ACKNOWLEDGEMENT

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Date: **SINCERELY,**

Place: Warananagar **MR. RAVINDRA JAGANNATH SUTAR**

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LIST OF FIGURE

ABSTRACT

This paper is reports on the review of compressed air engine for the design and development of single cylinder engine which can be run by the compressed air. Current four strokes single cylinder engine (bikes/moped) can be run on the compressed air with a few modifications that are the main objective of the study. Compressed air filled by electricity using a compressor.

The electricity requirement for compressing air has to be considered while computing overall efficiency. Nevertheless the compressed air vehicle will contribute to reducing a air pollution and tend to zero pollution level and promoting great environment. Main advantage of this engine is that no hydrocarbon fuel required means no combustion process is take place.

Today the whole world is in search of alternative fuel, to fulfill the need of fossil fuel because in coming years there will be scarcity of fossil fuel. There are couples of option of alternative fuel such as solar power, tidal power, geo-thermal power, etc. and one of them is Compressed Air. The important condition for the alternative fuel is it should be renewable and eco-friendly. In India only 52.5% of rural house have access to electricity and 93.1% in urban house. Overall 35.5% of total Indian population doesn't have electricity access to their home. Compressed Air Engine is a better option to produce power to run automobile, generators etc. This paper contains design and dynamic analysis of a light weight single stroke compressed air engine it does not required any of the fossil fuels like petrol, diesel, CNG, LPG, hydrogen etc. to run engine and no power is required to start up engine only compressed air valve is to be opened. It works on compressed pressure air and hence is pollution free and 100% eco-friendly.

Keywords- Compressed air engine, zero pollution, air fuel, eco-friendly engine, single stroke engine

Chapter 1. Introduction

1.1. Compressed Air Engine Basics:

A Compressed-air engine is a pneumatic actuator that creates useful work by compressed air. A compressed-air vehicle is powered by an air engine, using compressed air, which is stored in a tank. Instead of mixing fuel with air and burning it in the engine to drive pistons with hot expanding gases, compressed air vehicles (CAV) use the expansion of compressed air to drive their pistons.

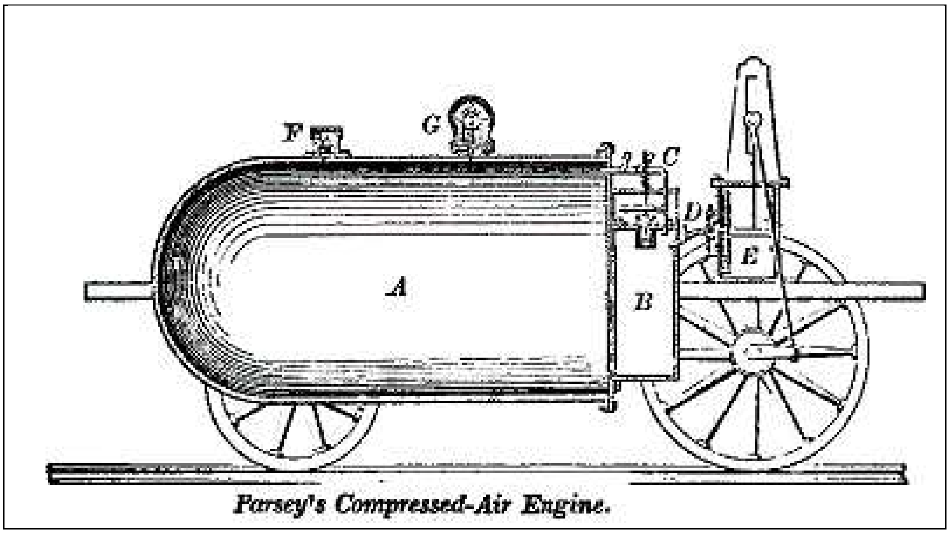
They have existed in many forms over the past two centuries, ranging in size from hand held turbines up to several hundred horsepower. For example, the first mechanically-powered submarine, the 1863 Plongeur, used a compressed air engine.
the laws of physics dictate that uncontained gases will fill any given space. The easiest way to see this in action is to inflate a balloon. The elastic skin of the balloon holds the air tightly inside, but the moment you use a pin to create a hole in the balloon's surface, the air expands outward with so much energy that the balloon explodes. Compressing a gas into a small space is a way to store energy. When the gas expands again, that energy is released to do work. That's the basic principle behind what makes an air car go. Some types rely on pistons and cylinders, others use turbines. Many compressed air engines improve their performance by heating the incoming air, or the engine itself. Some took this a stage further and burned fuel in the cylinder or turbine, forming a type of internal combustion engine.

One manufacturer claims to have designed an engine that is 90 percent efficient. Compressed air propulsion may also be incorporated in hybrid systems, e.g., battery electric propulsion and fuel tanks to recharge the batteries. This kind of system is called hybrid-pneumatic electric propulsion. Additionally, regenerative braking can also be used in conjunction with this system.

1.2. History:

(a) The first compressed-air vehicle was devised by Bompas, a patent for a locomotive being taken out in England in 1828. There were two storage tanks between the frames, with conventional cylinders and cranks. It is not clear if it was actually built. (Knight, 1880)

(b) The first recorded compressed-air vehicle in France was built by the Frenchmen Andraud and Tessie of Motay in 1838. A car ran on a test track at Chaillot on the 9th July 1840, and worked well, but the idea was not pursued further.



Compressed-Air Engine

Fig: 1.1

(c) In 1848 Barin von Rathlen constructed a vehicle which was reported to have been driven from Putney to Wandsworth (London) at an average speed of 10 to 12 mph.

(d) At the end of 1855, a constructor called Julienne ran some sort of vehicle at Saint-Denis in France, driven by air at 25 atmospheres (350 psi), for it to be used in coal mines.

(e) Compressed air locomotives were use for haulage in 1874 while the Simplon tunnel was being dug. An advantage was that the cold exhaust air aided the ventilation of the tunnel.

(f) Louis Mékarski built a standard gauge self-contained tramcar which was tested in February 1876 on the Courbevoie-Etoile Line of the Paris Tramways Nord (TN), where it much impressed the current president and minister of transport Maréchal de MacMahon. The tramcar was also shown at the exhibition of 1878 as it seemed to be an ideal transport method, quiet, smooth, without smoke, fire or the possibility of boiler explosion.

(g) The compressed-air locos were soon withdrawn due to a number of accidents, possibly caused by icing in the pipes of the brakes, which were also worked by compressed air.

(h) In Louis Mékarski built a standard gauge self-contained tramcar which was tested in February 1876 on the Courbevoie-Etoile Line of the Paris Tramways Nord (TN), where it much impressed the current president and minister of transport Maréchal de MacMahon.

The tramcar was also shown at the exhibition of 1878 as it seemed to be an ideal transport method, quiet, smooth, without smoke, fire or the possibility of boiler explosion.

Chapter 2:

2.1. Description of Mechanical Components
2.2. Study of the Compressed Air Engine and its Working

2. Description of Components of Compressed Air Engine:

Various Mechanical parts used in engine are:

1. Crank shaft
2. Camshaft
3. Piston cylinder
4. Valves
5. Connecting rod
6. Roller bearing
7. Timing gear
8. Nozzle

2.1. Description of Mechanical Parts:

2.1.1. Crank shaft:

The **crankshaft**, sometimes casually abbreviated to crank, is the part of an engine which translates reciprocating motion into rotary motion or vice versa. Crank shaft consists of the shaft parts which revolve in the main bearing, the crank pins to which the big ends of the connecting rod are connected, the crank webs or cheeks which connect the crank pins and the shaft parts.

Carank shaft
Fig 2.1

Crank shafts can be divided into two types:
1. Crank shaft with a side crank or overhung crank.
2. Crank shaft with a centre crank.
A crank shaft can be made with two side cranks on each end or with two or more centre cranks. A crank shaft with only one side crank is called a single throw crank shaft and the one with two side cranks or two centre cranks as a multi throw crank shaft.
The overhung crank shaft is used for medium size and large horizontal engines. Its main advantage is that only two bearings are needed, in either the single crank or two crank, crank shafts. Misalignment causes most crank shaft failures and this danger is less in shafts with two bearings than with three or more supports. Hence, the number of bearings is very important
factor in design. To make the engine lighter and shorter, the number of bearings in automobiles should be reduced.
For the proper functioning, the crank shaft should fulfill the following conditions:
1. Enough strength to withstand the forces to which it is subjected i.e. the bending and twisting moments.
2. Enough rigidity to keep the distortion a minimum.
3. Stiffness to minimize. And strength to resist, the stresses due to torsional vibrations of the shaft.

4. Sufficient mass properly distributed to see that it does not vibrate critically at the speeds at which it is operated.
5. Sufficient projected areas of crank pins and journals to keep down the bearing pressure to a value dependent on the lubrication available.
6. Minimum weight, especially in aero engines.

The crank shafts are made much heavier and stronger than necessary from the strength point of view so as to meet the requirements of rigidity and vibrations. Therefore, the weight cannot be reduced appreciably by using a material with a very high strength. The material to be selected will always depend upon the method of manufacture i.e. cast, forged, or built up. Built up crank shafts are sometimes used in aero engines where light weight is very important.

In industrial engines, 0.35 carbon steel of ultimate tensile strength 500 to 525 MPa and 0.45 carbon steel of ultimate tensile strength of about 627 to 780 MPa are commonly used. In transport engines, alloy steel e.g. manganese steel having ultimate strength of about 784 to 940 MPa is generally used. In aero engines, nickel chromium steel having ultimate tensile strength of about 940 to 1100 MPa is generally used.

Failure of crank shaft may occur at the position of maximum bending; this may be at the centre of the crank or at either end. In such a condition the failure is due to bending and the pressure in the cylinder is maximal. Second, the crank may fail due to twisting, so the connecting rod needs to be checked for shear at the position of maximal twisting. The pressure at this position is the maximal pressure, but only a fraction of maximal pressure.

2.1.2. Camshaft:-

A camshaft is a shaft to which a cam is fastened or of which a cam forms an integral part. The relationship between the rotation of the camshaft and the rotation of the crankshaft is of critical importance. Since the valves control the flow of the air/fuel mixture intake and exhaust gases, they must be opened and closed at the appropriate time during the stroke of the piston. For this reason, the camshaft is connected to the crankshaft either directly, via a gear mechanism, or indirectly via a belt or chain called a timing belt or timing chain.The camshaft not only opens and closes your valves to let air in and out, but determines when and for how long the valves remain open. With this in mind, let’s talk about what happens as the engine spins. What follows next is a basic explanation of four-cycle engine operation, described in relation to the four valve events. For each rotation of the cam, we have four valve events. The crankshaft rotates twice for each revolution of the camshaft, so four valve events happen for every two revolution of the engine in four stroke engine.

Event 1 - Intake valves opening

The camshaft opens the intake valve, and the piston moves down the cylinder. As the pressure drops in the cylinder, the air starts moving past the intake valve to fill the cylinder. This period of the engine cycle is known as the intake stroke.

Event 2 - Intake valves closing

At some point, usually after the piston reaches the bottom of the intake stroke, the intake valve closes. The piston moves up the cylinder, beginning the compression stroke and compressing the fuel/air mixture within. At some point, usually before the piston reaches the top of the compression stroke, the spark plug ignites the mixture, causing it to burn and expand rapidly. The crankshaft has rotated once at this point.

Event 3 – Exhaust valves opening

After the piston reaches the top of the compression stroke, pressure from the burning, expanding mixture pushes the piston back down the cylinder. The exhaust valve starts to open, usually before the piston is all the way down, allowing some of the burnt gasses to exit the cylinder. This is commonly referred to as the blow down phase. The piston begins to move back up, forcing the rest of the hot gas out of the cylinder.

Event 3 – Exhaust valves closing

As the piston moves back up the cylinder, the exhaust valve remains open, usually until slightly after the piston reaches the top of the cylinder. We refer to this as the exhaust stroke. As the piston reaches the top again, the intake valve begins to open again, often before the exhaust valve is fully closed, and the whole cycle begins anew. The period when both valves are open simultaneously is referred to as “overlap.” The crankshaft has now gone around twice.

Cam Nomenclature;-

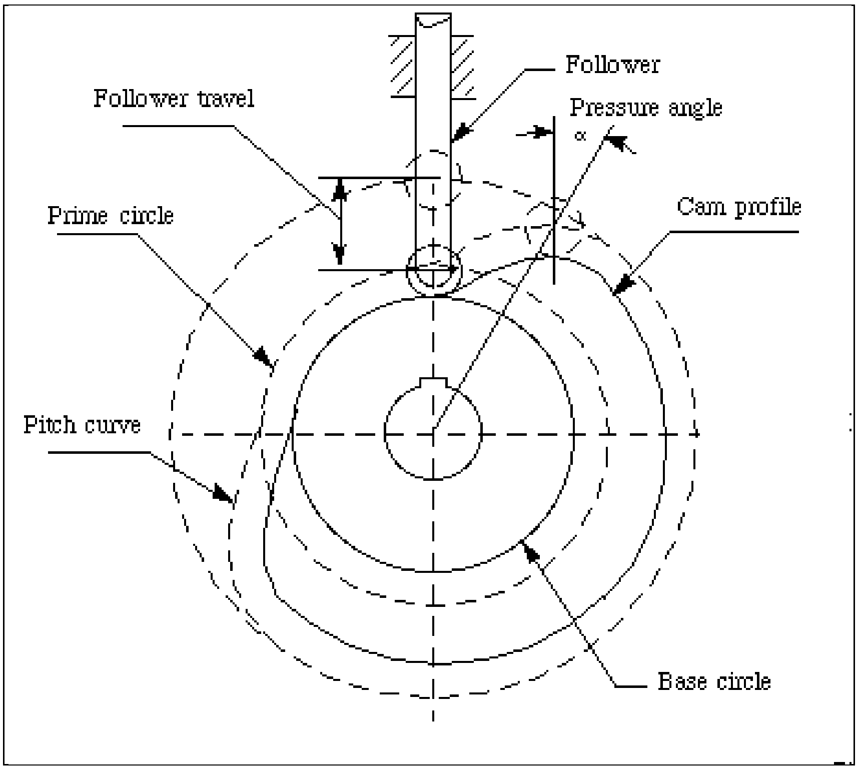


Fig 2.2 Cam nomenclature

Trace point: A theoretical point on the follower, corresponding to the point of a fictitious knife-edge follower. It is used to generate the pitch curve. In the case of a roller follower, the trace point is at the center of the roller.

Pitch curve: The path generated by the trace point at the follower is rotated about a stationary cam.

Working curve: The working surface of a cam in contact with the follower. For the knife-edge follower of the plate cam, the pitch curve and the working curves coincide. In a close or grooved cam there is an inner profile and an outer working curve.

Pitch circle: A circle from the cam center through the pitch point. The pitch circle radius is used to calculate a cam of minimum size for a given pressure angle.

Prime circle (**reference circle**): The smallest circle from the cam center through the pitch curve.

Base circle: The smallest circle from the cam center through the cam profile curve.

Stroke or **throw**: The greatest distance or angle through which the follower moves or rotates.

Follower displacement: The position of the follower from a specific zero or rest position (usually its the position when the follower contacts with the base circle of the cam) in relation to time or the rotary angle of the cam.

Pressure angle: The angle at any point between the normal to the pitch curve and the instantaneous direction of the follower motion. This angle is important in cam design because it represents the steepness of the cam profile.

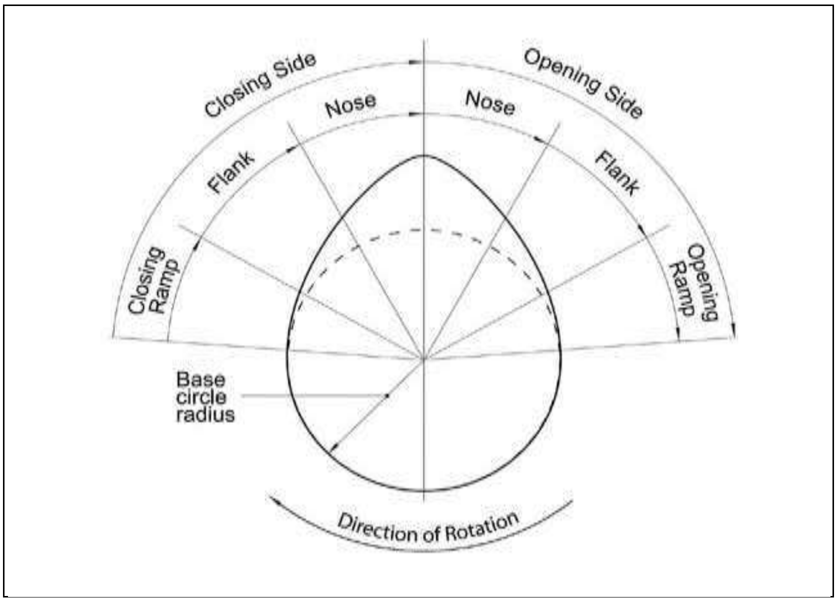


Fig 2.3
Pressure angle

Cam nomenclature
Fig 2.4

Camshaft Terminology:-

Camshaft terminology can sometimes become very confusing. The diagram below should help to explain some of the terms used in the design and selection of camshafts.

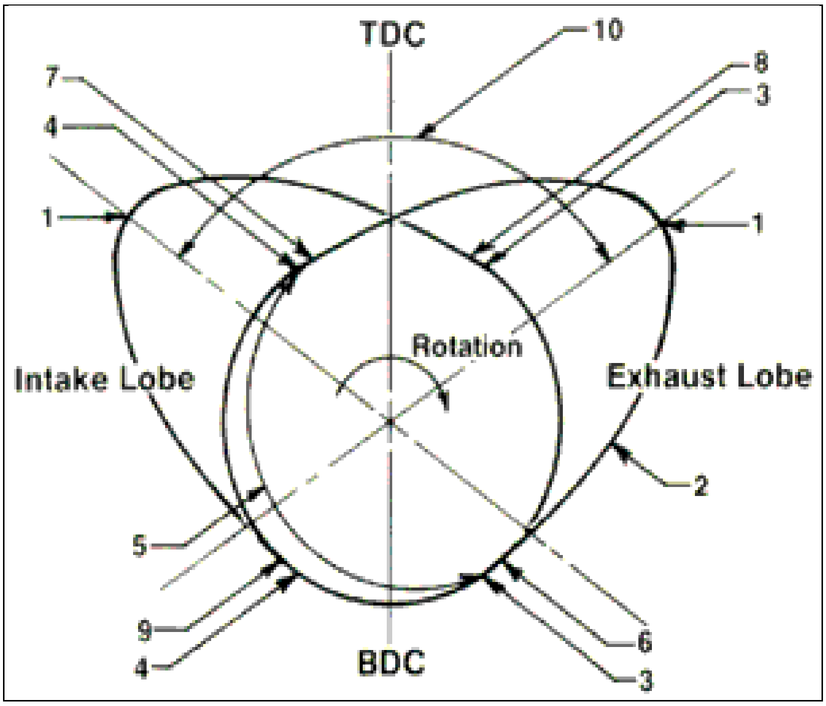


Fig 2.5 Cam terminology

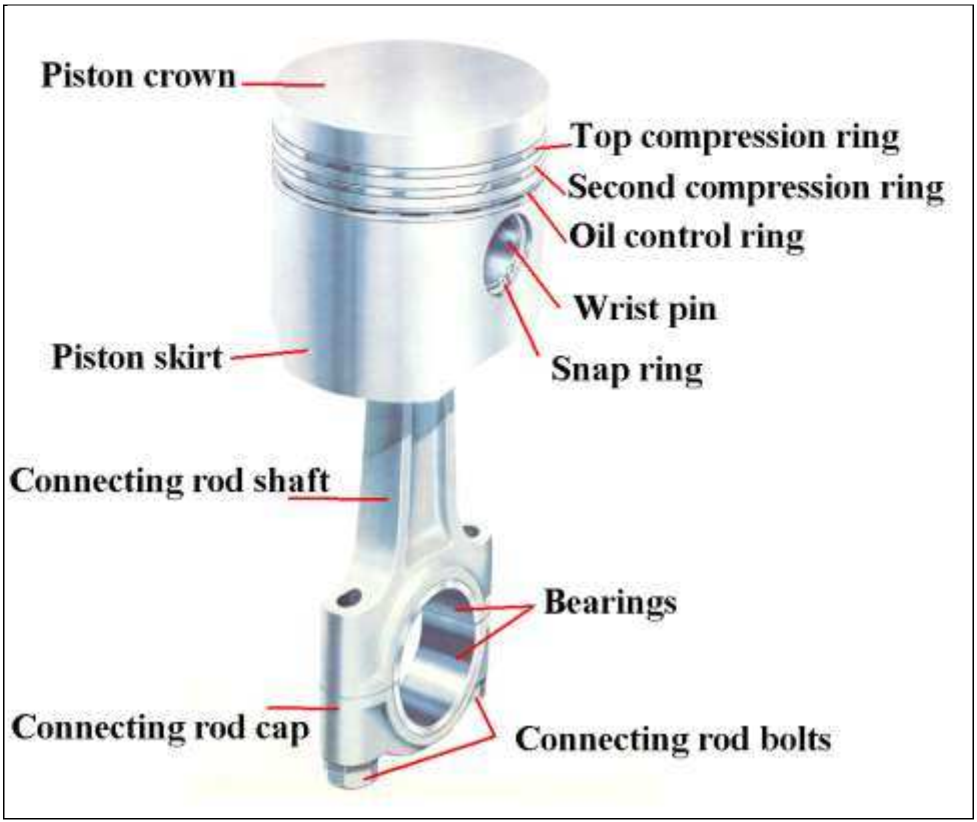
1. Max Lift or Nose
2. Flank
3. Opening Clearance Ramp
4. Closing Clearance Ramp
5. Base Circle
6. Exhaust Opening Timing Figure
7. Exhaust Closing Timing Figure
8. Intake Opening Timing Figure
9. Intake Closing Timing Figure
10. Intake to Exhaust Lobe Separation

2.1.3. Piston and Cylinder:-

A **piston** is a component of reciprocating engines among other similar mechanisms. It is the moving component that is contained by a cylinder and is made gas-tight by piston rings. In an engine, its purpose is to transfer force from expanding gas in the cylinder to the crankshaft via a piston rod and/or connecting rod.

The piston of an air compressed air is acted upon by the pressure of the expanding compressed air in the space at the top of the cylinder. This force then acts downwards through the connecting rod and onto the crankshaft. The connecting rod is attached to the piston by a swiveling gudgeon pin. This pin is mounted within the piston: unlike the steam engine, there is no piston rod or crosshead.

The pin itself is of hardened steel and is fixed in the piston, but free to move in the connecting rod. A few designs use a 'fully floating' design that is loose in both components. All pins must be prevented from moving sideways and the ends of the pin digging into the cylinder wall.



Piston
Fig 2.6

Gas sealing is achieved by the use of piston rings. These are a number of narrow iron rings, fitted loosely into grooves in the piston, just below the crown. The rings are split at a point in the rim, allowing them to press against the cylinder with a light spring pressure. Two types of ring are used: the upper rings have solid faces and provide gas sealing; lower rings have narrow edges and a U-shaped profile, to act as oil scrapers. There are many proprietary and detail design features associated with piston rings.

A **cylinder** is the central working part of a reciprocating engine the space in which a piston travels. A cylinder's displacement, or swept volume, can be calculated by multiplying its cross-sectional area (the square of half the bore by pi) and again by the distance the piston travels within the cylinder (the stroke). The engine displacement can be calculated by multiplying the swept volume of one cylinder by the number of cylinders.

Cylinder

Fig 2.7

2.1.4. Bearing:

The concept behind a bearing is very simple: Things roll better than they slide. The wheels on your car are like big bearings. If you had something like skis instead of wheels, your car would be a lot more difficult to push down the road. That is because when things slide, the **friction** between them causes a **force** that tends to slow them down. But if the two surfaces can roll over each other, the friction is greatly reduced. Bearings reduce friction by providing smooth metal balls or rollers, and a smooth inner and outer metal surface for the balls to roll against. These balls or rollers "bear" the load, allowing the device to spin smoothly.

Working of a Bearing:

As one of the bearing races rotates it causes the balls to rotate as well. Because the balls are rolling they have a much lower coefficient of friction than if two flat surfaces were rotating on each other.Ball bearings tend to have lower load capacity for their size than other kinds of rolling-element bearings due to the smaller contact area between the balls and races. However, they can tolerate some misalignment of the inner and outer races. Compared to other rolling-element bearings, the ball bearing is the least expensive, primarily because of the low cost of producing the balls used in the bearing.

Types of Bearings:

There are many types of bearings, each used for different purposes. These include ball bearings, roller bearings, ball thrust bearings, roller thrust bearings and tapered roller thrust bearings.

Cut away view of a ball bearing

Cut away view of a roller bearing

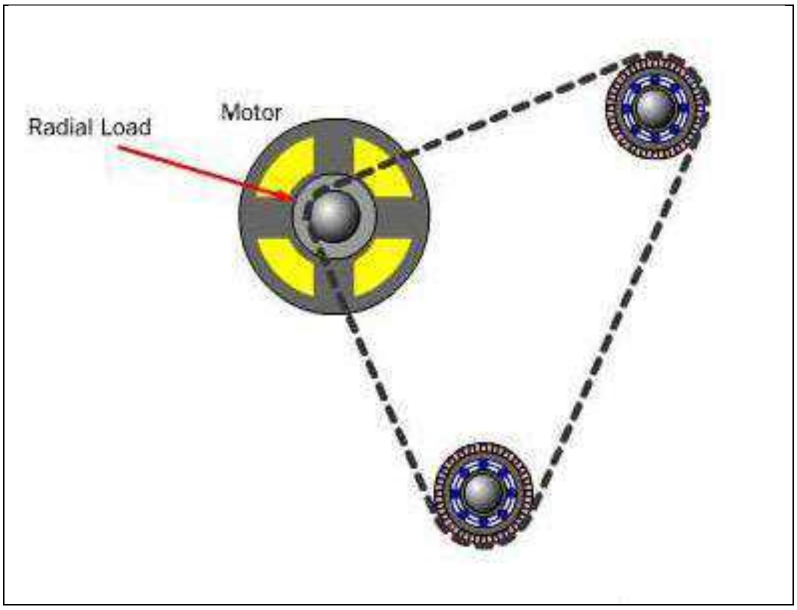
Ball thrust bearing

Roller thrust bearing

Cutaway view of (left) a spherical roller thrust bearing and (right) a radial tapered roller bearing
Fig 2.8

Bearing Loads:

Bearings typically have to deal with two kinds of loading, radial and thrust. Depending on where the bearing is being used, it may see all radial loading, all thrust loading or a combination of both.



The bearings that support the shafts of motors and pulleys are subject to a radial load. Fig 2.9

Bearing Used:

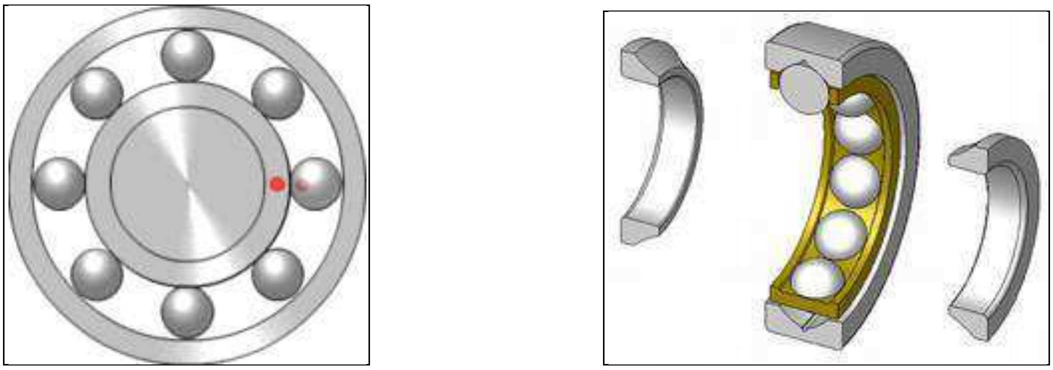


Fig: 2.10 - Ball bearings

A ball bearing is a type of rolling-element bearing which uses balls to maintain the separation between the moving parts of the bearing. The purpose of a ball bearing is to reduce rotational friction and support radial and axial loads. It achieves this by using at least two races to contain the balls and transmit the loads through the balls. Usually one of the races is held fixed.

2.1.5. Connecting rod:

Connecting rod is a part of the engine which is used to transmit the push and pull from the piston pin to the crank pin. In many cases, its secondary function is to convey the lubricating oil from the bottom end to the top end i.e. from the crank pin to the piston pin and then for the splash of jet cooling of piston crown. The usual form of connecting rod used in engines has an eye at the small end for the piston pin bearing, a long shank, and a big end opening which is usually split to take the crankpin bearing shells. The connecting rods of internal combustion engine are mostly manufactured by drop forging. The connecting rod should have adequate strength and stiffness with minimum weight. The materials for connecting rod range from mild or medium carbon steel to alloy steels. In industrial engines, carbon steel with ultimate tensile strength ranging from 550 to 670 MPa is used. In transport engines, alloy steel having a strength of about 780 to 940 MPa is used e.g., manganese steel. In aero engines, nickel chrome steel having ultimate tensile strength of about 940 to 1350 MPa is most commonly used. For connecting rod of low speed horizontal engines, the material may be sometimes steel castings. For high speed engines, connecting rod may also be made up of duralumin and aluminum alloys.

The usual shape of connecting rod is:
(1) Rectangular
(2) Circular
(3) Tubular
(4) I section
(5) H section

In low speed engines, the section is usually circular with flattened sides, or rectangular, the larger dimension being in the plane of rotation. In high speed engines, lightness of connecting rod is a major factor. Therefore tubular, I-section or H-section rods are used.

Connecting Rod
Fig 2.11

The length of the connecting rod depends upon the ratio of connecting rod length and stroke i.e. l/r ratio; on l/r ratio depends the angularity of the connecting rod with respect to the cylinder centre line. The shorter the length of the connecting rod l in respect to the crank radius r, the smaller the ratio l/r, and greater the angularity. This angularity also produces a side thrust of the piston against the liner. The side thrust and the resulting wear of the liner decreases with a decrease in the angularity. However, an increase of l/r ratio increases the overall height of the engine. Due to these factors, the common values of l/r ratio are 4 to 5.

The stresses in the connecting rod are set up by a combination of forces. The various forces acting on the connecting rod are:

1. The combined effect of gas pressure on the piston and the inertia of the reciprocating parts.
2. Friction of the piston rings and of the piston.
3. Inertia of the connecting rod.
4. The friction of the two end bearings i.e. of the piston pin bearing and the crank pin bearing.

2.1.6. Valves:-

In four stroke the "Poppet Valve" performed the opening of the cylinder to inlet or exhaust manifold at the correct moment. Generally the face of valve is ground at 45 degree but in same cases it is ground at 30 degree also. It is not important to have a same angle of face in inlet and exhaust valve of same engines. To make it in right order, the valve may be reground after some use. There is some margin provided to avoid sharp edges. The groove, retain the valve spring which aids in keeping the valve pressed against the seat when closed and thus seal the combustion space tightly. In close position, the valve face, fits the accurately matched ground seat in the cylinder block. Generally replaceable ring inserts are used for exhaust valve seat. The inlet valves are made from plain nickel, nickel chrome or chrome molybdenum. Where as exhaust valves are made from nickel chrome, silicon chrome steel, high speed steel, stainless steel, high nickel chrome, tungsten steel and cobalt chrome steel.

A poppet valve (also called mushroom valve is a valve typically used to control the timing and quantity of gas flow into an engine. It consists of a hole, usually round or oval, and a tapered plug, usually a disk shape on the end of a shaft also called a valve stem. The shaft guides the plug portion by sliding through a valve guide.

Valve
Fig 2.12

The poppet valve is fundamentally different from slide and oscillating valves; instead of sliding or rocking over a seat to uncover a port, the poppet valve lifts from the seat with a movement perpendicular to the port. The main advantage of the poppet valve is that it has no movement on the seat, thus requiring no lubrication.

Poppet valves are used in most piston engines to open and close the intake and exhaust ports in the cylinder head. The valve is usually a flat disk of metal with a long rod known as the valve stem attached to one side.

The stem is used to push down on the valve and open it, with a spring generally used to return it to the closed position when the stem is not being depressed. At high revolutions per minute (RPM), the inertia of the spring makes it too slow to return the valve to its seat between cycles, leading to 'valve float'. In this situation desmodromic valves are used which, being closed by a positive mechanical action instead of by a spring, are able to cycle at the high speeds required in, for instance, motorcycle and auto racing engines .

2.1.7. Timing Gear:-

The timing gear is connected by chain, gears or a belt to the crankshaft at one end and the camshaft on the other. The timing gear is marked with tiny increments all around its perimeter. The marks correspond to degrees of timing from the straight-up timing position of the camshaft and crankshaft. These marks assist the individual that is tuning up the engine to set the timing to the determined optimal timing degrees of the camshaft and engine designers.

In order to set an engine's timing gear to the correct inclination, the mechanic must confer with the engine manufacturer as well as the camshaft manufacturer. The purpose of timing an engine with the timing gear is to ensure that the valves are opening and closing at the correct time to best fill the cylinder with an air/fuel mixture as well as to release all of the spent fumes from the exhaust cycle of the cylinder. A mere few degrees off on the timing gear can be the difference in an engine that performs perfectly and an engine that will not run correctly. A poor running engine will make less power and use more fuel than a properly-timed engine.

While the timing gear rotates a full 360 degrees, the timing marks are concerned with just a few degrees before and after top dead center of the piston's rotation. Top dead center is when the piston is at its absolute highest point of travel within the cylinder or at the top of the stroke at the dead center of when the crankshaft is neither traveling up nor down in the cylinder. The timing gear is used to measure the amount of rotation in degrees in relation to when the valves begin to open and close.

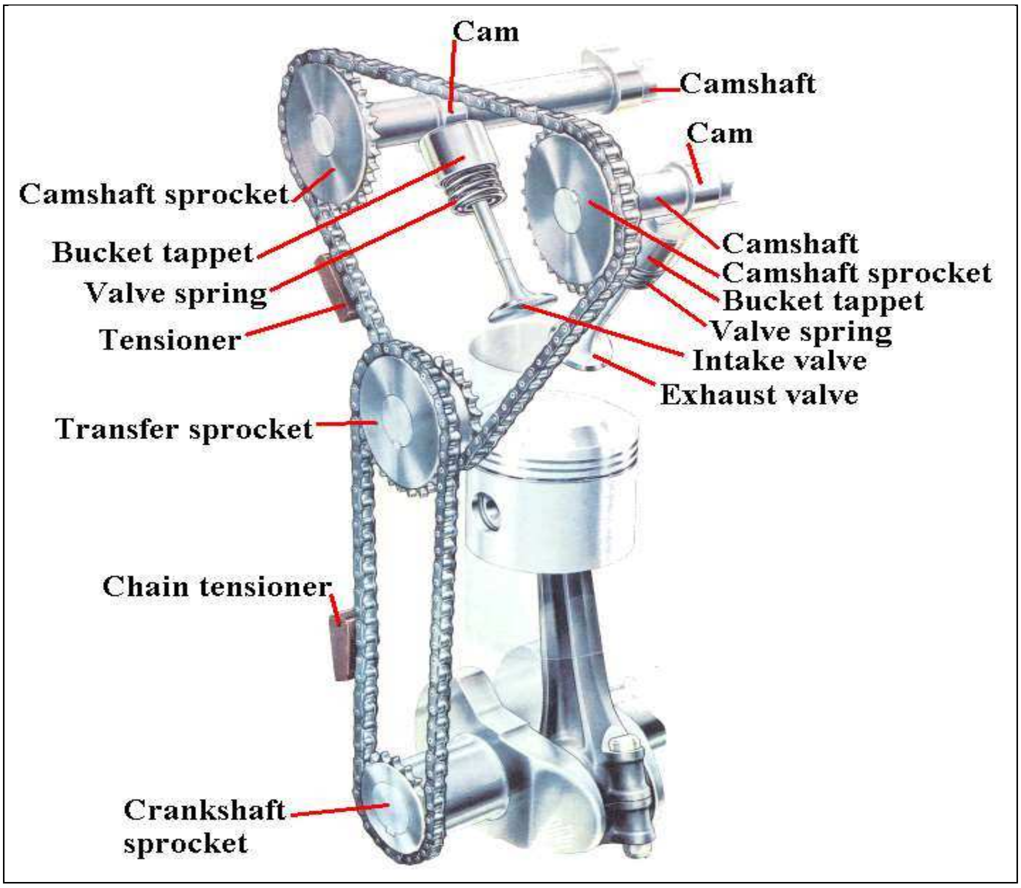
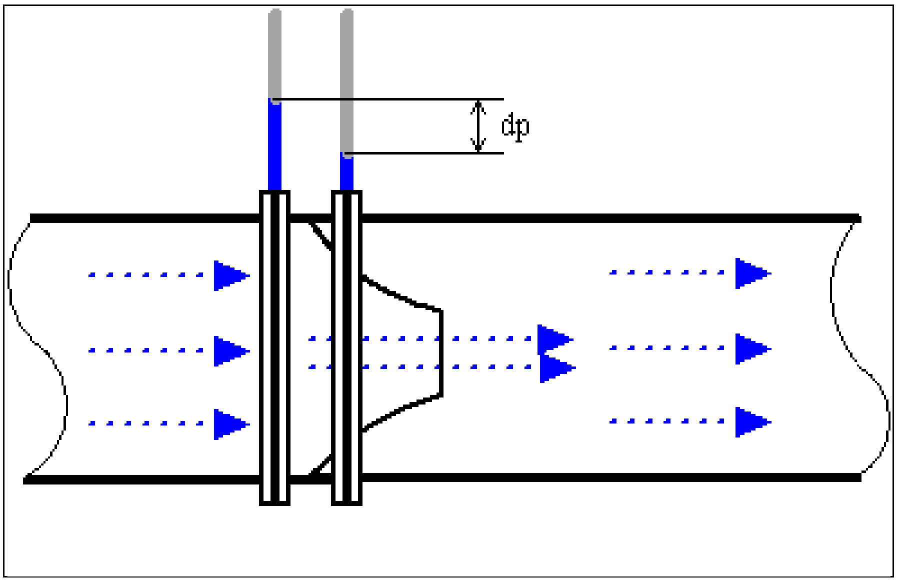


Fig 2.13 Timing Gear

2.1.7. Nozzle:-

A **nozzle** is a device designed to control the direction or characteristics of a fluid flow (especially to increase velocity) as it exits (or enters) an enclosed chamber or pipe via an orifice.

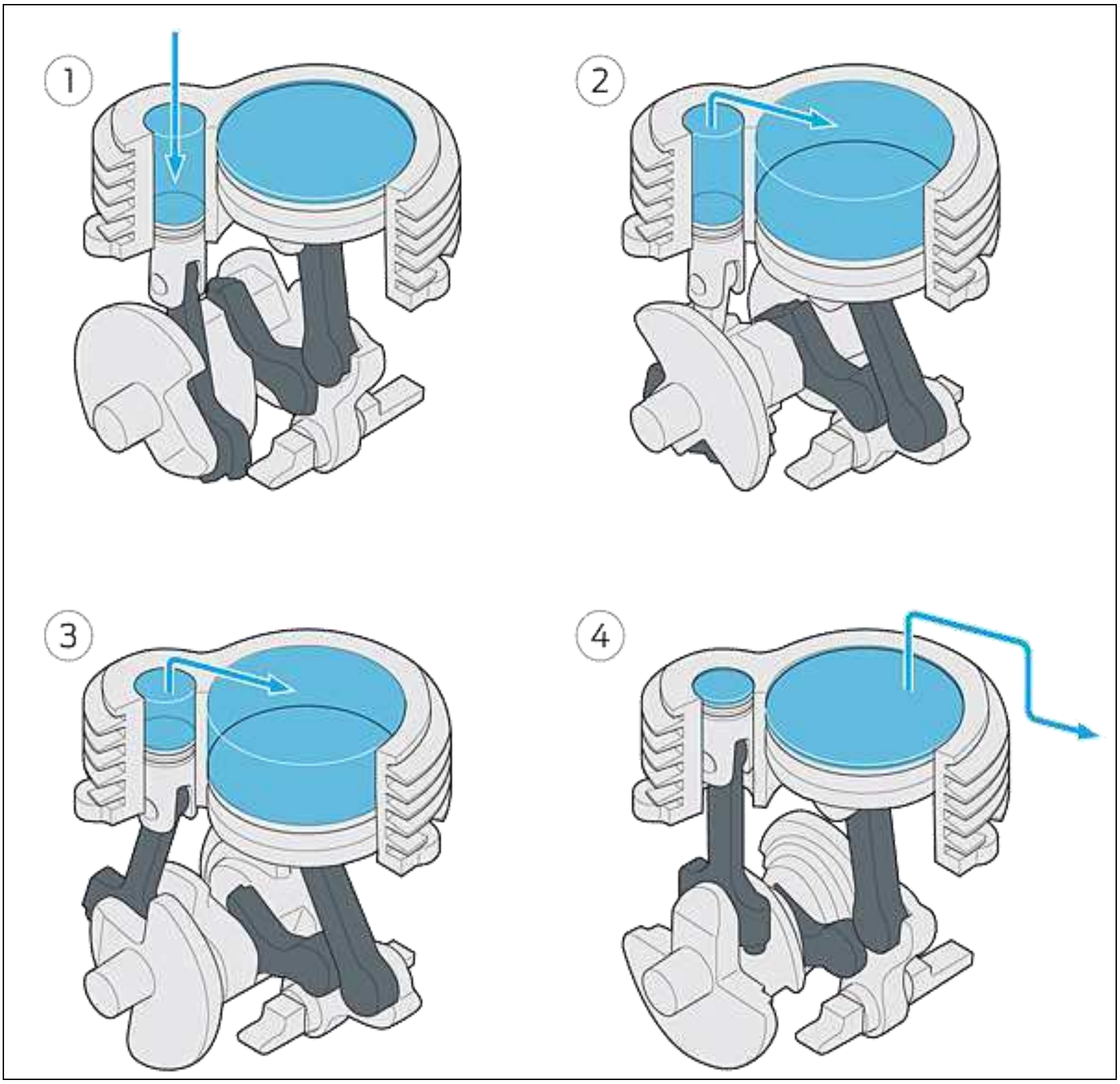
A nozzle is often a pipe or tube of varying cross sectional area, and it can be used to direct or modify the flow of a fluid (liquid or gas). Nozzles are frequently used to control the rate of flow, speed, direction, mass, shape, and/or the pressure of the stream that emerges from them. Frequently the goal is to increase the kinetic energy of the flowing medium at the expense of its pressure and internal energy.



Nozzle
Fig 2.14

Nozzles can be described as convergent (narrowing down from a wide diameter to a smaller diameter in the direction of the flow) or divergent (expanding from a smaller diameter to a larger one).

2. Study of the Compressed Air Engine and its Working:



The laws of physics dictate that uncontained gases will fill any given space. The easiest way to see this in action is to inflate a balloon. The elastic skin of the balloon holds the air tightly inside, but the moment you use a pin to create a hole in the balloon's surface, the air expands outward with so much energy that the balloon explodes. Compressing a gas into a small space is a way to store energy. When the gas expands again, that energy is released to do work. That's the basic Principle behind what makes an air car go.The first air cars will have air compressors built into them. After a brisk drive, you'll be able to take the car home, put it into the garage and plug in the compressor. The compressor will use air from around the car to refill the compressed air tank**.** Unfortunately, this is a rather slow method of refuelling and will probably take up to two hours for a complete refill. If the idea of an air car catches on, air refuelling stations will become available at ordinary gas stations, where the tank can be refilled much more rapidly with air that's already been compressed. Filling your tank at the pump will probably take about three minutes.

The first air cars will almost certainly use the Compressed Air Engine (CAE) developed by the French company, Motor Development International (MDI). Air cars using this engine will have tanks that will probably hold about 3,200 cubic feet (90.6 kiloliters) of compressed air. The vehicle's accelerator operates a valve on its tank that allows air to be released into a pipe and then into the engine, where the pressure of the air's expansion will push against the pistons and turn the crankshaft. This will produce enough power for speeds of about 35 miles (56 kilometres) per hour. When the air car surpasses that speed, a motor will kick in to operate the in-car air compressor so it can compress more air on the fly and provide extra power to the engine. The air is also heated as it hits the engine, increasing its volume to allow the car to move faster.

India's Tata Motors will likely produce the first air car in the marketplace in the next few years. Tata Motors' air car will also use the CAE engine. Although Tata announced in August 2008 that they aren't quite ready to roll out their air cars for mass production, Zero Pollution Motors still plans to produce a similar vehicle in the United States. Known collectively as the FlowAIR, these cars will cost about $17,800. The company, based in New Paltz, N.Y., says that it will start taking reservations in mid-2009 for vehicle deliveries in 2010. The company plans to roll out 10,000 air cars in the first year of production. MDI also recently unveiled the joystick-driven AirPod, the newest addition to its air car arsenal. Although the AirPod generates a top speed of only 43 mph, it's also extremely light and generates zero emissions. Major automobile makers are watching the air car market with interest. If the first models catch on with consumers, they'll likely develop their own air car models. At present, a few smaller companies are planning to bring air cars to the market in the wake of the MDI-based vehicles. These include:

K'Airmobiles -- French company K'Air Energy has built prototypes of an air-fuelled bicycle and light road vehicle based on the K'air air compression engine

Air Car Factories SA -- This Spanish company has an air car engine currently in development. The company's owner is currently involved in a dispute with former employer MDI over the rights to the technology.

AIRPOD

Fig 2.14

MDI AIR CAR

Fig 2.15

3. Design of components:

3.1. Design of Mechanical Components:

3.1.1. Design of Camshaft:

Initially, we having 4-stroke camshaft which do not works for our purpose. (i.e. compressed-air engine). Thus we converting 4-stroke into 2-stroke and made slight modifications in camshaft. Previously it was v-shaped for 4stroke, now we converting this to I-shaped i.e. the inlet & exhaust at180°. Also for continuous supply of air, to generate more torque we shaped OVAL-CAM to the individual side through180°. (i.e. in both inlet & exhaust-cams).

Design of Cam Shaft

Fig 3.1

3.1.2. Design of Timing Gear:

You take a 4-stroke engine, and make the following changes.

Change crank and cam gear ratio to 1:1 instead of 2:1, so for every revolution of the crank, the cams also turn once. Cams profiles have to be changed (new cams of course).

Fig 3.2 Camshaft Gear

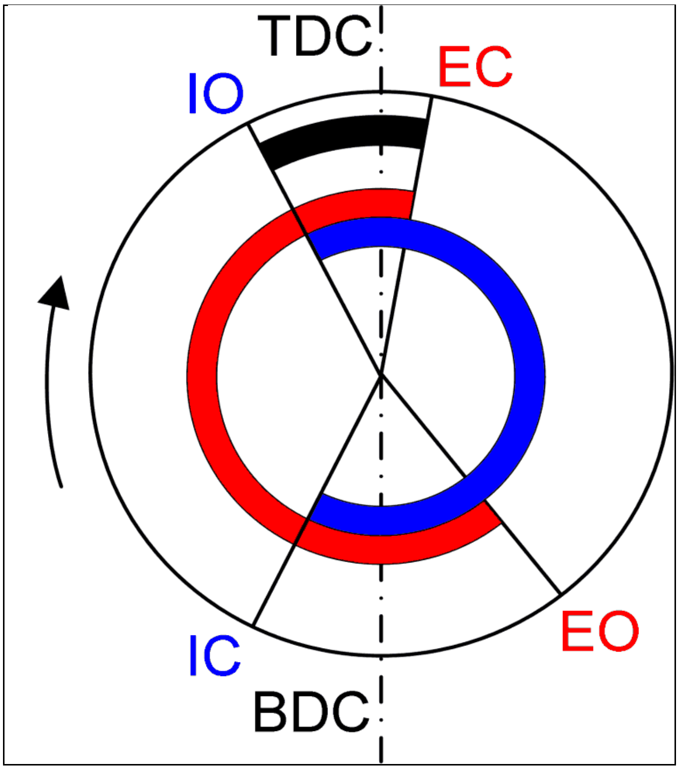


Fig 3.3 Valve Timing Diagram

Valve Timing as follows -:
Inlet Valve open - 10 degree before T.D.C.
Exhaust Valve open – 20 degree before B.D.C.
Inlet Valve close – 10 degree after B.D.C.
Exhaust Valve close – 5 degree after T.D.C.

Pressure of compressed air - 25 PSI.
R.P.M. of Crankshaft – 650- 700 R.P.M

SAFETY FEATURES OF THE CAR:-

In the case of an accident, with air tank breakage, there would be no explosion or shattering, now that the tanks are not metallic . Due to the fact that they are made of glass fibre the tanks would crack longitudinally, and the air would escape, causing a stron buzzing sound with no dangerous factor.For avoiding "Rocket effect", car is so designed that valves are placed at middle of the tanks which reduce rocket effect to minimum. In the case of loading or unloading of tank, process is so simple and safe due to presence of refilling valve at rear end.

CASE STUDY:-

Indian car maker Tata hopes to bring a car powered by compressed air — an idea that's been contemplated for years but has proved difficult to build commercially — to market. Built on technology licensed from Luxembourg's MDI, the AirPod is a light, apparently one-seated car that's supposed to be able to run at between 45 and 70 kilometers an hour (28 to 43 miles per hour). Instead of running on gas or electricity, however, the engine is powered by a tank of compressed air, which can either be pumped in through a charging station or taken in while driving with the help of an electric engine. The car can also recapture some energy during braking, similar to current hybrid vehicles. The concept still seems a bit shaky, but it could offer cheaper and more environmentally friendly recharging without waiting for something like IBM's lithium-air battery.

While MDI has been working on the technology for years, it signed a licensing agreement with Tata in early 2007, and a concept car was unveiled in late 2011. In May, the engine concept was successfully tested in two Tata cars, allowing Tata and MDI to proceed to the next phase: figuring out how to actually create a product that could go to market. We've heard nothing more so far, but it's meant to be developed "over the coming years."

4. Advantages:

Main advantages of Compressed Air Engine (C.A.E.) are:

1. Major advantage of using compressed engine is that a pure compressed air vehicle produces no pollution at the tailpipe.
2. Use of renewable fuel.
3. Compressed-air technology reduces the cost of vehicle production by about 20%, because there is no need to build a cooling system, fuel tank, Ignition Systems or silencers.
4. Air, on its own, is non-flammable.
5. The engine can be massively reduced in size.
6. The engine runs on cold or warm air, so can be made of lower strength light weight material such as aluminium, plastic, low friction teflon or a combination.
7. Low manufacture and maintenance costs as well as easy maintenance.
8. The air tank may be refilled more often and in less time than batteries can be recharged, with re-filling rates comparable to liquid fuels.
9. Lighter vehicles cause less damage to roads, resulting in lower maintenance cost.
10. The price of filling air powered vehicles is significantly cheaper than petrol, diesel or biofuel. If electricity is cheap, then compressing air will also be relatively cheap.

5. Disadvantages:

Compressed Air Engine (C.A.E.) has some disadvantages, which are:

1. Less power output
2. Probability of air leakage.
3. Tanks get very hot when filled rapidly. SCUBA tanks are sometimes immersed in water to cool them down when they are being filled. That would not be possible with tanks in a car and thus it would either take a long time to fill the tanks, or they would have to take less than a full charge, since heat drives up the pressure
4. Biggest disadvantage is the energy needed to compress the air is greater than the energy stored
5. At the supply station, compressing the air heats it, and if then directly transferred in a heated state to the vehicle storage tanks will then cool and reduce the pressure. If cooled before transfer, the energy in this heat will be lost unless sophisticated low grade heat utilization is employed
6. Within the vehicle, expansion and consequent pressure reduction in the throttle or engine chills the air, reducing its effective pressure. Addition of ambient heat will increase this pressure and this addition leads to a more complex propulsion system.

7. Passenger compartment heating is more difficult since the propulsion system does not provide a source of waste heat. Some form of heat pump, or more likely, an electric heater would be required.

Safety features of the car-

In the case of an accident, with air tank breakage, there would be no explosion or shattering, now that the tanks are not metallic . Due to the fact that they are made of glass fibre the tanks would crack longitudinally, and the air would escape, causing a strong buzzing sound with no dangerous factor. For avoiding “Rocket effect”, car is so designed that valves are placed at middle of the tanks which reduce rocket effect to minimum. In the case of loading or unloading of tank, process is so simple and safe due to presence of refilling valve at rear end.

6. Applications:

The compressed air engine can be used in many vehicles. Some of its applications to be used as engine for vehicles are:

(a) Mopeds

Jem Stansfield, an English inventor has been able to convert a regular scooter to a compressed air moped. This has been done by equipping the scooter with a compressed air engine and air tank.

(b) Buses

MDI makes MultiCATs vehicle that can be used as buses or trucks. RATP has also already expressed an interest in the compressed-air pollution-free bus.

(c) Locomotives

Compressed air locomotives have been historically used as mining locomotives and in various areas.

(d) Trams

Various compressed-air-powered trams were trailed, starting in 1876 and has been successfully implemented in some cases.

(e) Watercraft and aircraft

Currently, no water or air vehicles exist that make use of the air engine. Historically compressed air engines propelled certain torpedoes.

Chapter 4. Conclusion

- The model designed by us is a small scale working model of the compressed air engine. When scaled to higher level it can be used for driving automobiles independently or combined (hybrid) with other engines like I.C. engines.
- Compressed air technology allows for engines that are both non-polluting and economical.
- Unlike electric and hydrogen powered vehicles compressed air vehicles are not expensive and do not have limiting driving range.
- Compressed air vehicles are easy to get around in cities and have performance rate that stands up to current standards.

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