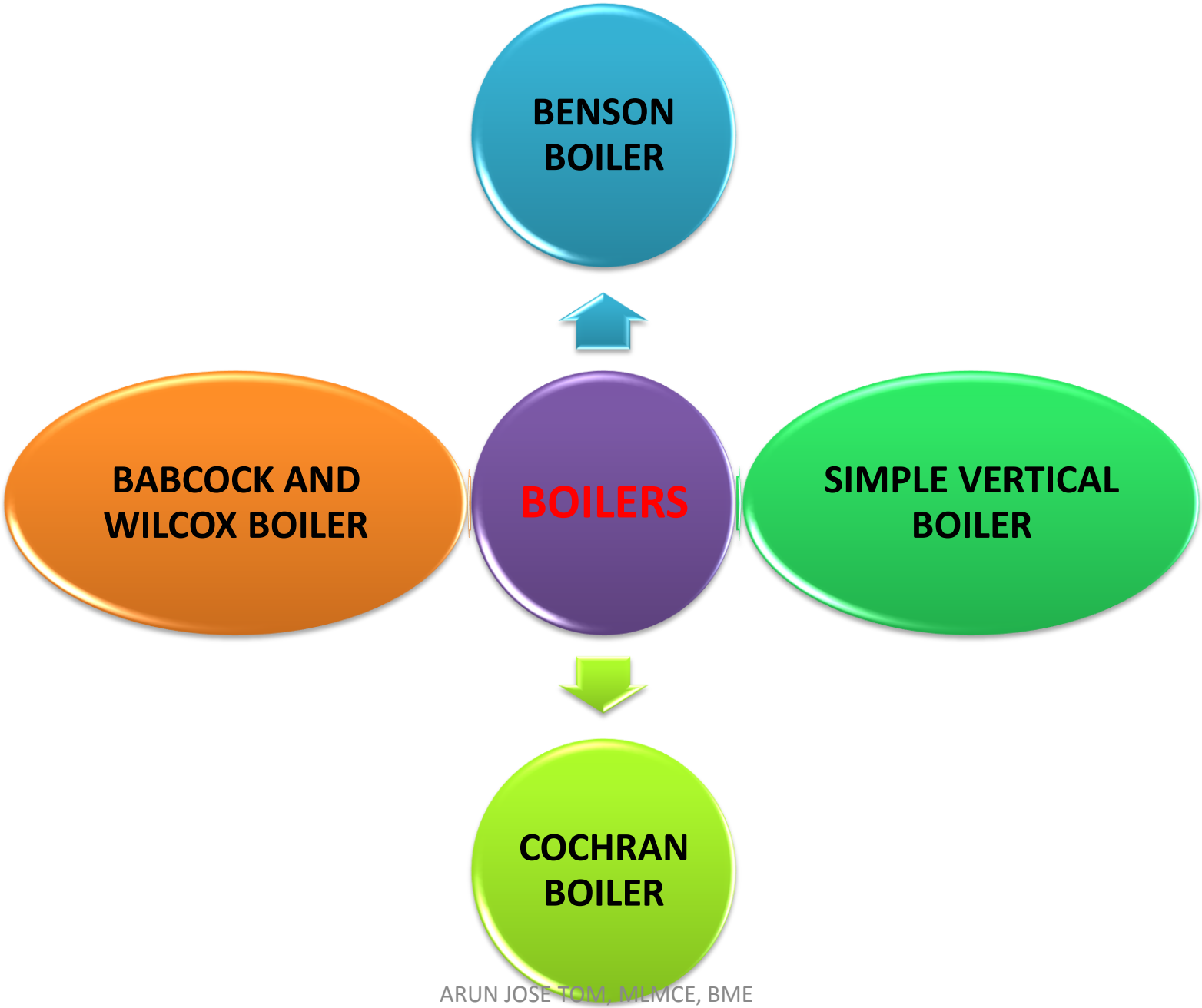
MODULE II

ENERGY CONVERSION DEVICES


GAS TURBINES
PUMPS
COMPRESSORS
ENERGY CONVERSION DEVICES
HYDRAULIC TURBINES
INTERNAL COMBUSTION ENGINES
STEAM TURBINES

CONTENTS

- BOILERS
- HYDRAULIC TURBINES
- STEAM TURBINES
- GAS TURBINES
- INTERNAL COMBUSTION ENGINES(SI & CI)
- PUMPS

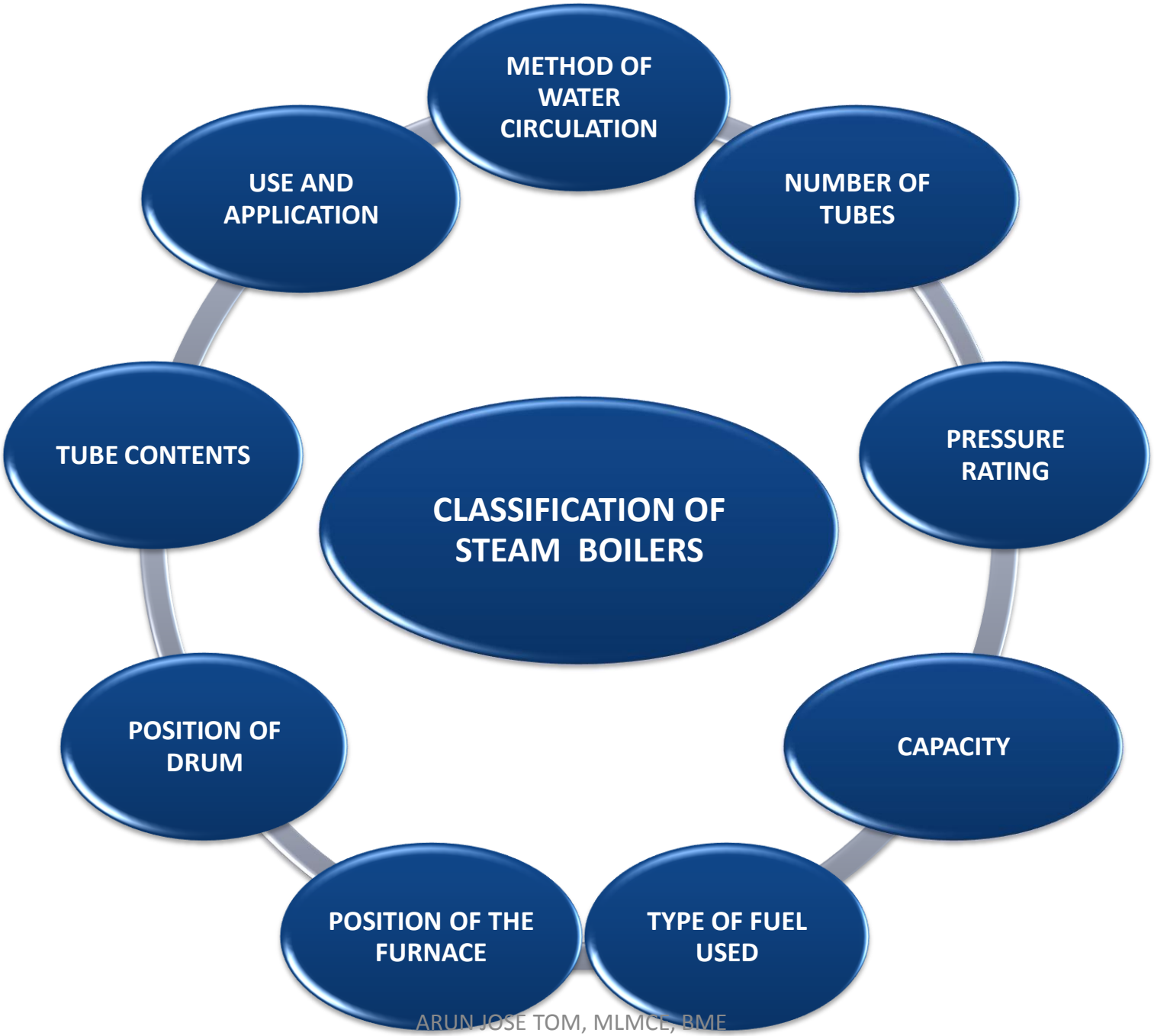

BENSON BOILER
BABCOCK AND WILCOX BOILER
BOILERS
SIMPLE VERTICAL BOILER
COCHRAN BOILER

BOILERS

- A steam boiler is a steam generator, is a closed vessel in which water is heated, vaporized and converted to steam at the desired pressure and temperature by adding heat energy to it
- Heat from the combustion gas is transferred to water for steam generation
- Fuels used are coal, coke, oil, wood, saw dust…etc

Requirements of a good boiler

- Maximum steam generation with minimum fuel consumption
- Initial cost, running cost and maintenance cost must be low
- High combustion efficiency and better heat transfer effectiveness
- Occupy only less space
- Able to meet load variation
- Can be quickly started and stopped
- Appropriate safety apparatus


CLASSIFICATION OF STEAM BOILERS
METHOD OF WATER CIRCULATION
NUMBER OF TUBES
PRESSURE RATING
CAPACITY
TYPE OF FUEL USED
POSITION OF THE FURNACE
POSITION OF DRUM
TUBE CONTENTS
USE AND APPLICATION

1).Use and applications

- Stationary boilers: Used in power plants and industrial process
- Mobile boilers: Used in locomotive engines

2). Tube contents

- Fire tube boilers(smoke tube): Hot gases pass through the tubes which are surrounded by water
- Water tube boilers: Water is contained inside the tubes, which are surrounded by hot gases

3). Position of drum

- Horizontal boilers: Axis of the boiler drum is horizontal
- Vertical boilers: Axis of the boiler drum is vertical

4). Position of the furnace

- Internally fired boilers: Furnace is located inside the boiler shell
- Externally fired boiler: Furnace is arranged underneath in a brick work

5) .Type of fuel used

- Coal
- Oil
- Gas

6). Capacity

- Low capacity boilers(upto 1000kg/hr of steam production)
- Medium capacity (1000kg/hr – 10000kg/hr)
- High capacity (above 10000kg/hr)

7). Pressure rating

- Low pressure boilers(upto 10bar)
- Medium pressure boilers(10bar – 30bar)
- High pressure boiler(above 30bar)

8). Number of tubes

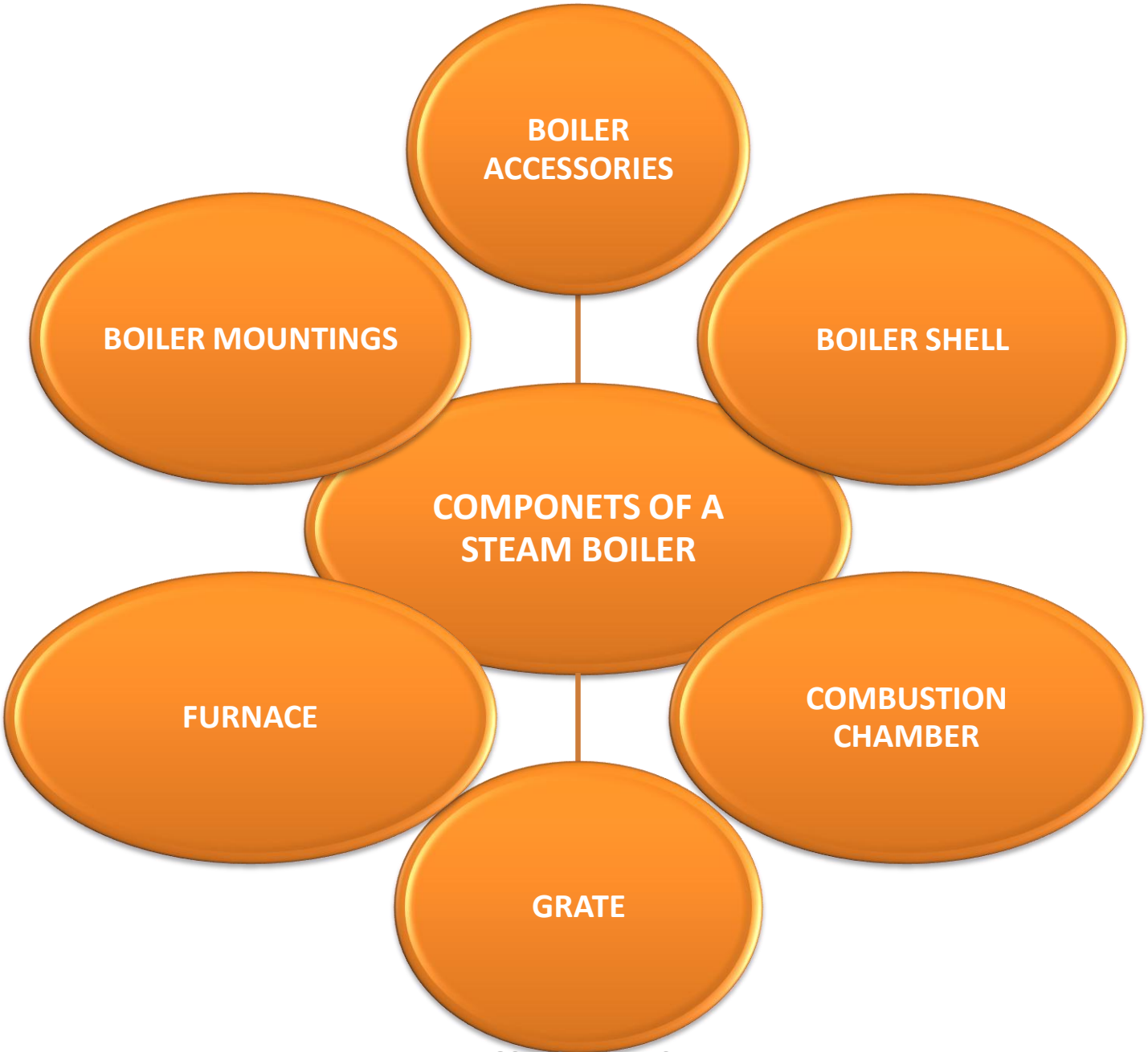
- Single tube boiler: One fire tube or water tube
- Multi tubular boilers: Two or more fire tubes or water tubes

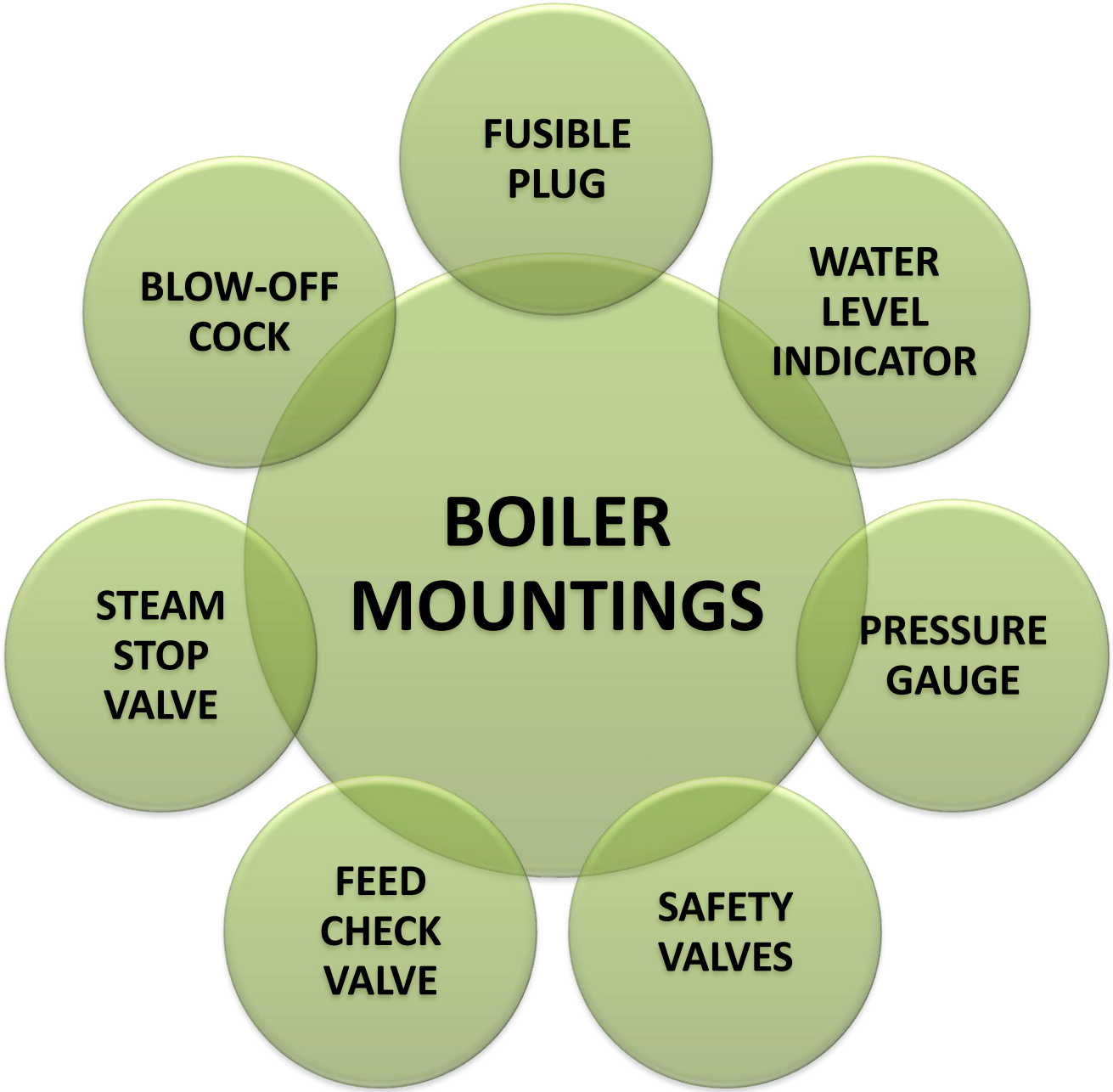
9). Method of water circulation

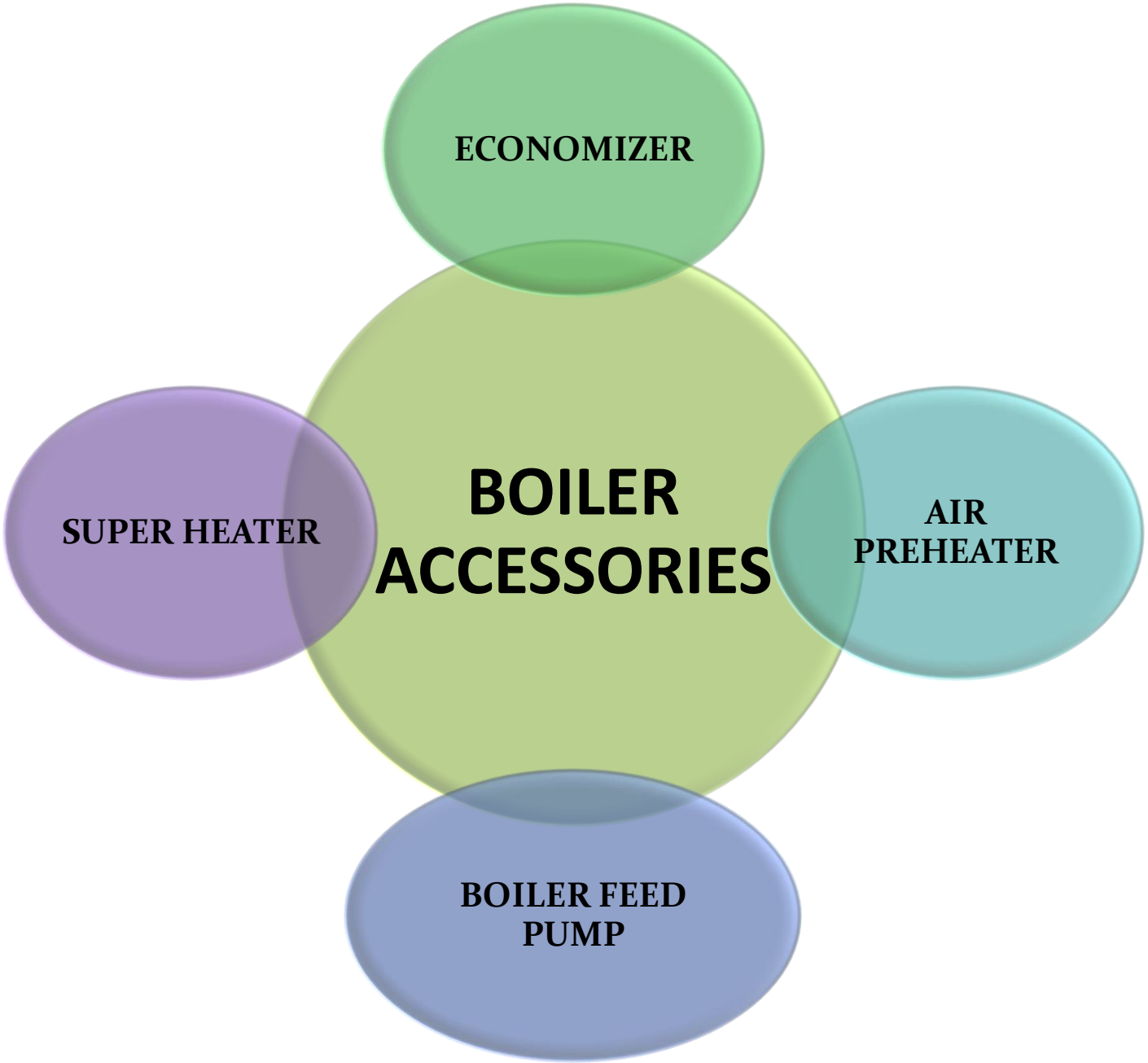
- Natural convection boiler: Due to density difference
- Forced circulation boiler: Using a pump

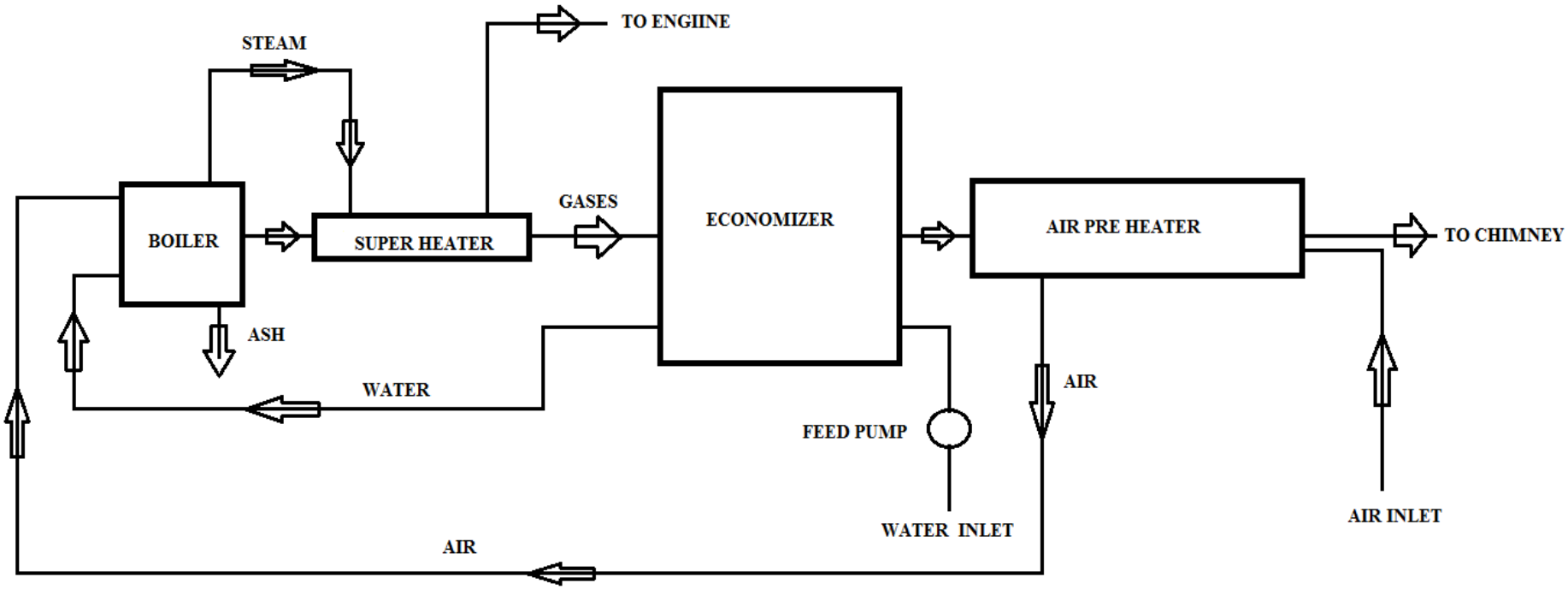
Comparison between Water tube(WTB) and Fire tube boilers(FTB)

- Fire tube-hot gases flow inside the tubes, water tube- water flowing inside the tubes
- FTB holds large amount of water , hence evaporation process will be slower
- WTB are used for high pressure purpose
- Transportation for FTB is difficult because of its large size
- Capacity of FTB are low
- WTB require frequent purification
- Operating cost is more for WTB


BOILER ACCESSORIES
BOILER MOUNTINGS
BOILER SHELL
COMPONETS OF A STEAM BOILER
FURNACE
COMBUSTION CHAMBER
GRATE


BOILER MOUNTINGS
FUSIBLE PLUG
WATER LEVEL INDICATOR
PRESSURE GAUGE
SAFETY VALVES
FEED CHECK VALVE
STEAM STOP VALVE
BLOW-OFF COCK

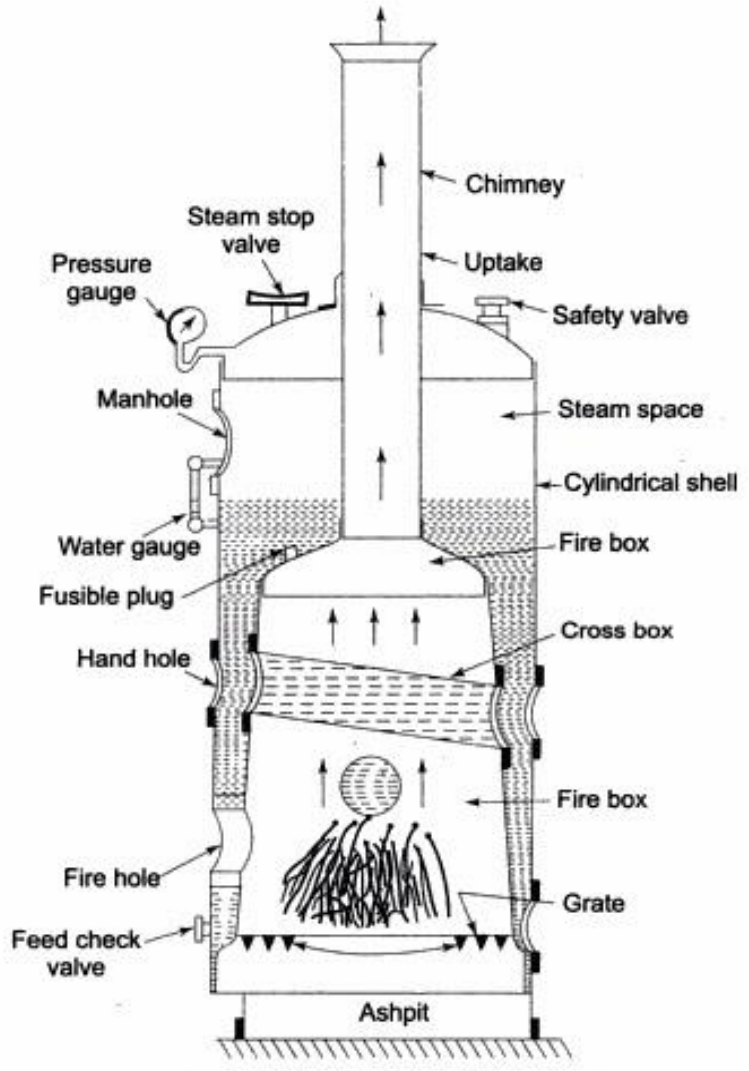

ECONOMIZER
SUPER HEATER
BOILER ACCESSORIES
AIR PREHEATER
BOILER FEED PUMP



SCHEMATIC DIAGRAM OF BOILER POWER PLANT

SIMPLE VERTICAL BOILER

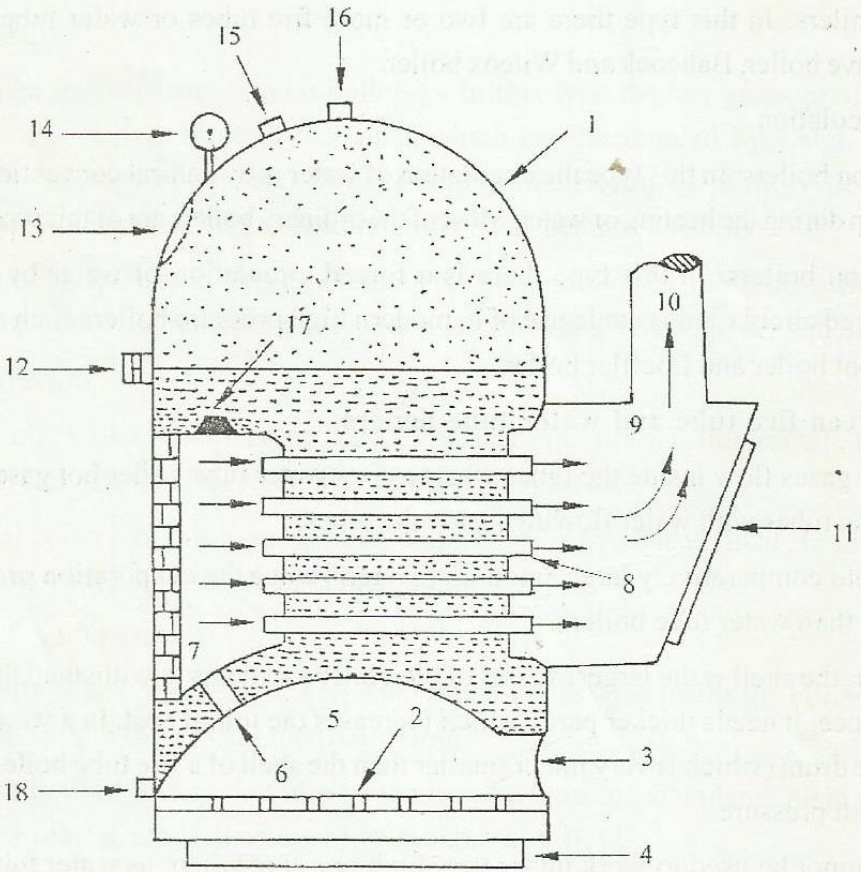
- Steam at low pressure and in small quantities



- Firebox is provided with two cross tubes
- Cross tubes for efficient circulation of water
- Hand holes for cleaning the tubes
- Manhole for cleaning the interior of the boiler and exterior of the combustion chamber

COCHRAN BOILER

- Low pressure , medium capacity boiler



1. Cylindrical shell 2. Greate 3. Fire hole 4. Ash pit 5. Fire box 6. Flue pipe 7. Combustion chamber 8. Flue tubes 9. Smoke box 10. Chimmney 11. Door 12. Water gauge 13. Man hole 14. Pressure gauge 15. Safety valve 16. Stop valve 17. Fusible plug 18. Blow off cock.

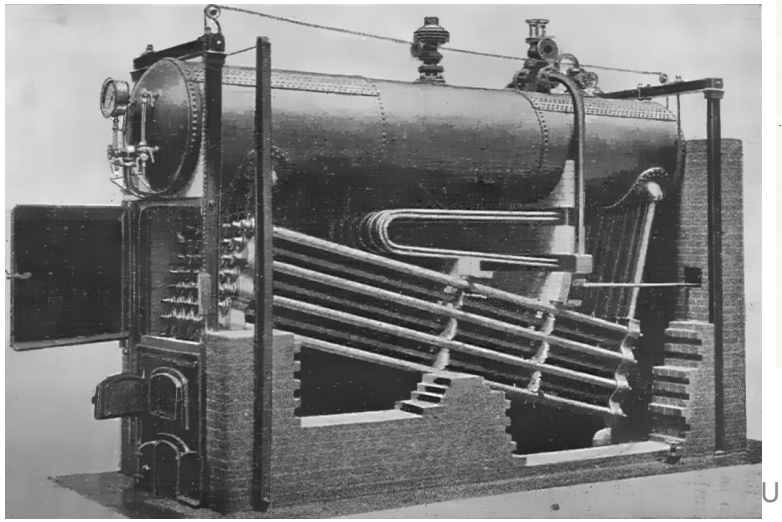
Cochran boiler

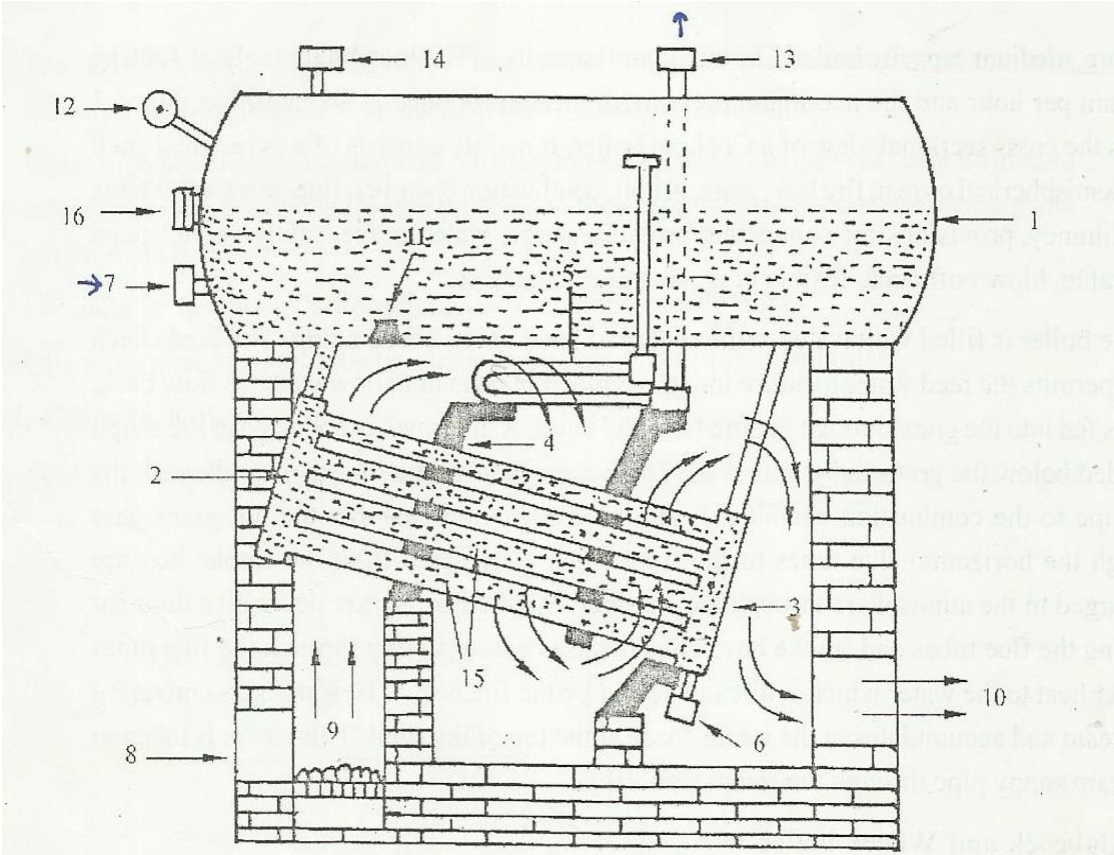
Cochran boiler

- Hot gases from the firebox pass through the flue pipe to the combustion chamber
- Flue gases passes through a number of horizontal tubes, being surrounded by water
- Steam raising capacity is less

BABCOCK AND WILCOX BOILER

- Pressure- 10 bar to 20 bar
- Capacity – 2000 to 4000kg of steam/hr





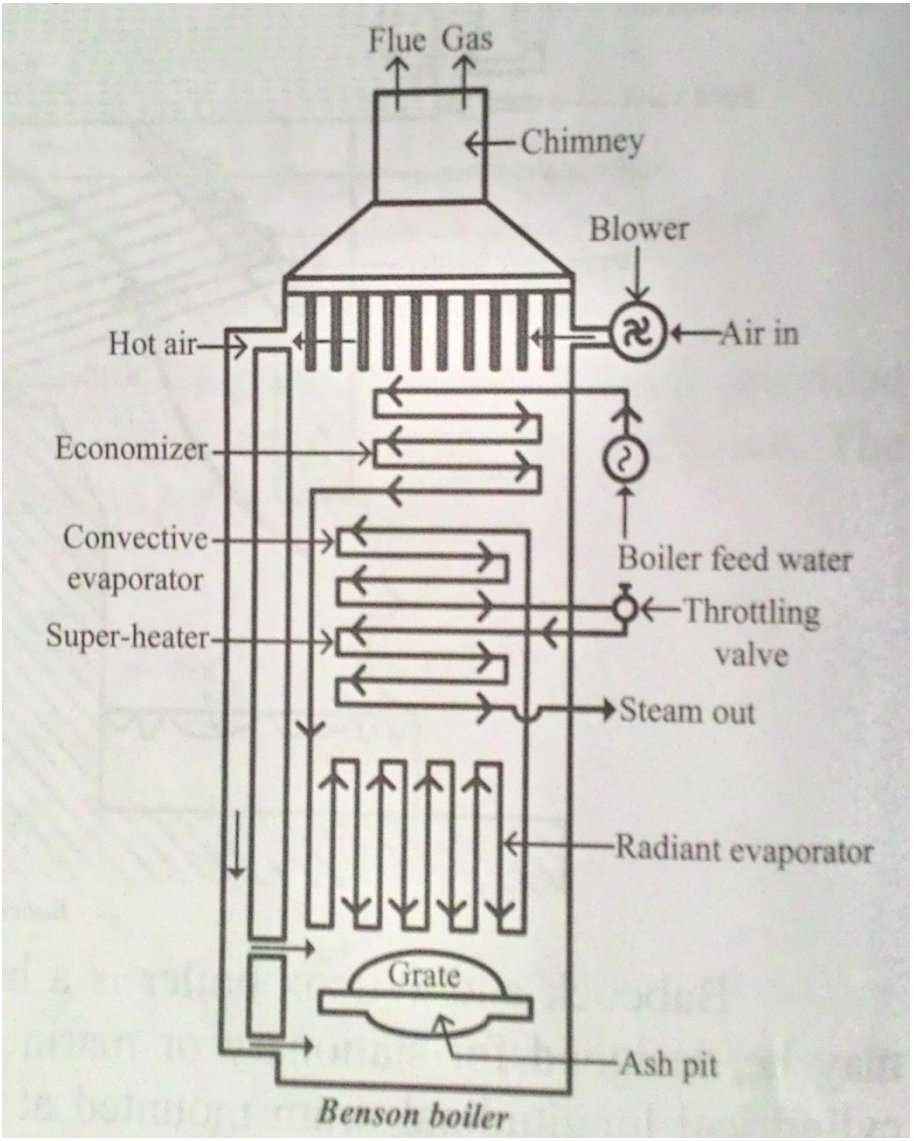
1. Drum 2. Uptake header 3. Down take header 4. Baffles 5. Super heater tubes 6. Mud box 7. Feed valve 8. Grate 9. To Chimmney 11. Fusible plug 12. Pressure Gauge 13. Stop valve 14. Safety valve 15. Water tubes 16. Water gauge

Babcock and Wilcox boiler

- Horizontal water tube boiler
- Cylindrical drum mounted at the top
- Hot gases are forced to move upwards and downwards and again upwards between the tubes by baffle plates
- Water from the drum flows through the inclined tubes via downtake header and goes back to the shell in the form of water and steam via uptake header.. The steam gets collected in the steam space of the drum
- Water is circulated by natural convection due to temperature difference
- Steam in the drum enters the anti-priming pipe and flows in the superheater tubes where it is further heated and is finally taken out through the main stop valve

BENSON BOILER

- Drumless
- Pressure -80 bar or above



- High pressure, water tube steam boiler
- Feed water is introduced into 1).Economizer 2).Radiant evaporator(water partially evaporated by receiving heat by radiation) 3)Convective evaporator(water + steam) changed to 100% steam by convection heat transfer)
- Throttling valve located between the convective evaporator and radiant evaporator enables the boiler to maintain supercritical operation
- Then superheated steam is supplied for useful work
- Radiant evaporator, convective evaporator and the convection superheater are all arranged in the path of the flue gases
- Cold air blown by the blower is preheated by flue gases


IMPULSE TURBINE
HYDRAULIC TURBINES
REACTION TURBINE

HYDRAULIC TURBINES

- Turbines convert hydraulic energy or hydro-potential into mechanical energy.
- Mechanical energy developed by turbines is used to run electric generators coupled to the shaft of turbines
- Hydro electric power is the most cheapest source of power generation
- Modern hydraulic turbines have been developed by L.A. Pelton (Impulse), G. Coriolis and J.B. Francis (Reaction) and V Kaplan (Propeller)

Classification of turbines

Turbines can be classified on the basis of:

Head and quantity of water available

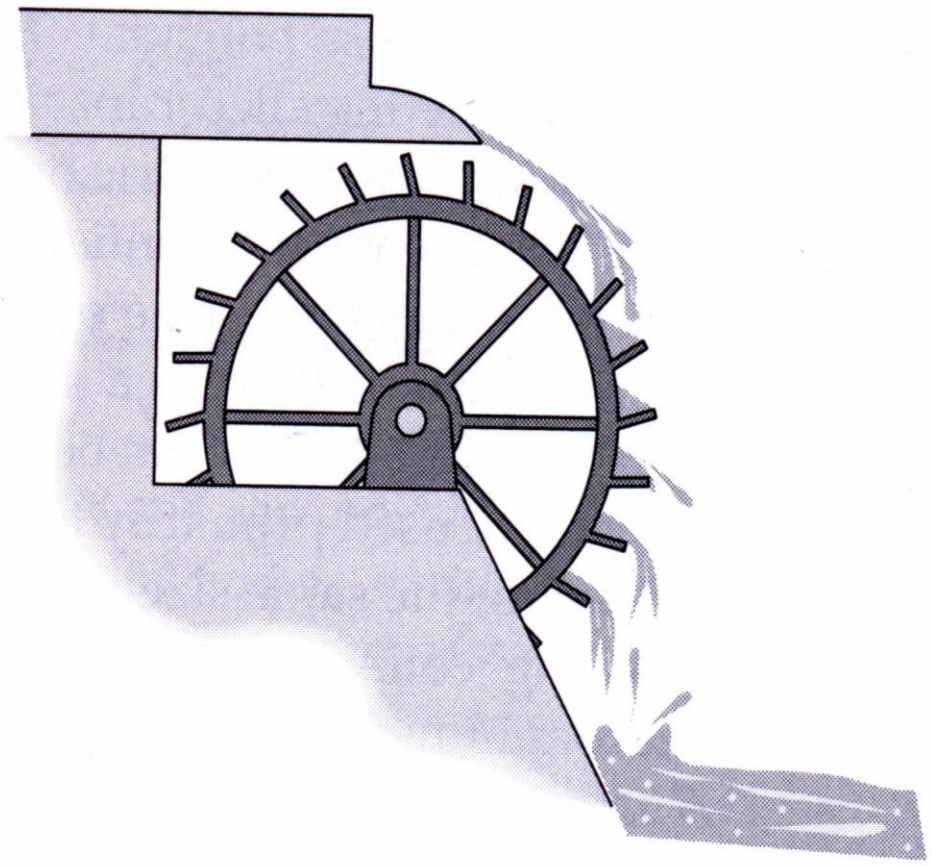
- a) High head turbine: Head is more than 250m, low discharge, eg. Pelton turbine
- b)Medium head turbine: 60m to 250m, medium discharge types, eg. Francis turbine
- c) Low head turbine: Head will be below 60m, high discharge, eg. Kaplan turbine

Direction of flow of water in the runner

- a) Tangential flow: Water strikes tangentially, eg.Pelton turbine
- b) Radial flow: Water enters and leaves radially, eg. Francis turbine
- c) Mixed flow : Water enters radially and leaves axially, eg. Modern Francis turbine
- d) Axial flow: Water flows parallel to the axis of the turbine shaft, eg. Kaplan turbine

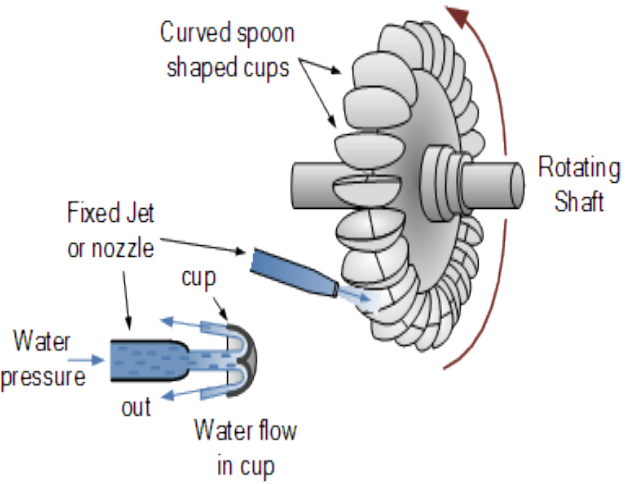
Action of water on moving blades

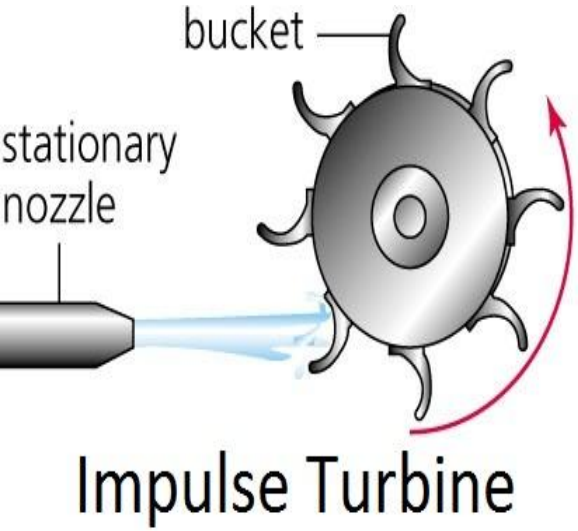
- a) Impulse turbine: Water possess only kinetic energy at the inlet of the turbine, eg. Pelton turbine
- b) Reaction turbine: Water possess both kinetic energy and pressure energy at the inlet, eg. Francis and Kaplan turbine

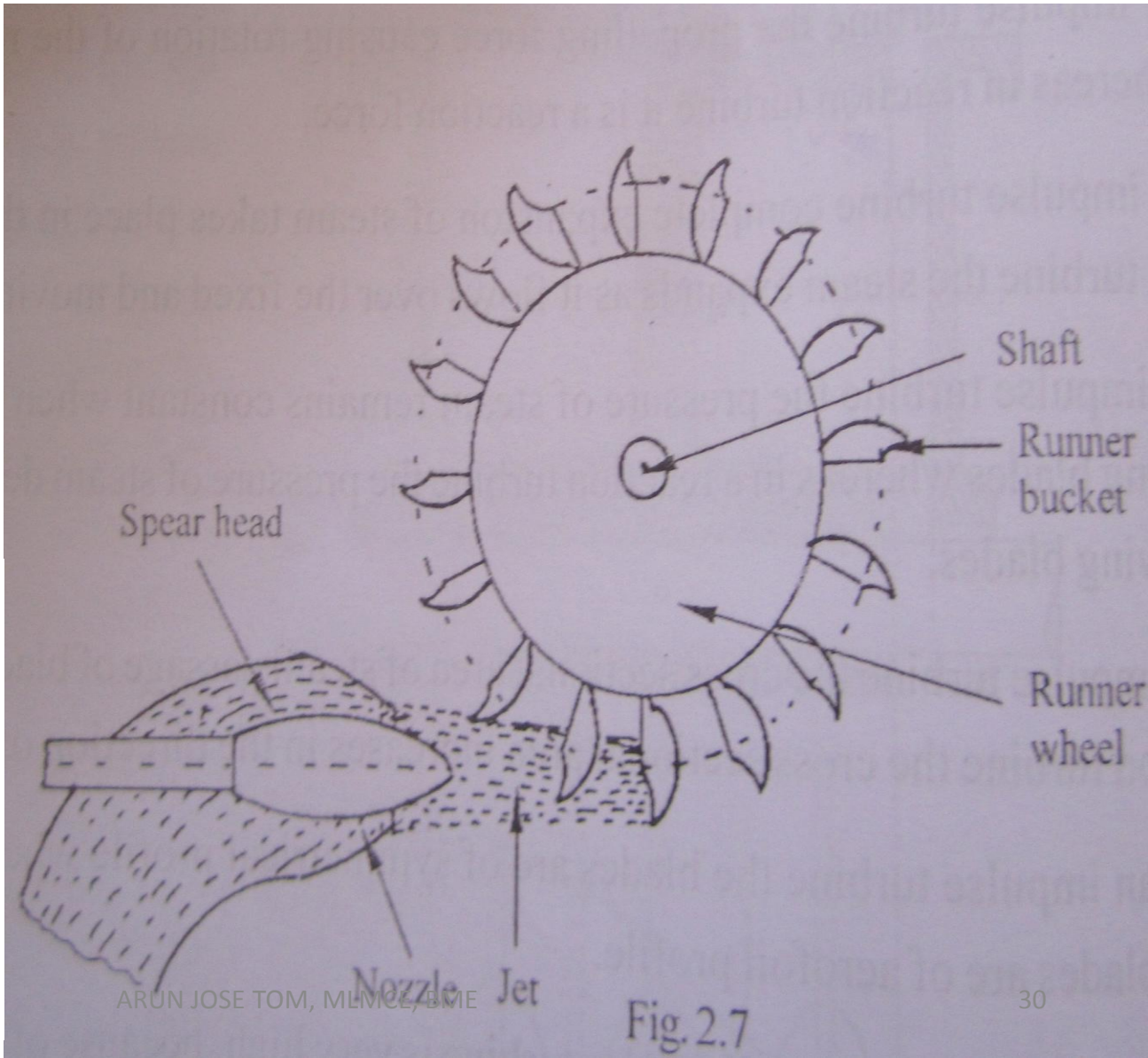


- Humans first learned to harness the kinetic energy in water by using **waterwheels**.
- A waterwheel is a revolving wheel fitted with blades, buckets, or vanes.
- Waterwheels convert the kinetic energy of flowing water to **mechanical energy**

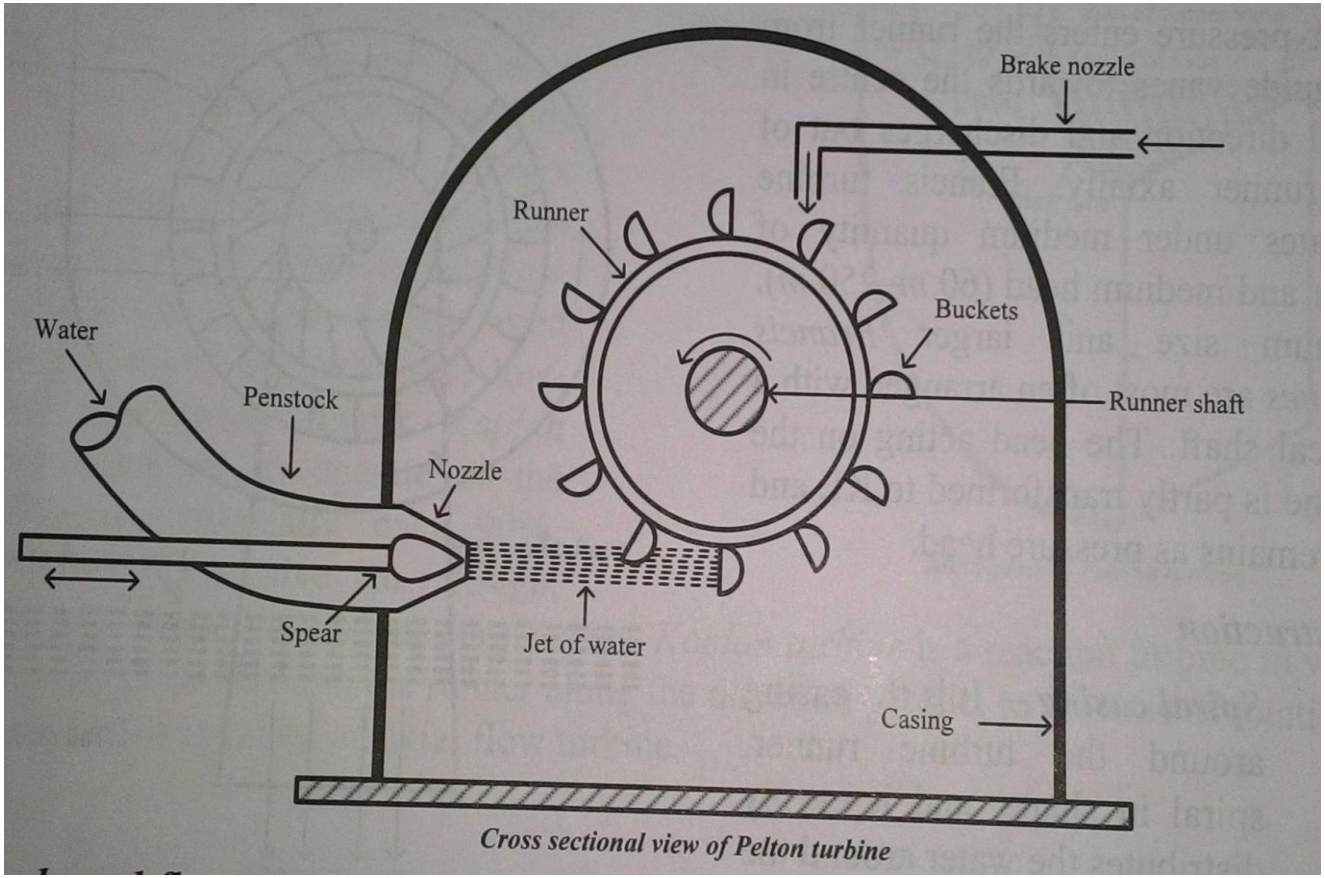
IMPULSE TURBINE







- **Pelton Wheel**



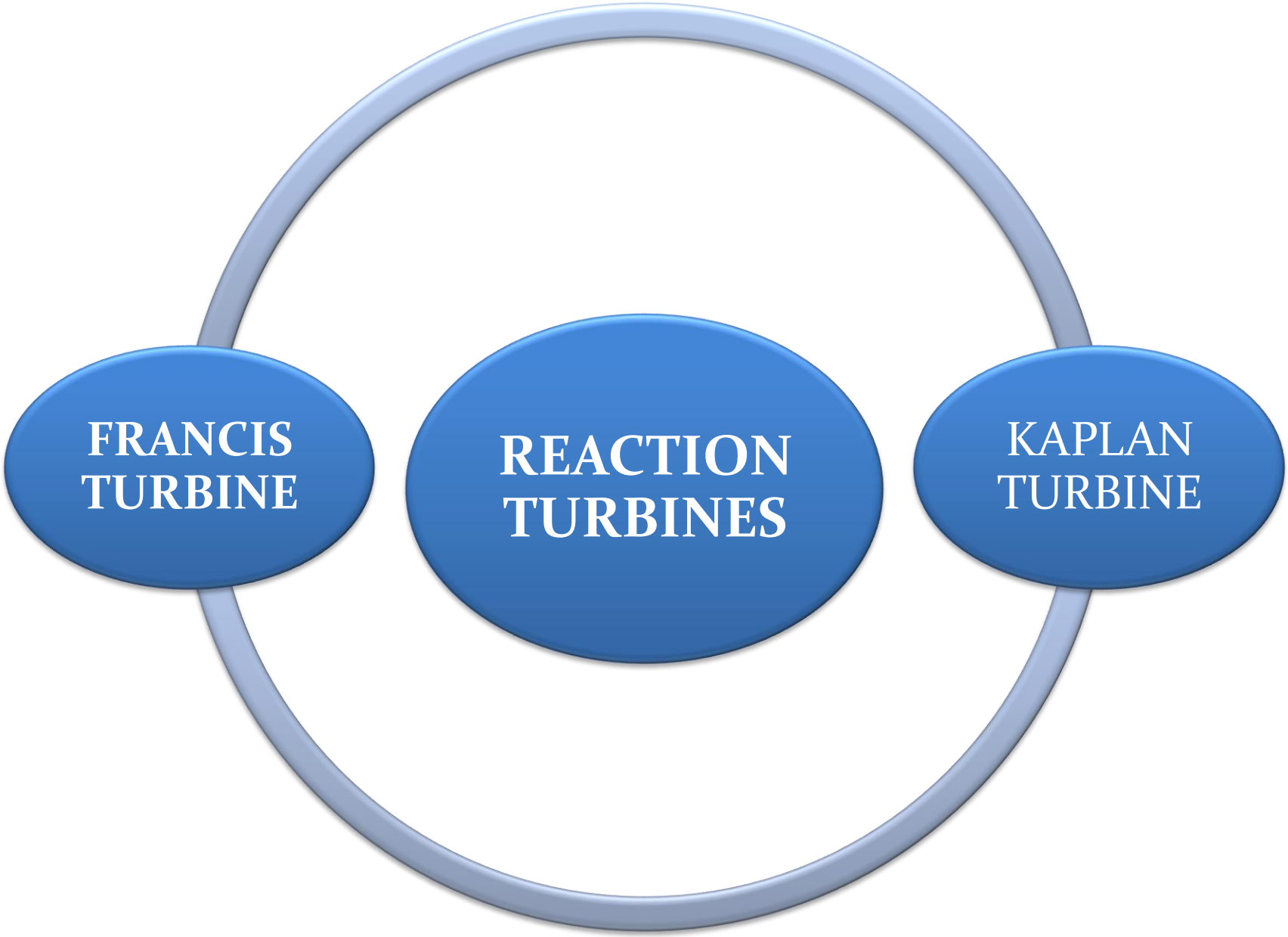
Cross sectional view of Pelton turbine

Main Parts of a Pelton Turbine

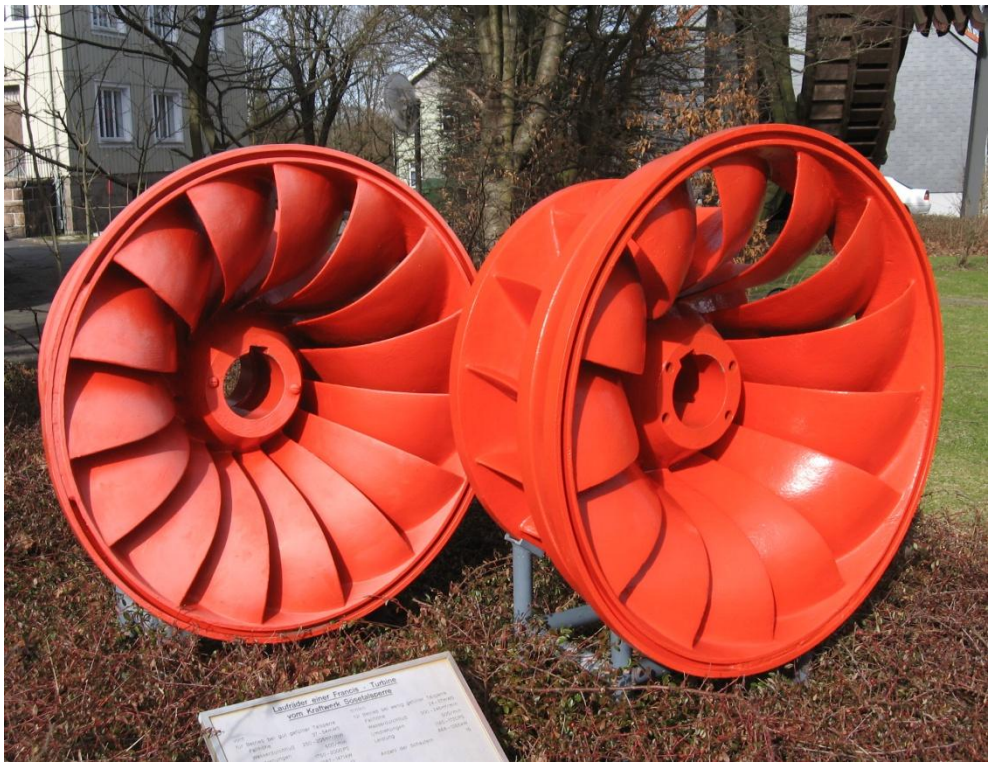
- Nozzle and flow regulating arrangement
- Runner and buckets: Runner is a circular disc on the periphery of which a number of buckets are fixed
- Casing: Prevent the splashing of water
- Breaking jet: Used to stop the runner

Working

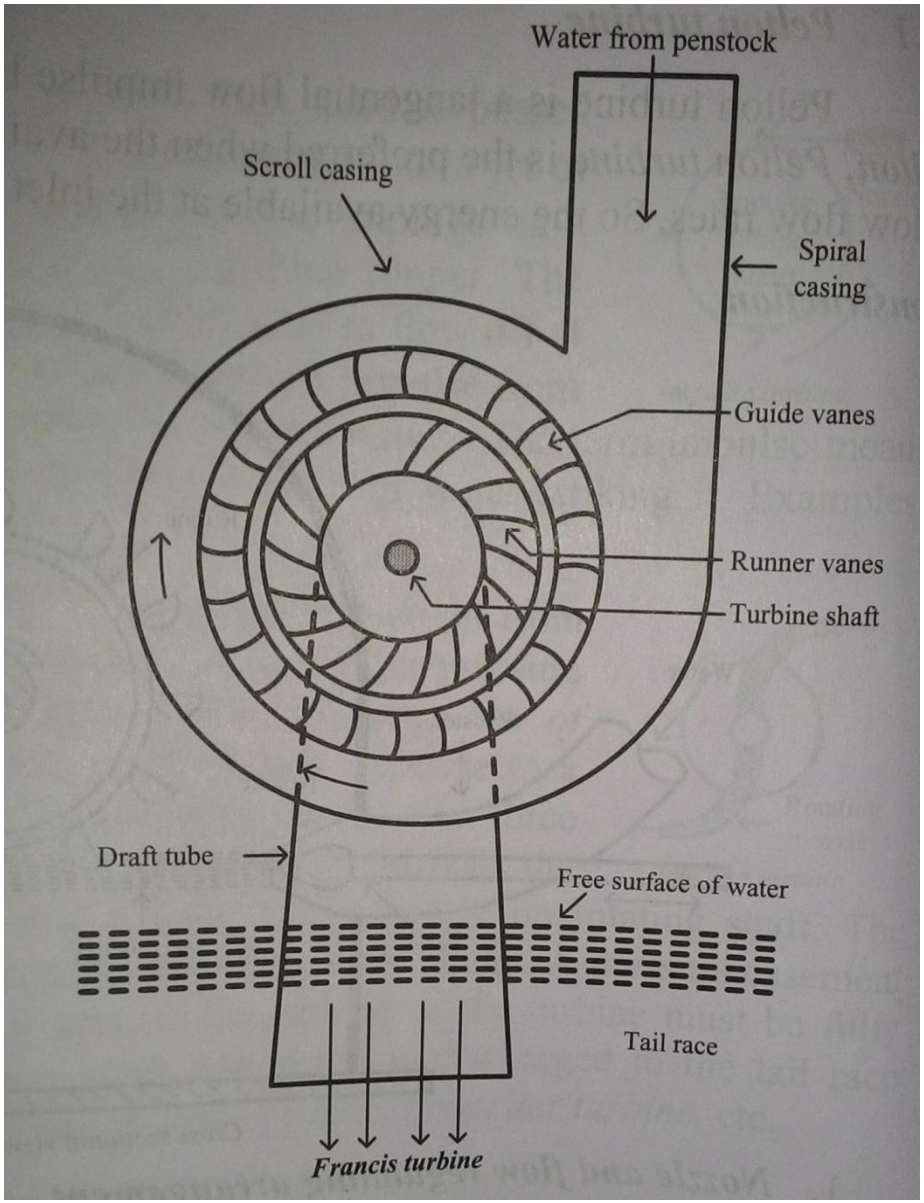
- Nozzle directs the water against buckets mounted around the runner
- When the water jet strikes the bucket, the water exerts pressure on the bucket and hence the runner revolves.
- The runner shaft is connected with the generator, thus the electricity is produced

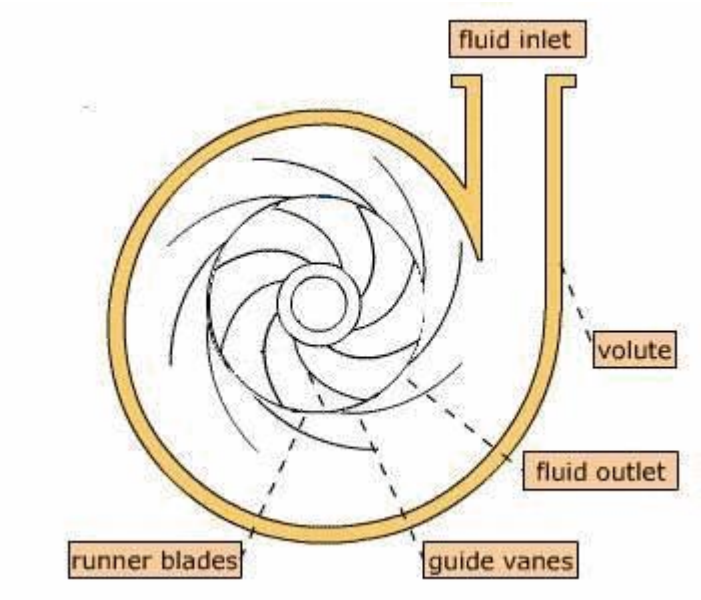

FRANCIS TURBINE
REACTION TURBINES
KAPLAN TURBINE

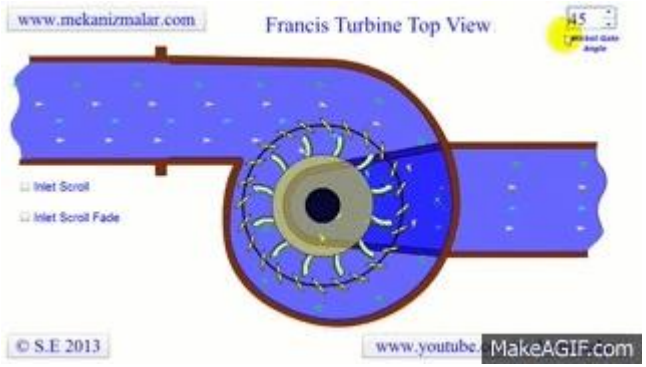
FRANCIS TURBINE



- Water enters the runner from the guide vanes towards the centre in radial direction and discharges out of the runner axially




fluid inlet
volute
fluid outlet
runner blades
guide vanes


www.mekanizmalar.com
Francis Turbine Top View
Inlet Scroll
Inlet Scroll Fade
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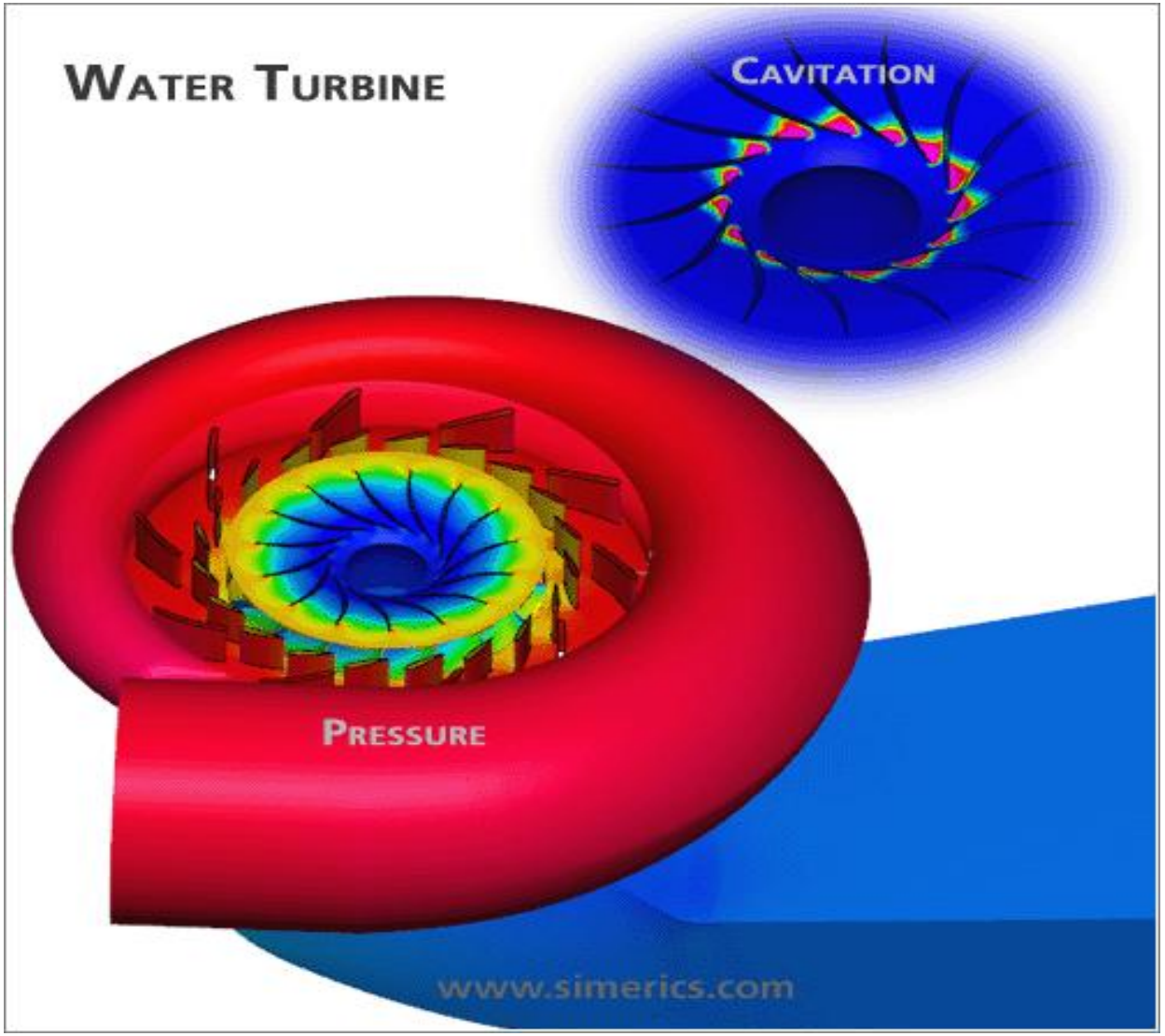
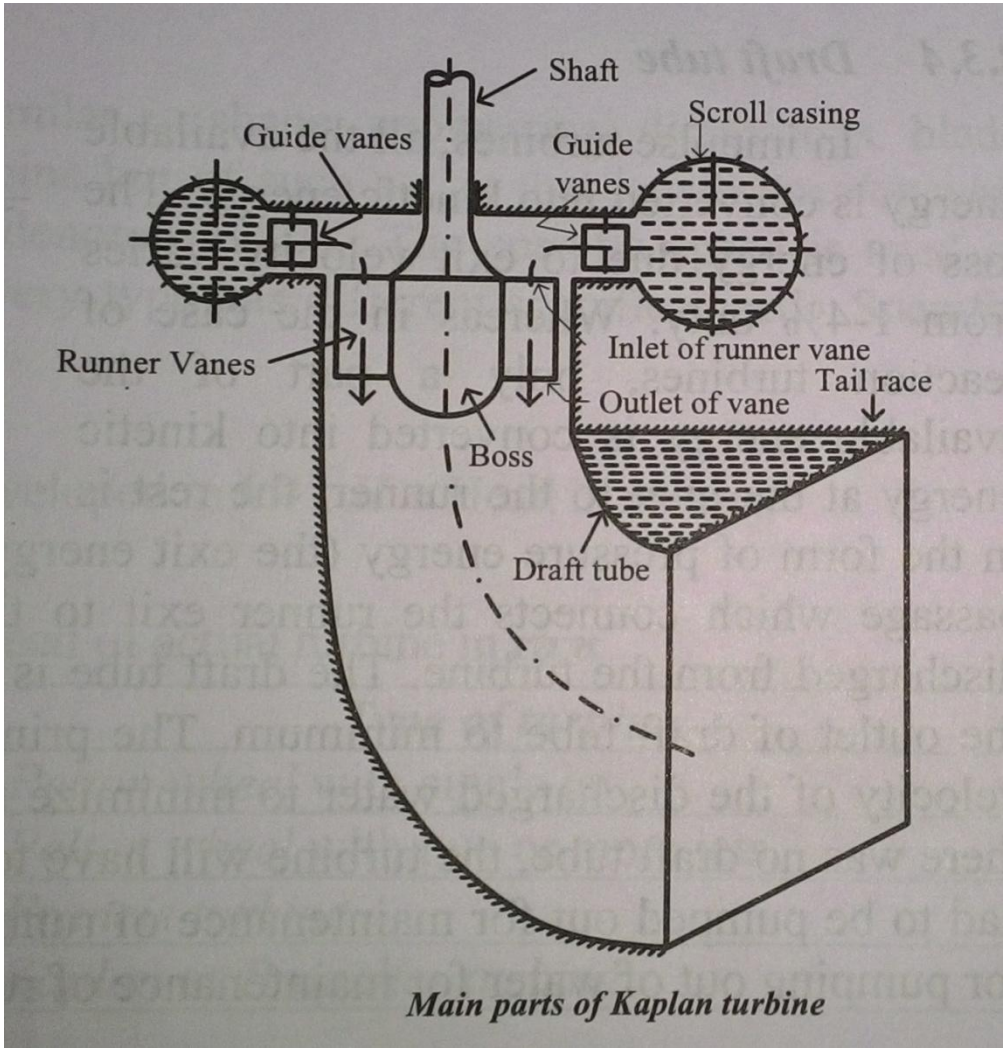

WATER TURBINE
CAVITATION
PRESSURE
www.simerics.com

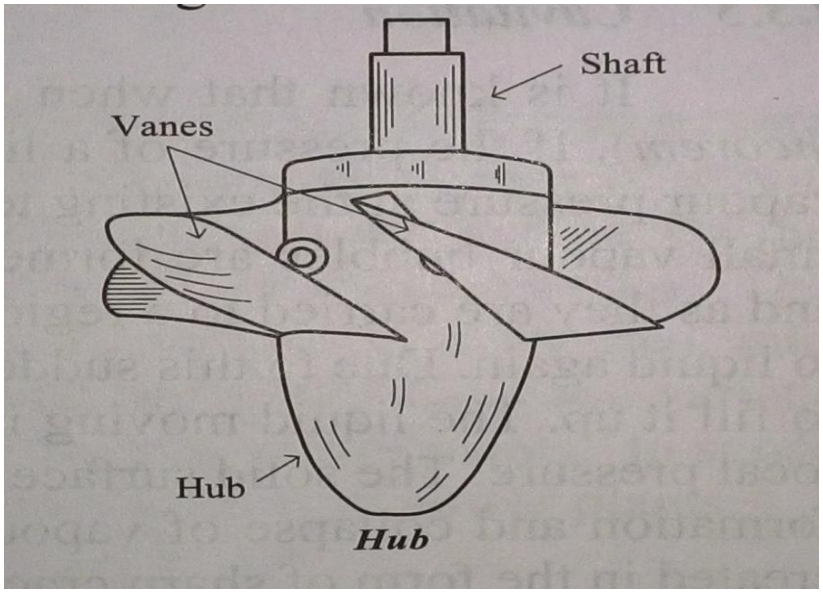
Main parts of Francis Turbine

- Spiral casing: Maintain a uniform velocity around the guide vanes
- Guide vanes: Around the circumference of the runner. It acts like a nozzle to increase the velocity of water. It also regulates the amount of water inlet to the turbine
- Runner and runner vanes: Runner vanes have aerofoil like structure. Pressure difference on the blades cause the rotation
- Draft tube: Water flows from runner outlet to tail race through draft tube

KAPLAN TURBINE



Main parts of Kaplan turbine



Hub

Main parts of a Kaplan Turbine

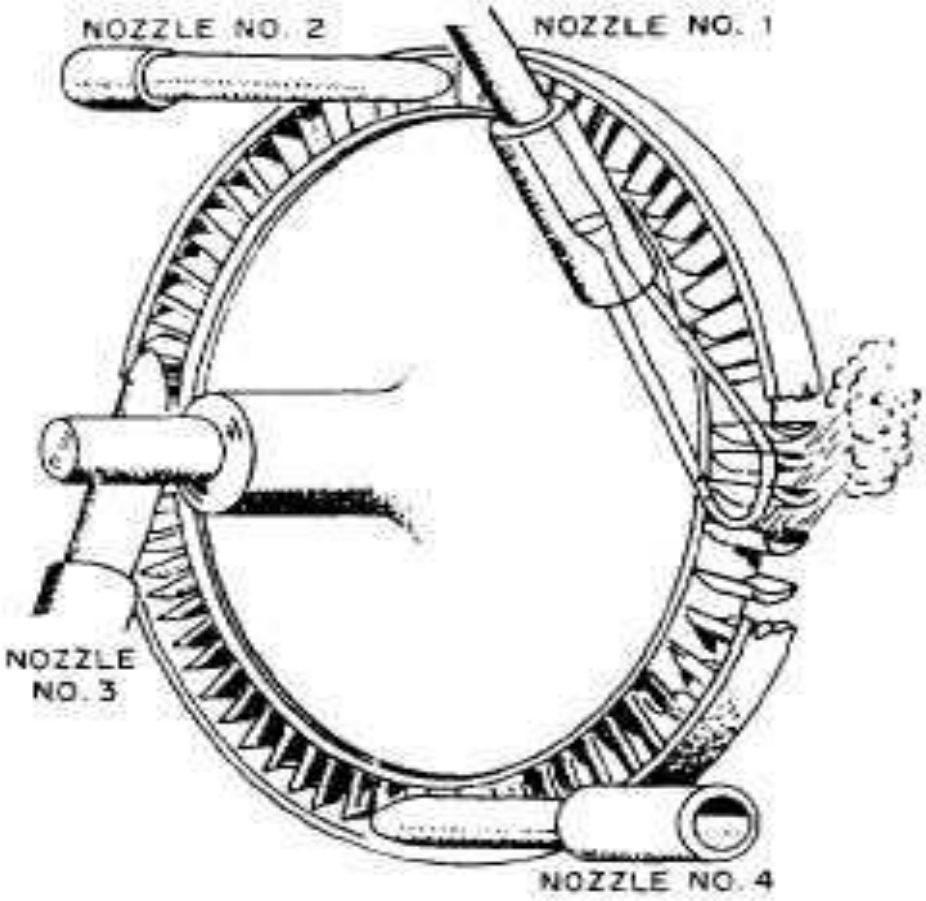
- Scroll casing
- Guide vanes: Used to turn the water through 90^0
- Hub and vanes: Vanes are fixed to hub. Vanes are adjustable. Vanes are adjusted according to the flow rate. Vanes are aerofoil shaped profile
- Draft tube

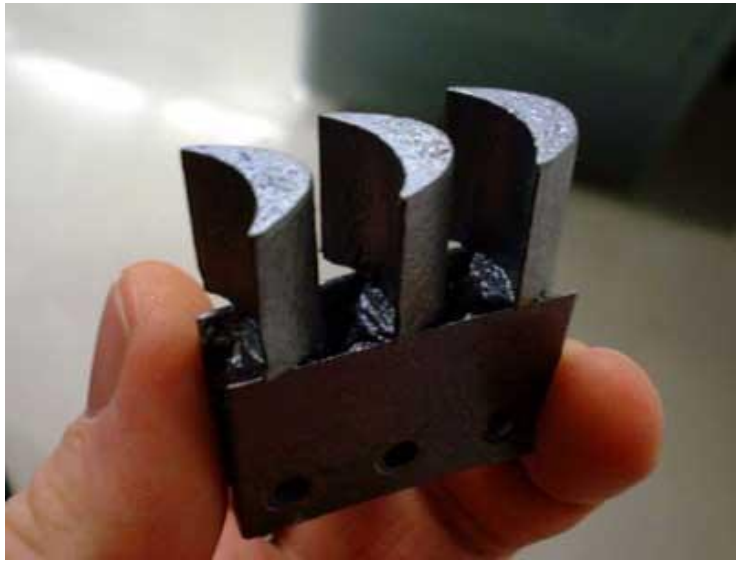
Steam Turbines

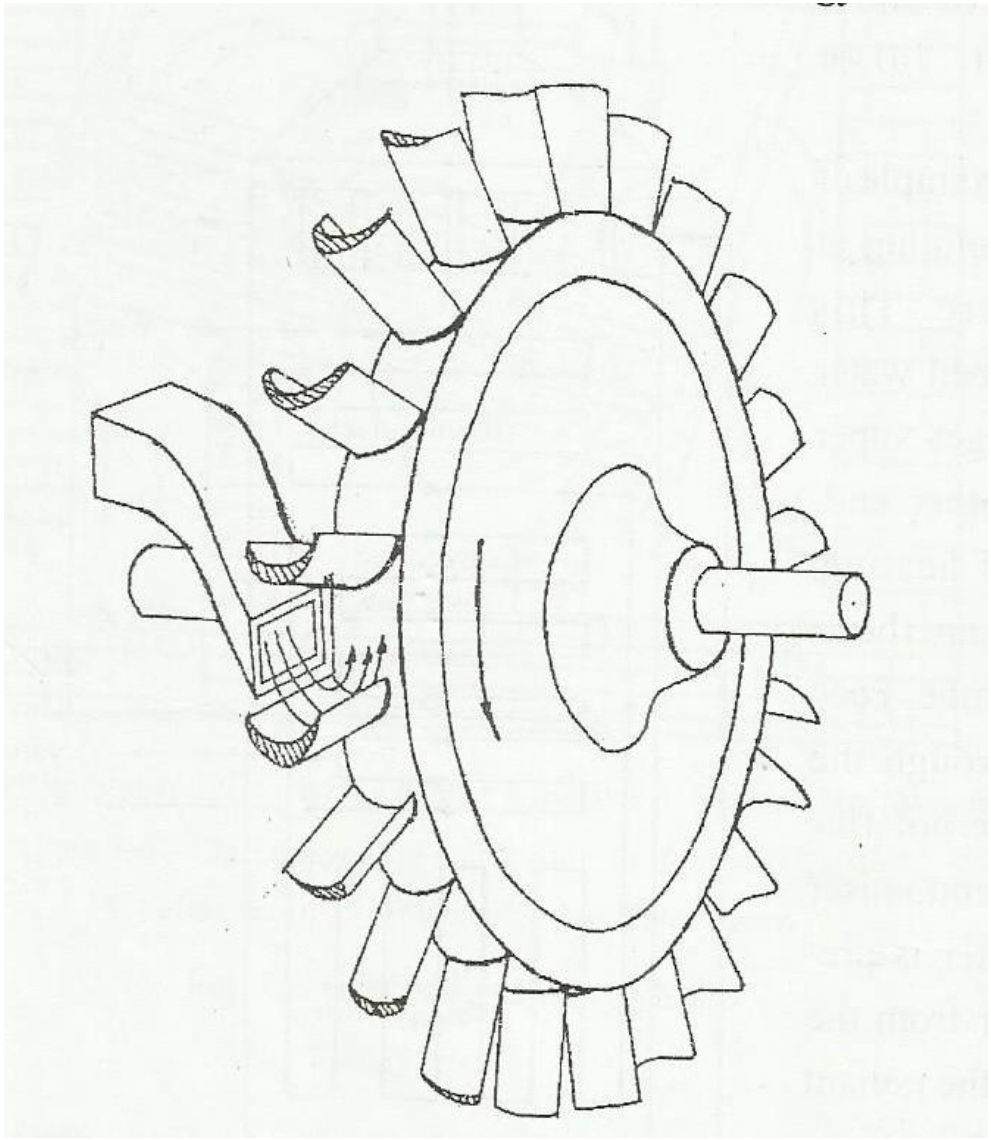
- Steam turbine is a prime mover in which pressure energy of steam is transformed into mechanical energy of rotation of turbine shaft

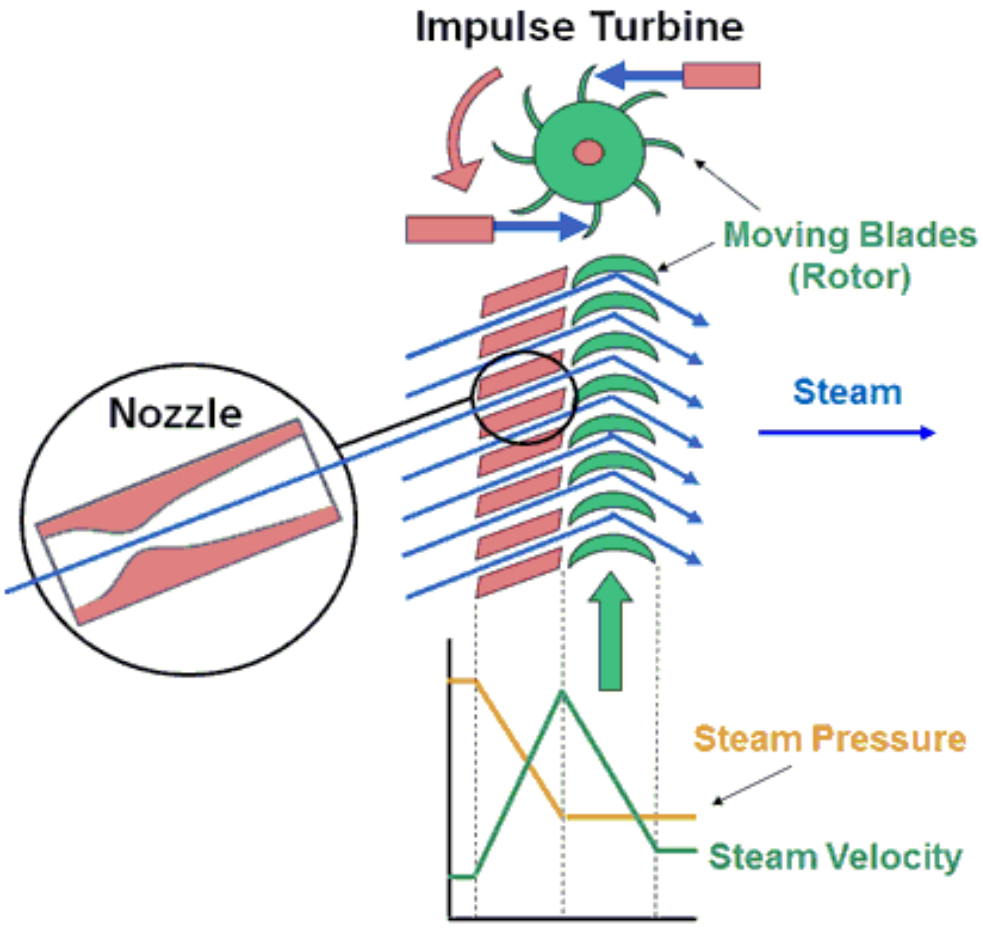

IMPULSE TURBINES
STEAM TURBINES
REACTION TURBINES

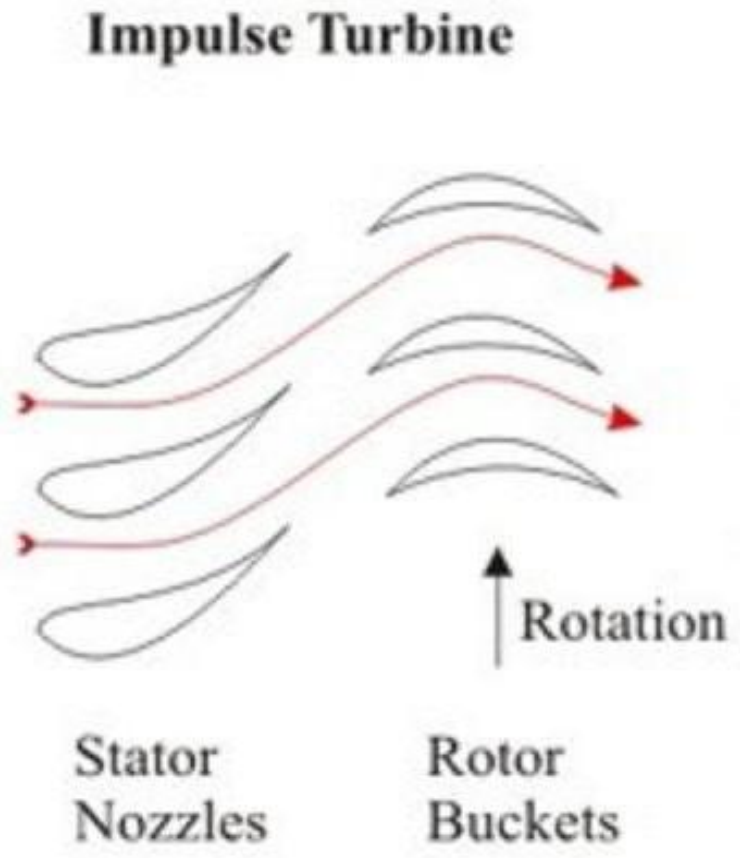
IMPULSE TURBINE

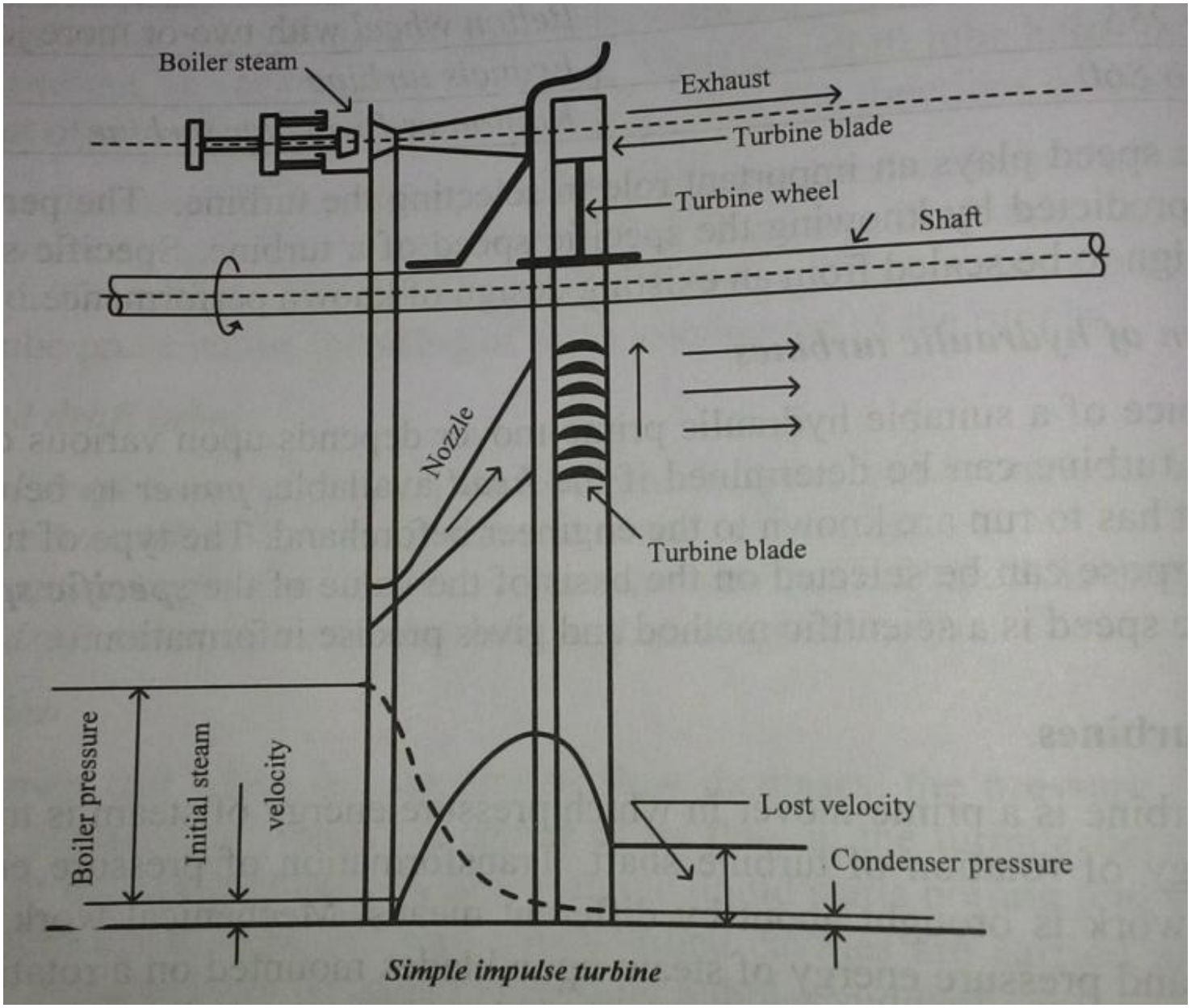

NOZZLE NO. 2
NOZZLE NO. 1
NOZZLE
NO. 3
NOZZLE NO. 4






Impulse Turbine
Moving Blades
(Rotor)
Nozzle
Steam
Steam Pressure
Steam Velocity


Impulse Turbine
Rotation
Stator
Nozzles
Rotor
Buckets



Simple impulse turbine

Components

- Nozzle, Shaft, Disc with Curved Blades Fixed on it Periphery, Casing

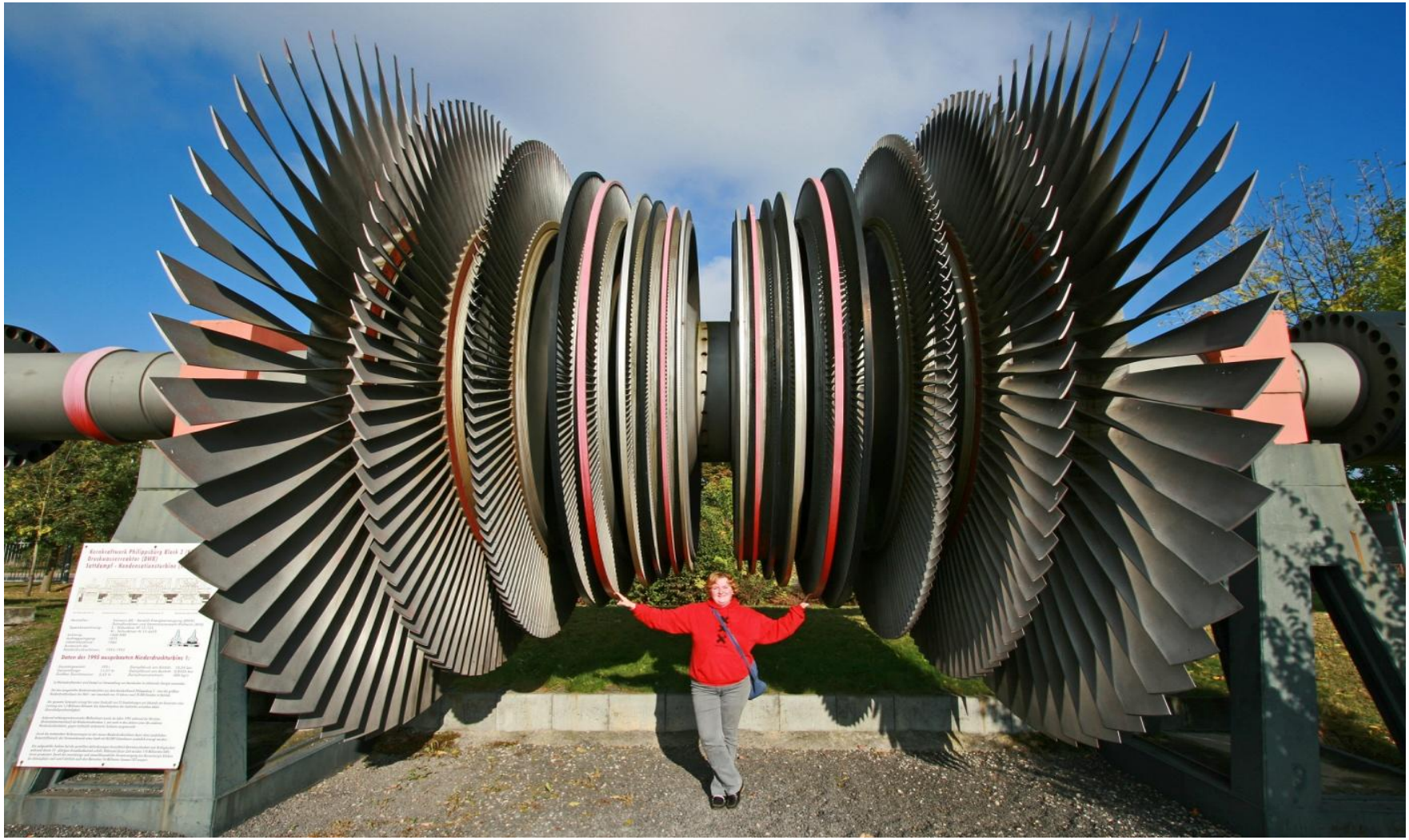
NOZZLE

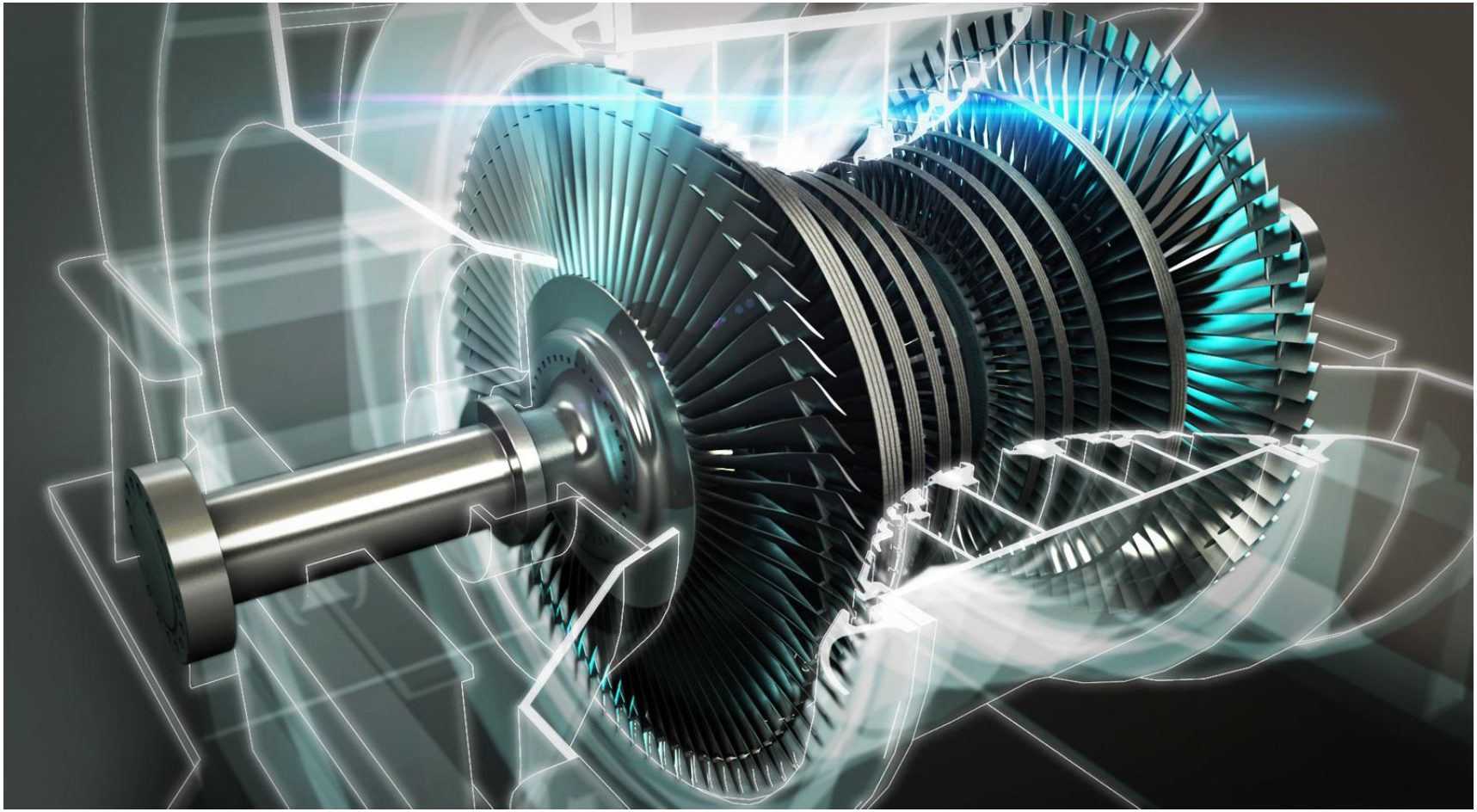
- Pressure energy decreases
- Kinetic energy increases

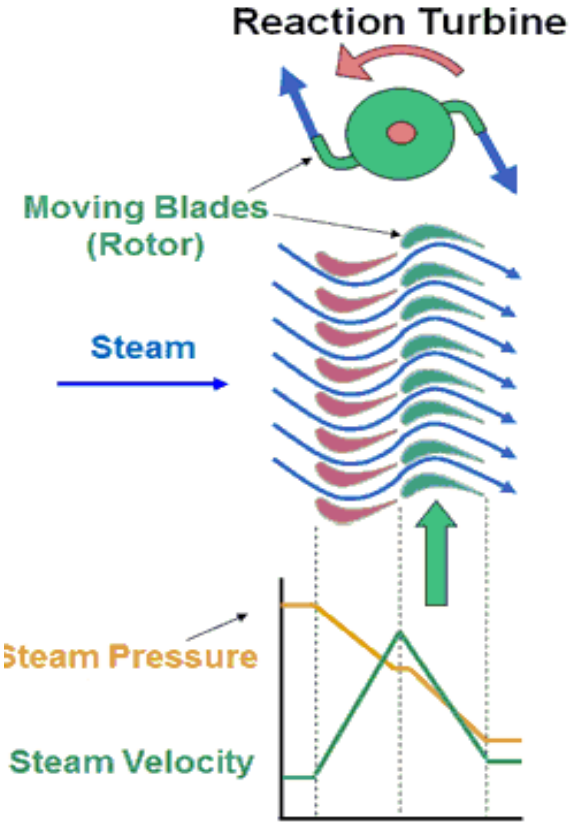
MOVING BLADES

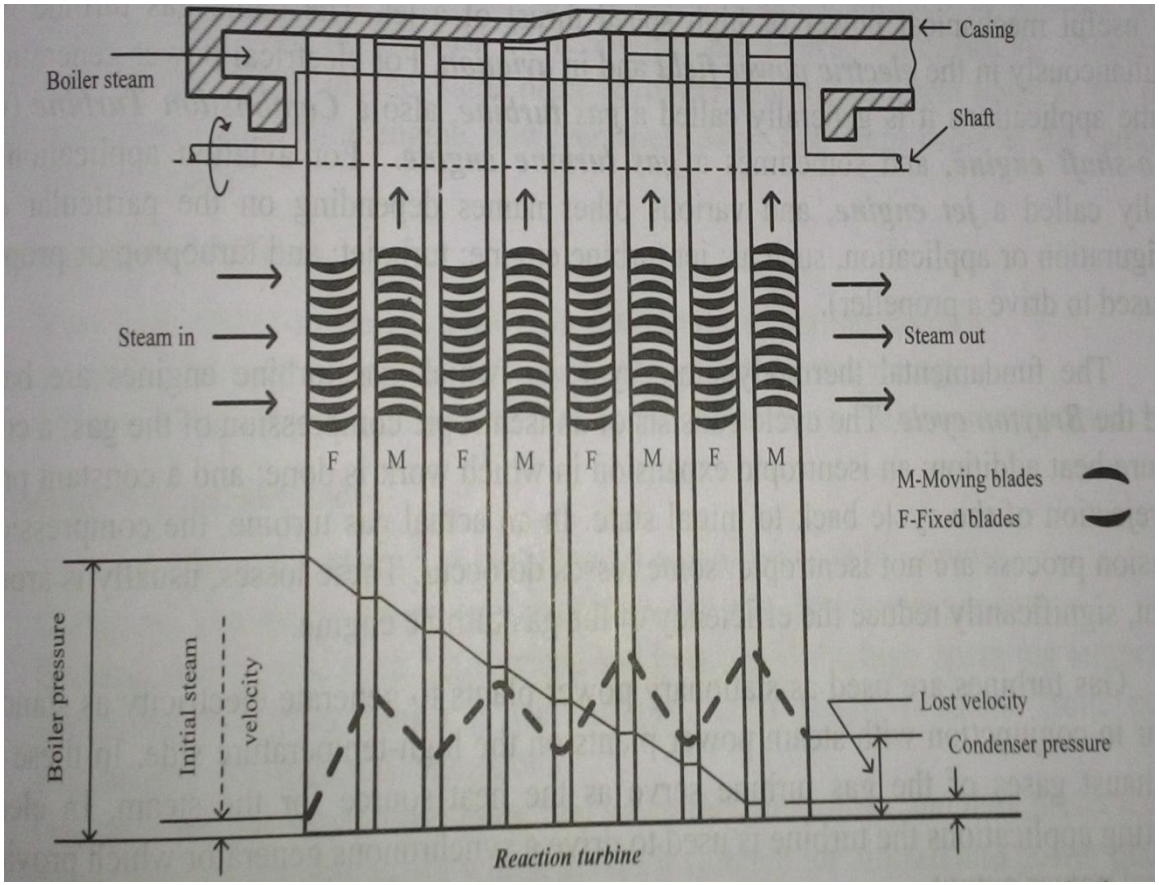
- Pressure remains constant
- Velocity decreases

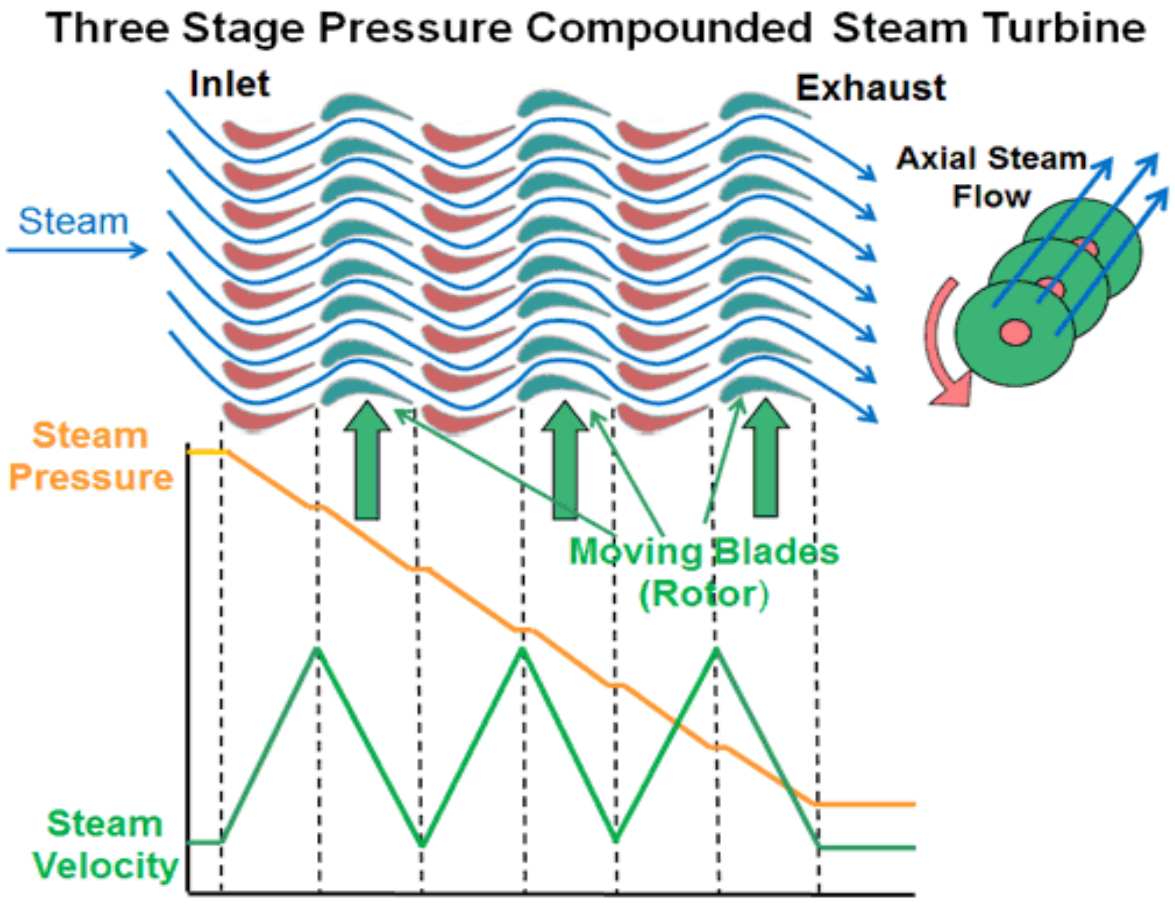
REACTION TURBINE






Reaction Turbine
Moving Blades
(Rotor)
Steam
Steam Pressure
Steam Velocity


Boiler steam
Casing
Shaft
Steam in
Steam out
F
M
F
M
F
M
F
M
M-Moving blades
F-Fixed blades
Boiler pressure
Initial steam
velocity
Lost velocity
Condenser pressure
Reaction turbine


Three Stage Pressure Compounded Steam Turbine
Inlet
Exhaust
Steam
Axial Steam Flow
Steam Pressure
Moving Blades (Rotor)
Steam Velocity

- Steam expands while flowing through fixed and moving blades. Therefore the cross sectional area increases in the direction of flow
- Blades are aerofoil profile

Fixed blades

- Acts like a nozzle
- Velocity increases and pressure reduces

Moving blades

- Velocity decreases and pressure also decreases
- Pressure drop in moving blades provide the reactive force

Comparison of Impulse and Reaction steam turbine

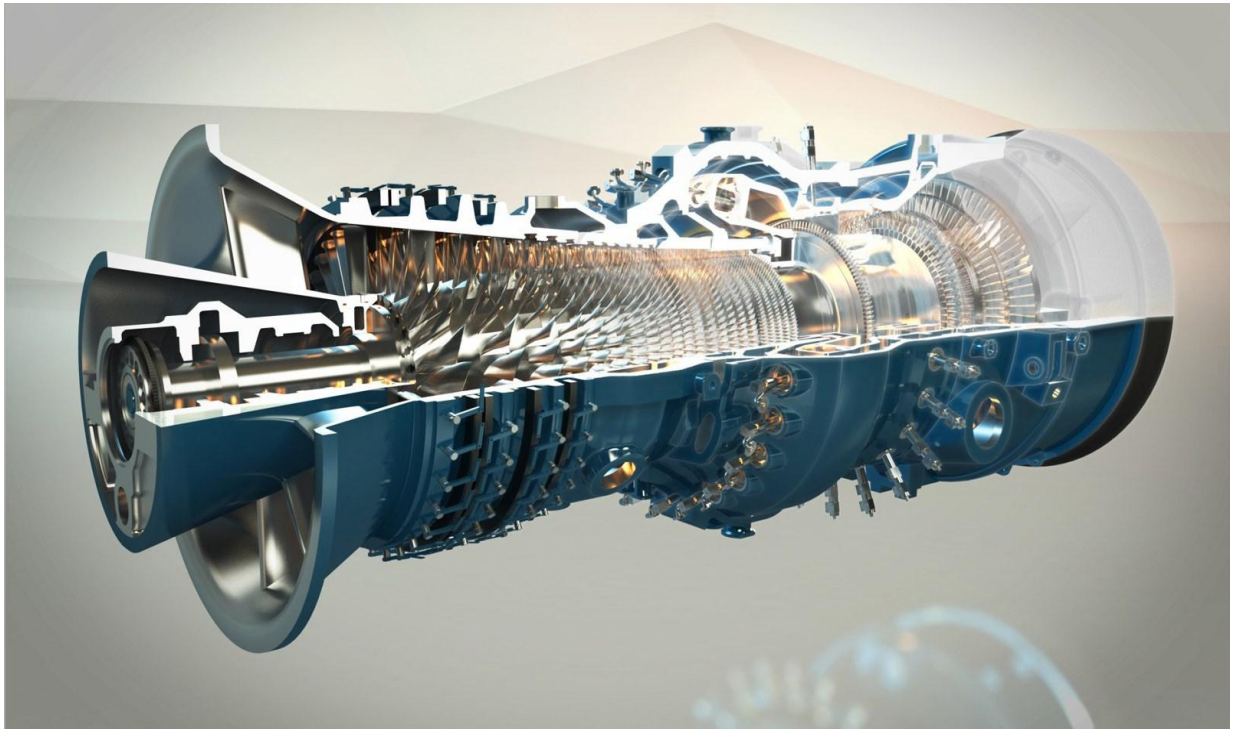
IMPULSE TURBINE

- Expansion taken place in the nozzle
- Blades are symmetrical profile
- Size is small for same output
- Speed is very high
- Cross sectional area of steam passage is same

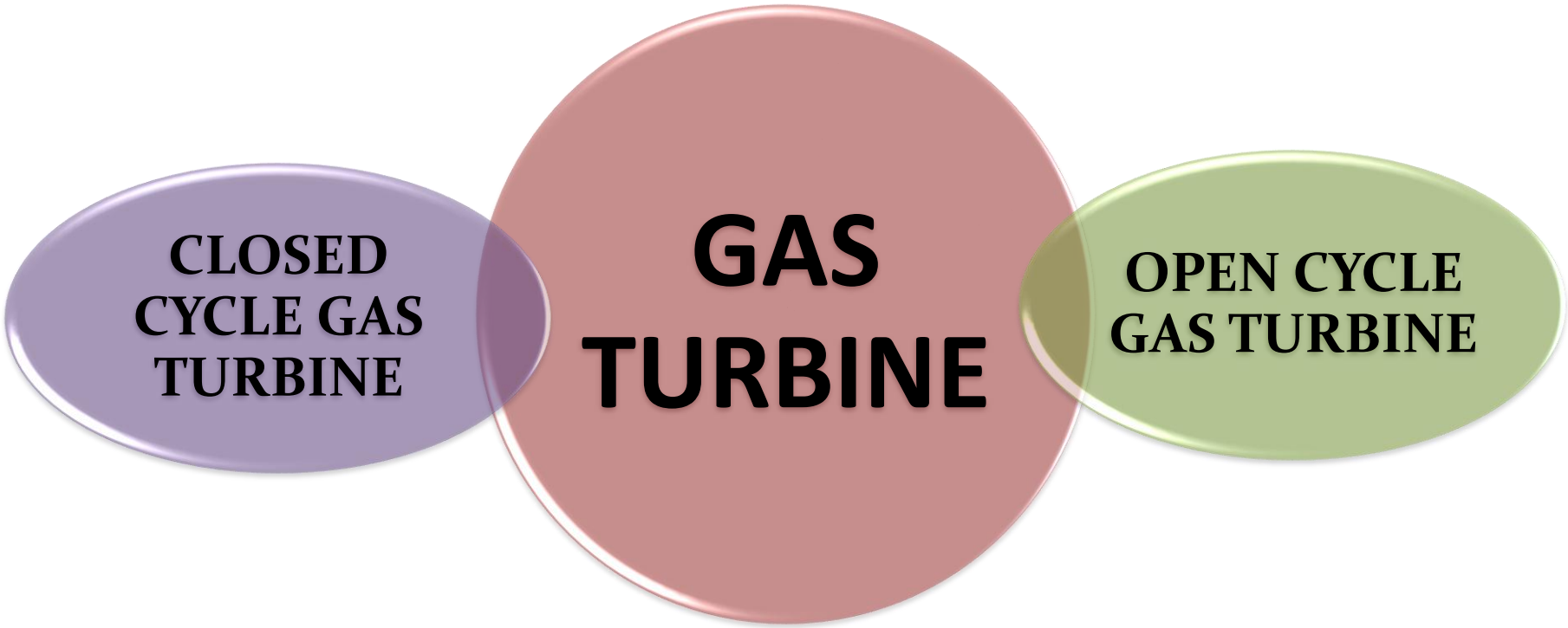
REACTION TURBINE

- Expansion of steam taken place over fixed and moving blades
- Blades are aerofoil profile
- Size is large
- Speed is not high
- Cross sectional area increases in the direction of flow

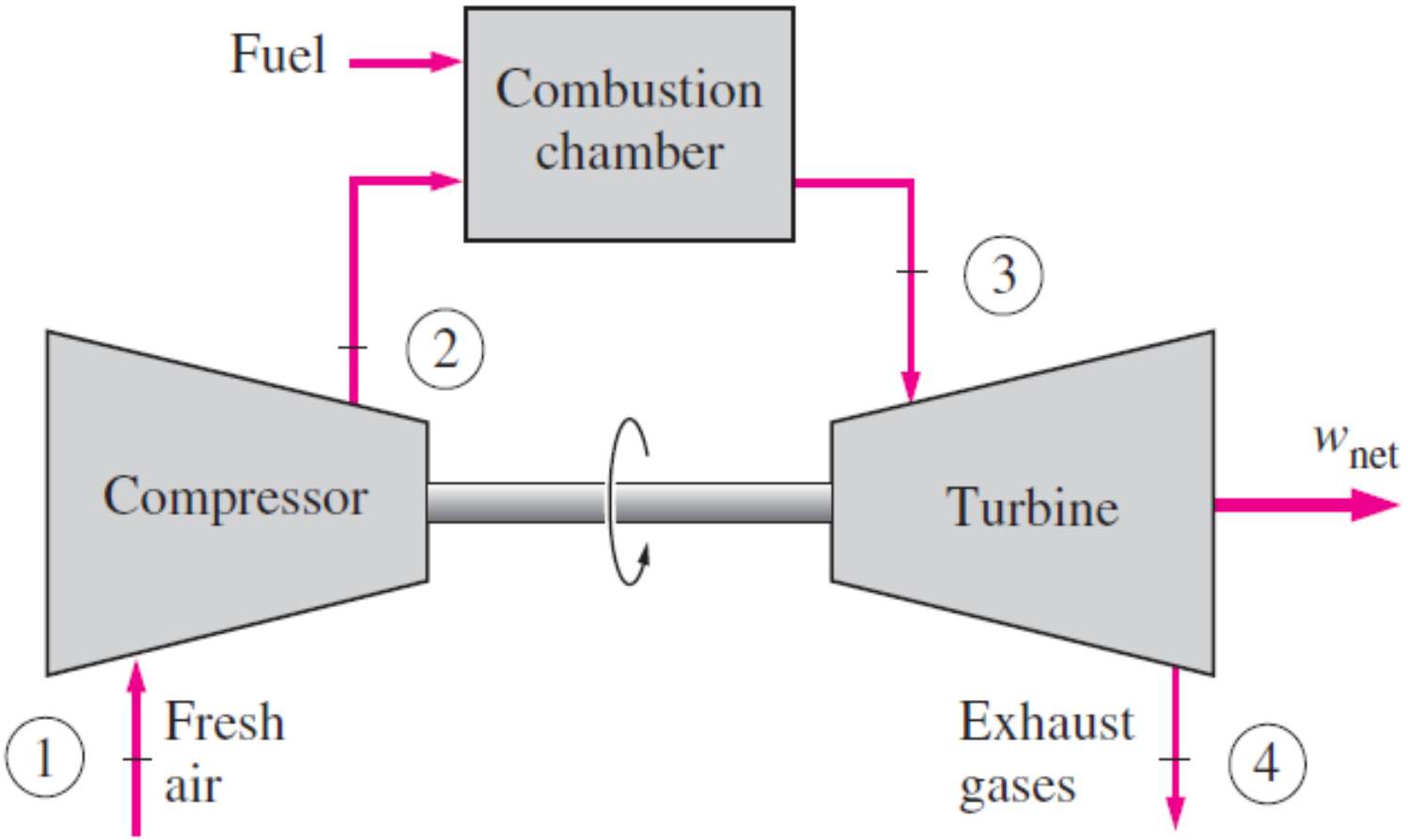
GAS TURBINES



- Device that converts the thermal energy of a working fluid(hot gas) into useful mechanical power

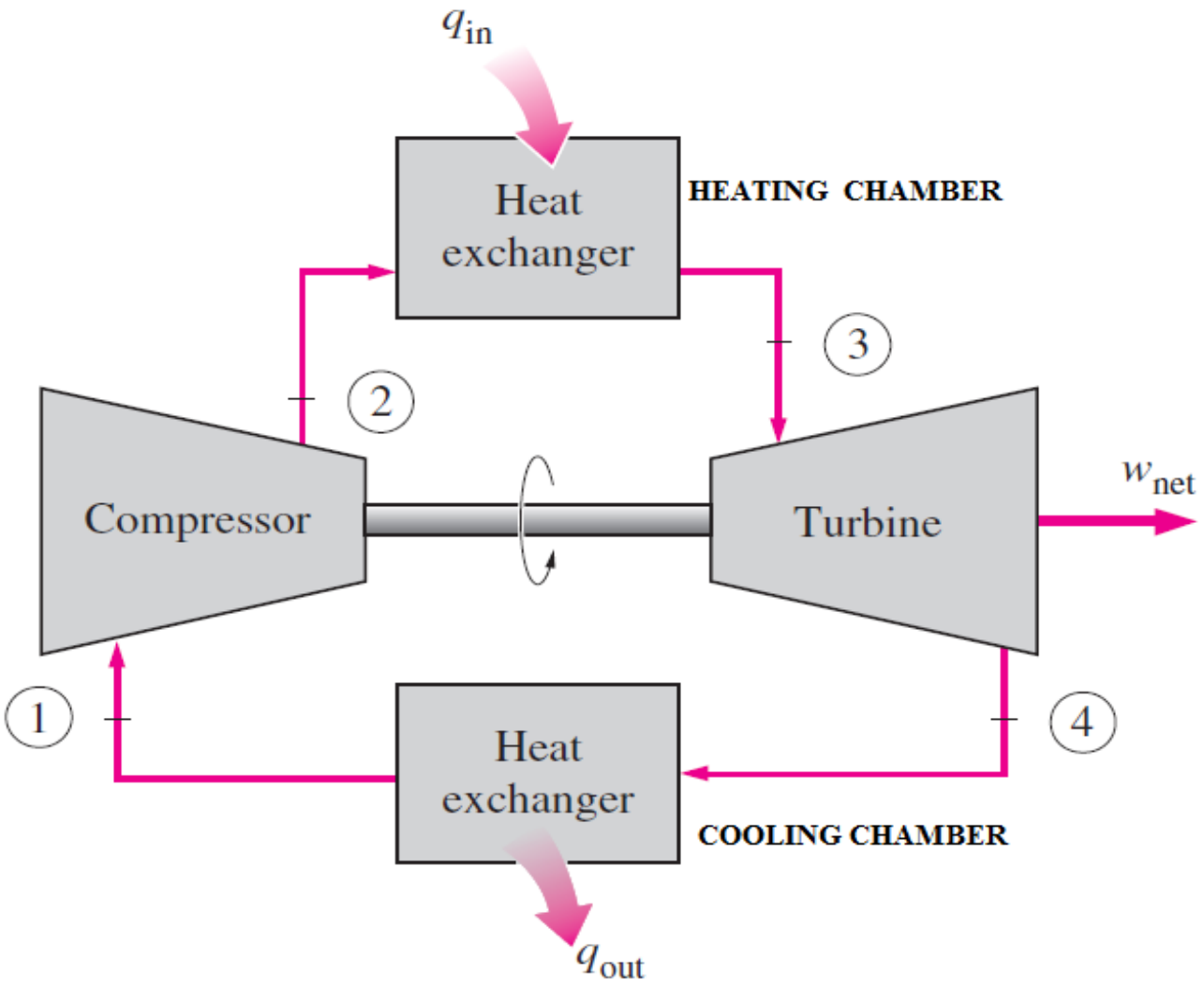

CLOSED CYCLE GAS TURBINE
GAS TURBINE
OPEN CYCLE GAS TURBINE

Open Cycle Gas Turbine



- Compressor takes in ambient air and raises its pressure
- High pressure gas then enters into the combustion chamber. After combustion, the product of combustion is expanded in the turbine to develop work
- Part of the turbine work is used to drive the compressor
- The expanded product is discharged to the atmosphere

Closed Cycle Gas Turbine



- Same working fluid is continuously circulated
- Heat of product of combustion is transferred to the compressed working medium using a heating chamber
- Heat is removed from the expanded working medium using a cooling chamber

Comparison of closed cycle and open cycle gas turbine

Closed Cycle

- High thermal efficiency
- More complex system
- Coolant is needed
- Working fluid is circulated continuously
- Any fluid with better thermodynamic properties can be used
- Strong enough to resist high pressures
- Turbine vane do not wear away much

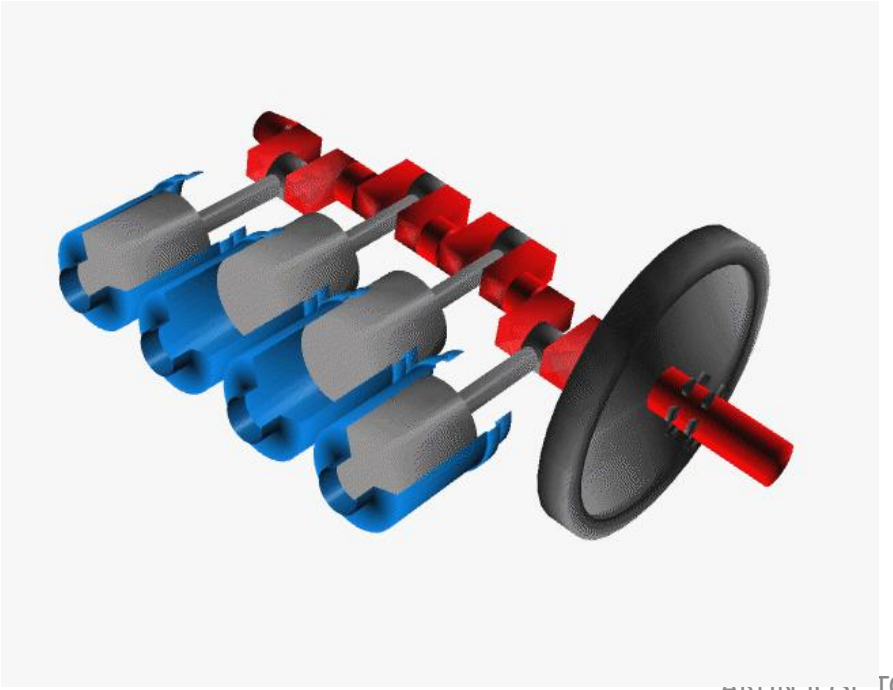
Open Cycle

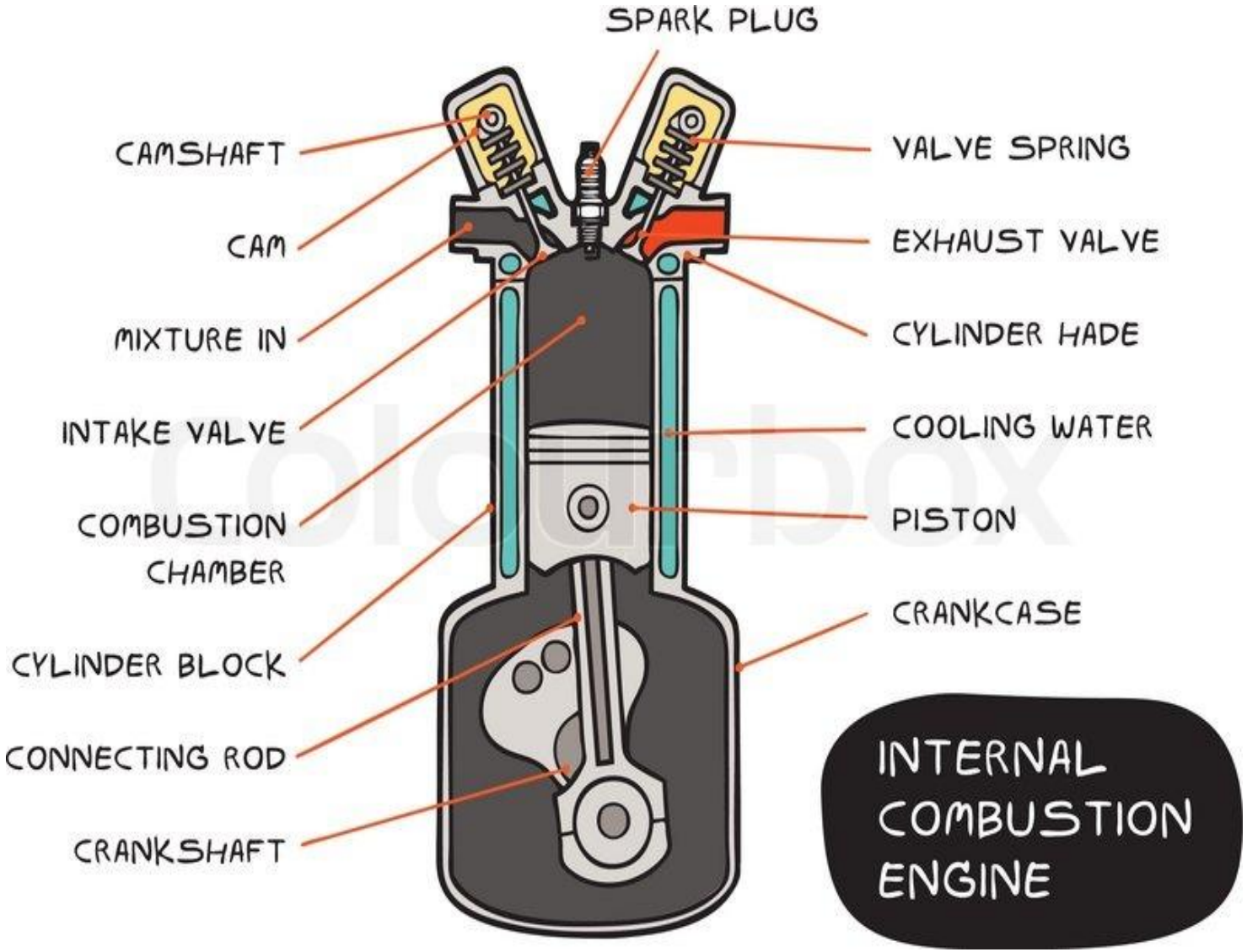
- Less thermal efficiency
- Less complex system
- Coolant is not needed
- Working fluid is repeated continuously
- Only air can be used as working fluid
- Contaminated air increases the wear rate of turbine vane

INTERNAL COMBUSTION ENGINES

Internal Combustion(IC) Engines

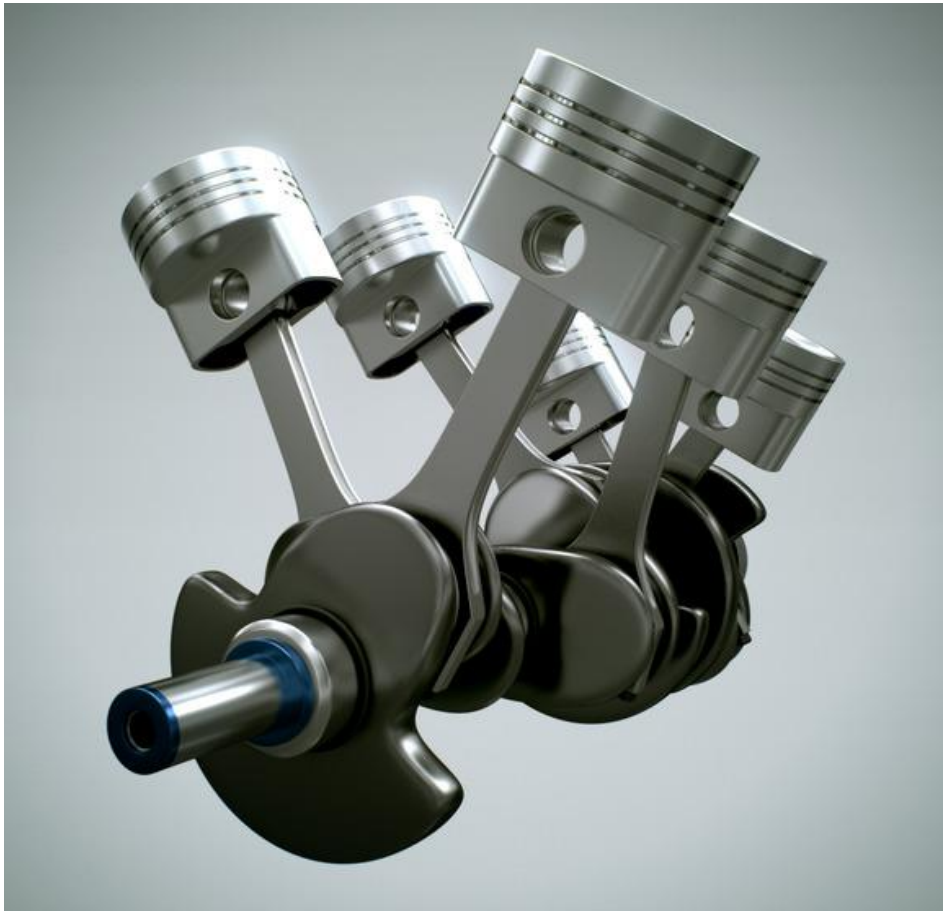
- Heat engine which converts chemical energy in a fuel into mechanical energy




SPARK PLUG
CAMSHAFT
CAM
MIXTURE IN
INTAKE VALVE
COMBUSTION CHAMBER
CYLINDER BLOCK
CONNECTING ROD
CRANKSHAFT
VALVE SPRING
EXHAUST VALVE
CYLINDER HADE
COOLING WATER
PISTON
CRANKCASE
INTERNAL COMBUSTION ENGINE

Main Components Of IC Engines

- Cylinder
- Piston
- Crank shaft
- Connecting rod
- Crank
- Inlet and Exhaust valves
- Flywheel



PISTON

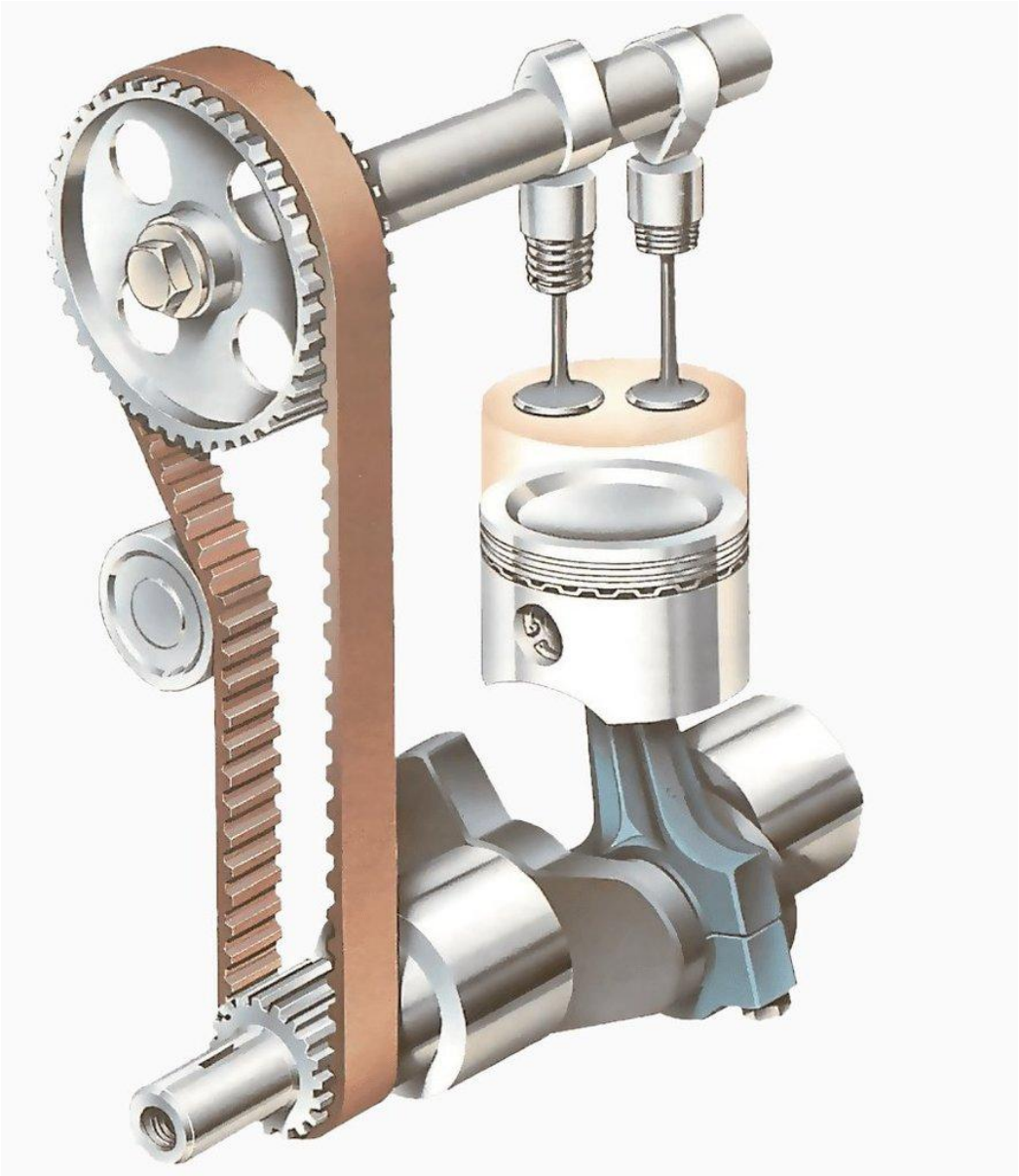
CONNECTING ROD

VALVES

CRANKSHAFT

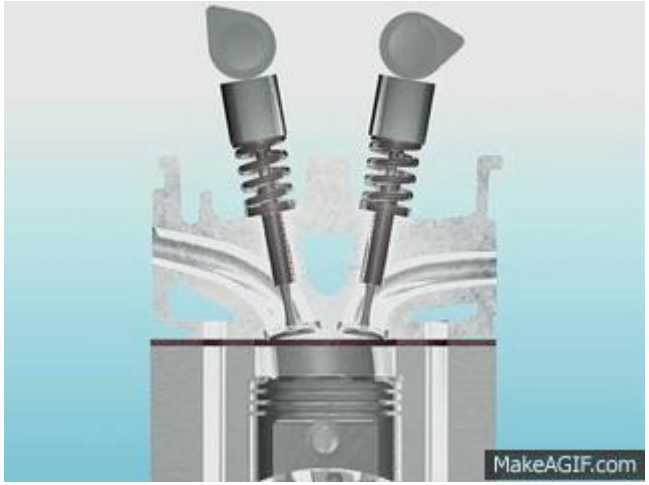
CYLINDER BLOCK

FLYWHEEL

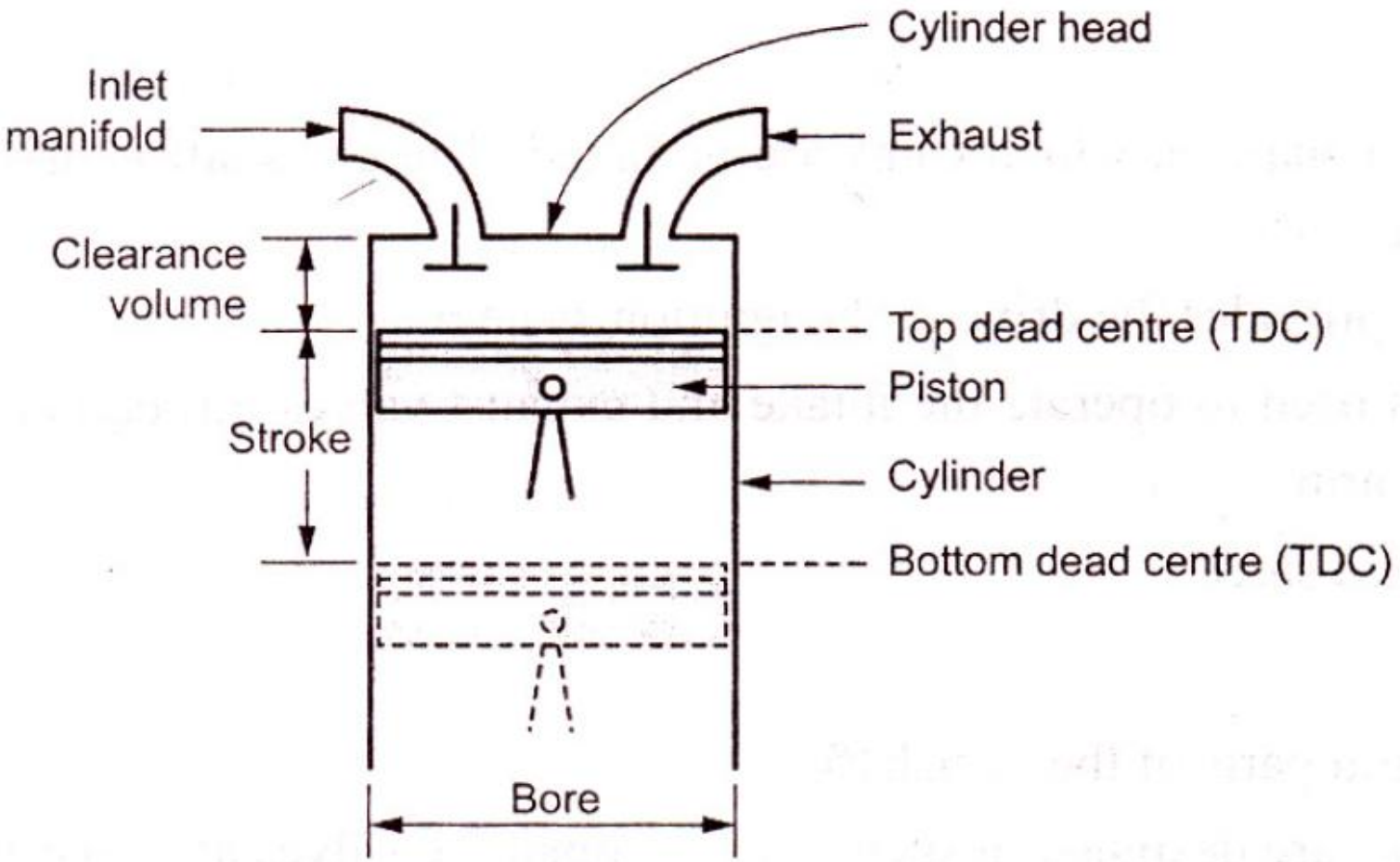


PISTON AND CONNECTING ROD

CAMSHAFT



IC ENGINE TERMINOLOGY



- **Top dead centre(TDC):** Extreme position of the piston at the top of the cylinder is the top dead centre
- **Bottom dead centre(BDC):** Position of the piston when it is farthest from the top of the cylinder is the bottom dead centre
- **Stroke:** Travel of the piston from one dead centre to the other.
- **Stroke length:** The distance between the two dead centres
- **Swept volume:** Volume of the cylinder in between the two dead centres
- **Clearance volume:** Volume of the cylinder in between the top dead centre and the cylinder head

Classification of IC Engines

Based on the ignition system

- Spark ignition engines
- Compression ignition engines

Based on the type of fuel used

- Petrol engines
- Diesel engines
- LPG engines
- CNG engines
- Dual- fuel engines

Based on the working cycle

- Otto cycle engine
- Diesel cycle engine

Based on the number of strokes per cycle

- Four stroke engines
- Two stroke engines

Based on the application of the engine

- Stationary engines
- Mobile engines

Based on the cooling system

- Air cooled engines
- Water cooled engines

Based on the speed of the engine

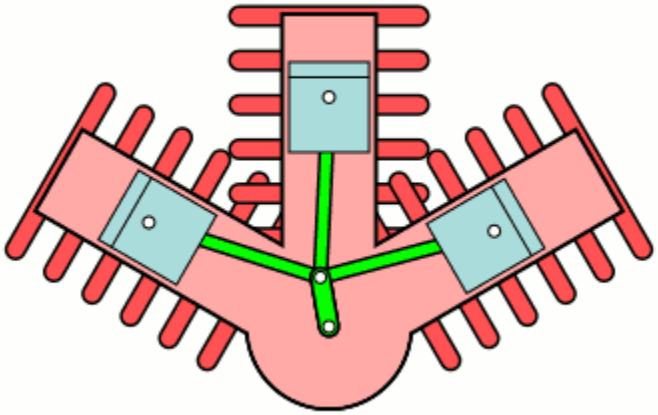
- Low speed engines (up to 350rpm)
- Medium speed engines (350-1000rpm)
- High speed engines (above 1000rpm)

Based on the number of cylinders

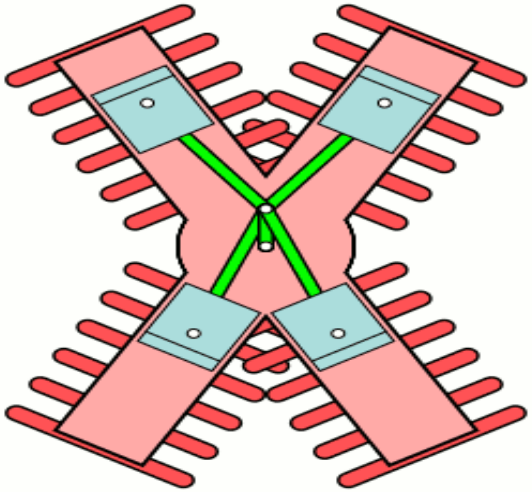
- Single cylinder engine
- Multi cylinder engine

Based on cylinder arrangement

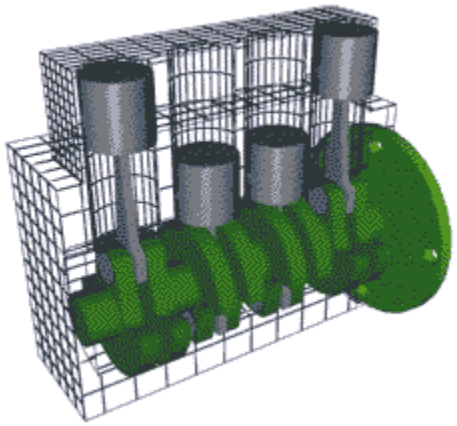
- a) Vertical engine b) Horizontal engine c) In-line engine d)V-engine e) Radial engine f) Opposed cylinder engine g)W – engine h) X-engine



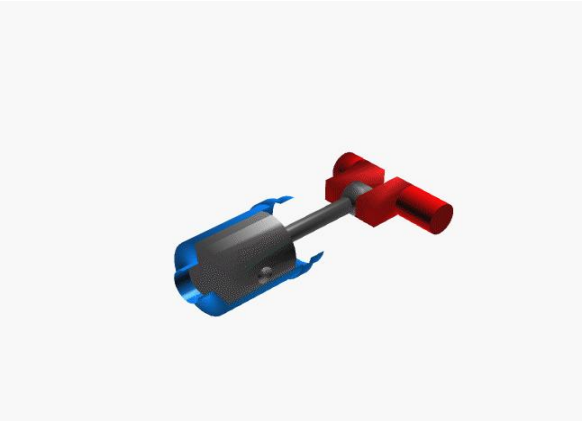
W-ENGINE



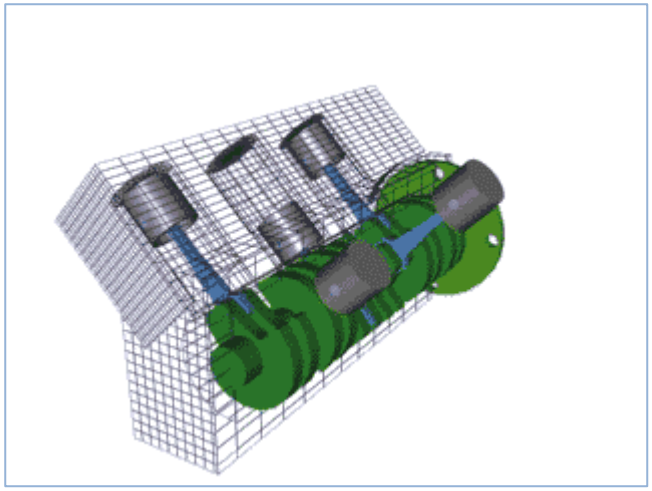
X-ENGINE



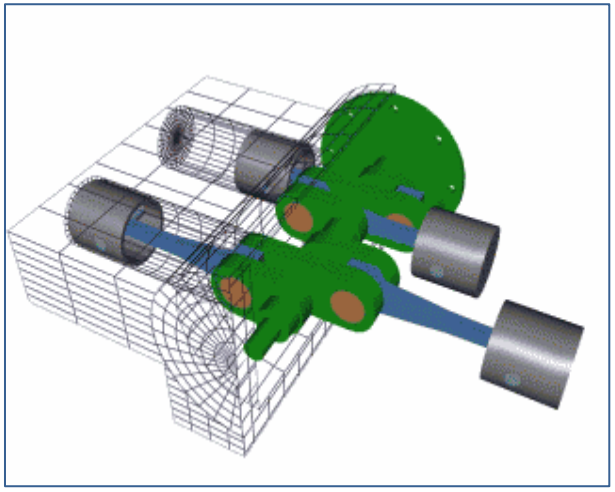
IN-LINE ENGINE



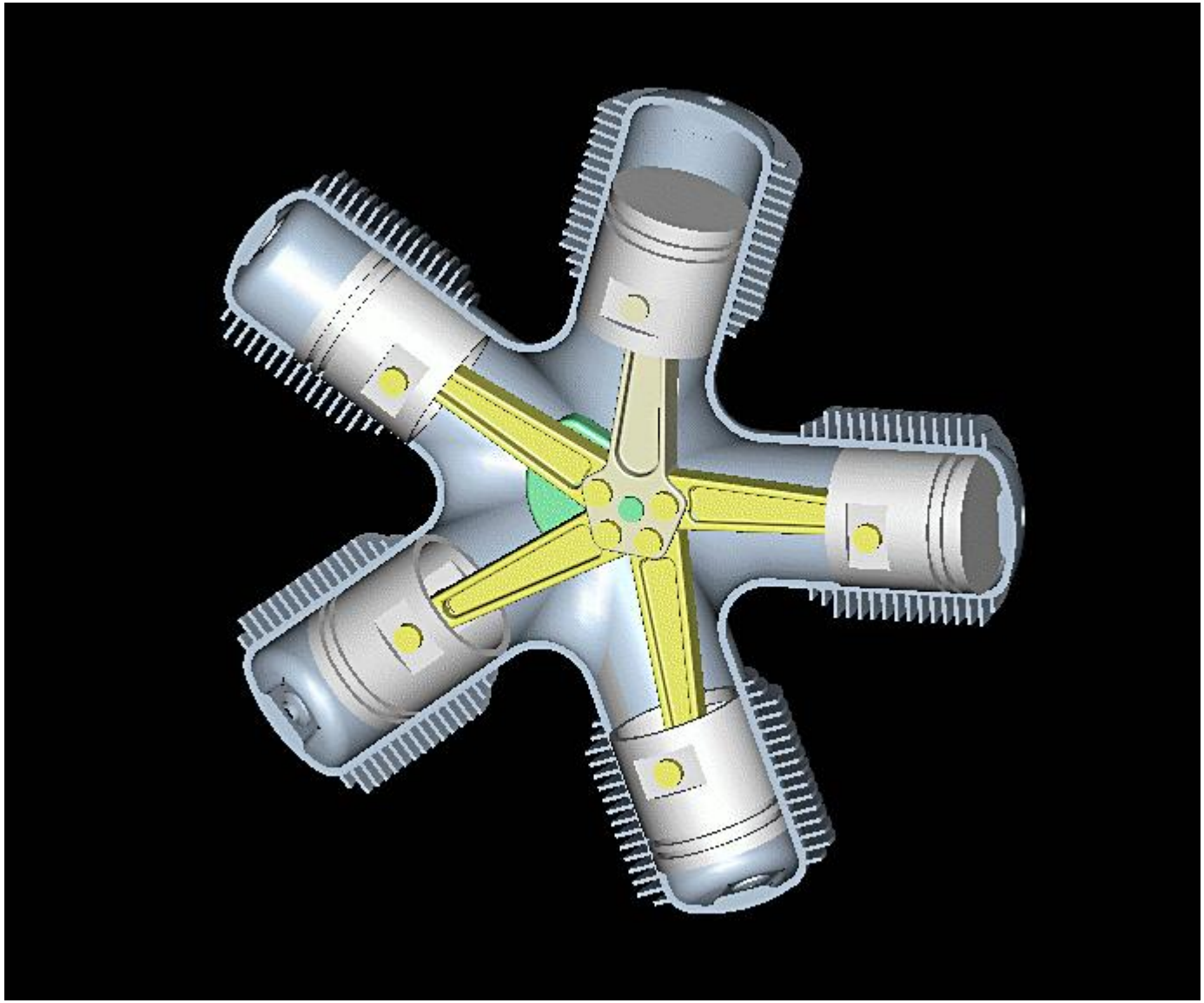
HORIZONTAL ENGINE



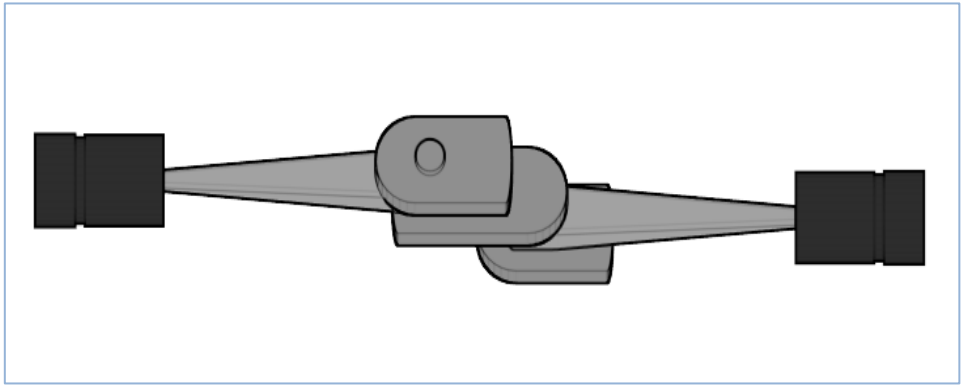
V-ENGINE



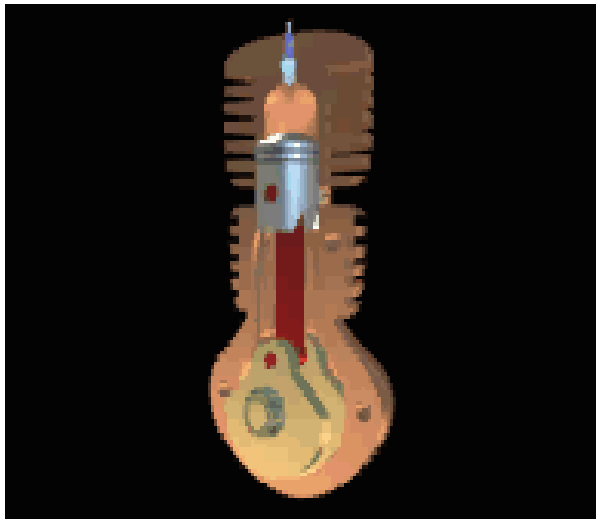
OPPOSED CYLINDER ENGINE



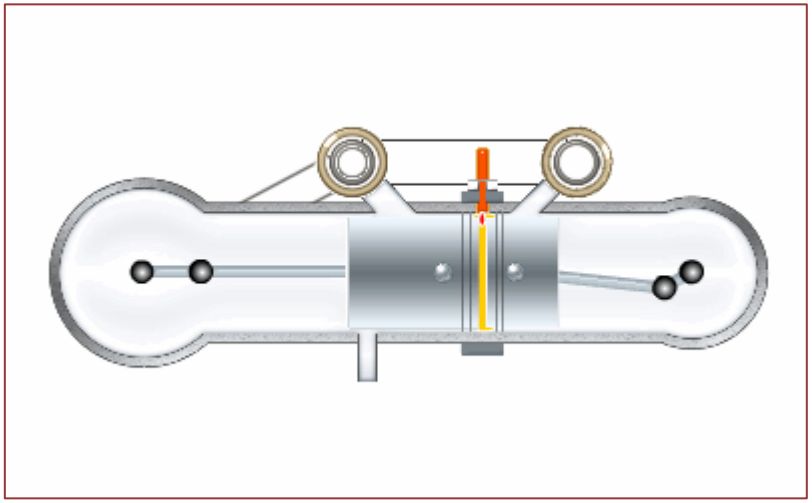
RADIAL ENGINE



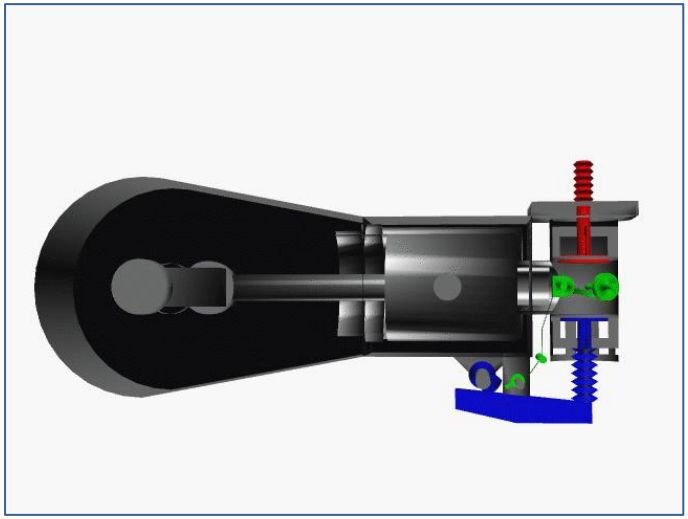
OPPOSED CYLINDER ENGINE



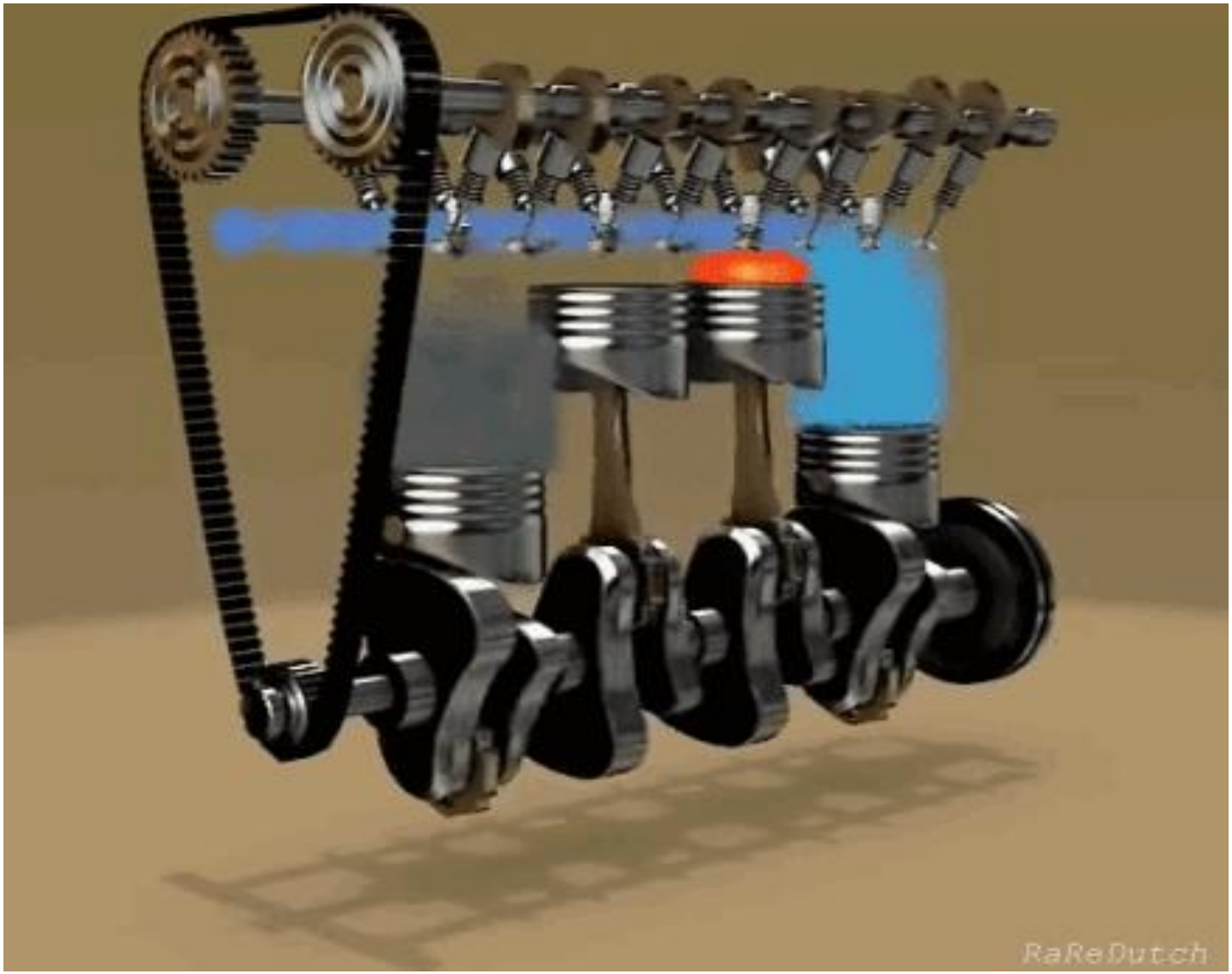
VERTICAL CYLINDER ENGINE

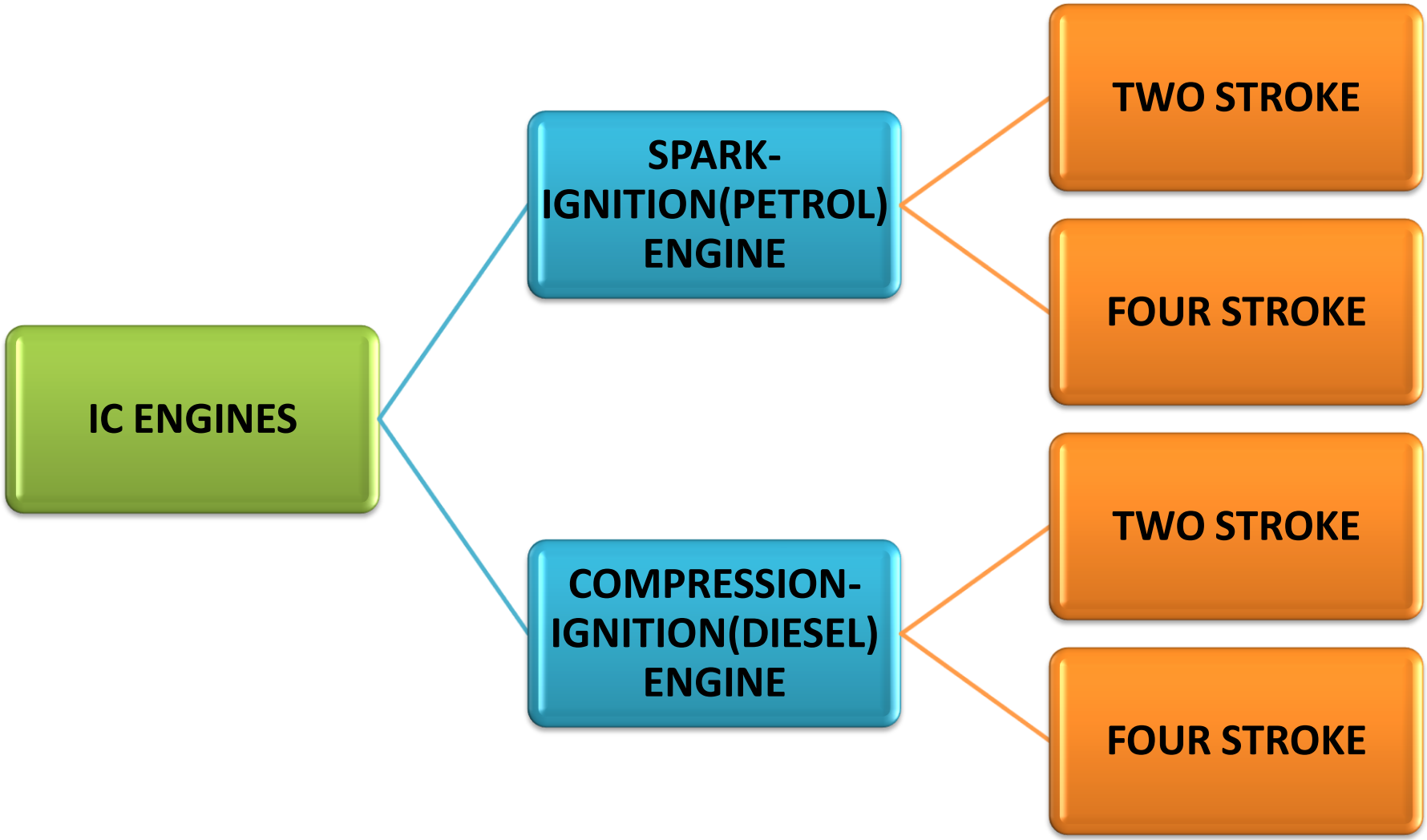


OPPOSED PISTON ENGINE



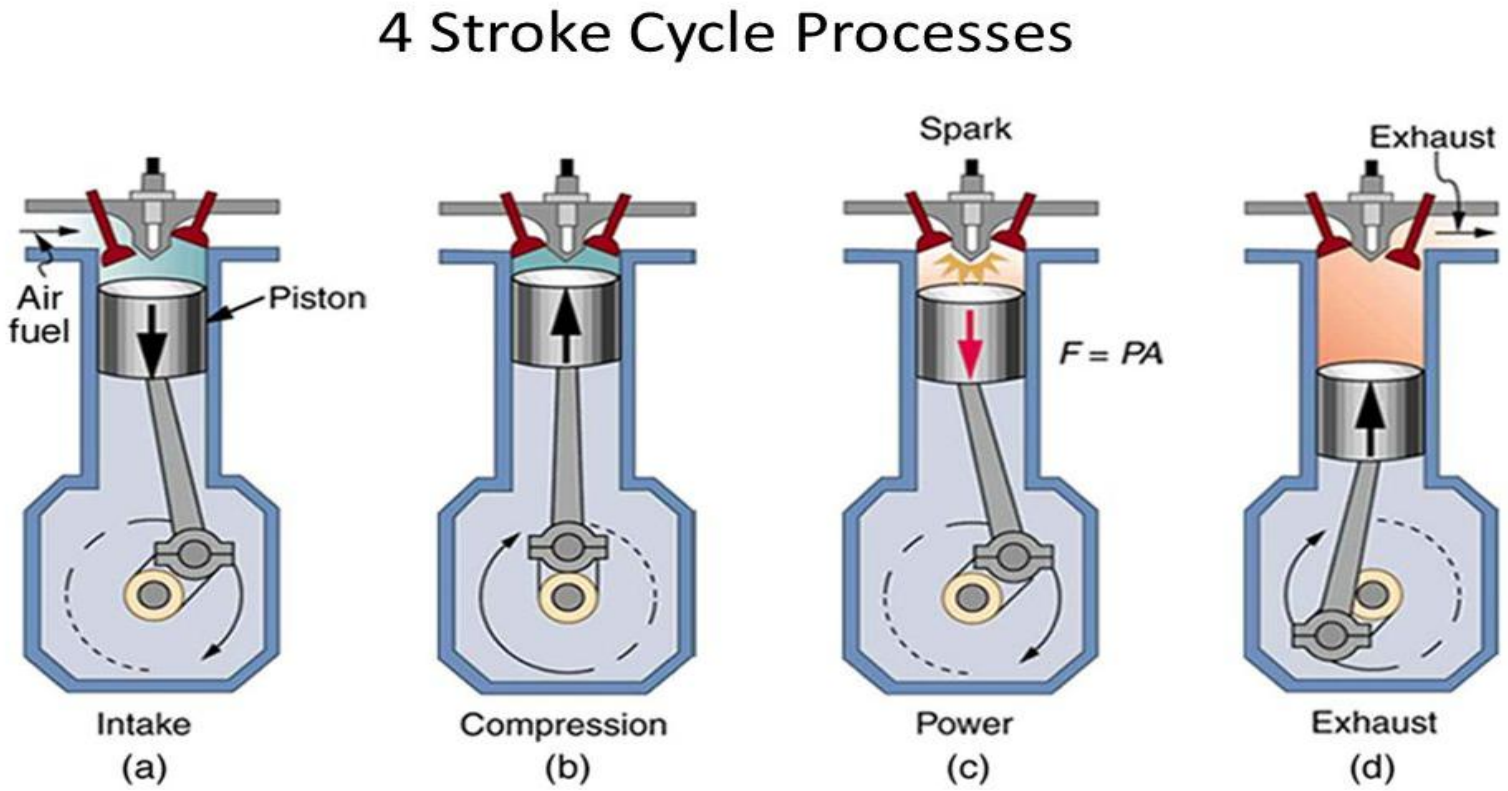
HORIZONTAL CYLINDER ENGINE


RaReDutch

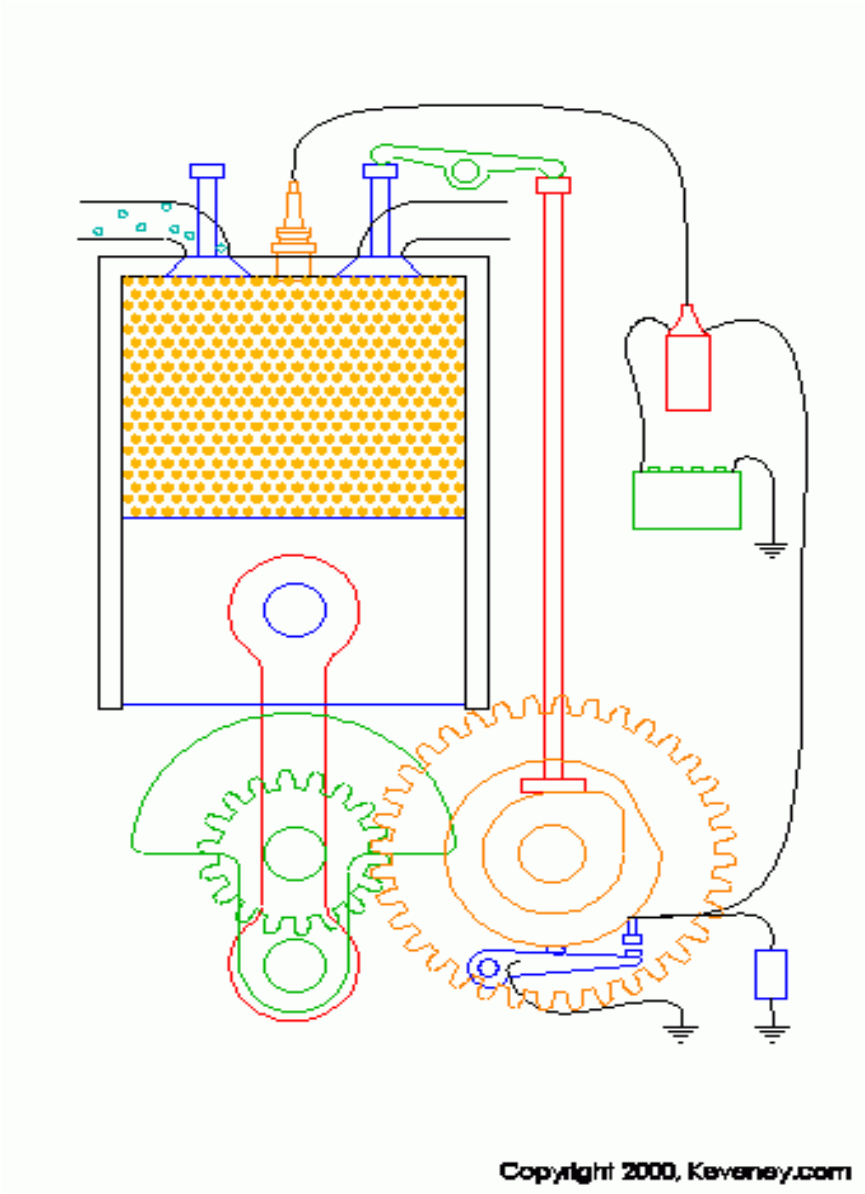

IC ENGINES
SPARK-IGNITION(PETROL) ENGINE
COMPRESSION-IGNITION(DIESEL) ENGINE
TWO STROKE
FOUR STROKE
TWO STROKE
FOUR STROKE

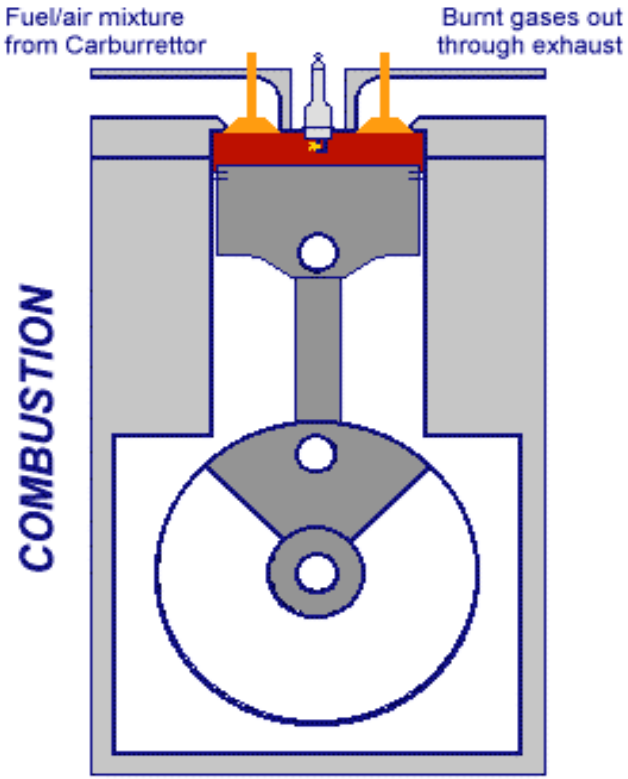
SPARK-IGNITION(PETROL) ENGINE

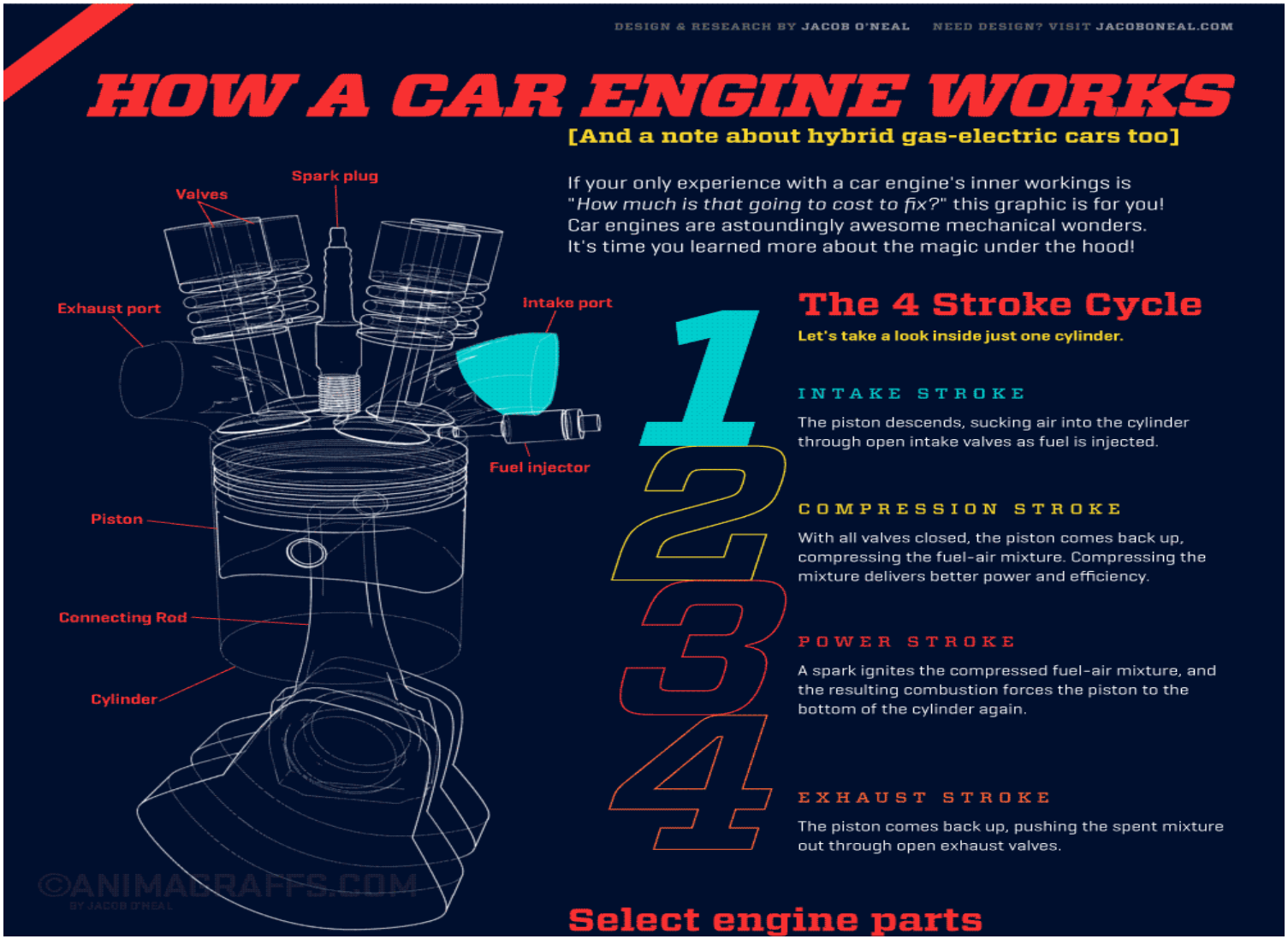
- **FOUR STROKE PETROL ENGINE**

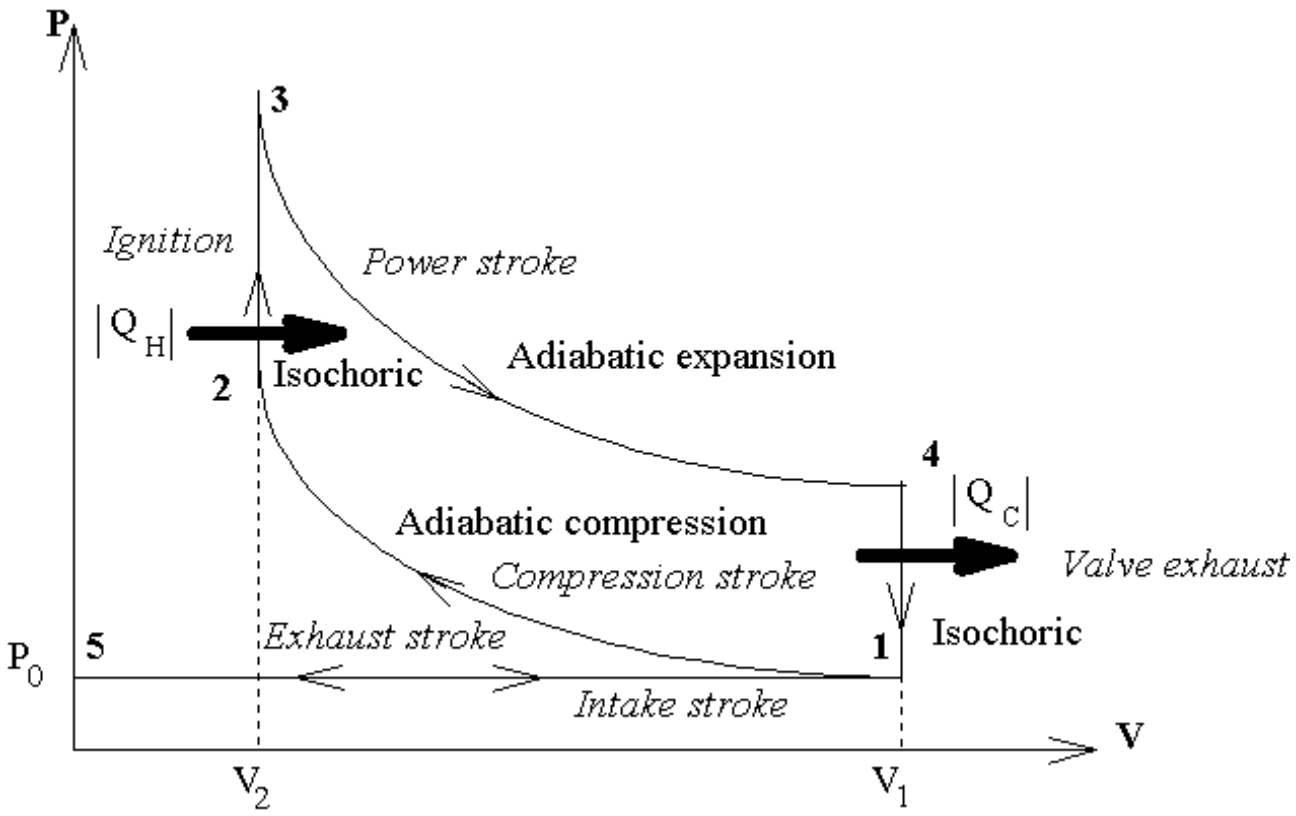


- Four stroke petrol engine requires 4 strokes of piston or 2 revolution of crank shaft to complete 1 cycle of operation


Copyright 2000, Keveney.com


Fuel/air mixture
from Carburrettor
Burnt gases out
through exhaust
COMBUSTION


DESIGN & RESEARCH BY JACOB O'NEAL
NEED DESIGN? VISIT JACOBONEAL.COM
HOW A CAR ENGINE WORKS
[And a note about hybrid gas-electric cars too]
If your only experience with a car engine's inner workings is "How much is that going to cost to fix?" this graphic is for you! Car engines are astoundingly awesome mechanical wonders. It's time you learned more about the magic under the hood!
Spark plug
Valves
Exhaust port
Intake port
Fuel injector
Piston
Connecting Rod
Cylinder
1
2
3
4
The 4 Stroke Cycle
Let's take a look inside just one cylinder.
INTAKE STROKE
The piston descends, sucking air into the cylinder through open intake valves as fuel is injected.
COMPRESSION STROKE
With all valves closed, the piston comes back up, compressing the fuel-air mixture. Compressing the mixture delivers better power and efficiency.
POWER STROKE
A spark ignites the compressed fuel-air mixture, and the resulting combustion forces the piston to the bottom of the cylinder again.
EXHAUST STROKE
The piston comes back up, pushing the spent mixture out through open exhaust valves.
©ANIMATRAFFS.COM
BY JACOB O'NEAL
Select engine parts



- Pressure – volume diagram for petrol engine

Working Principle of Petrol Engine

Process 5-1; SUCTION STROKE

- Piston moves from TDC to BDC. Inlet valve opens and the fuel- air mixture is drawn into the engine cylinder. Exhaust valve remains closed

Process 1-2; COMPRESSION STROKE

- Piston moves from BDC to TDC and compresses the air – fuel mixture. Both valve remains closed.

Process 2-3; spark ignites

- Just before the end of the stroke, the spark plug initiates a spark, which ignites the mixture and combustion takes place at constant volume. Both the valves remains closed

Process 3-4; POWER STROKE

- Piston moves from TDC to BDC and thus work is done. Both valves remain closed.

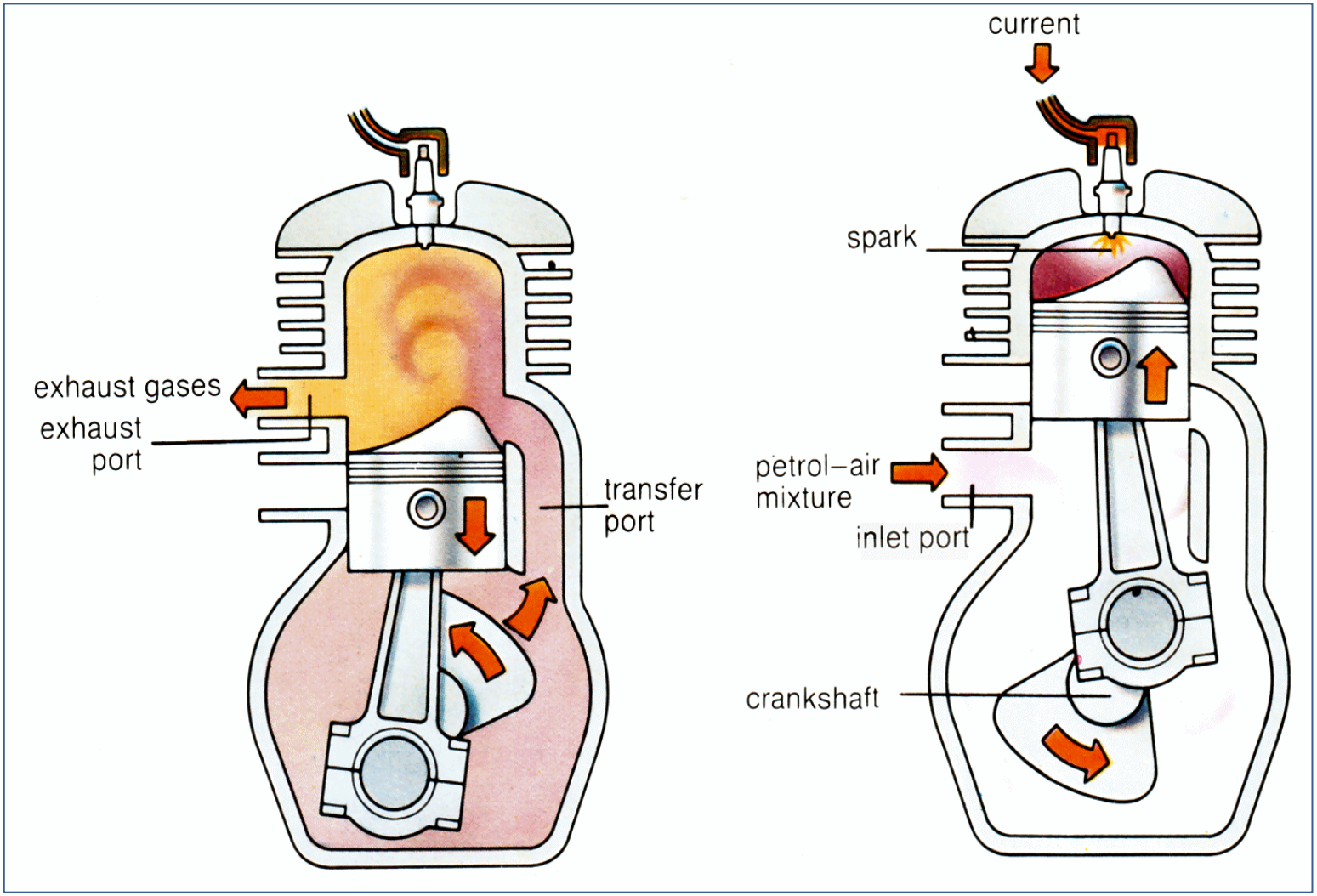
Process 4-1; constant volume hear rejection

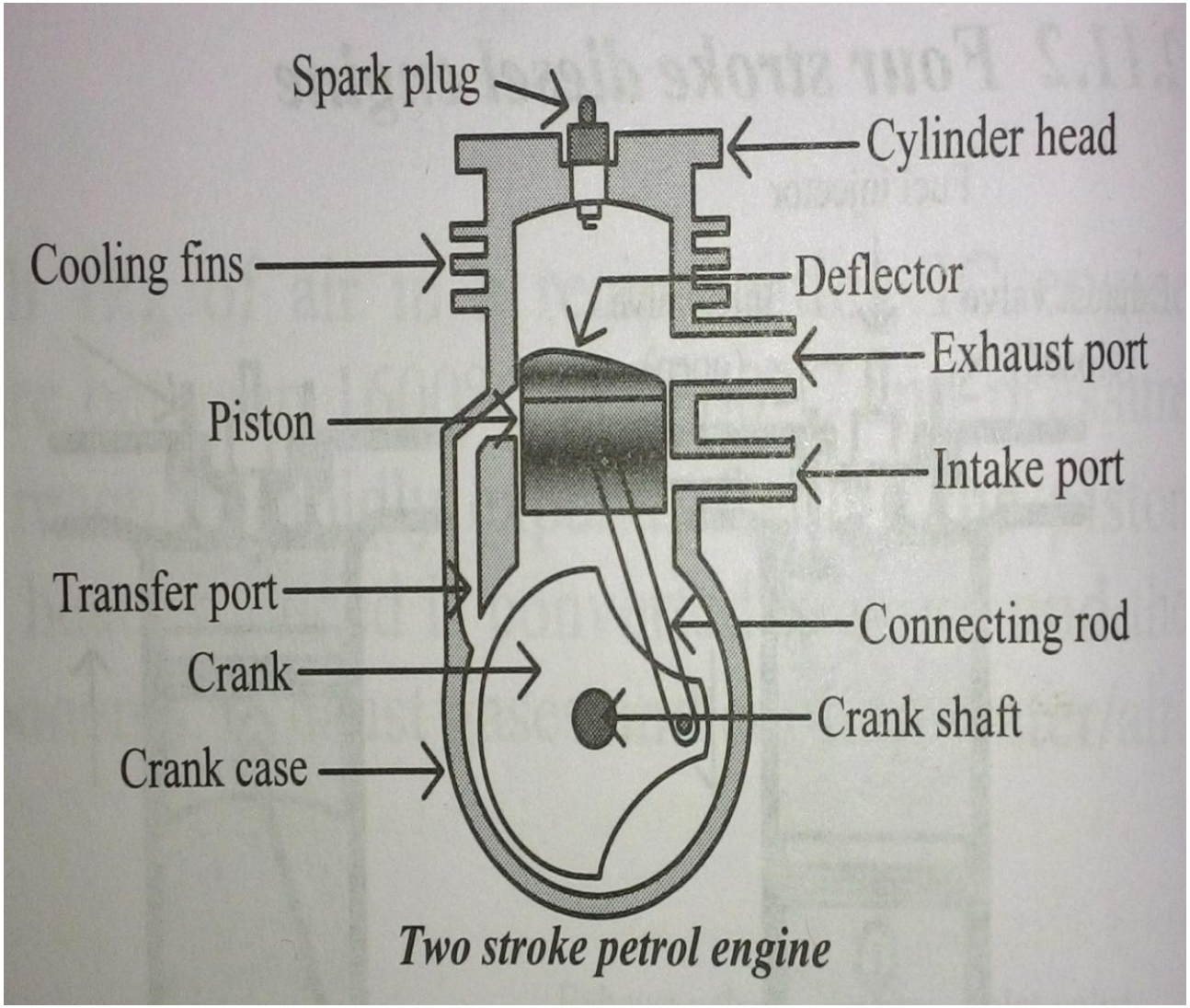
- At the end of stroke exhaust valve opens and exhaust gas flow outside through exhaust valve

Process 1-5; EXHAUST STOKE

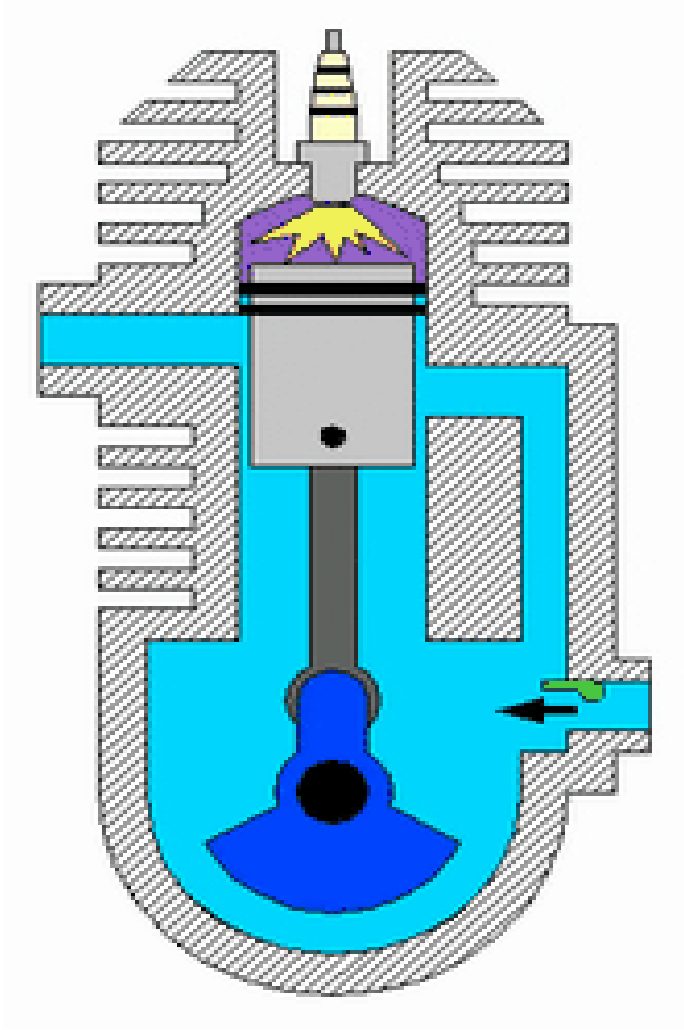
- Piston moves from BDC to TDC for the removal of the burnt gases. Inlet valve remains closed and exhaust opens. This completes the cycle and the engine is ready to suck the charge again

- **TWO STROKE PETROL ENGINE**

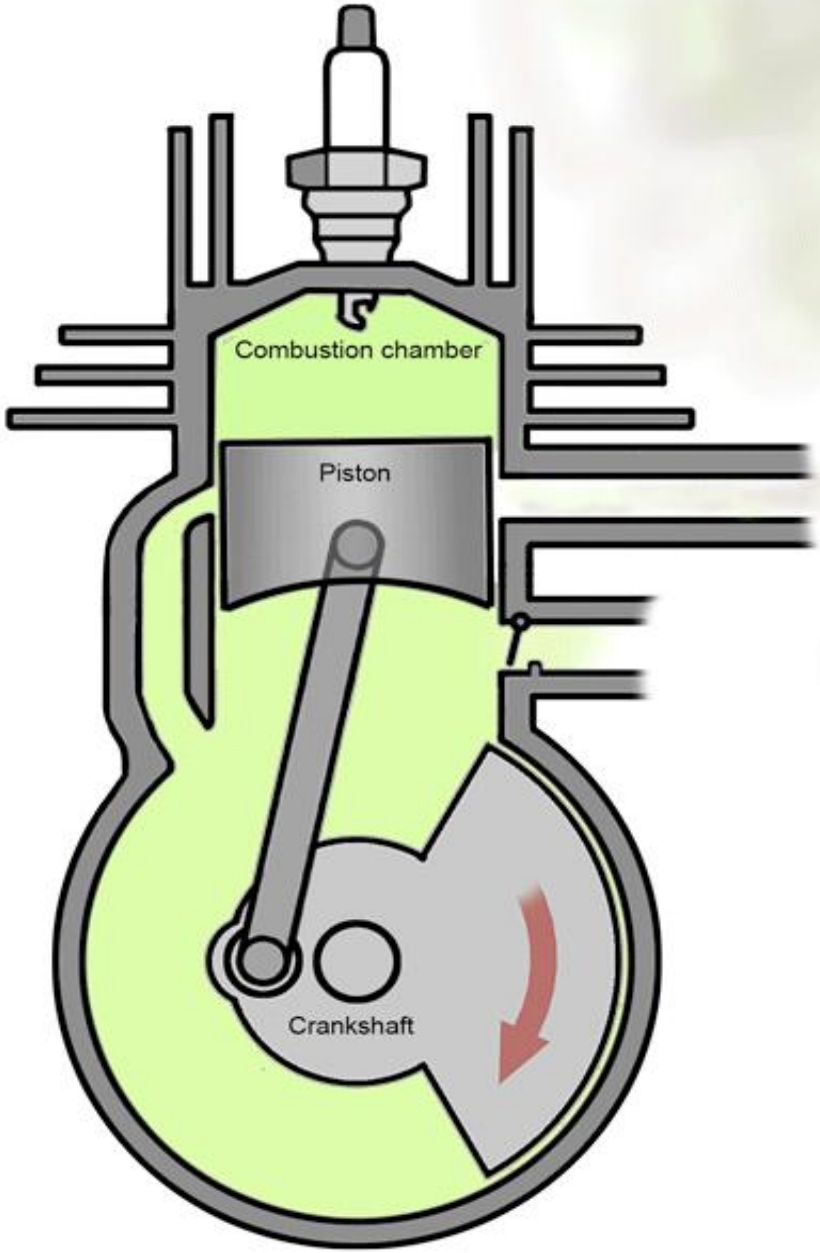


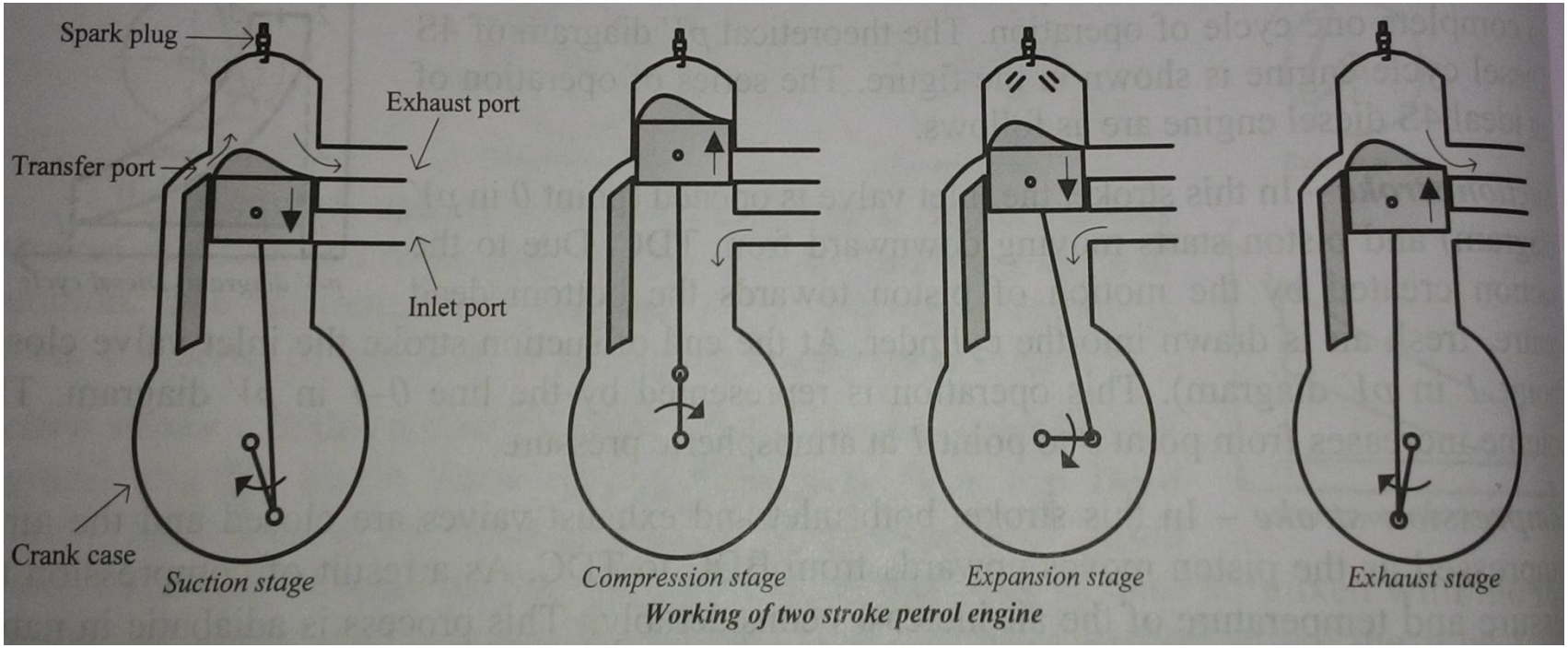


Two stroke petrol engine



- Two stroke engine requires two strokes of piston or one revolution of crank shaft to complete one cycle


Combustion chamber
Piston
Crankshaft



Working of two stroke petrol engine

WORKING PRINCIPLE

- Piston crown is used for controlling the movement of air-fuel mixture and emission

SUCTION STAGE

- Piston going toward BDC, uncovers both the transfer port and the exhaust port while the inlet port remains closed. Fresh air-fuel mixture flows into the cylinder from the crank case due to the compression of charge by the lower side of the piston. Introduction of fresh charge pushes the burned gases out of the cylinder.

COMPRESSION STAGE

- Upward movement of piston, first covers the transfer port and then the exhaust port. Air – fuel mixture is compressed due to the upward motion of piston. Also, in this stage, the inlet port opens and the fresh air –fuel mixture enters into the crank case through inlet port

EXPANSION STAGE

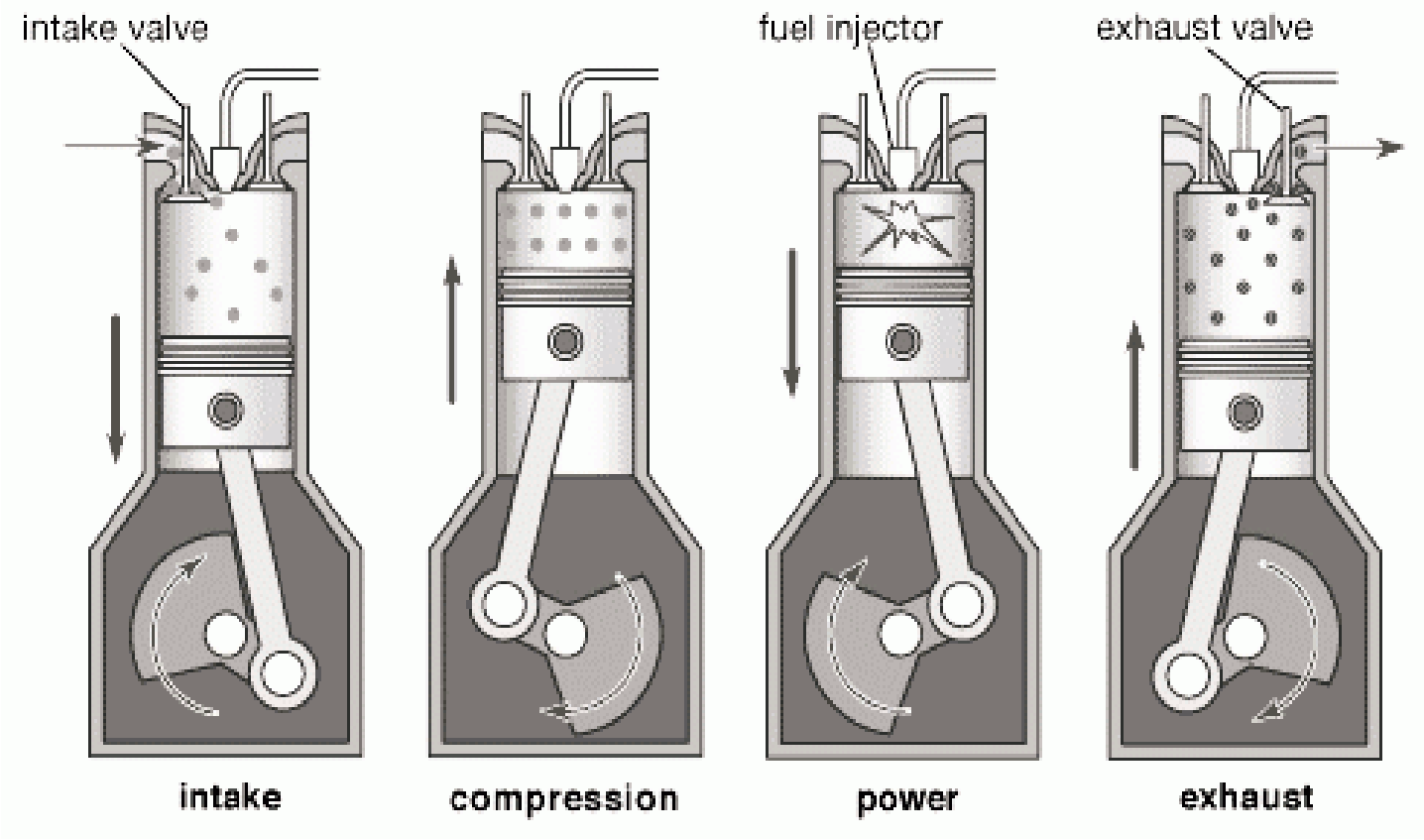
- When piston reaches TDC, the charge is ignited with the help of a spark plug. Due to combustion, piston is pushed down, piston moves from TDC to BDC

EXHAUST STAGE

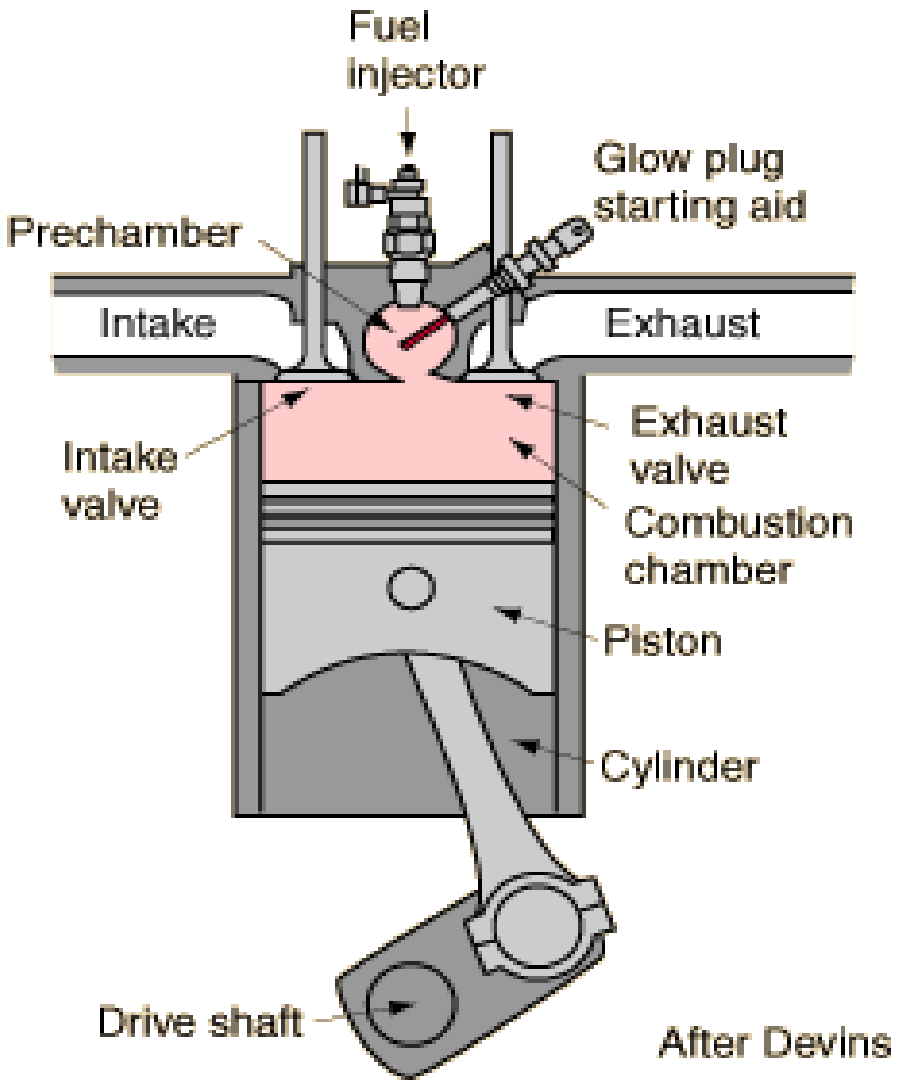
- Movement of piston toward BDC, the exhaust port is opened. The products of combustion are exhausted through the exhaust port into atmosphere. This completes the cycle and the engine is ready to suck the charge again.

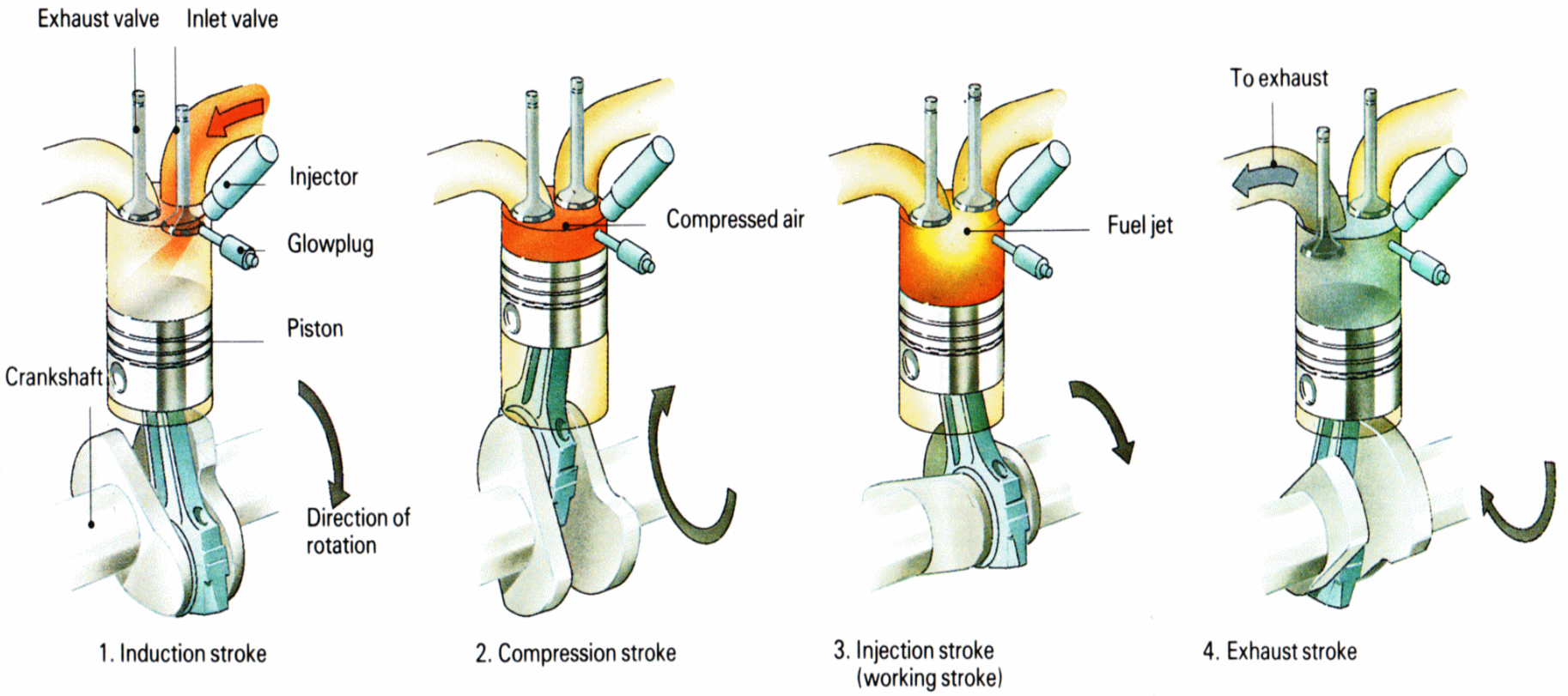
COMPRESSION IGNITION(DIESEL) ENGINE

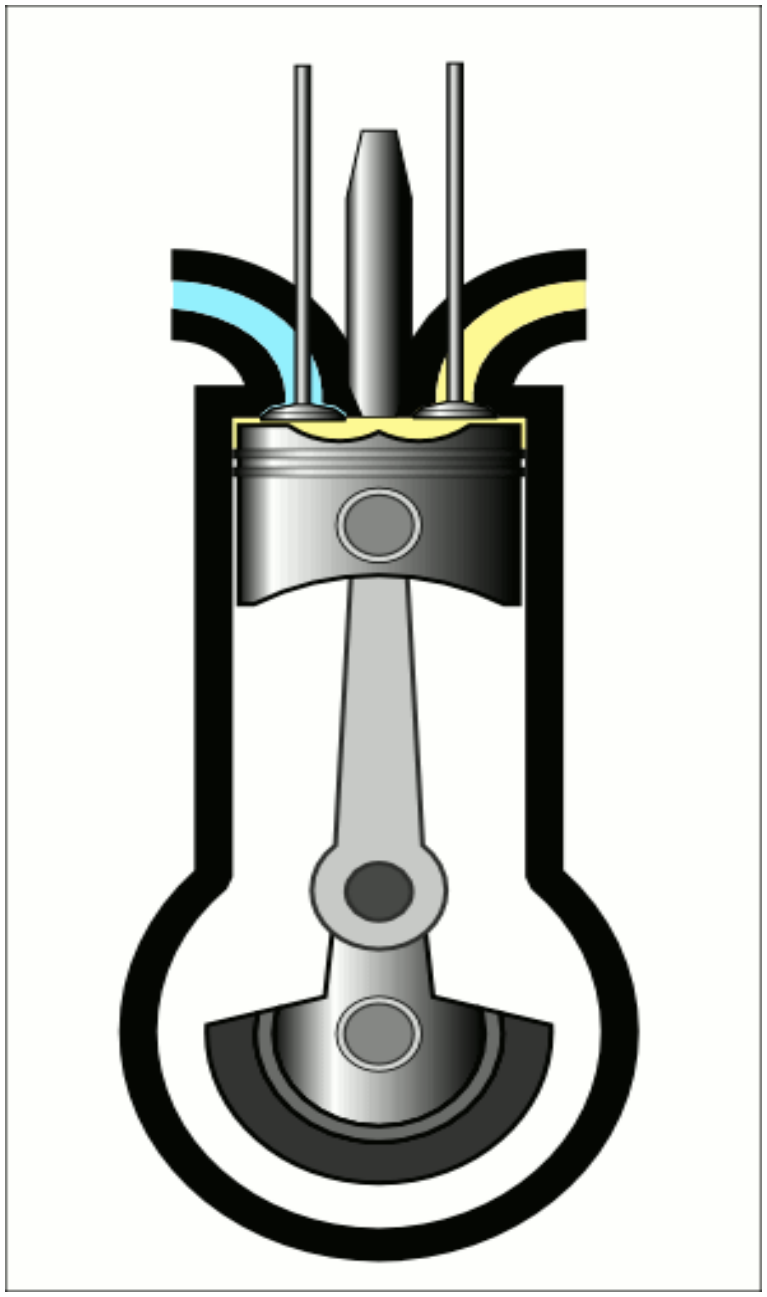
- **FOUR STROKE DIESEL ENGINE**

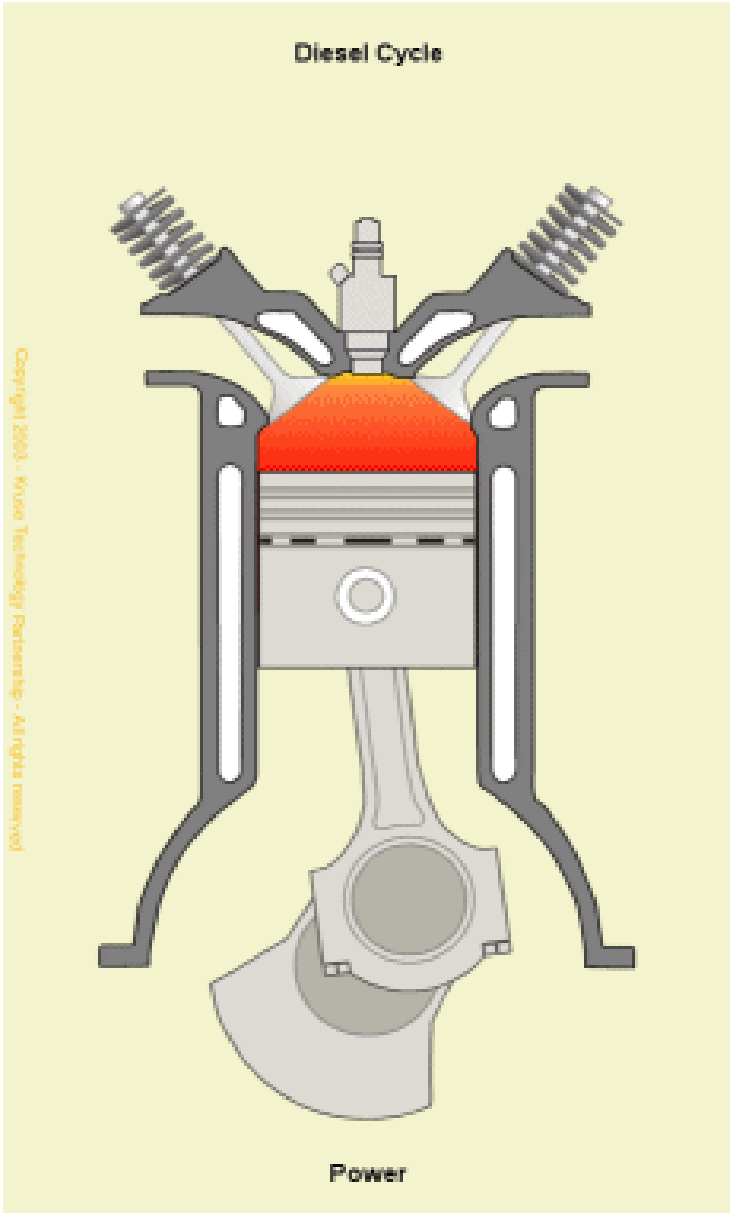


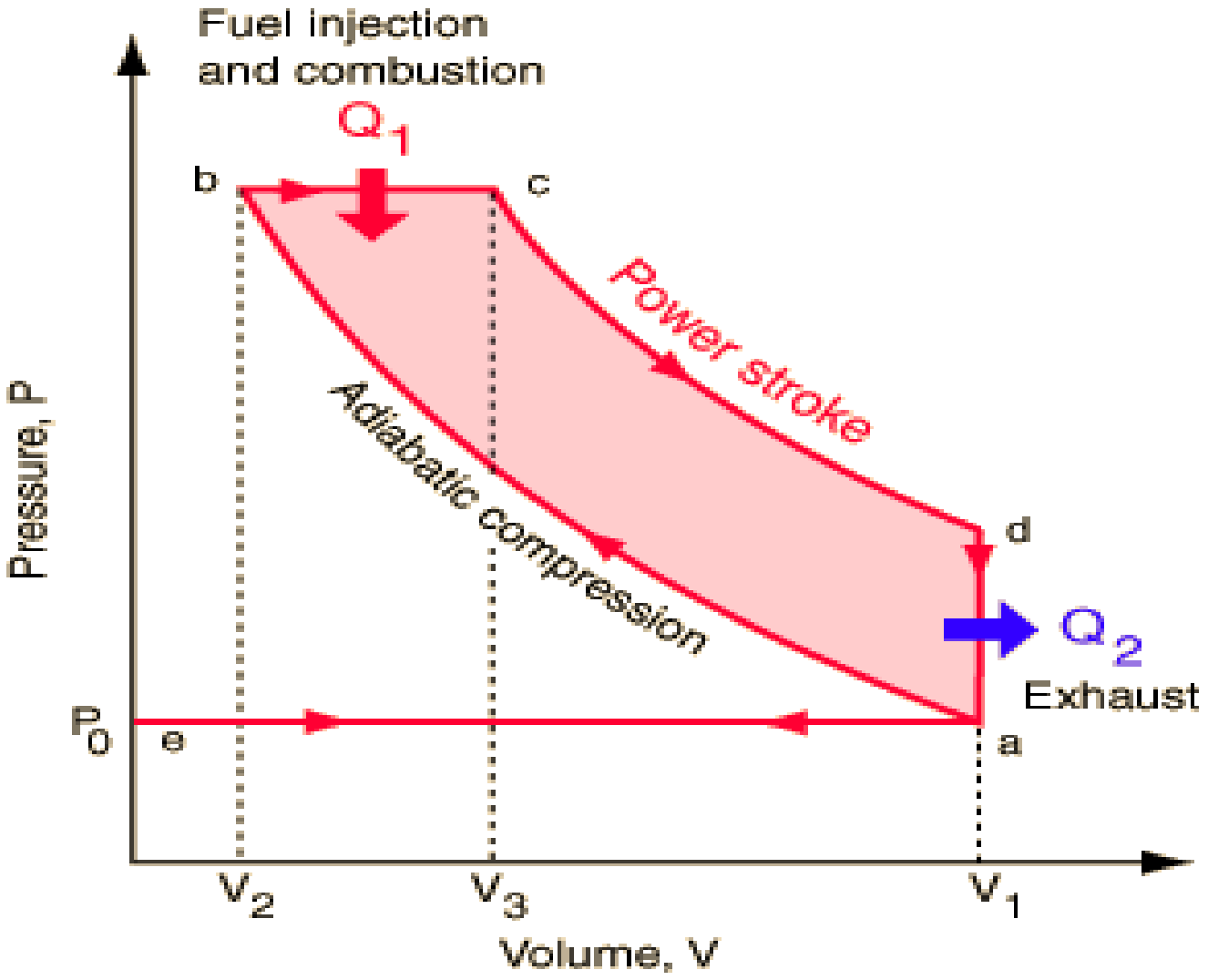
- Four stroke diesel engine requires 4 strokes of piston or 2 revolution of crank shaft to complete 1 cycle of operation




Exhaust valve
Inlet valve
Injector
Glowplug
Piston
Crankshaft
Direction of rotation
1. Induction stroke
Compressed air
2. Compression stroke
Fuel jet
3. Injection stroke (working stroke)
To exhaust
4. Exhaust stroke




Diesel Cycle
Power


Fuel injection
and combustion
Q_1
b
c
Power stroke
Adiabatic compression
d
Q_2
Exhaust
p_0
e
a
Pressure, P
V_2
V_3
V_1
Volume, V

Working Principle of Diesel Engine

Process e-a; SUCTION STROKE

- Piston moves from TDC to BDC. inlet valve opens and the Fresh -Air is drawn into the engine cylinder. Exhaust valve remains closed

Process a-b; COMPRESSION STROKE

- Piston moves from BDC to TDC and compresses the air. Both valve remains closed.

Process b-c; Fuel injection

- Just before the end of the stroke, the fuel is injected in the form of fine spray through fuel injection valve, the temperature of the compressed air is sufficiently high to ignite the fuel and combustion takes place. The injection of fuel is continued for some time and is cut off at point ‘c’. Both the valves remains closed

Process c-d; POWER STROKE

- Piston moves from TDC to BDC and thus work is done. Both valves remain closed.

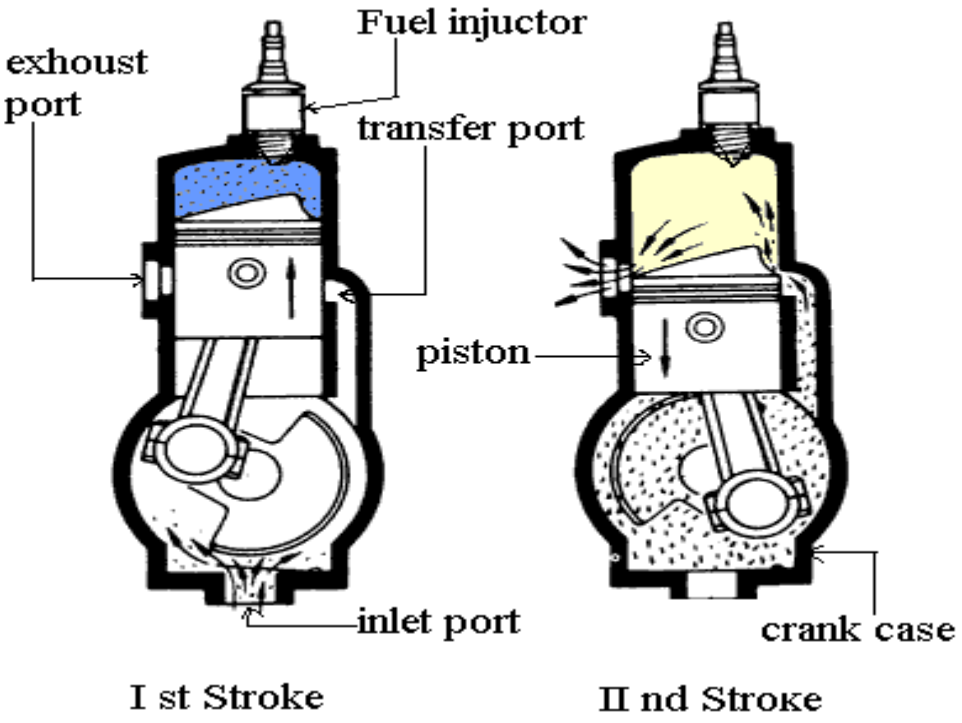
Process d-a; Constant volume hear rejection

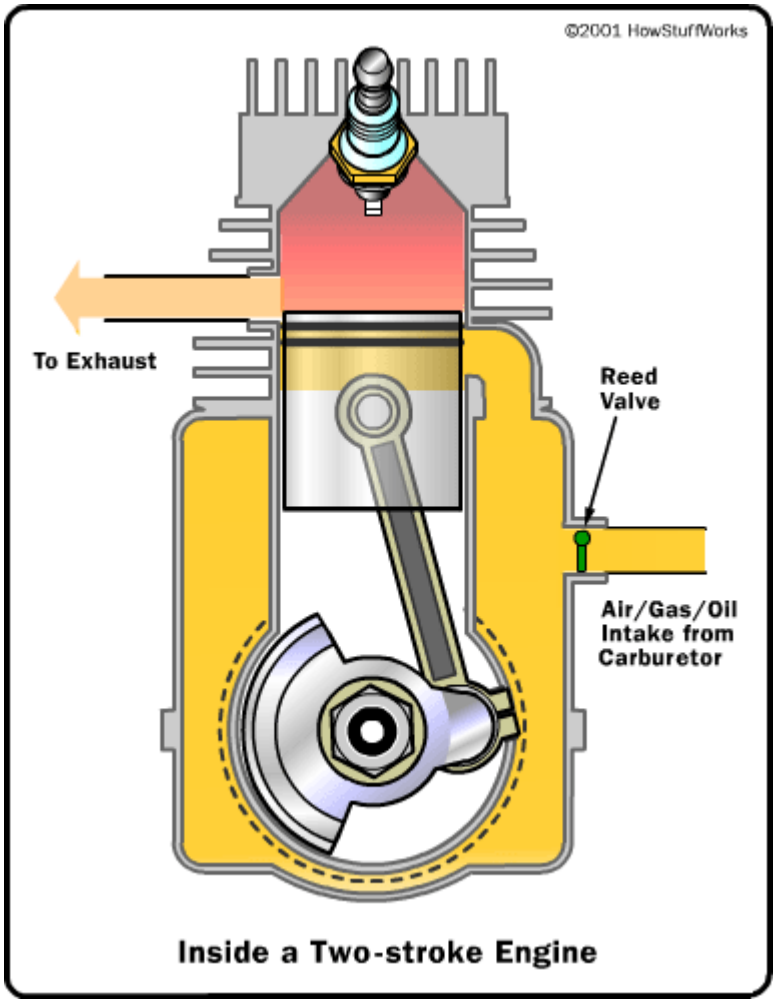
- At the end of stroke exhaust valve opens and exhaust gas flow outside through exhaust valve

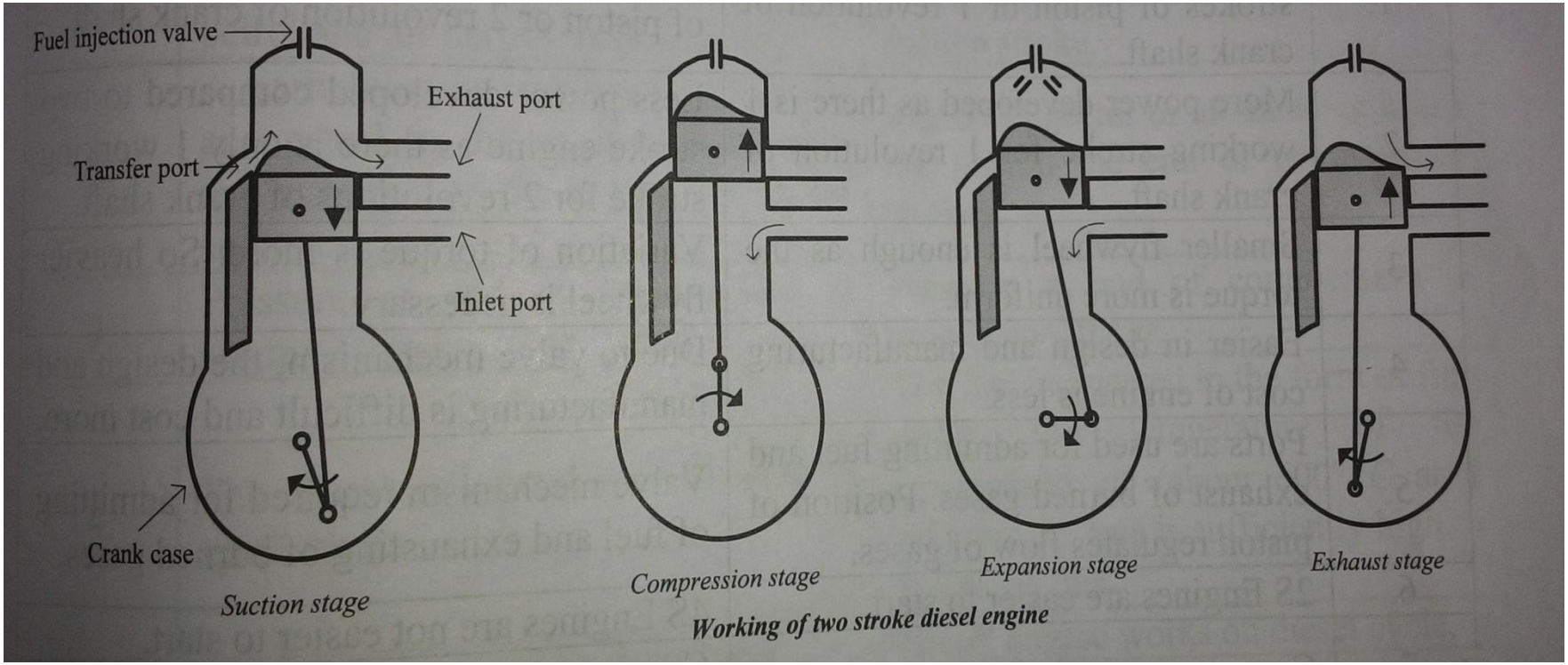
Process a-e; EXHAUST STOKE

- Piston moves from BDC to TDC for the removal of the burnt gases. Inlet valve remains closed and exhaust opens. This completes the cycle and the engine is ready to suck air again.

- **TWO STROKE DIESEL ENGINE**







Working of two stroke diesel engine

WORKING PRINCIPLE

- Piston crown is used for controlling the movement of air and emission

SUCTION STAGE

- Piston going toward BDC, uncovers both the transfer port and the exhaust port while the inlet port remains closed. Fresh air flows into the cylinder from the crank case due to the compression of air by the lower side of the piston. Introduction of fresh air pushes the burned gases out of the cylinder.

COMPRESSION STAGE

- Upward movement of piston, first covers the transfer port and then the exhaust port. Air is compressed due to the upward motion of piston. Also, in this stage, the inlet port opens and the fresh air enters into the crank case through inlet port

EXPANSION STAGE

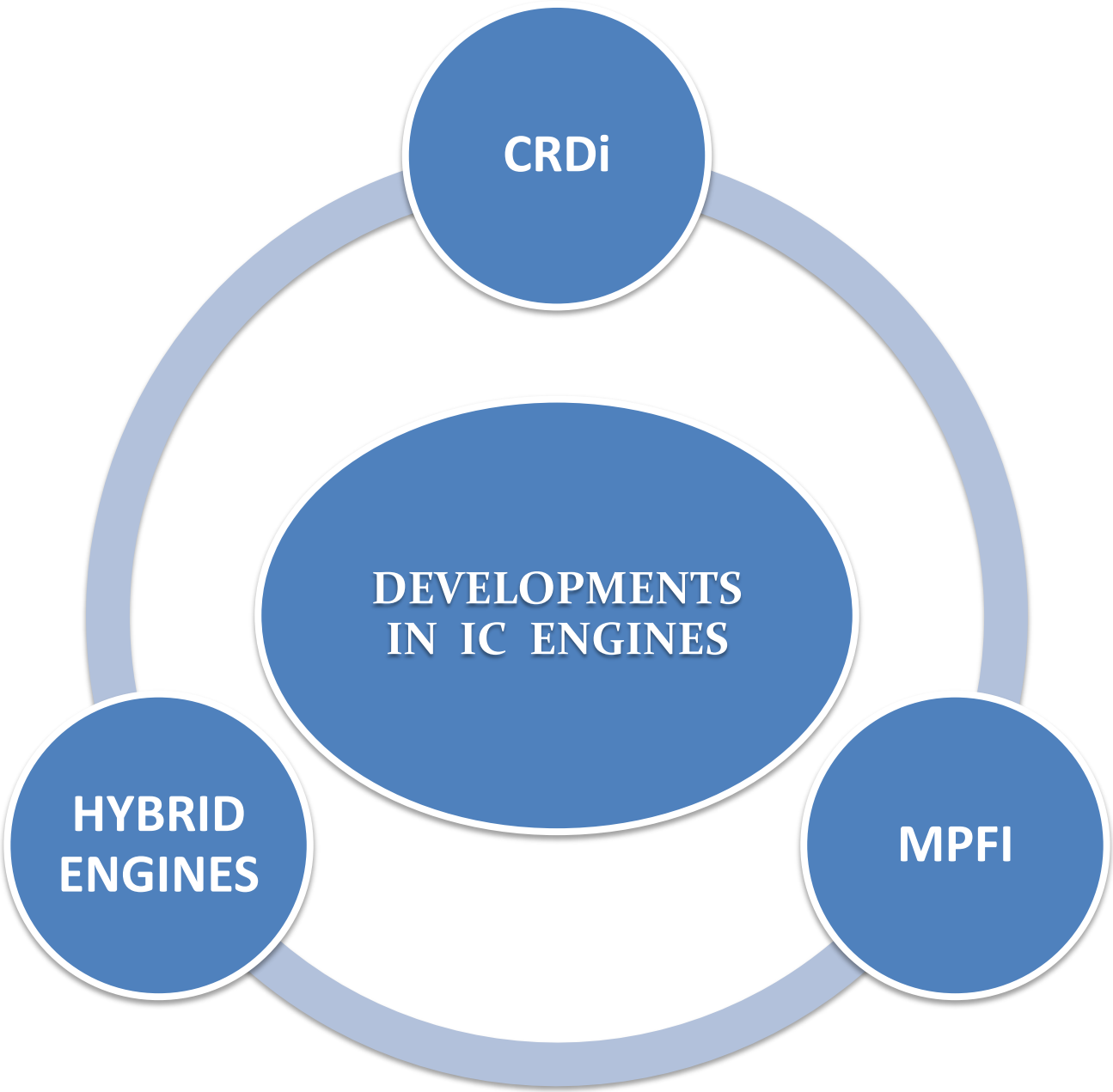
- When piston reaches TDC, the fuel is injected in the form of fine spray through fuel injection valve. The temperature of the compressed air is sufficiently high to ignite the fuel and combustion takes place. Due to combustion, piston is pushed down, piston moves from TDC to BDC

EXHAUST STAGE

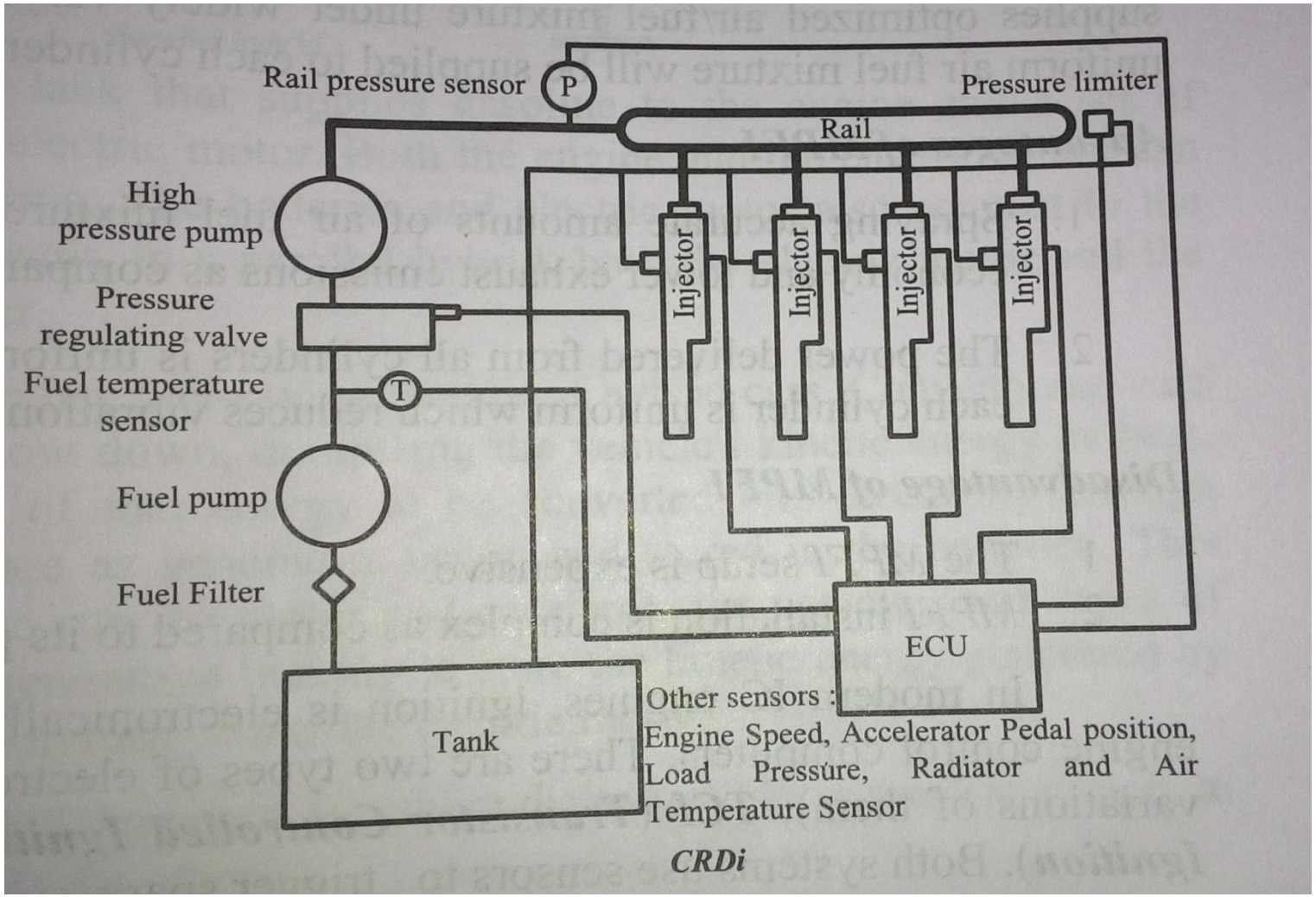
- Movement of piston toward BDC, the exhaust port is opened. The products of combustion are exhausted through the exhaust port into atmosphere. This completes the cycle and the engine is ready to suck the fresh air again.

TWO STROKE ENGINE	FOUR STROKE ENGINE
Cycle completed in 2 strokes or 1 revolution of crankshaft	Cycle completed in 4 strokes or 2 revolution of crankshaft
More power developed	Less power developed
Smaller flywheel	Heavier flywheel
Easier design	Complicated design
Ports are used	Valves are used
Easier to start	Not easier to start
Compression ratio is lower	Higher compression ratio
Less thermal efficiency	Higher thermal efficiency
Operating temperature is more	Less operating temperature
Less weight	Heavier engine
More noisy engine	Less noisy

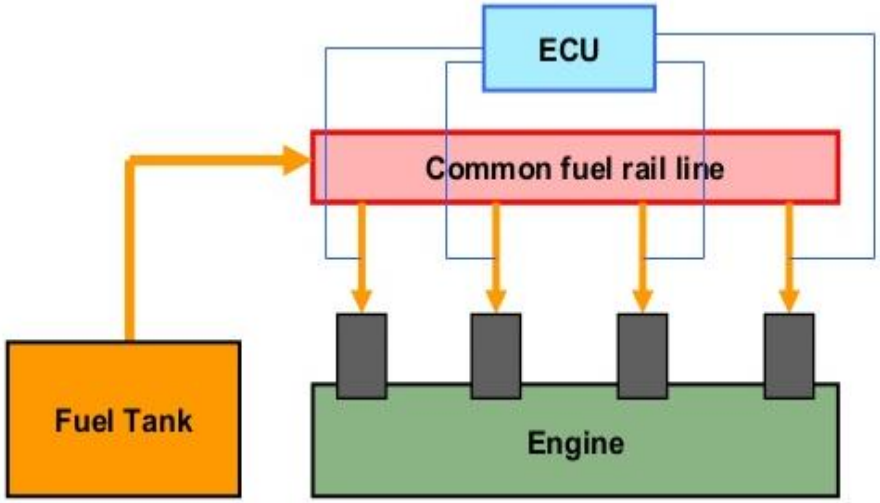
PETROL ENGINE	DIESEL ENGINE
Petrol air mixture flows through the inlet valve	Air flows through the inlet valve
Carburetor is used	Fuel injector is used
Maximum pressure 10 bar	Maximum pressure 35-40 bar
Spark plug is used	No spark plug
Otto cycle	Diesel cycle
Compression ratio 6 to 10	Compression ratio 15 to 25
Easier to start	Not easier to start
Less vibration	Vibration is more
Less weight	Heavier engine
High speed engines	Low speed engines
Maintenance cost is less	Maintenance cost is more

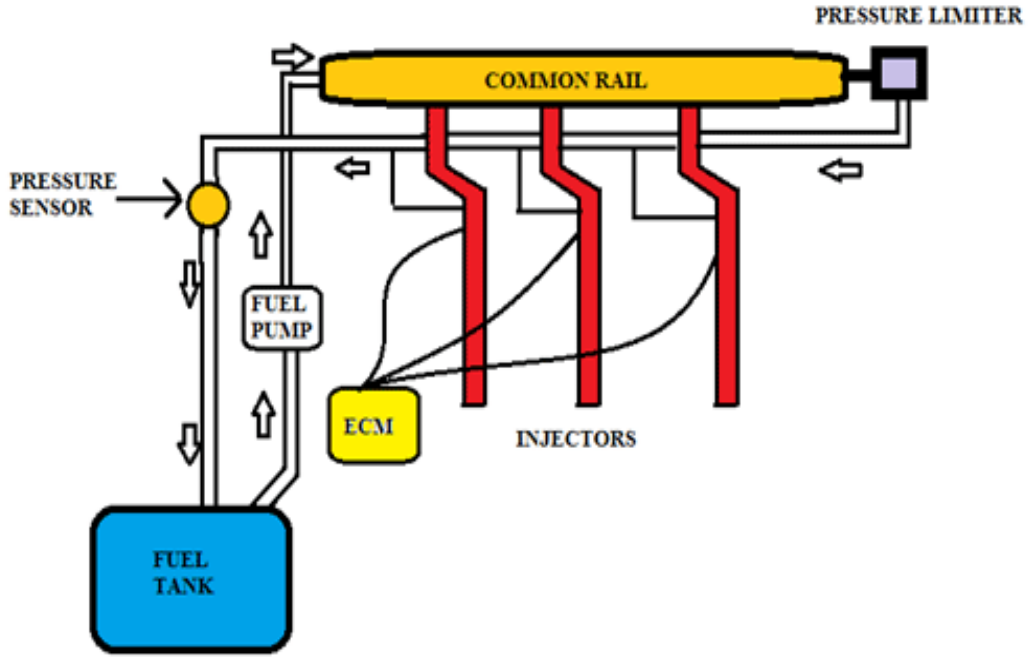

CRDi
DEVELOPMENTS IN IC ENGINES
HYBRID ENGINES
MPFI

COMMON RAIL DIRECT INJECTION(CRDi)



CRDi


ECU
Common fuel rail line
Fuel Tank
Engine


PRESSURE LIMITER
COMMON RAIL
PRESSURE SENSOR
FUEL PUMP
ECM
INJECTORS
FUEL TANK

- Common rail distributes the fuel to the computer controlled injectors at a constant pressure of up to 1600 bar
- Electronic control unit(ECU) receives signals from various sensors and uses those signals to operate injection
- Common rail engines maintain a constant pressure regardless of the injection sequence
- More accurately measured and timed fuel spray in the combustion chamber significantly reduces unburned fuel and increases the fuel efficiency

Elements of CRDi

- Low pressure circuit: comprises of fuel tank, fuel pump and fuel filter. Responsible for transporting the fuel to the high pressure circuit
- High pressure circuit: comprises of high pressure pump with pressure control valve, common rail with rail pressure sensor and injectors.

- ECU and Sensors: ECU receives and evaluates the signal from the sensors, viz., speed sensor, air temperature sensor, air mass meter and rail pressure sensor.
- ECU calculates injected fuel quantity, start of injection, duration of injection and control the correct functioning of the injection system as a whole

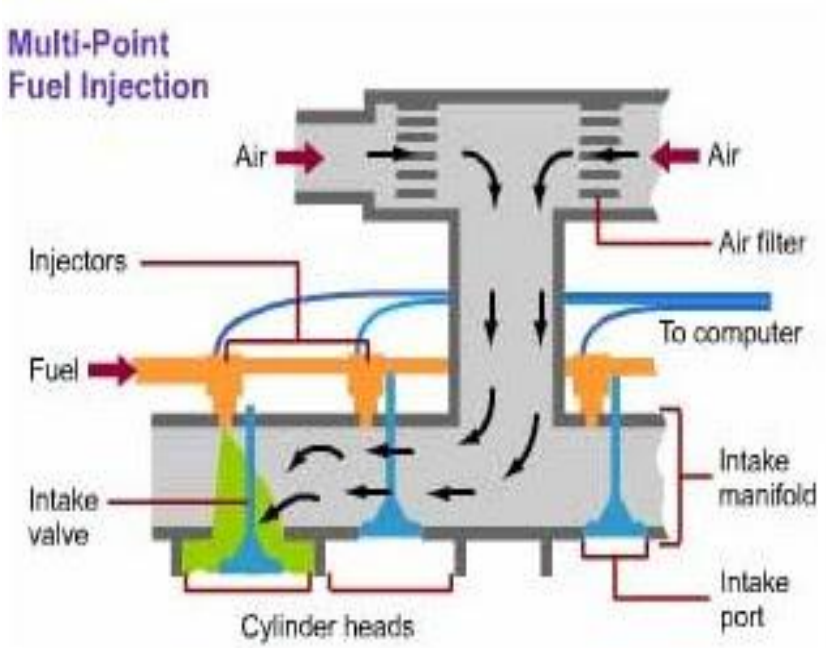
Advantages

- Deliver 25% more power and torque
- Lower level of noise and vibration
- Higher mileage
- Lower emission and improved performance

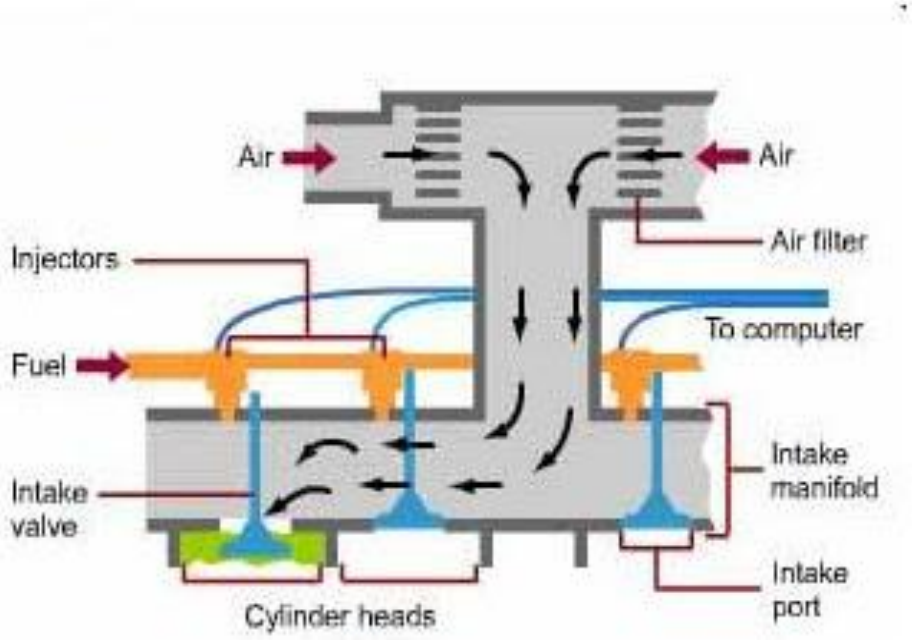
Disadvantages

- Costly spare parts
- More maintenance

MULTI POINT FUEL INJECTION(MPFI)



1



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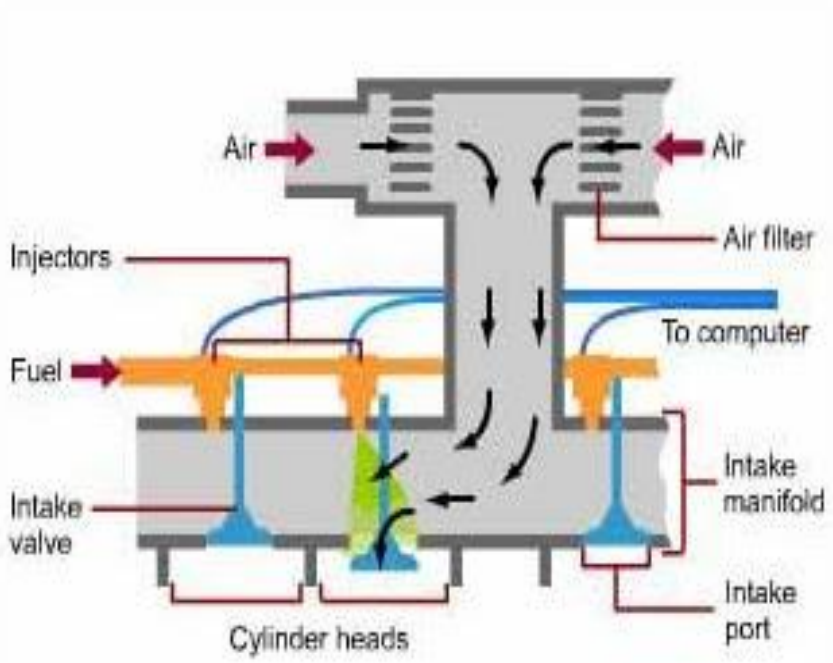
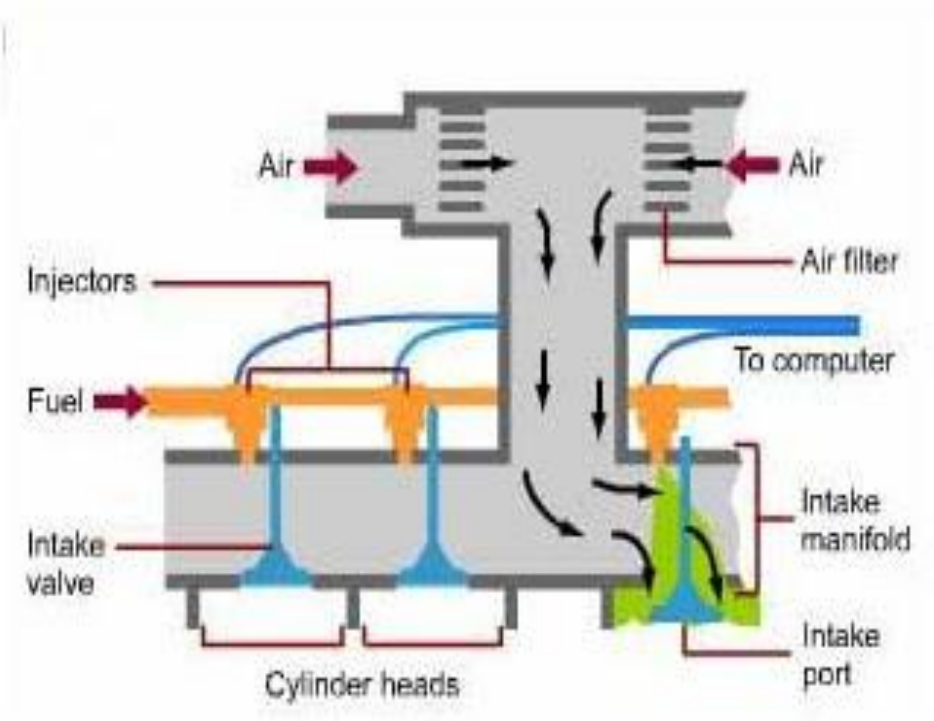
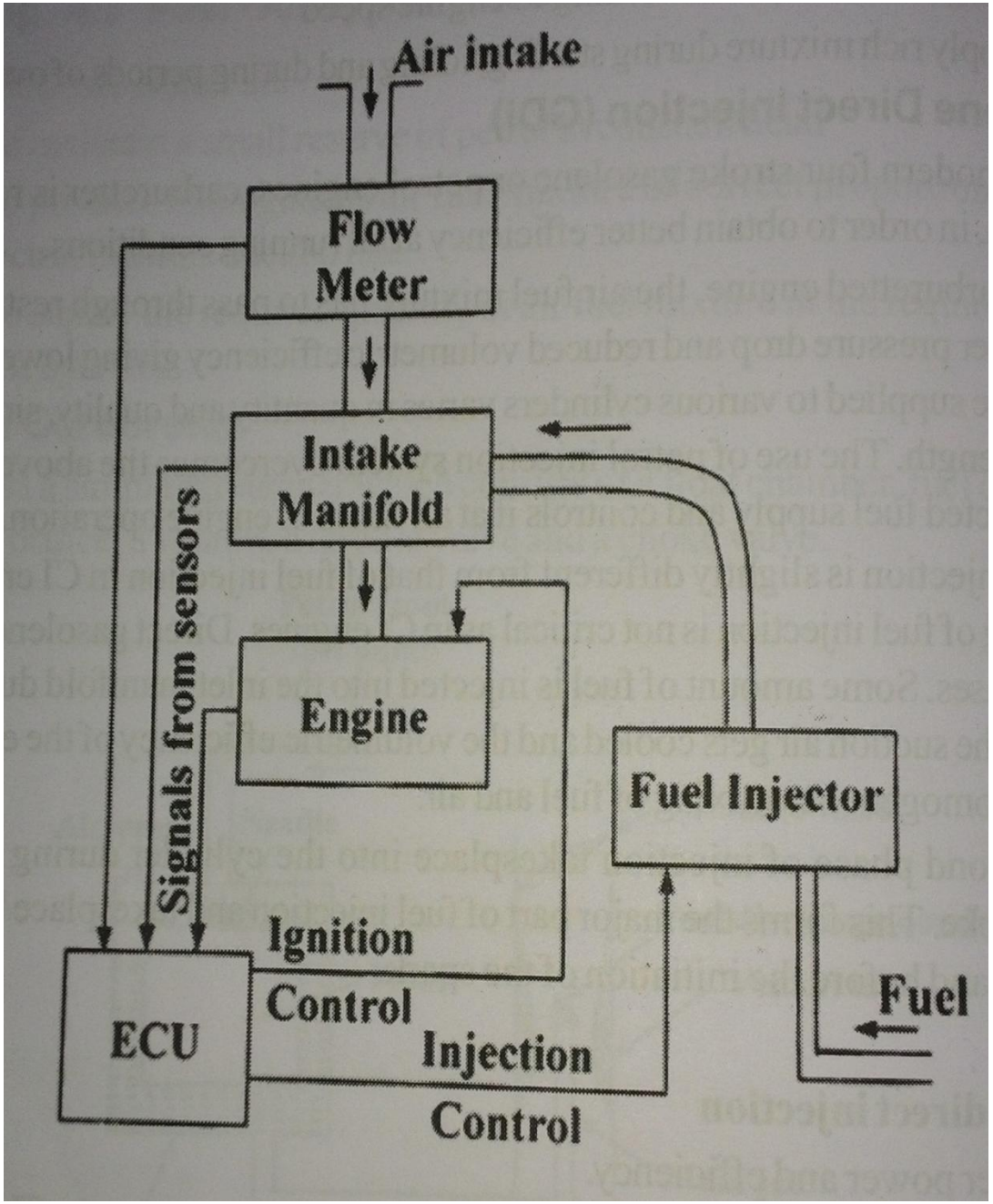
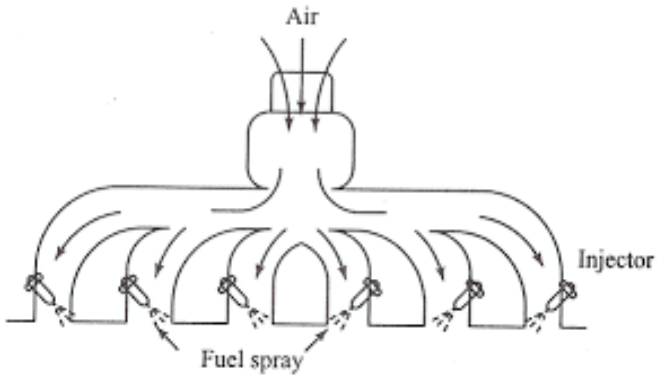

Air
Air
Air filter
Injectors
To computer
Fuel
Intake manifold
Intake valve
Intake port
Cylinder heads

3

4


Air
Air
Air filter
Injectors
To computer
Fuel
Intake manifold
Intake valve
Intake port
Cylinder heads


Air intake
Flow Meter
Intake Manifold
Engine
Signals from sensors
Fuel Injector
Ignition
Control
ECU
Injection
Control
Fuel


Air
Injector
Fuel spray

- MPFI is used in SI engines
- MPFI system injects fuel just upstream of each cylinder's intake valve, based on commands from ECU.
- In MPFI system, each cylinder has one injector placed on the side of the intake manifold near the intake valve to supply fuel in the cylinders
- Uniform air-fuel mixture will be supplied to each cylinder

Advantages

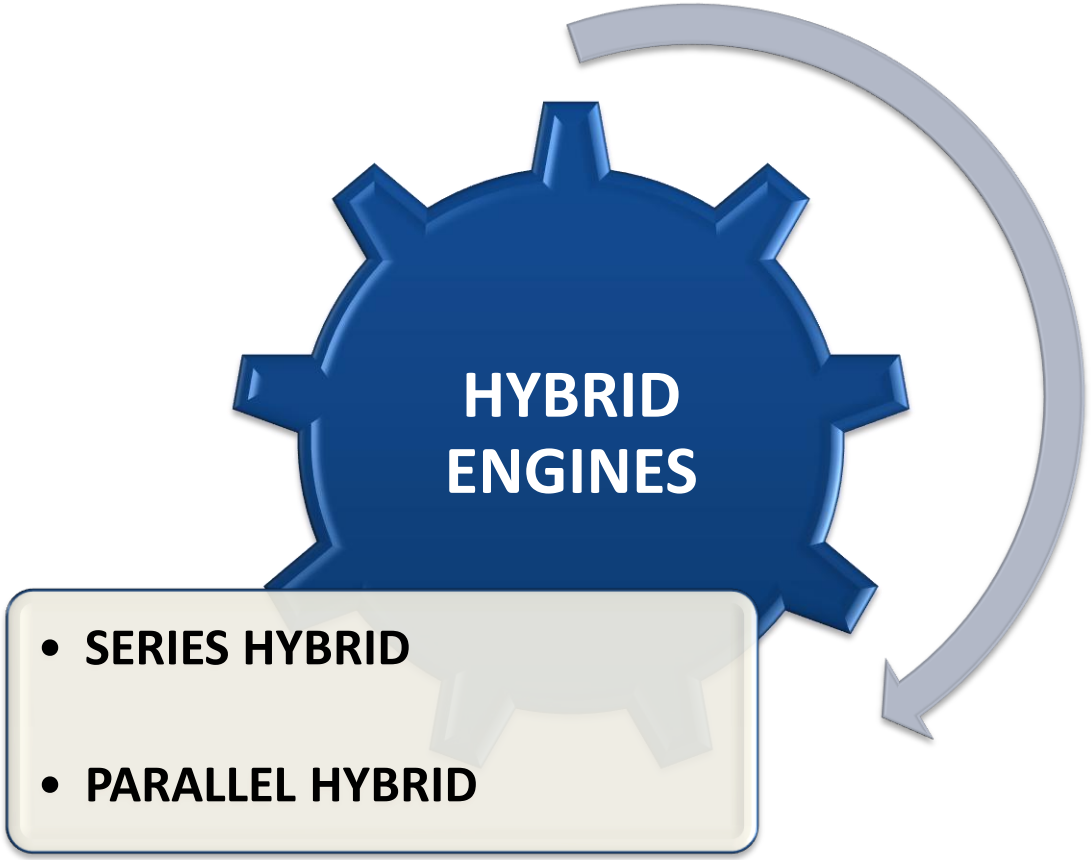
- Better fuel economy and lower emissions
- Better performance and less vibrations

Disadvantages

- Expensive setup
- System is complex


HYBRID
SYNERGY
DRIVE


HYBRID

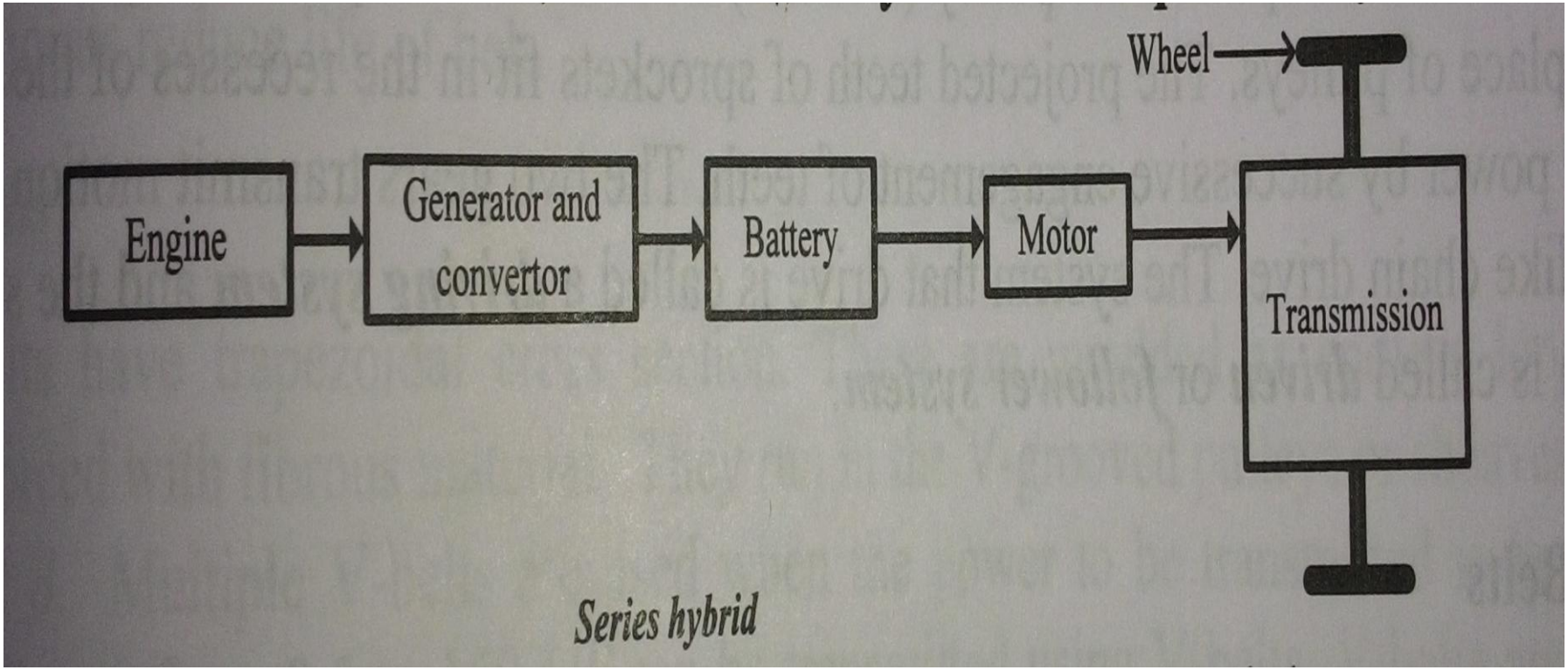

HYBRID ENGINES
• SERIES HYBRID
• PARALLEL HYBRID

HYBRID ENGINES

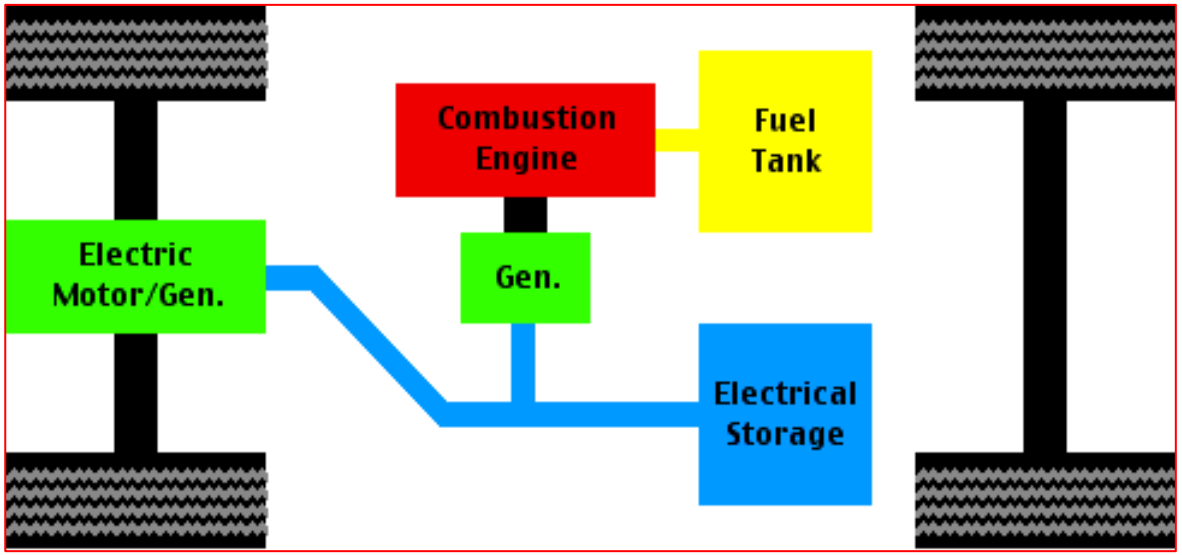
- A hybrid vehicle is a vehicle that uses two or more distinct power sources to move the vehicle.eg. A conventional internal combustion engine and also a high voltage electric motor.

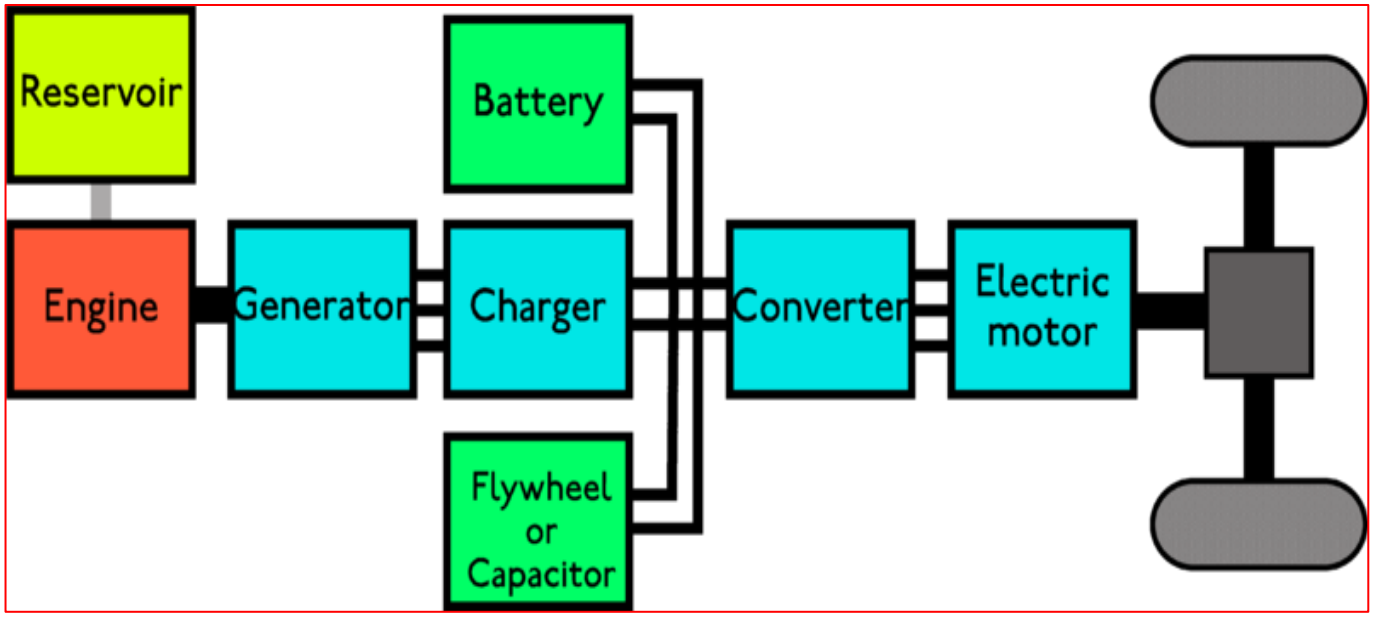
- Concept of hybrid drive combines the best aspects of IC engines and Electric drives

SERIES HYBRID



Series hybrid


Combustion Engine
Fuel Tank
Electric Motor/Gen.
Gen.
Electrical Storage


Reservoir
Battery
Engine
Generator
Charger
Converter
Electric motor
Flywheel or Capacitor

- The petrol(gasoline) engine turns a generator, and the generator can either charge the batteries or power an electric motor that drives the transmission.

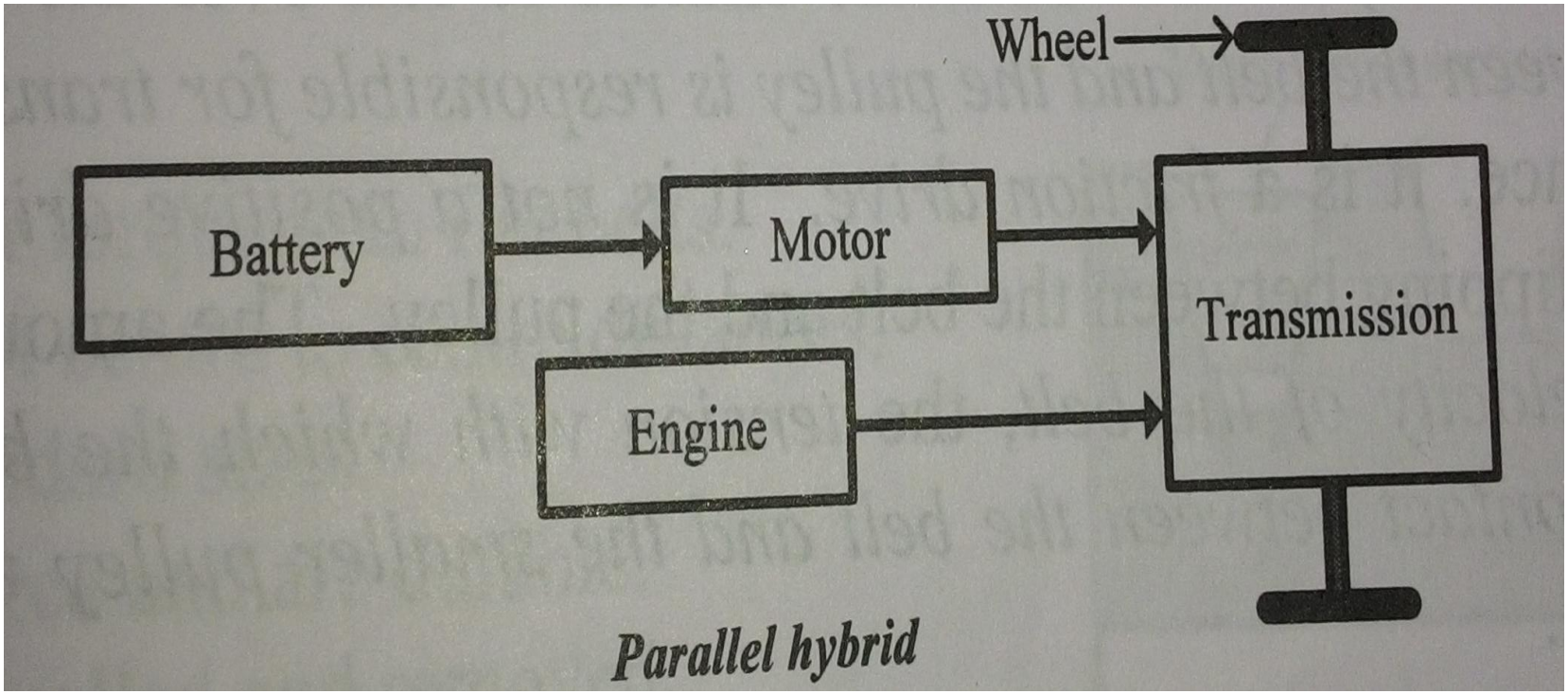
Engine mode operation

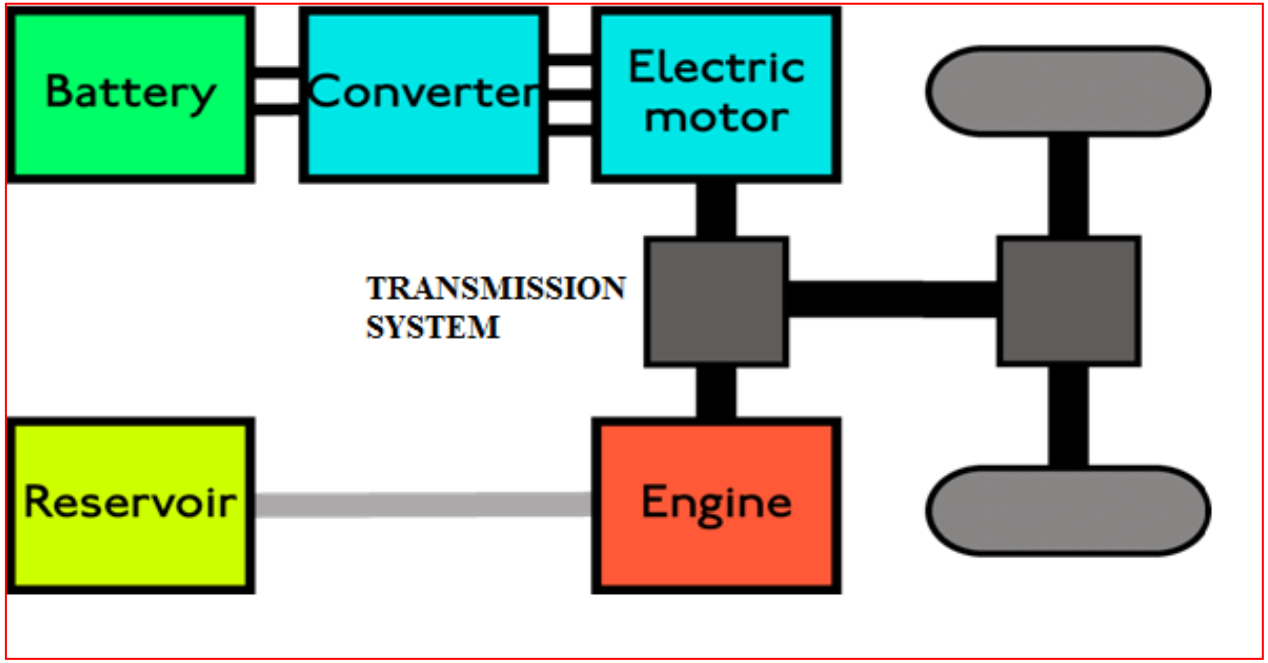
- Engine operates a generator, that operates a motor, which in turn drive the wheels

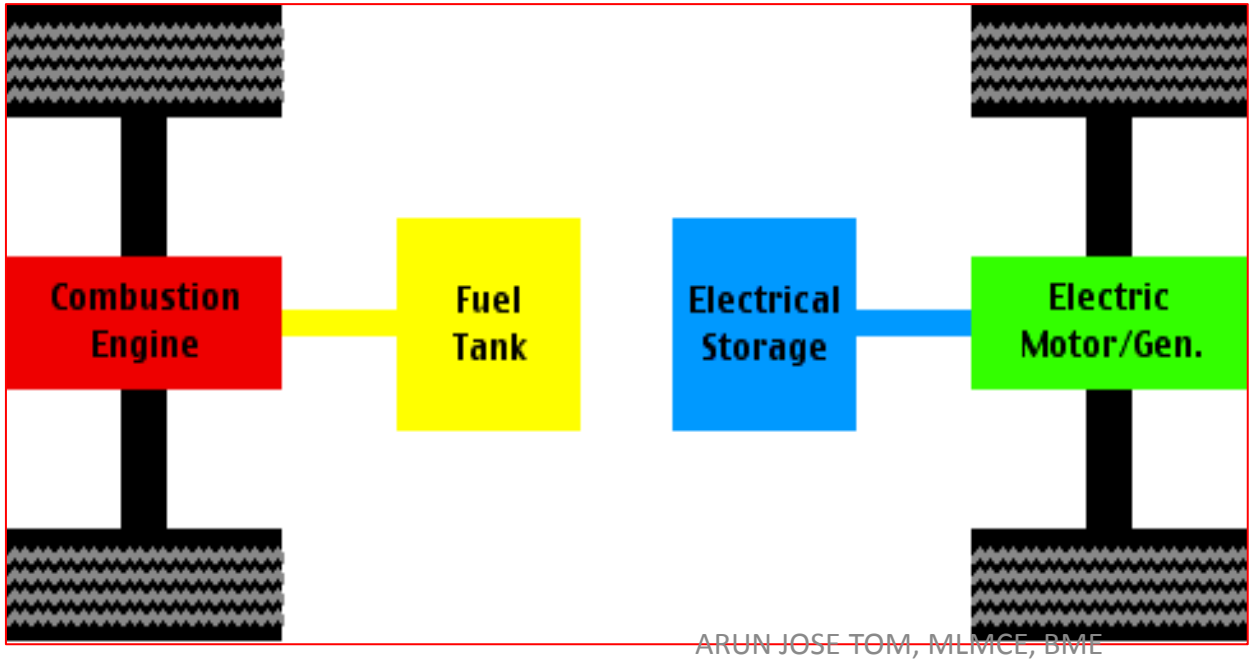
Battery mode operation

- Battery directly drives the motor which in turn drive the wheels

PARALLEL HYBRID




Battery
Converter
Electric motor
TRANSMISSION SYSTEM
Reservoir
Engine

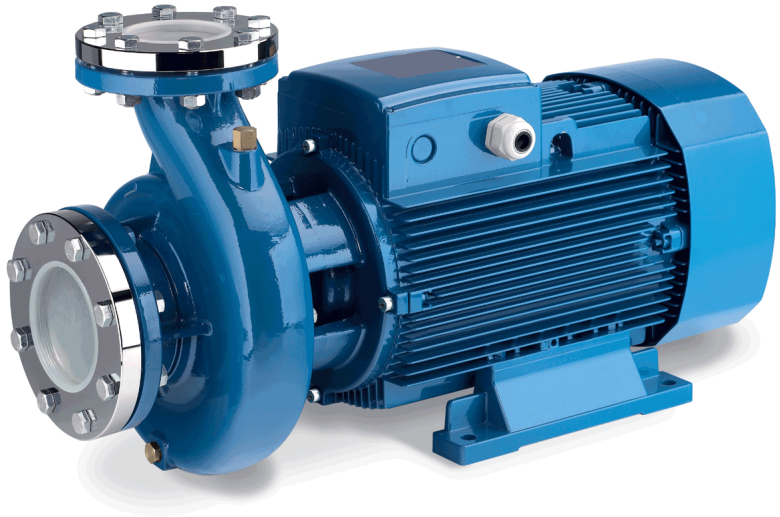

Combustion Engine
Fuel Tank
Electrical Storage
Electric Motor/Gen.

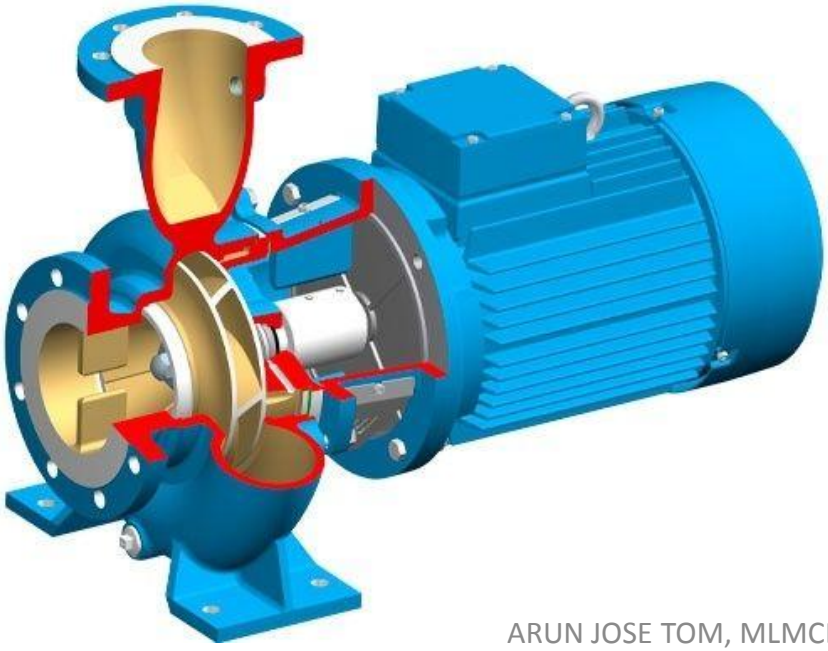
- Fuel tank supplies gasoline to the engine and a set of batteries that supplies power to the electric motor.

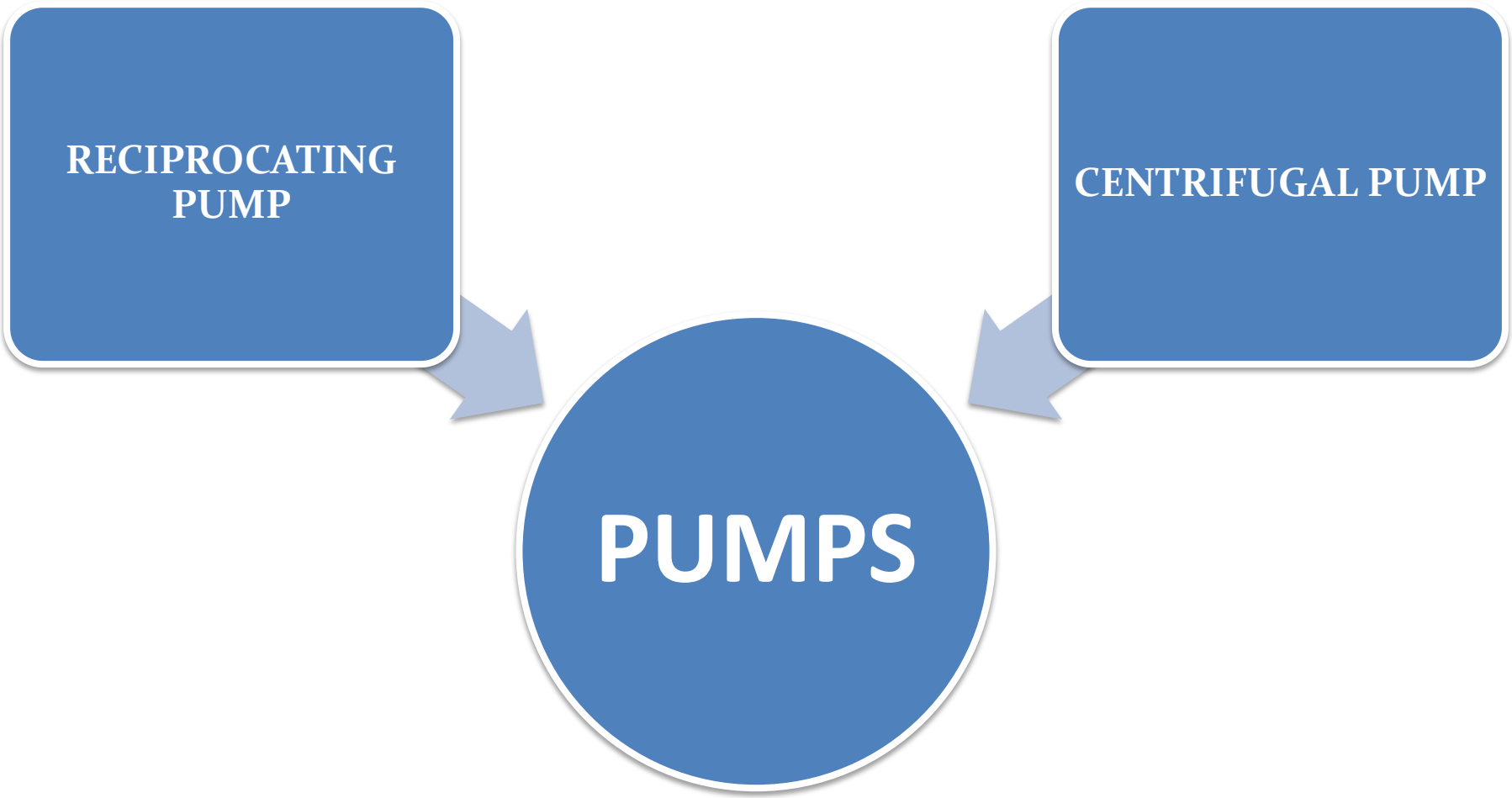
- Depending on requirement, **Engine alone** or **Motor alone** or **Engine and Motor** together can drive the wheels

- This system permits the engine to recharge the battery while powering the vehicle

PUMPS



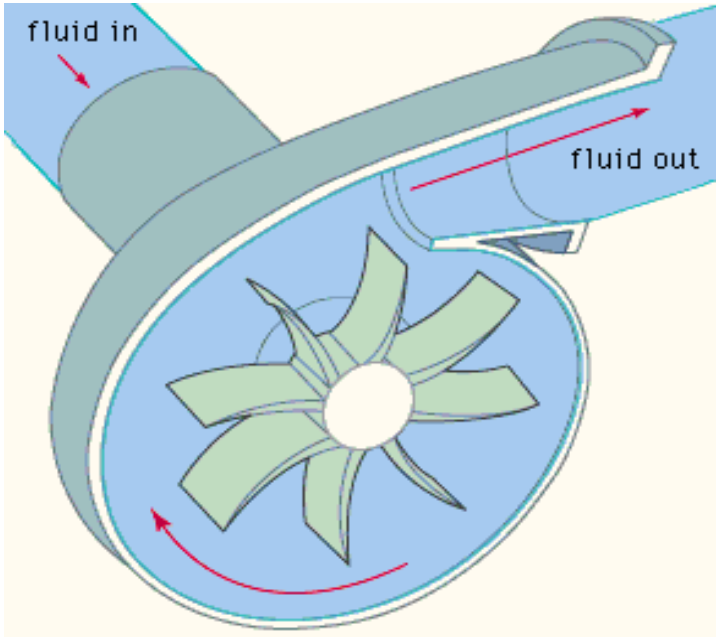


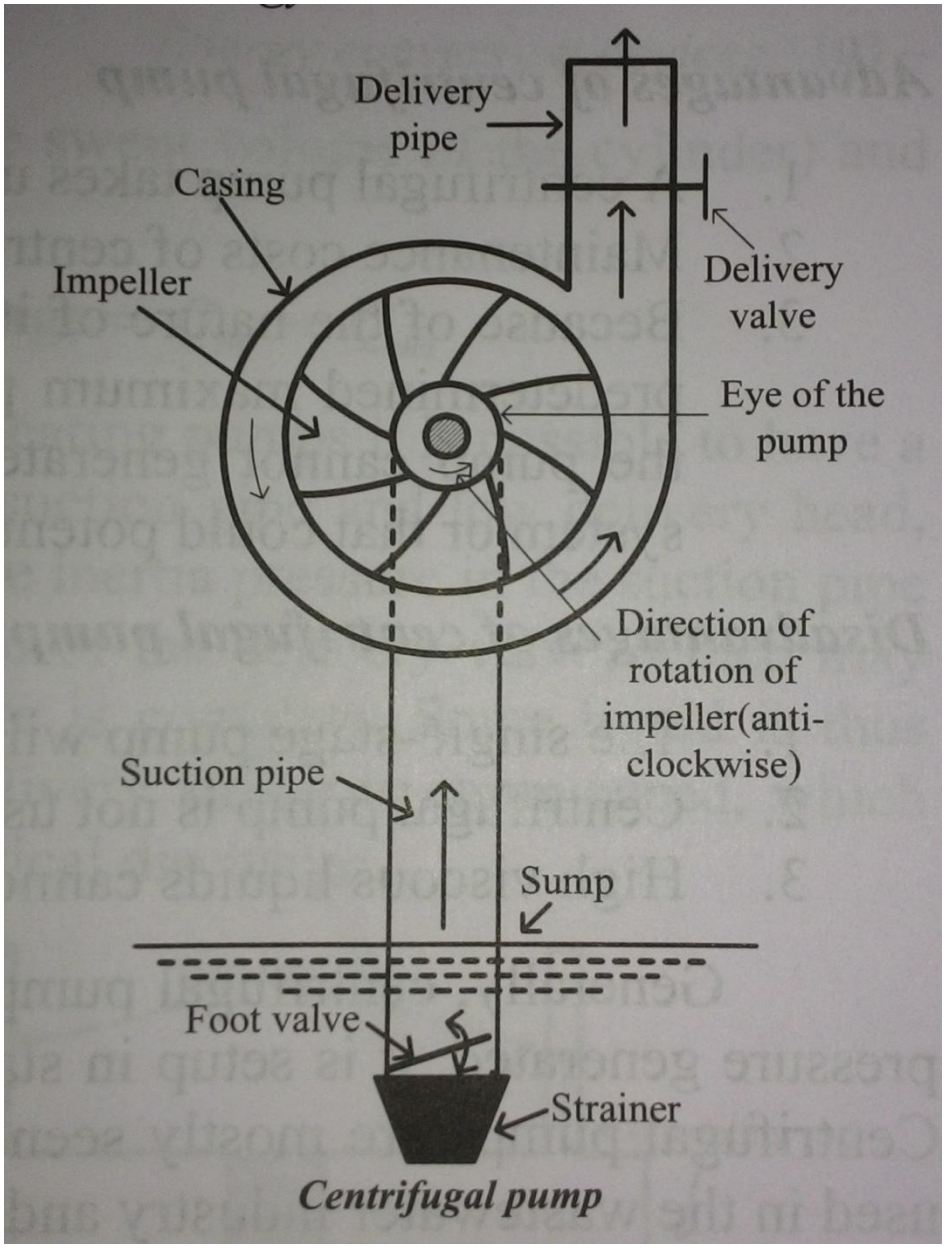

RECIPROCATING PUMP
CENTRIFUGAL PUMP
PUMPS

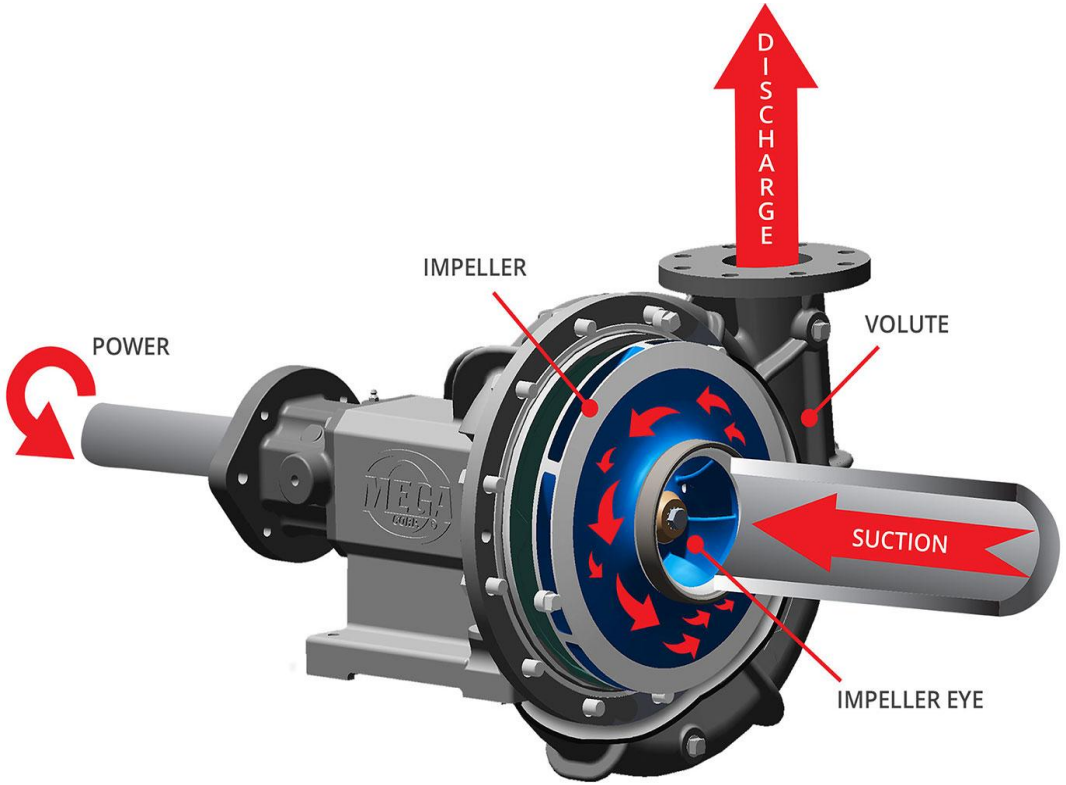
- Pumps are hydraulic machines which convert the mechanical energy into hydraulic energy

- Pump is generally used for raising liquid from low level to high level

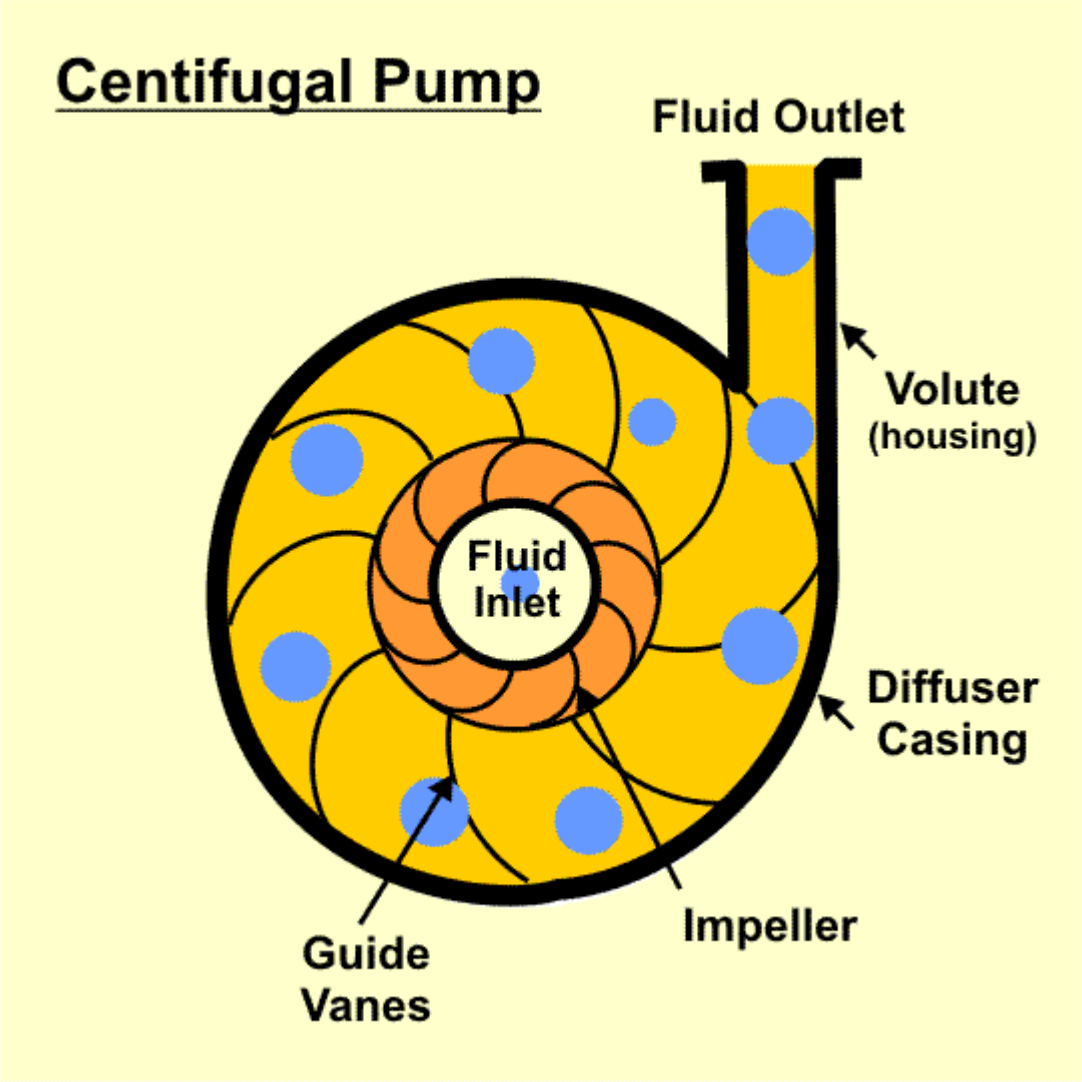
CENTRIFUGAL PUMP

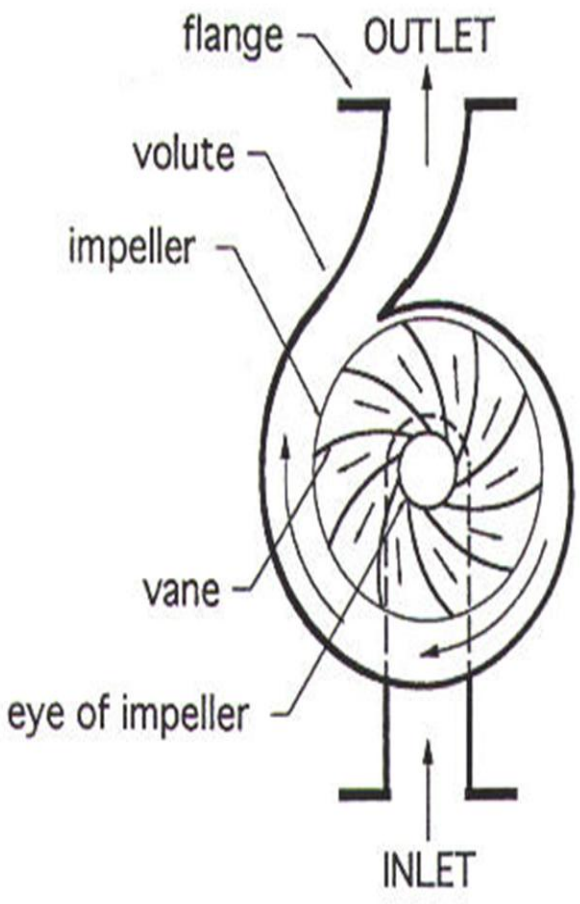


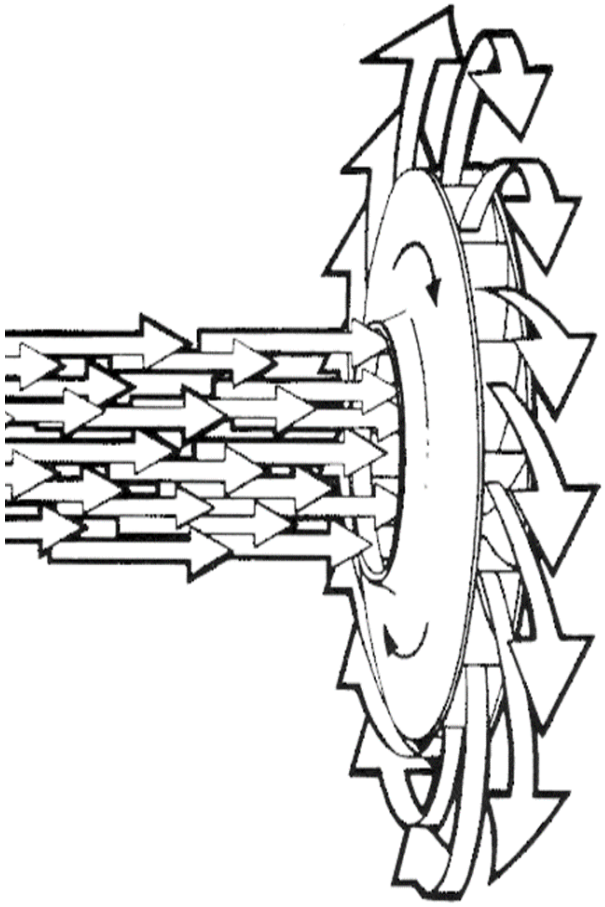


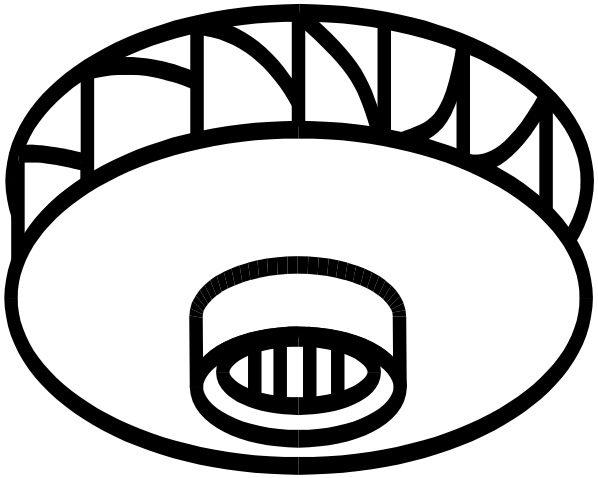


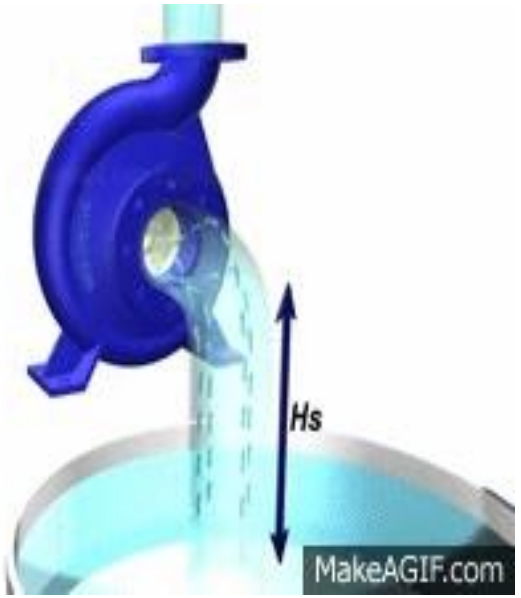
- A centrifugal pump is a rotodynamic pump that uses a rotating impeller to create flow by the addition of energy to a fluid

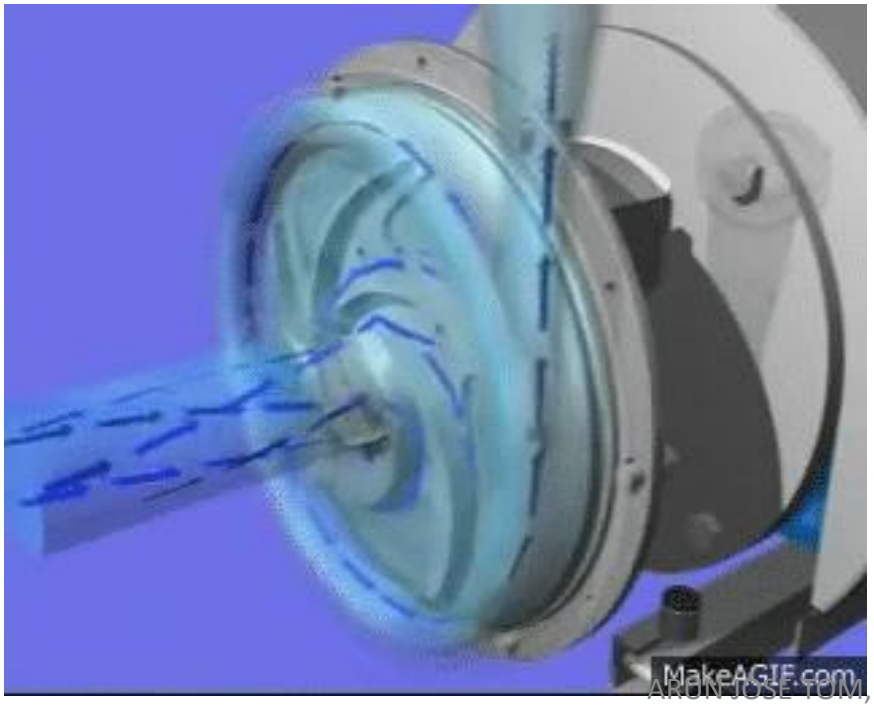

Centifugal Pump
Fluid Outlet
Volute
(housing)
Fluid
Inlet
Diffuser
Casing
Impeller
Guide
Vanes


flange
OUTLET
volute
impeller
vane
eye of impeller
INLET






Hs
MakeAGIF.com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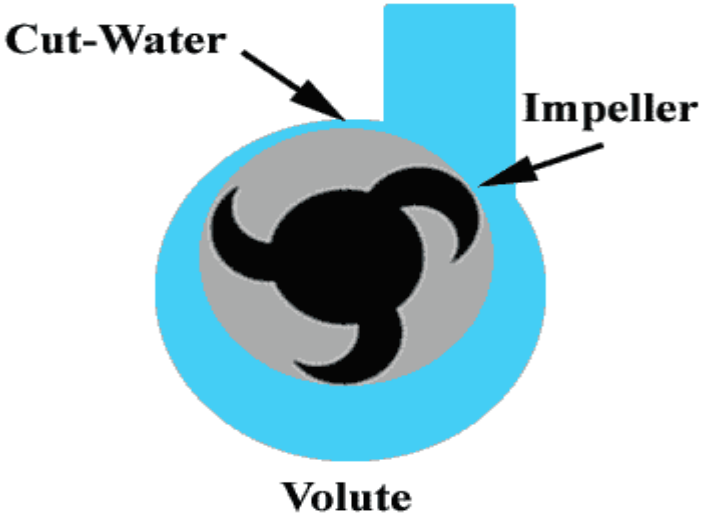
TYPES OF IMPELLER

ENCLOSED IMPELLER

SEMI-OPEN IMPELLER

OPEN IMPELLER



PUMP CASING

Parts of a centrifugal pump

1)Impeller: Rotating solid disc with curved blades. Impeller is mounted on a shaft connected to the shaft of an electric motor. As the impeller rotates, fluid is drawn into the impeller inlet(eye of pump) is accelerated as it is forced radially outwards

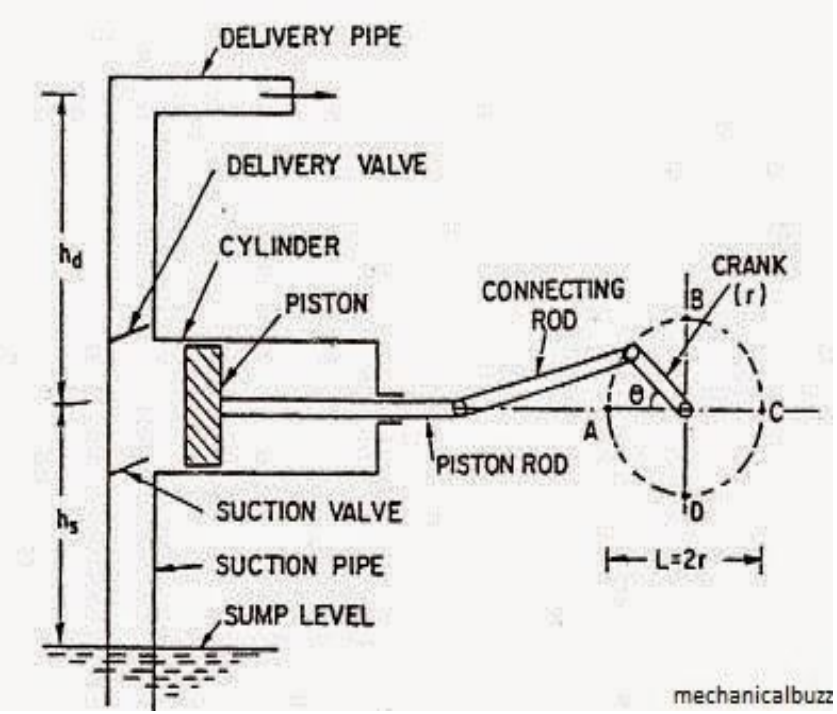
2)Casing: Air tight passage around the impeller

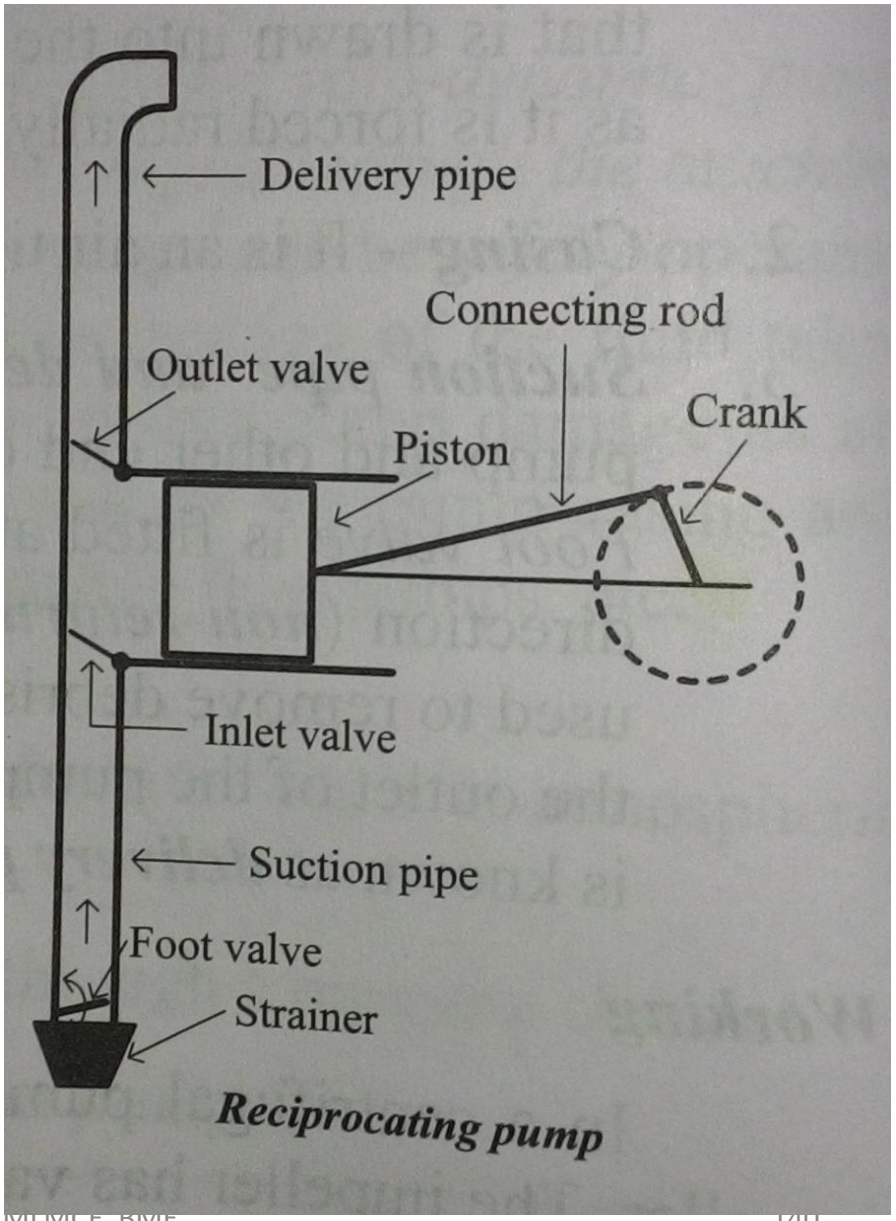
3)Suction pipe and delivery pipe: Pipe whose one end is connected to the inlet of pump and other end dipped in a sump is known as suction pipe. Pipe whose one end is connected to the out let of the pump and the other end delivers the working fluid at a required height is known as delivery pipe.

Working

- Working fluid enters the pump at the centre of a rotating impeller.
- Impeller impart centrifugal force on the liquid entrapped in the impeller and throws the liquid towards the outer periphery of the impeller
- Outward movement of liquid in the impeller creates a partial vacuum near the eye of the impeller. Consequently, liquid from the sump is sucked in towards the impeller eye and enters through the inlet tip of impeller vanes. Thus, there is a continuous flow of liquid from the sump to the casing
- The liquid leaving the impeller vanes is at a higher pressure and velocity
- The velocity head is converted to pressure head in the casing

RECIPROCATING PUMP





- Reciprocating pump is a positive displacement pump. It creates the lift and pressure by displacing the liquid using a moving mechanical element called plunger(piston) inside a cylinder

Main parts of a reciprocating pump

1)Cylinder with valves at inlet and delivery: Suction and delivery pipes with suction valve and delivery valve are connected to the cylinder. The suction and delivery valves are one-way valves or non-return valves, which allow the water to flow in one direction only

2)Plunger or piston: Piston reciprocates in the closely fitted cylinder

3)Connecting rod and crank mechanism: Crank and connecting rod mechanism is operated by a power source

4)Suction and delivery pipe with one way valve: One end of suction pipe remains dip in the liquid and other end attached to the inlet of the cylinder. One end of delivery pipe attached with delivery part and other end at discharge point

Working

- Working similar to that of reciprocating engines
- Piston moves creates a vacuum inside the cylinder and atmospheric pressure forces the liquid up through the suction pipe into the cylinder. Delivery valve will be closed during this stroke.
- During the return stroke, the pressure developed in the fluid opens the delivery valve, closes the inlet valve and pushes the fluid through the delivery valve.
- This pump is suitable for high heads and low discharge

Thank you