Energy

Energy is the quantitative property that must be **transferred to an object in order to perform work on, or to heat, the object. Energ**y is a conserved quantity; the law of conservation of energy states that energy can be converted in form, but not created or destroyed. The SI unit of energy is the joule, which is the energy transferred to an object by the work of moving it a distance of 1 metre against a force of 1 newton.

Common forms of energy include the **kinetic energy of a moving object**, the potential energy stored by an object's position in **a force field (gravitational**, electric or magnetic), the elastic **energy stored by stretching solid objects**, the chemical energy **released when a fuel burns**, the radiant energy carried by light, and the thermal energy due to an object's temperature. Living organisms require energy to stay alive, such as the energy humans get from food. Human civilization requires energy to function, which it gets from energy resources such as fossil fuels, nuclear fuel, or renewable energy. The processes of Earth's climate and ecosystem are driven by the radiant energy Earth receives from the **sun and the geothermal** energy contained within the earth

Some forms of energy (that an object or system can have as a measurable property)

Type of energy	Description
Mechanical	the sum of macroscopic translational and rotational kinetic and potential energies
Electric	potential energy due to or stored in electric fields
Magnetic	potential energy due to or stored in magnetic fields
Gravitational	potential energy due to or stored in gravitational fields
Chemical	potential energy due to chemical bonds
Ionization	potential energy that binds an electron to its atom or molecule
Nuclear	potential energy that binds nucleons to form the atomic nucleus (and nuclear reactions)
Chromodynamic	potential energy that binds quarks to form hadrons
Elastic	potential energy due to the deformation of a material (or its container) exhibiting a restorative force
Mechanical wave	kinetic and potential energy in an elastic material due to a propagated deformational wave
Sound wave	kinetic and potential energy in a fluid due to a sound propagated wave (a particular form of mechanical wave)
Radiant	potential energy stored in the fields of propagated by electromagnetic radiation, including light
Rest	potential energy due to an object's rest mass
Thermal	kinetic energy of the microscopic motion of particles, a form of disordered equivalent of mechanical energy

The Different Uses of Energy in our Daily lives

Energy use can be divided many dfferent ways but the most common is through the the end product — either electricity; themal energy, which is heating/cooling (including hot water); or transportation. You can also break down energy into its end-users, which are described below.

1. **Residential uses of energy**

When we talk about residential uses of energy, these are the most basic uses of energy. They include watching television, washing clothes, heating and lighting the home, taking a shower, working from home on your laptop or computer, running appliances and cooking. Residential uses of energy account for almost forty percent of total energy use globally. Waste in this category of use is also the highest globally. This can be attributed to the lack of education offered to the public on how to conserve the energy they use daily, or to the lack of energy conservation products available in the market. Most people are ignorant to the fact that there are avenues or companies and innovations available that can help them monitor and reduce the amount of energy they use.

2. **Commercial uses of energy**

Commercial use of energy is what energy is used for in the commercial sector. This includes heating, cooling and lighting of commercial buildings and spaces, power used by companies and business throughout our cities for computers, fax machines, workstations, copiers just to name but a few. The uses of energy in the commercial space is more or less similar to the uses in the industrial space save for personal uses. Energy saving here though, is targeted at the corporate world rather than at individuals. Players in the sector of energy conservation should introduce energy saving campaigns in order to curb the culture of waste present at our places of work.

3. **Transportation**

Transportation is one hundred percent dependent on energy. Over seventy percent of petroleum used goes into the transport sector. The transport sector includes all vehicles from personal cars to trucks to buses and motorcycles. It also includes aircrafts, trains, ship and pipelines. The transportation sector can be very vital in the overall quest for energy conservation. Innovations such as the introduction of more fuel efficient vehicles and development of alternative sources of energy for our transport system can greatly help in the saving of energy Efforts at energy conservation can be made on a global scale if we factor in the uses and deal with them one by one. If we focus on them as individual uses rather than trying to find a solution as a whole, we will make much bigger strides in conservation.

Mechanical energy and transport

Mechanical energy: - In physical sciences, **mechanical energy** is the sum of potential energy and kinetic energy. It is the energy associated with the motion and position of an object.

Energy is a scalar quantity and the mechanical energy of a system is the sum of the potential energy (which is measured by the position of the parts of the system) and the kinetic energy (which is also called the energy of motion)

$$E_{\text{mechanical}} = U + K$$

The potential energy, U, depends on the position of an object subjected to a conservative force. It is defined as the object's ability to do work and is increased as the object is moved in the opposite direction of the direction of the force. If F represents the conservative force and x the position, the potential energy of the force between the two positions x_1 and x_2 is defined as the negative integral of F from x_1 to x_2:

$$U = -\int_{x_1}^{x_2} \vec{F} \cdot d\vec{x}$$

The kinetic energy, K, depends on the speed of an object and is the ability of a moving object to do work on other objects when it collides with them. It is defined as one half the product of the object's mass with the square of its speed, and the total kinetic energy of a system of objects is the sum of the kinetic energies of the respective objects:

$$K = \frac{1}{2}mv^2$$

Conservation of mechanical energy: - According to the principle of conservation of mechanical energy, the mechanical energy of an isolated system remains constant in time, as long as the system is free of friction and other non-conservative forces. In any real situation, frictional forces and other non-conservative forces are present, but in many cases their effects on the system are so small that the principle of conservation of mechanical energy can be used as a fair approximation. Though energy cannot be created or destroyed in an isolated system, it can be converted to another form of energy

Energy in Transportation

Transportation uses a huge amount of energy—powering our cars, boats and planes and getting us where we need to go. We even transport energy sources themselves—for example, delivering crops to the plants that make biodiesel and then shipping the biodiesel to the companies that use them! But how fuel for transportation created is—and what is it created from? Energy for transportation is created from a variety of sources, including solar, biofuels, petroleum and more.

Vehicles using solar power include cars, bicycles and even spacecraft (which use solar panels in conjunction with electric propulsion)! Solar-powered cars use photovoltaic cells to turn sunlight into electricity. Solar vehicles are not currently a viable option for everyday transportation, because PV cells are expensive to create and it's difficult to create solar panels that are big enough to collect the sunlight vehicles need to run regularly. Vehicles that combine solar power with electric power could prove to be successful for transportation—the future will tell.

Biofuels have a long history in transportation—the first diesel engine ran on peanut oil in the late 1800s, and Henry Ford's Model T was designed to run on ethanol in 1908—and it has been gaining in popularity in recent years. The biofuel ethanol is created by fermenting starch or sugar crops such as sugarcane, barley, rice and other grains. Biodiesel is made by mixing cooking grease, vegetable oil or animal fat with alcohol. Both these biofuels are usually added to other fuels to cut down on vehicle emissions, but they can also be used in their pure form in some engines.

Even coal can be used as a fuel for transportation! Coal liquefaction, the process of converting coal to liquid, can create fuels for cars and jets. The only commercial coal liquefaction industry in the world is located in South Africa, and it has been producing fuels since 1955.

Of course, by far the most common fuel for transportation is petroleum. In the United States, 97% of the energy that moves the transportation sector (cars, buses, subways, railroads, airplanes, etc.) comes from fuels made from oil. Auto manufacturers are developing cars to run on alternative fuels such as hydrogen and ethanol or even powered by electricity. But the batteries in electric cars need to be charged, and the fuel to generate the electricity comes from oil or gas. Also, the hydrogen needed for fuel cells may be generated from natural gas or petroleum-based products. Even as alternative fuels are developed, oil will be crucially important to assuring that people can get where they need to be and want to go for many years.

Heat energy:- In thermodynamics, heat is **energy in transfer to or from a thermodynamic system, by mechanisms other than thermodynamic work or transfer of matter.**

Difference Between Conduction Convection and Radiation

Conduction	Convection	Radiation
In conduction, the heat transfer takes place between objects by direct contact.	In convection, the heat transfer takes within the fluid.	In radiation, the heat transfer occurs through electromagnetic waves without involving particles.
The heat transfer takes place due to the difference in temperature.	The heat transfer occurs due to the difference in density.	The heat transfer occurs in all object with a temperature greater than 0 K.
The heat transfer in conduction is slow	The heat transfer in convection is faster.	The heat transfer in radiation is fastest.
The heat transfer occurs through a heated solid object.	The heat transfer occurs through intermediate objects. For example, heat transfer between air and water.	The heat transfer occurs through electromagnetic waves.
It does not follow the law of reflection and refraction.	It does not follow the law of reflection and refraction.	It follows the law of reflection and refraction.

Conversion between heat and mechanical energy

Energy is one of the fundamental quantities in physics. Energy can be found in different forms and converted from one to other forms. Mechanical energy conversion into heat and establish the relationship between the conventional units of work and heat.

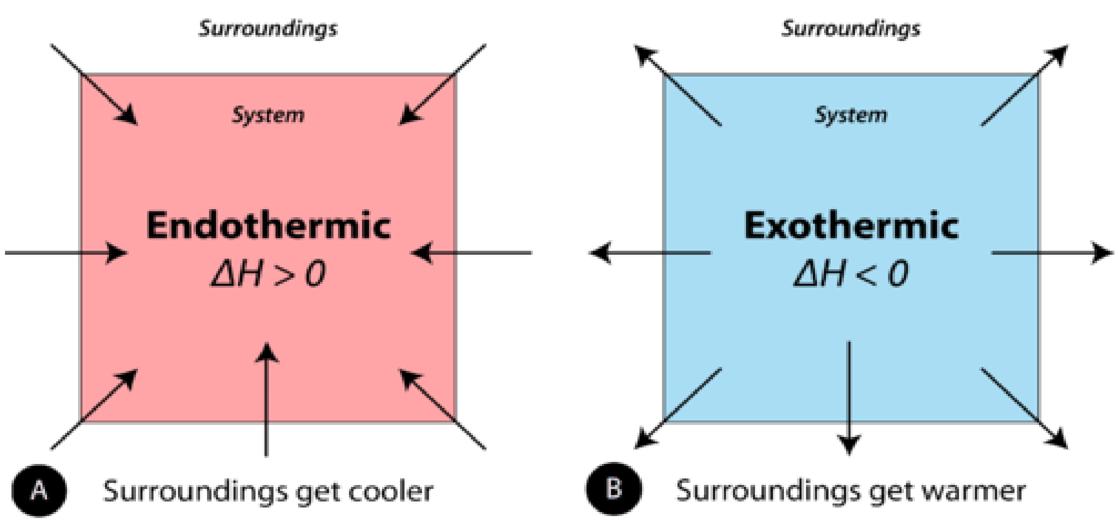
Mechanical energy can be converted into heat, and heat can be converted into some mechanical energy. This important physical observation is known as the mechanical equivalent of heat. This means one can change the internal energy of a system by either doing work to the system, or adding heat to the system. This concept is fundamental to thermodynamics which applies the ideas of heat and work in order to create useful systems such as engines, power plants, and refrigerators.

According to the work-energy theorem, which follows from Newton's laws of motion, when a force does work on an object, the object's energy increases. Sometimes this energy takes the form of kinetic and potential energy of the object as a whole (such as when you throw a ball up in the air). But sometimes it can take the form of internal energy. For example, if you rub your hands you can feel your hands getting warm. When the force of friction acts on an object, the object's temperature increases, indicating an increase of internal energy. We will turn a metal cylinder against friction for mechanical work.

This idea of work and heat equivalence is stated in the First law of thermodynamics, which says that the change in internal energy of a system is the sum of the work done and the heat added to any system.

Energy in chemical systems and processes :- Energy plays a key role in chemical processes. According to the modern view of chemical reactions, bonds between atoms in the reactants must be broken, and the atoms or pieces of molecules are reassembled into products by forming new bonds. Energy is absorbed to break bonds, and energy is evolved as bonds are made.

. The quantity of heat for a process is represented by the letter q . The sign of q for an endothermic process is positive because the system is gaining heat. A chemical reaction or physical change is exothermic if heat is released by the system into the surroundings. Because the surroundings is gaining heat from the system, the temperature of the surroundings increases. The sign of q for an exothermic process is negative because the system is losing heat.



PHASE CHANGE ENERGY CONVERSION

A phase change material (PCM) is a **substance which releases/absorbs sufficient energy at phase transition to provide useful heat/cooling. The energy** released/absorbed by phase transition from solid to liquid, or vice-versa, the heat of fusion is generally much higher than the sensible heat.

There are two principal classes of phase change material: organic (carbon-containing) materials derived either from petroleum, from plants or from animals; and salt hydrates, which generally either use natural salts from the sea or from mineral deposits or are by-products of other processes. A third class is solid to solid phase change.

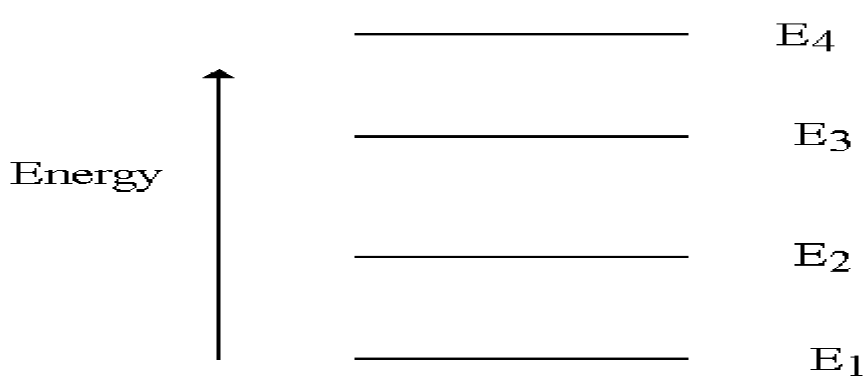
Characteristics and classification

Latent heat storage can be achieved through changes in the State of matter from liquid→solid, solid→liquid, solid→gas and liquid→gas. However, only solid→liquid and liquid→solid phase changes are practical for PCMs. Although liquid–gas transitions have a higher heat of transformation than solid–liquid transitions, liquid→gas phase changes are impractical for thermal storage because large volumes or high pressures are required to store the materials in their gas phase. Solid–solid phase changes are typically very slow and have a relatively low heat of transformation.

ENERGY QUANTIZATION

The system can have only certain energies and not a continuum of energies.

- Any atom or molecule can only have certain fixed energies, energy is quantized and an atom or molecule can exist only in certain discrete levels.



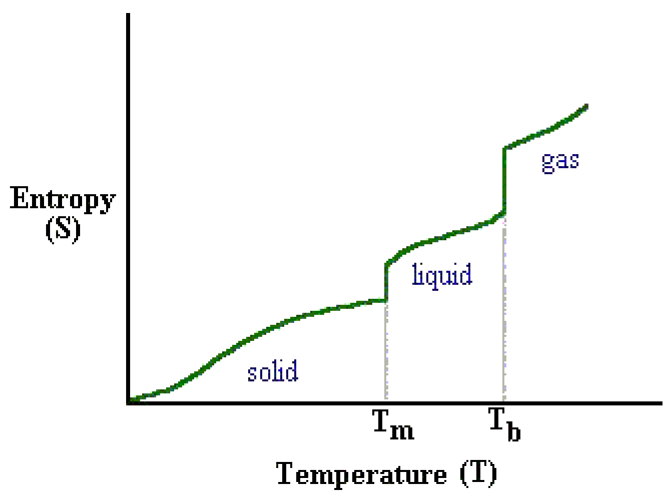
In quantum physics, photons are packages of energy and correspond to different colors in the spectrum or different types of electromagnetic radiation (radio waves, microwaves, X -rays, etc). A red photon has specific energy value different from a blue photon. The red and blue photons are therefore "quantized"

More technically, the uniqueness -- or "quantization" -- of energy is related to Plank's constant, which specifies "how quantized" energy can get.

The formula is: E=hf where E is energy, f is frequency and h is a very tiny constant called the Plank's constant (6.62·10−36m2kgsec). This constant regulates and "quantizes" the energy of the universe.

Entropy and Temperature

_Entropy is a measure of the random activity in a system. From thermodynamics the change in entropy can be expressed as dS = dQ/T, where dQ is change in heat energy and dS is change in entropy at a given absolute temperature T. From this relation, it appears that as we keep on increase the temperature the change in entropy 'dS' decreases. However, this is true only when the change in heat energy dQ remains constant. But, in practice, the heat energy dQ also changes with the temperature. Therefore, It is not only the absolute temperature 'T' decides the change in entropy, the corresponding change in heat energy 'dQ' also has to be considered. In other words the ratio dQ/T determines 'dS', but not only the 'T'.



Affecting Entropy

Several factors affect the amount of entropy in a system. If you increase temperature, you increase entropy.

(1) More energy put into a system excites the molecules and the amount of random activity.

(2) As a gas expands in a system, entropy increases. This one is also easy to visualize. If an atom has more space to bounce around, it will bounce more. Gases and plasmas have large amounts of entropy when compared to liquids and solids.

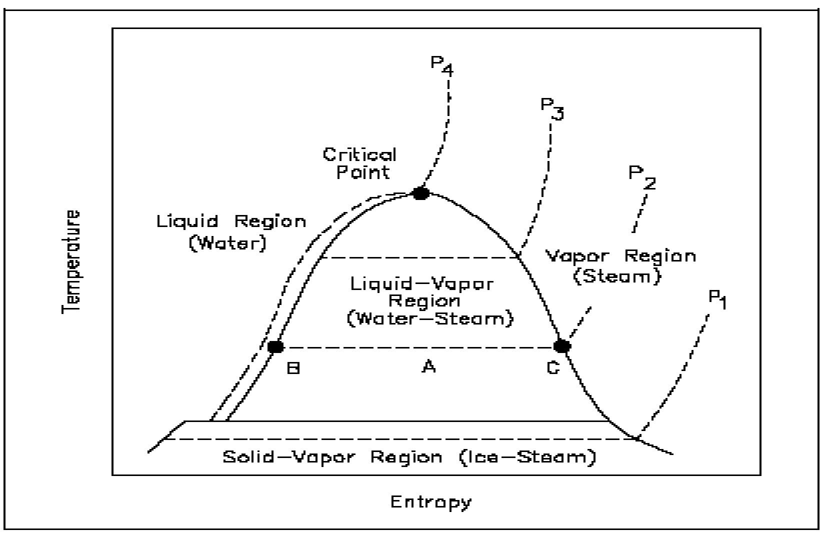
(3) When a solid becomes a liquid, its entropy increases.

(4) When a liquid becomes a gas, its entropy increases. We just talked about this idea. If you give atoms more room to move around, they will move. You can also think about it in terms of energy put into a system. If you add energy to a solid, it can become a liquid. Liquids have more energy and entropy than solids.

(5) Any chemical reaction that increases the number of gas molecules also increases entropy. A chemical reaction that increases the number of gas molecules would be a reaction that pours energy into a system. More energy gives you greater entropy and randomness of the atoms.

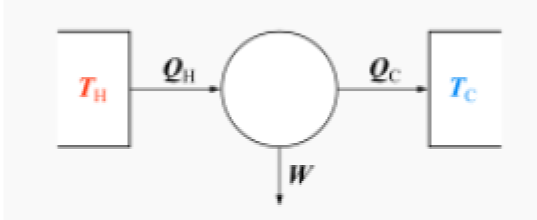
Temperature Entropy Diagram (T-s diagram)

A T-s diagram is the type of diagram most frequently used to analyze energy transfer system cycles. This is because the work done by or on the system and the heat added to or removed from the system can be visualized on the T-s diagram. By the definition of



<u>CARNOT HEAT ENGINE</u>

The Carnot cycle is a theoretical ideal thermodynamic cycle. It provides an upper limit on the efficiency that any classical thermodynamic engine can achieve during the conversion of heat into work, or conversely, the efficiency of a refrigeration system in creating a temperature difference by the application of work to the system.



The classical Carnot heat engine

The Carnot Cycle

The Carnot cycle consists of the following four processes:

I. A reversible isothermal gas expansion process. In this process, the ideal gas in the system absorbs q_{in} amount heat from a heat source at a high temperature T_{high}, expands and does work on surroundings.

II. A reversible adiabatic gas expansion process. In this process, the system is thermally insulated. The gas continues to expand and do work on surroundings, which causes the system to cool to a lower temperature, T_{low}.

III. A reversible isothermal gas compression process. In this process, surroundings do work to the gas at T_{low}, and causes a loss of heat, q_{out}.

IV. A reversible adiabatic gas compression process. In this process, the system is thermally insulated. Surroundings continue to do work to the gas, which causes the temperature to rise back to T_{high}.

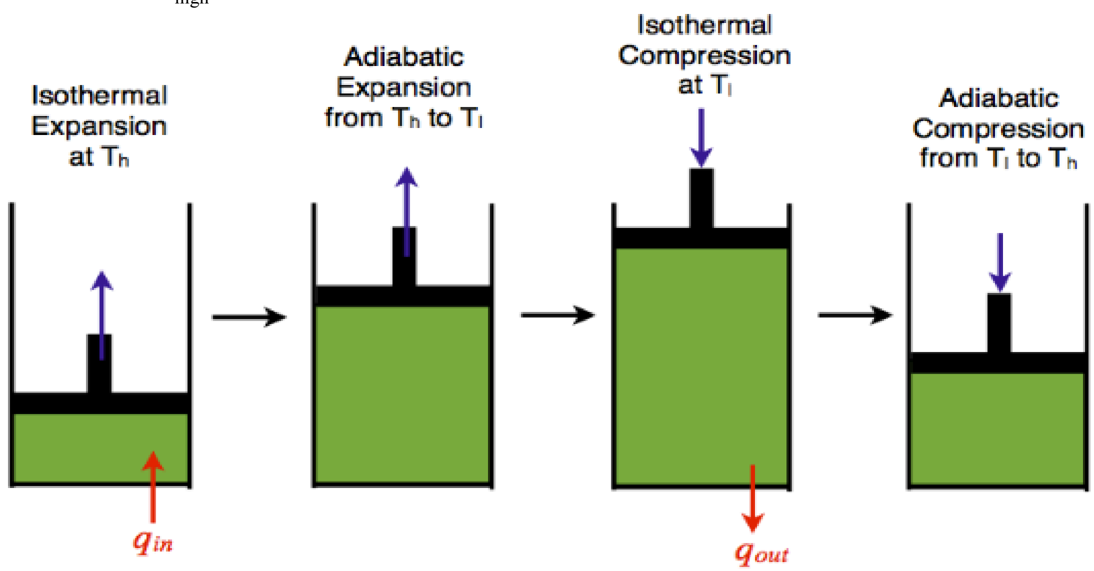


Figure 1: An ideal gas-piston model of the Carnot cycle.

P-V Diagram

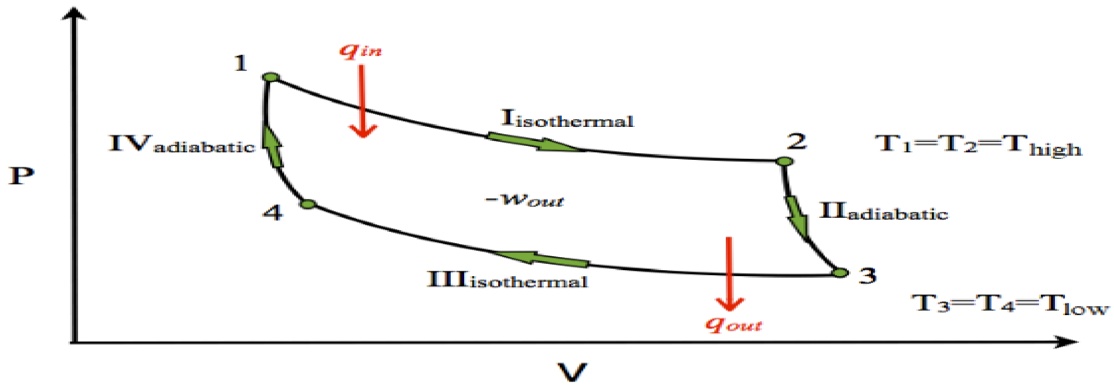


Figure 2: A P-V diagram of the Carnot Cycle.

T-S Diagram

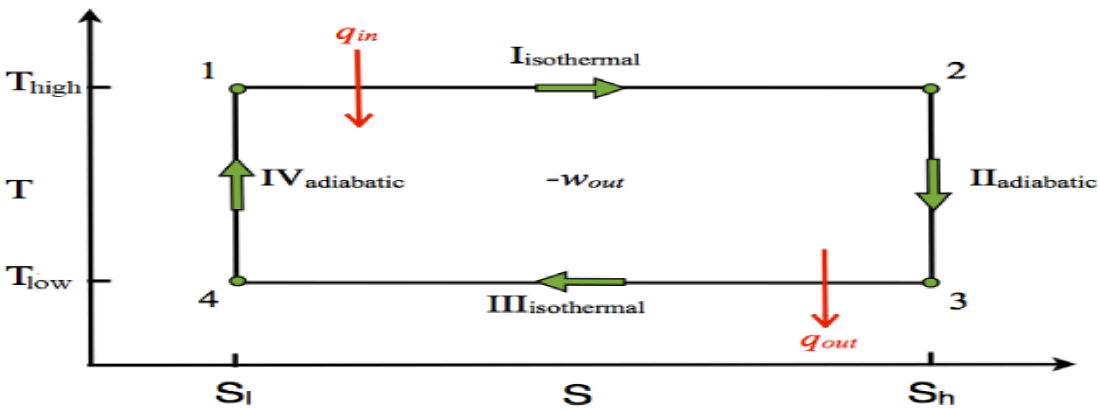
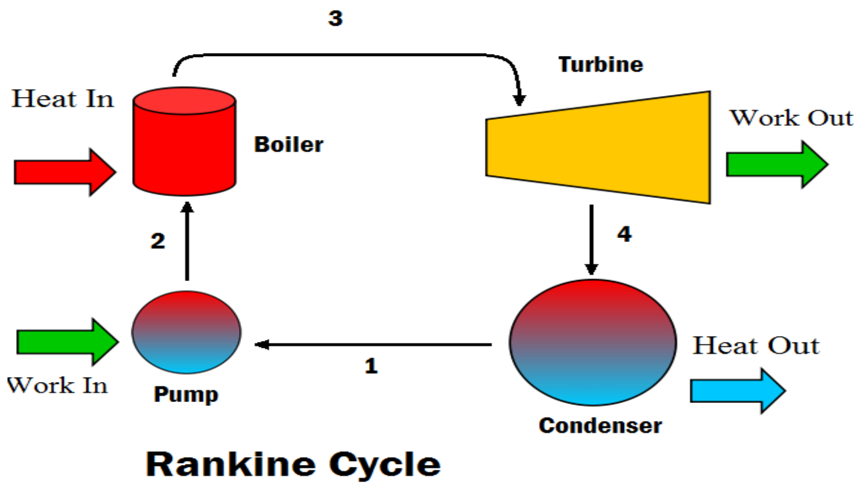


Figure 3: A T-S diagram of the Carnot Cycle.

The Efficiency of Carnot's Cycle:- The Carnot cycle is reversible representing the upper limit on the efficiency of an engine cycle. Practical engine cycles are irreversible and thus have inherently lower efficiency than the Carnot efficiency when operating at the same temperatures. One of the factors determining efficiency is the addition of to the working fluid in the cycle and its removal. The Carnot cycle achieves maximum efficiency because all the heat is added to the working fluid at the maximum temperature.

Rankine cycle

The Rankine cycle or Rankine Vapor Cycle is the process widely used by power plants such as coal-fired power plants or nuclear reactors. In this mechanism, a fuel is used to produce heat within a boiler, converting water into steam which then expands through a turbine producing useful work. This process was developed in 1859 by Scottish engineer William J.M. Rankine. This is a thermodynamic cycle which converts heat into mechanical energy—which usually gets transformed into electricity by electrical generation.



Fig(1)

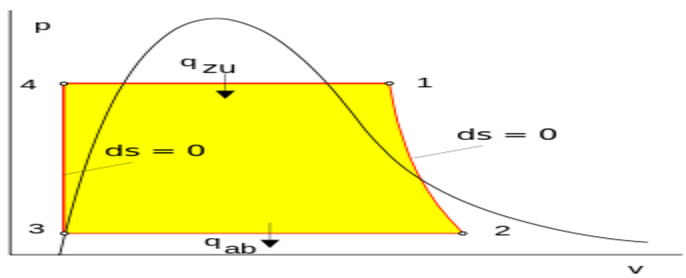


Fig.2

The steps in the Rankine Cycle as shown in Figure 1 and the corresponding steps in the pressure volume diagram (figure 2) are outlined below:

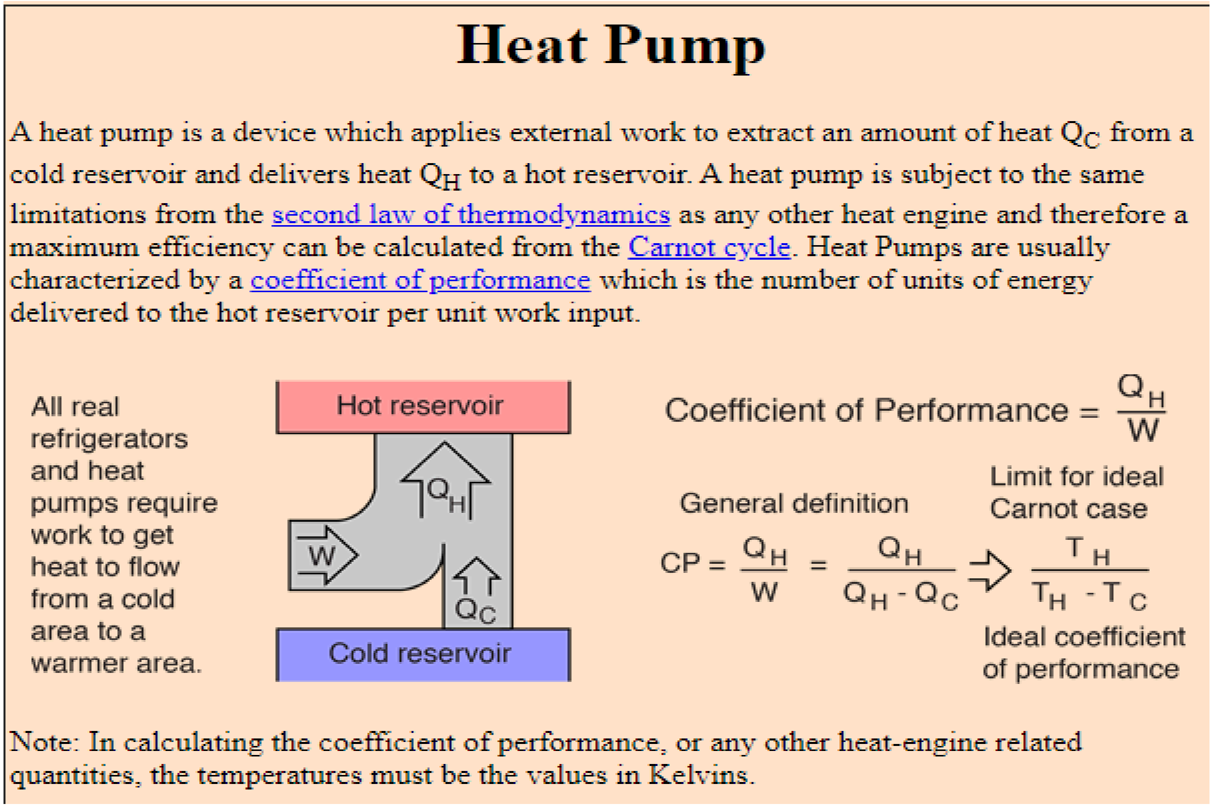
- **Pump:** Compression of the fluid to high pressure using a pump (this takes work) (*Figure 2:* Steps 3 to 4)
- **Boiler:** The compressed fluid is heated to the final temperature (which is at boiling point), therefore, a phase change occurs—from liquid to vapor. (*Figure 2:* Steps 4 to 1)
- **Turbine:** Expansion of the vapor in the turbine. (*Figure 2:* Steps 1 to 2)
- **Condenser:** Condensation of the vapor in the condenser (where the waste heat goes to the final heat sink (the atmosphere or a large body of water (ex. lake or river). (*Figure 2:* Steps 2 to 3)

Regeneration process:- The efficiency of the Rankine cycle is limited by the high heat of vaporization by the fluid. The fluid must be cycled through and reused constantly; therefore, water is the most practical fluid for this cycle. This is *not* why many power plants are located near a body of water—that's for the waste heat.

As the water condenses in the condenser, waste heat is given off in the form of water vapor—which can be seen billowing from a plant's cooling towers. This waste heat is necessary in any thermodynamic cycle. Due to this condensation step, the pressure at the turbine outlet is lowered.

HEAT PUMP

A heat pump, as part of a central heating and cooling system, uses **the outside air to both heat a home in winter and cool it in summer.**



HOW DOES A HEAT PUMP WORK?

Technically, a heat pump **is a mechanical-compression cycle refrigeration system that can be reversed to either heat or cool a controlled** space. Think of a heat pump as a heat transporter constantly moving warm air from one place to another, to where it's needed or not needed, depending on the season. Even in air that seems too cold, heat energy is present. When it's cold outside, a heat pump extracts what outside heat is available and transfers it inside. When it's warm outside, it reverses directions and acts like an air conditioner, removing heat from your home.

COMPONENTS OF A HEAT PUMP: - A heat pump consists of two main components: an indoor air handler and an outdoor unit similar to a central air conditioner, but referred to as a heat pump. The outdoor unit contains a compressor that circulates refrigerant that absorbs and releases heat as it travels between the indoor and outdoor units.

AIR CONDITIONER VS. HEAT PUMP: WHAT'S THE DIFFERENCE?

The main difference between heat pumps and air conditioners is that a heat pump can also heat your home while an air conditioner can't. An air conditioner needs to be paired with a furnace for a home to have full central heating and cooling.

INTERNAL COMBUSTION ENGINES

An Engine is a device which transforms the chemical energy of a fuel into thermal energy and uses this thermal energy to produce mechanical work. Engines normally convert thermal energy into mechanical work and therefore they are called heat engines.

Heat engines can be broadly classified into :

i) External combustion engines (E C Engines)

ii) Internal combustion engines (I C Engines)

External combustion engines are those in which combustion takes place outside the engine. For example, In steam engine or **steam turbine the heat generated due to combustion of fuel and it is employed to generate high pressure steam, which is used as working fluid in a reciprocating** engine or turbine. See Figure 1.

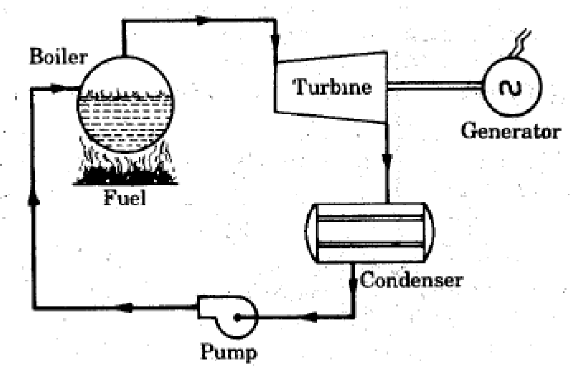
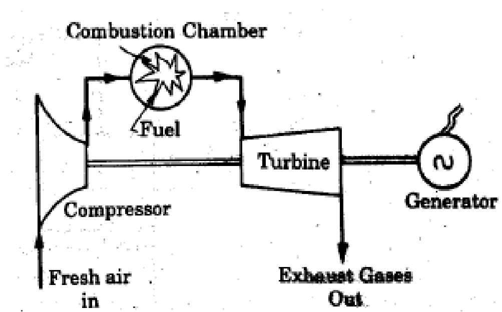


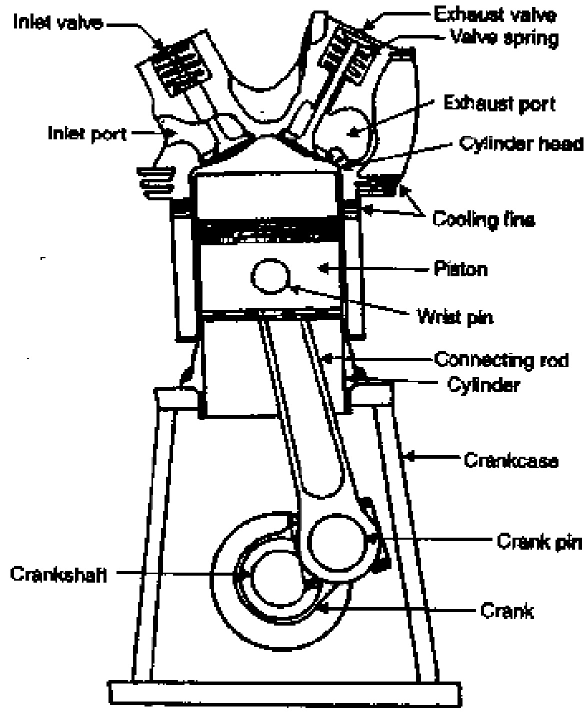
Figure 1 : External Combustion Engine

Internal combustion engines can be classified as Continuous IC engines and Intermittent IC engines.

In continuous IC engines products of combustion of the fuel enters into the prime mover as the working fluid. For example : In Open cycle gas turbine plant. Products of combustion from the combustion chamber enters through the turbine to generate the power continuously . See Figure 2.



In Intermittent internal combustion engine combustion of fuel takes place inside the engine cylinder. Power is generated intermittently (only during power stroke) and flywheel is used to provide uniform output torque. Usually these engines are reciprocating engines. The reciprocating engine mechanism consists of piston which moves in a cylinder and forms a movable gas tight seal. By means of a connecting rod and a crank shaft arrangement, the reciprocating motion of piston is converted into a rotary motion of the crankshaft. They are most popular because of their use as main prime mover in commercial vehicles.



ADVANTAGES OF INTERNAL COMBUSTION ENGINES

1. Greater mechanical simplicity.
2. Higher power output per unit weight because of absence of auxiliary units like boiler , condenser and feed pump
3. Low initial cost
4. Higher brake thermal efficiency as only a small fraction of heat energy of the fuel is dissipated to cooling system
5. These units are compact and requires less space
6. Easy starting from cold conditions

DISADVANTAGES OF INTERNAL COMBUSTION ENGINES

1. I C engines cannot use solid fuels which are cheaper. Only liquid or gaseous fuel of given specification can be efficiently used. These fuels are relatively more expensive.
2. I C engines have reciprocating parts and hence balancing of them is problem and they are also susceptible to mechanical vibrations.

CLASSIFICATION OF INTERNAL COMBUSTION ENGINES.

There are different types of IC engines that can be classified on the following basis.

1. According to thermodynamic cycle
   i) Otto cycle engine or Constant volume heat supplied cycle.
   ii) Diesel cycle engine or Constant pressure heat supplied cycle
   iii) Dual-combustion cycle engine

2. According to the fuel used:
   i) Petrol engine ii) Diesel engine iii) Gas engine

2. According to the cycle of operation:
   i) Two stroke cycle engine ii) Four stroke cycle engine

4. According to the method of ignition:
   i) Spark ignition (S.I) engine ii) Compression ignition (C I) engine

5. According to the number of cylinders.
   i) Single cylinder engine ii) Multi cylinder engine

6. According to the arrangement of cylinder:
   I) Horizontal engine ii) Vertical engine iii) V-engine
   v) In-line engine vi) Radial engine, etc.

7. According to the method of cooling the cylinder:
   I) Air cooled engine ii) Water cooled engine

8. According to their applications:
   i) Stationary engine ii) Automobile engine iii) Aero engine
   iv) Locomotive engine v) Marine engine, etc.

INTERNAL COMBUSTION ENGINE PARTS AND THEIR FUNCTION

1. Cylinder :- It is a container fitted with piston, where the fuel is burnt and power is produced.

2. Cylinder Head/Cylinder Cover:- One end of the cylinder is closed by means of cylinder head. This consists of inlet valve for admitting air fuel mixture and exhaust valve for removing the products of combustion.

3. Piston:- Piston is used to reciprocate inside the cylinder. It transmits the energy to crankshaft through connecting rod.

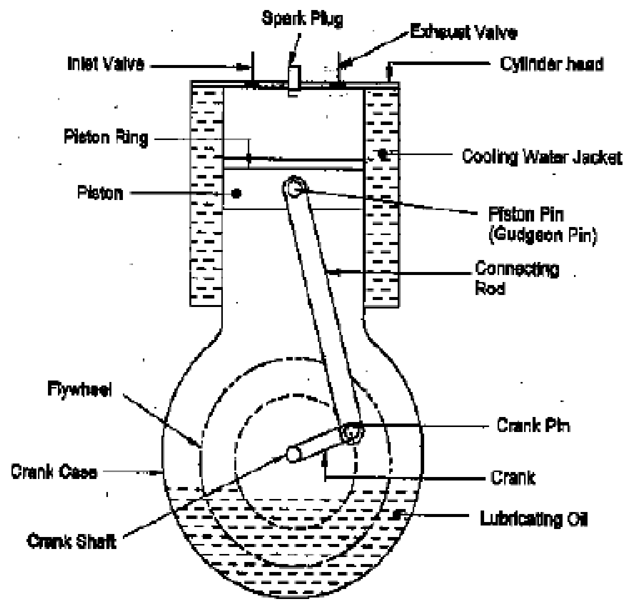


Figure: 1 I.C. Engine Parts

4. Piston Rings:- These are used to maintain a pressure tight seal between the piston and cylinder walls and also it transfer the heat from the piston head to cylinder walls.

5. Connecting Rod:- One end of the connecting rod is connected to piston through piston pin while the other is connected to crank through crank pin. It transmits the reciprocatory motion of piston to rotary crank.

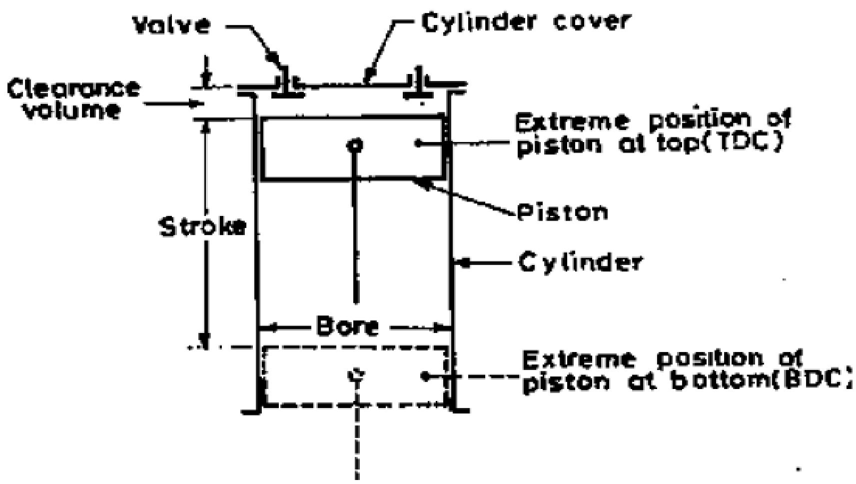
6. Crank:- It is a lever between connecting rod and crank shaft.

7. Crank Shaft:- The function of crank shaft is to transform reciprocating motion in to a rotary motion.

8. Fly wheel:- Fly wheel is a rotating mass used as an energy storing device.

9. Crank Case:- It supports and covers the cylinder and the crank shaft. It is used to store the lubricating oil.

IC ENGINE – TERMINOLOGY



Bore: The inside diameter of the cylinder is called the bore.

Stroke: The linear distance along the cylinder axis between the two limiting positions of the piston is
called stroke.

Top Dead Centre (T.D.C) The top most position of the piston towards cover end side of the cylinder" is called top dead centre. In case of horizontal engine, it is called as inner dead centre

Bottom Dead Centre (B.D.C) The lowest position of the piston towards the crank end side of the cylinder is called bottom dead centre. In case of horizontal engine, it is called outer dead centre (O.D.C).

Clearance Volume The volume contained in the cylinder above the top of the piston, when the piston is at the top dead centre is called clearance volume.

Compression ratio It is the ratio of total cylinder volume to clearance volume

Four-Stroke Petrol Engine OR Four stroke Spark Ignition Engine (S.I. engine)

The four-stroke cycle petrol engines operate on Otto (constant volume) cycle shown in Figure 3.0. Since ignition in these engines is due to a spark, they are also called spark ignition engines. The four different strokes are:

i) Suction stroke

ii) Compression stroke

iii) Working or power or expansion stroke

iv) Exhaust stroke.

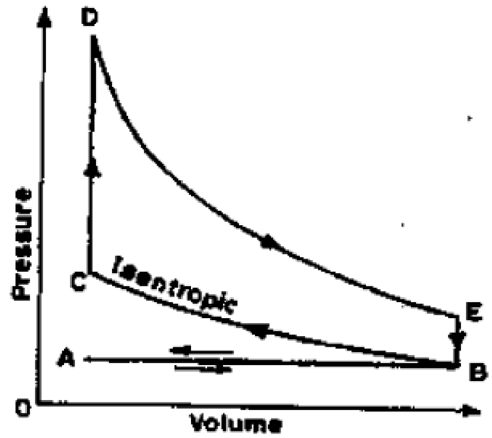
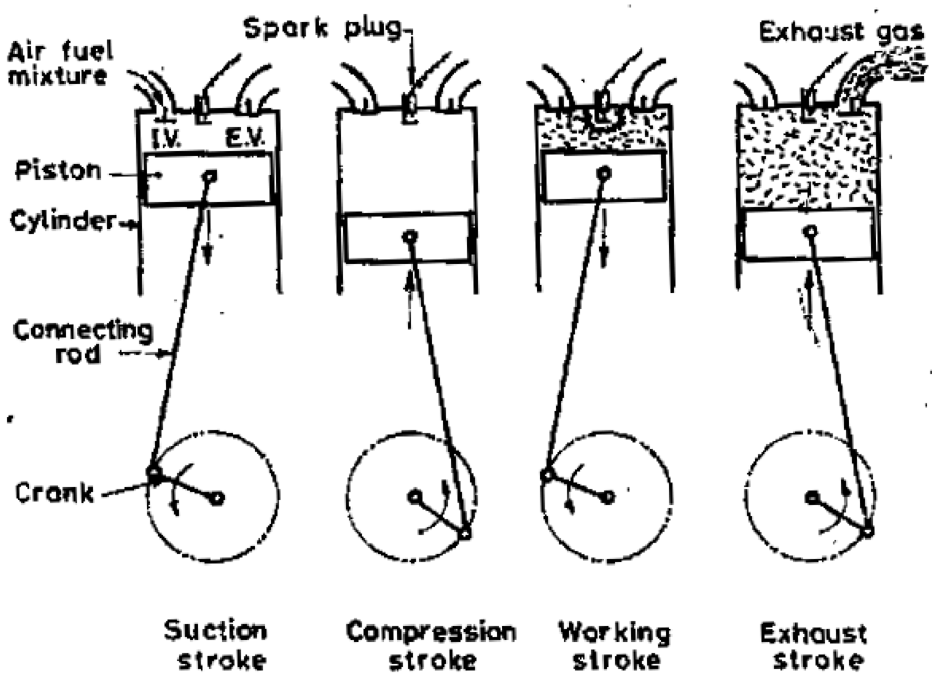


Figure: 3 Theoretical Otto Cycle

The construction and working of a four-stroke petrol engine is shown below:



Suction Stroke : During suction stroke, the piston is moved from the top dead centre to the bottom dead centre by the crank shaft. The crank shaft is revolved either by the momentum of the flywheel or by the electric starting motor. The inlet valve remains open and the exhaust valve is closed during this stroke. The proportionate air-petrol mixture is sucked into the cylinder due to the downward movement of the piston. This operation is represented by the line AB on the P-V diagram. (Figure 3)

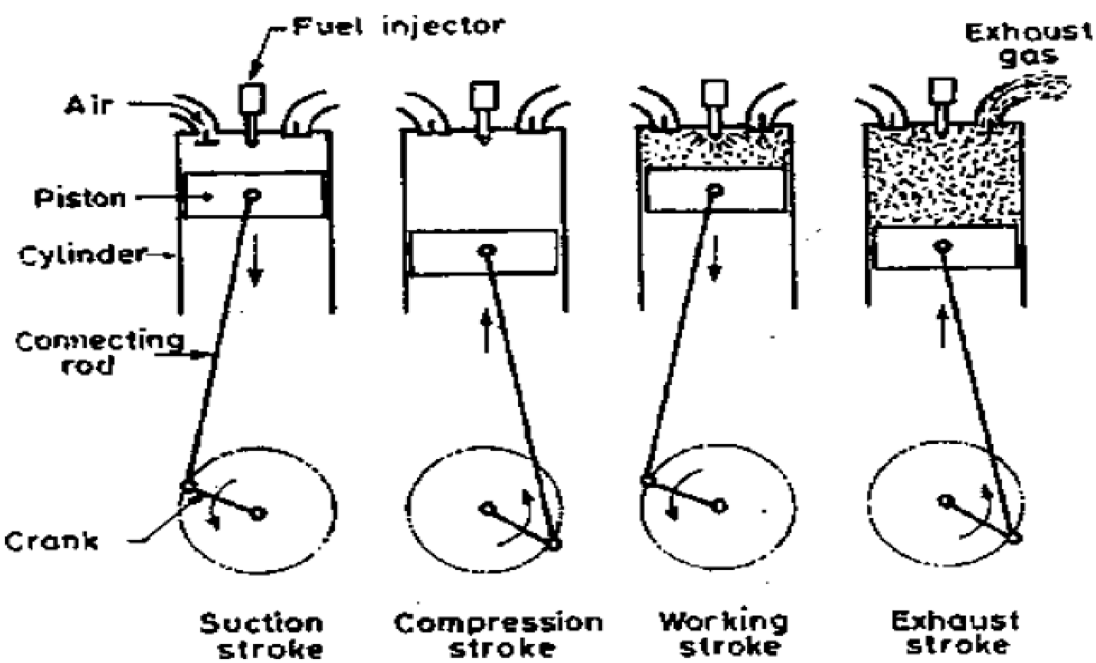
Compression Stroke: During compression stroke, the piston moves from bottom dead centre to the top dead centre, thus compressing air petrol mixture. Due to compression, the pressure and temperature are increased and is shown by the line BC on the P- V diagram. Just before the end of this stroke the spark - plug initiates a spark, which ignites the mixture and combustion takes place at constant volume as shown by the line CD. Both the inlet and exhaust valves remain closed during this stroke.

Working Stroke: The expansion of hot gases exerts a pressure on the piston. Due to this pressure, the piston moves from top dead centre to bottom dead centre and thus the work is obtained in this stroke. Both the inlet and exhaust valves remain closed during this stroke. The expansion of the gas is shown by the curve DE.

Exhaust Stroke: During this stroke, the inlet valve remains closed and the exhaust valve opens. The greater part of the burnt gases escapes because of their own expansion. The drop in pressure at constant volume is represented by the line EB. The piston moves from bottom dead centre to top dead centre and pushes the remaining gases to the atmosphere. When the piston reaches the top dead centre the exhaust valve closes and cycle is completed. This stroke is represented by the line BA on the P- V diagram. The operations are repeated over and over again in running the engine. Thus a four stroke engine completes one working cycle, during this the crank rotate by two revolutions.

FOUR STROKE DIESEL ENGINE (FOUR STROKE COMPRESSION IGNITION ENGINE— C.I. ENGINE)

The four stroke cycle diesel engine operates on diesel cycle or constant pressure cycle. Since ignition in these engines is due to the temperature of the compressed air, they are also called compression ignition engines. The construction and working of the four stroke diesel engine is shown in fig. 4, and fig. 5 shows a theoretical diesel cycle. The four strokes are as follows:



Suction Stroke: During suction stroke, the piston is moved from the top dead centre to the bottom dead centre by the crankshaft. The crankshaft is revolved either by the momentum of the flywheel or by the power generated by the electric starting motor. The inlet valve remains open and the exhaust valve is closed during this stroke. The air is sucked into the cylinder due to the downward movement of the piston. The line AB on the P- V diagram represents this operation.

Compression Stroke: The air drawn at the atmospheric pressure during suction stroke is compressed to high pressure and temperature as piston moves from the bottom dead centre to top dead centre. This operation is represented by the curve BC on the P- V diagram. Just before the end of this stroke, a metered quantity of fuel is injected into the hot compressed air in the form of fine sprays by means of fuel injector. The fuel starts burning at constant pressure shown by the line CD. At point D, fuel supply is cut off, Both the inlet and exhaust valves remain closed during this stroke

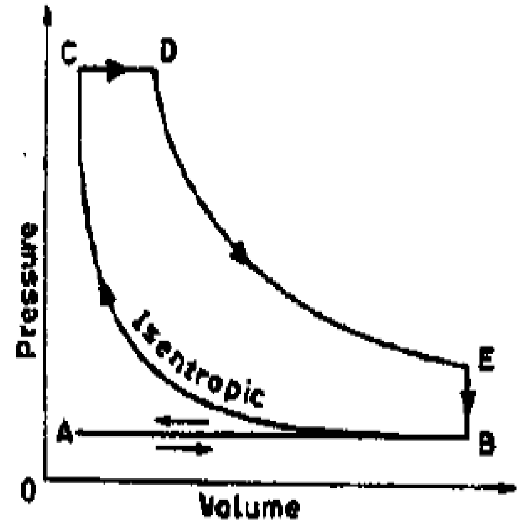


Figure: 6 Diesel Cycle (Constant Pressure cycle)

Working Stroke: The expansion of gases due to the heat of combustion exerts a pressure on the piston. Under this impulse, the piston moves from top dead centre to the bottom dead centre and thus work is obtained in this stroke. Both the inlet and exhaust valves remain closed during this stroke. The expansion of the gas is shown by the curve DE.

Exhaust Stroke: During this stroke, the inlet valve remains closed and the exhaust valve opens. The greater part of the burnt gases escapes because of their own expansion. The vertical line EB represents the drop in pressure at constant volume. The piston moves from bottom dead centre to top dead centre and pushes the remaining gases to the atmosphere. When the piston reaches the top dead centre the exhaust valve closes and the cycle is completed. The line BA on the F- V diagram represents this stroke.

Two Stroke Cycle Petrol Engine:-

The principle of two-stroke cycle petrol engine is shown in Figure 7. Its two strokes are described as follows:

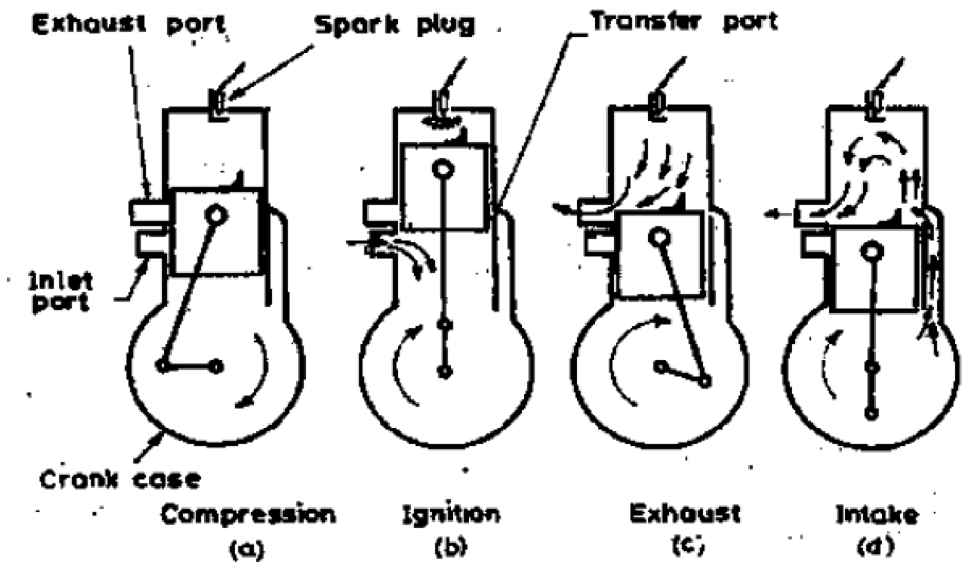


Figure: 7 Working of Two stroke Petrol Engine

Upward Stroke : During the upward stroke, the piston moves from bottom dead centre to top dead centre, compressing the air-petrol mixture in the cylinder. The cylinder is connected to a closed crank chamber. Due to upward movement of the piston, a partial vacuum is created in the crankcase, and a new charge is drawn into the crank case through the uncovered inlet port. The exhaust port and transfer port are covered when the piston is at the top dead centre position as shown in Figure 7 (b). The compressed charge is ignited in the combustion chamber by a spark provided by the spark plug.

Downward Stroke: **As soon as the charge is ignited, the hot gases force the piston to move downwards, rotating the crankshaft, thus doing the useful work. During this stroke** the inlet port is covered by the piston and the new charge is compressed in the crank case as shown in the Figure 7(c) Further downward movement of the piston uncovers first the exhaust port and then the transfer port as shown in Figure 7 (d). The burnt gases escape through the exhaust port. As soon as the transfer port opens, the compressed charge from the crankcase flows into the cylinder. The charge is deflected upwards by the hump provided on the head of the piston and pushes out most of the exhaust gases. It may be noted that the incoming air-petrol mixture helps the removal of burnt gases from the engine cylinder. **If in case these exhaust gases do not leave the** cylinder, the fresh charge gets diluted and efficiency of the engine will decrease. The cycle of events is then repeated.

COMPARISON OF FOUR-STROKE AND TWO-STROKE ENGINES

A comparison of four-stroke and two-stroke engines indicating their relative merits and demerits is presented in Table 2.0

Table 2.0 Comparison of four-stroke and two stroke engines

Four-stroke engine	*Two-stroke engine*
• One power stroke is obtained in every two revolutions of the crankshaft as the cycle is completed in four-strokes of the piston or in two revolutions of the crankshaft.	One power stroke is obtained in each revolution of the crankshaft as the cycle is completed in two strokes or in one revolution of the crankshaft.
• One power stroke in two revolutions of the crankshaft makes the turning movement of the shaft non-uniform and hence a heavier flywheel is needed to rotate the shaft uniformly.	The turning movement of the shaft is more uniform and hence a lighter flywheel is needed to rotate the shaft uniformly.
• Power produced for the same size of the engine is less and for the same power output, the engine is larger in size, because only one power stroke is obtained in two revolutions.	Power produced for the same size of the engine is more and for the same power output, the engine is smaller in size, because one power stroke is obtained in every revolution.
• It contains valves and valve mechanism.	It has ports. Some engines are fitted with exhaust valve or reed válve.