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Compressed Air Vehicle

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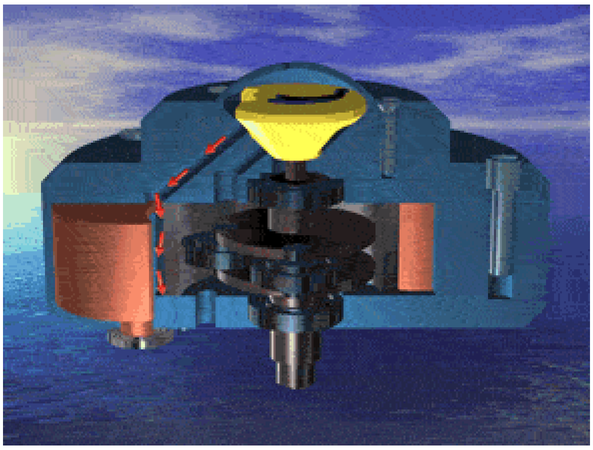
Abstract:

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. 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.

AIR ENGINE HISTORY

Angelo Di Petro's Rotary Positive Displacement Air Engine:-



Everything I've heard about this air engine is positive. Many people have written asking me to report on it, but the show you a picture and a Based on what is said about the engine, I think it sounds like a good idea. It seems like a good approach to simplifying the piston engine while lowering friction and wear. Quoting from the website,

"The space between stator and rotor is divided in 6 expansion chambers by pivoting dividers. These dividers follow the motion of the shaft driver as it rolls around the stator wall.

The motor shown is effectively a 6 cylinder expansion motor...Variation of performance parameters of the motor is easily achieved by varying the time during which the air is allowed to enter the chamber: A longer air inlet period allows more air to flow into the chamber and therefore results in more torque. A shorter inlet period will limit the air supply and allows the air in the chamber to perform expansion work at a much higher efficiency. In this way compressed air (energy) consumption can be exchanged for higher torque and power output depending on the requirements of the application...Motor speed and torque are simply controlled by throttling the amount or pressure of air into the motor. The Di Pietro motor gives instant torque at zero RPM and can be precisely controlled to give soft start and acceleration control."

From what I've read, I think this sounds like what other people have wished they could invent. A lot of people are counting on Mr. Di Pietro to get an air car on the market.

Spark Ignition Engine

A spark ignition (SI) engine runs on an Otto cycle—most gasoline engines run on a modified Otto cycle. This cycle uses a homogeneous air-fuel mixture which is combined prior to entering the combustion chamber. Once in the combustion chamber, the mixture is compressed, and then ignited using a spark plug (spark ignition). The SI engine is controlled by limiting the

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amount of air allowed into the engine. This is accomplished through the use of a throttling valve placed on the air intake (carburetor or throttle body). Mitsubishi is working on the development of a certain type of SI engine called the gasoline direct injection engine.

INTRODUCTION

Ball and roller bearings are used widely in instruments and machines in order to minimize friction and power loss. While the concept of the ball bearing dates back at least to Leonardo da Vinci, their design and manufacture has become remarkably sophisticated. This technology was brought to its p resent state o f perfection only after a long period of research and development. The benefits of such specialized research can be obtained when it is possible to use a standardized bearing of the proper size and type. However, such bearings cannot be used indiscriminately without a careful study of the loads and operating conditions. In addition, the bearing must be provided with adequate mounting, lubrication and sealing. Design engineers have usually two possible sources for obtaining information which they can use to select a bearing for their particular application:

a) Textbooks
b) Manufacturers'

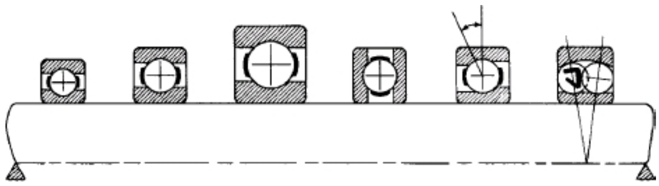
Catalogs Textbooks are excellent sources; however, they tend to be overly detailed and aimed at the student of the subject matter rather than the practicing designer. They, in most cases, contain information on how to design rather than how to select a bearing for a particular application. Manufacturers' catalogs, in turn, are also excellent and contain a wealth of information which relates to the products of the particular manufacturer. These catalogs, however, fail to provide alternatives – which may divert the designer's interest to products not manufactured by them. Our Company, however, provides the broadest selection of many types of bearings made by different manufacturers.

For this reason, we are interested in providing a condensed overview of the subject matter in an objective manner, using data obtained from different texts, handbooks and manufacturers' literature. This information will enable the reader to select the proper bearing in an expeditious manner. If the designer's interest exceeds the scope of the presented material, a list of references is provided at the end of the Technical Section. At the same time, we are expressing our thanks and are providing credit to the sources which supplied the material presented here.

Construction and Types of Ball Bearings

A ball bearing usually consists of four parts: an inner ring, an outer ring, the balls and the cage or separator.

To increase the contact area and permit larger loads to be carried, the balls run in curvilinear grooves in the rings. The radius of the groove is slightly larger than the radius of the ball, and a very slight amount of radial play must be provided. The bearing is thus permitted to adjust itself to small amounts of angular misalignment between the assembled shaft and mounting. The separator keeps the balls evenly spaced and prevents them from touching each other on the sides where their relative velocities are the greatest. Ball bearings are made in a wide variety of types and sizes. Single-row radial bearings are made in four series, extra light, light, medium, and heavy, for each bore, as illustrated in Fig. 1-3(a), (b), and (c).



100 Series 200 Series 300 Series Axial Thrust Angular Contact Self-aligning Bearing Fig. 1-3 Types of Ball Bearings

The heavy series of bearings is designated by 400. Most, but not all, manufacturers use a numbering system so devised that if the last two digits are multiplied by 5, the result will be the bore in

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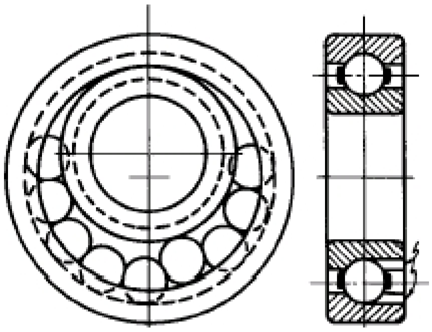
millimeters.The digit in the third place from the right indicates the series number. Thus, bearing 307 signifies a medium-series bearing of 35-mm bore. For additional digits, which may be present in the catalog number of a bearing, refer to manufacturer's details.



Some makers list deep groove bearings and bearings with two rows of balls. For bearing designations of Quality Bearings & Components (QBC), see special pages devoted to this purpose The radial bearing is able to carry a considerable amount of axial thrust. However, when the load is directed entirely along the axis, the thrust type of bearing should be used. The angular contact bearing will take care of both radial and axial loads.

The self-aligning ball bearing will take care of large amounts of angular misalignment. An increase in radial capacity may be secured by using rings with deep grooves, or by employing a double-row radial bearing. Radial bearings are divided into two general classes, depending on the method of assembly. These are the Conrad, or non filling-notch type, and the maximum or filling-notch type. In the Conrad bearing, the balls are placed between the rings as shown in Fig. 1-4(a). Then they are evenly spaced and the separator is riveted in place. In the maximum-type bearing, the balls are a (a) (b) (c) (d) (e) (f) 100 Series Extra Light 200 Series Light 300 Series Medium Axial Thrust Bearing Angular Contact Bearing Self-aligning Bearing Fig. 1-3 Types of Ball Bearings Fig. 1-4 Methods of Assembly for Ball Bearings (a) Conrad or non-filling notch type (b) Maximum or filling notch type

SPROCKET WITH CHAIN DRIVE

This is a cycle chain sprocket. The chain sprocket is coupled with another generator shaft. The chain converts rotational power to pulling power, or pulling power to rotational power, by engaging with the sprocket.

The sprocket looks like a gear but differs in three important ways:

- Sprockets have many engaging teeth; gears usually have only one or two.
- The teeth of a gear touch and slip against each other; there is basically no slippage in a sprocket.
- The shape of the teeth is different in gears and sprockets.

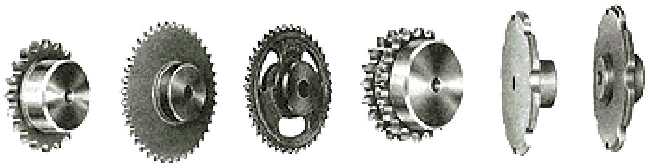


Figure Types of Sprockets

Engagement with Sprockets:

Although chains are sometimes pushed and pulled at either end by cylinders, chains are usually driven by wrapping them on sprockets. In the following section, we explain the relation between sprockets and chains when power is transmitted by sprockets.

1. Back tension

First, let us explain the relationship between flat belts and pulleys. Figure 2.5 shows a rendition of a flat belt drive. The circle at the top is a pulley, and the belt hangs down from each side. When the pulley is fixed and the left side of the belt is loaded with tension (T0), the force needed to pull the belt down to the right side will be:

T1 = T0 3 eμu

For example, T0 = 100 N: the coefficient of friction between the belt and pulley, μ = 0.3; the wrap angle u = ¼ (180).

T1 = T0 3 2.566 = 256.6 N

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In brief, when you use a flat belt in this situation, you can get 256.6 N of drive power only when there is 100 N of back tension.
For elements without teeth such as flat belts or ropes, the way to get more drive power is to increase the coefficient of friction or wrapping angle. If a substance, like grease or oil, which decreases the coefficient of friction, gets onto the contact surface, the belt cannot deliver the required tension.

In the chain's case, sprocket teeth hold the chain roller. If the sprocket tooth configuration is square, as in Figure 2.6, the direction of the tooth's reactive force is opposite the chain's tension, and only one tooth will receive all the chain's tension. Therefore, the chain will work without back tension.

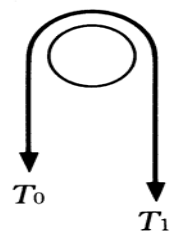

Figure Flat Belt Drive

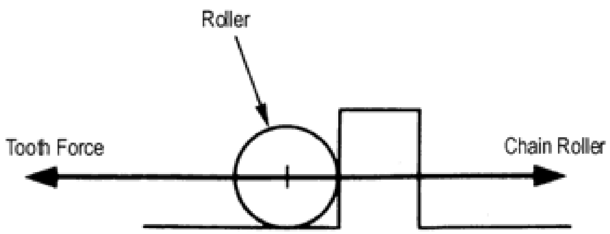

Figure Simplified Roller/Tooth Forces

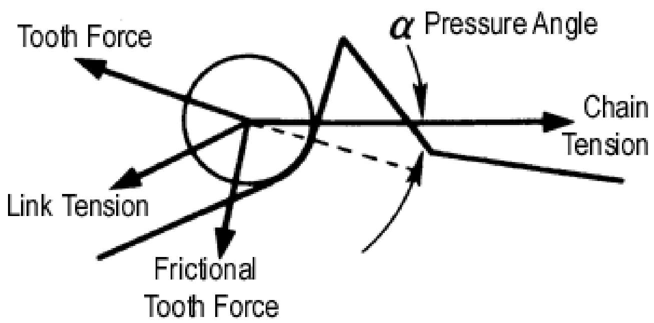

Figure The Balance of Forces Around the Roller

But actually, sprocket teeth need some inclination so that the teeth can engage and slip off of the roller. The balances of forces that exist around the roller are shown in Figure 2.7, and it is easy to calculate the required back tension.

For example, assume a coefficient of friction μ = 0, and you can calculate the back tension (Tk) that is needed at sprocket tooth number k with this formula:

Tk = T0 3 sin ø k-1
sin(ø + 2b) Where:

Tk= back tension at tooth k
T0 = chain tension
ø = sprocket minimum pressure angle 17 64/N(š)
N = number of teeth
2b = sprocket tooth angle (360/N)
k = the number of engaged teeth (angle of wrap 3 N/360); round down to the nearest whole number to be safe

By this formula, if the chain is wrapped halfway around the sprocket, the back tension at sprocket tooth number six is only 0.96 N. This is 1 percent of the amount of a flat belt.

Using chains and sprockets, the required back tension is much lower than a flat belt. Now let's compare chains and sprockets with a toothed-belt back tension. Although in toothed belts the allowable tension can differ with the number of pulley teeth and the revolutions per minute (rpm), the general recommendation is to use 1/3.5 of the allowable tension as the back tension (F). This is shown in below Figure 2.8. Therefore, our 257 N force will require 257/3.5 = 73 N of back tension. Both toothed belts and chains engage by means of teeth, but chain's back tension is only 1/75 that of toothed belts.

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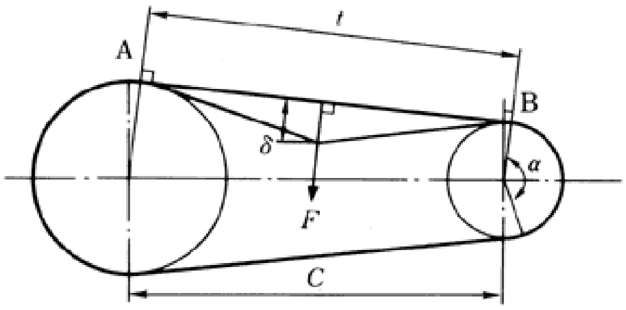

Figure 2.8 Back Tension on a Toothed Belt

Chain wear and jumping sprocket teeth

The key factor causing chain to jump sprocket teeth is chain wear elongation (see Basics Section 2.2.4). Because of wear elongation, the chain creeps up on the sprocket teeth until it starts jumping sprocket teeth and can no longer engage with the sprocket.

Figure 2.9 shows sprocket tooth shape and positions of engagement. Figure 2.10 shows the engagement of a sprocket with an elongated chain.

In Figure 2.9 there are three sections on the sprocket tooth face:

- Bottom curve of tooth, where the roller falls into place;
- Working curve, where the roller and the sprocket are working together;
- Where the tooth can guide the roller but can't transmit tension. If the roller, which should transmit tension, only engages with C, it causes jumped sprocket teeth.

The chain's wear elongation limit varies according to the number of sprocket teeth and their shape, as shown in Figure 2.11. Upon calculation, we see that sprockets with large numbers of teeth are very limited in stretch percentage. Smaller sprockets are limited by other harmful effects, such as high vibration and decreasing strength; therefore, in the case of less than 60 teeth, the stretch limit ratio is limited to 1.5 percent (in transmission chain).

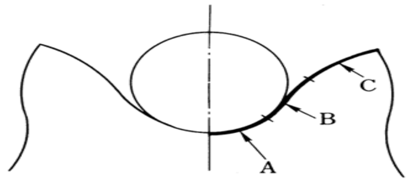

Figure 2.9 Sprocket Tooth Shape and Positions of Engagement

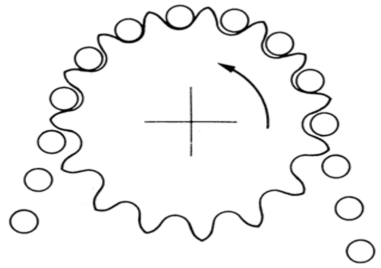

Figure 2.10 The Engagement Between a Sprocket and an Elongated Chain

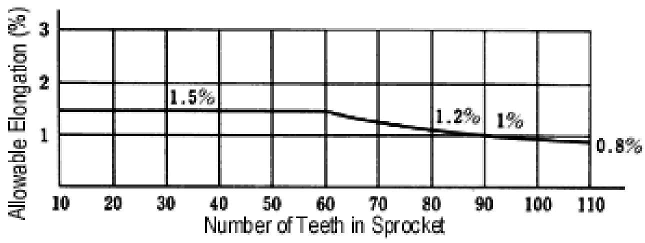

Figure 2.11 Elongations versus the Number of Sprocket Teeth

In conveyor chains, in which the number of working teeth in sprockets is less than transmission chains, the stretch ratio is limited to 2 percent. Large pitch conveyor chains use a straight line in place of curve B in the sprocket tooth face. A chain is a reliable machine component, which transmits power by means of tensile forces, and is used primarily for power transmission and conveyance systems. The function and uses of chain are similar to a belt. There are many kinds of chain. It is convenient to sort types of chain by either material of composition or method of construction.

We can sort chains into five types:

- Cast iron chain.
- Cast steel chain.
- Forged chain.
- Steel chain.

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Plastic chain.

Demand for the first three chain types is now decreasing; they are only used in some special situations. For example, cast iron chain is part of water-treatment equipment; forged chain is used in overhead conveyors for automobile factories.

In this book, we are going to focus on the latter two: "steel chain," especially the type called "roller chain," which makes up the largest share of chains being produced, and "plastic chain." For the most part, we will refer to "roller chain" simply as "chain."

NOTE: Roller chain is a chain that has an inner plate, outer plate, pin, bushing, and roller.

In the following section of this book, we will sort chains according to their uses, which can be broadly divided into six types:

1. Power transmission chain.
2. Small pitch conveyor chain.
3. Precision conveyor chain.
4. Top chain.
5. Free flow chain.
6. Large pitch conveyor chain.

The first one is used for power transmission; the other five are used for conveyance. In the Applications section of this book, we will describe the uses and features of each chain type by following the above classification.

In the following section, we will explain the composition of power transmission chain, small pitch chain, and large pitch conveyor chain. Because there are special features in the composition of precision conveyor chain, top chain, and free flow chain, checks the appropriate pages in the Applications section about these features.

Basic Structure of Power Transmission Chain

A typical configuration for RS60-type chain is shown in Figure 1.1.

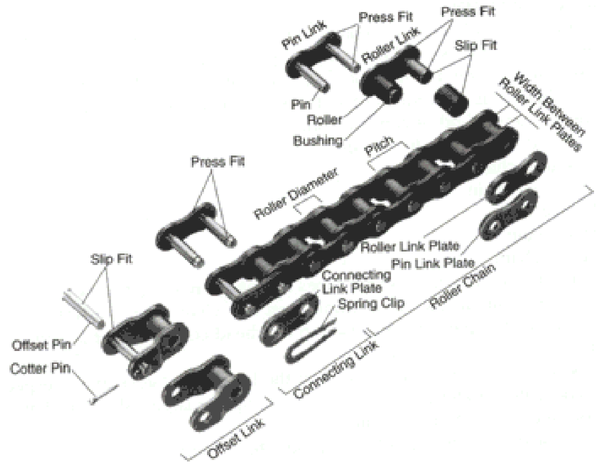

Figure 1.1 The Basic Components of Transmission Chain

Connecting Link

This is the ordinary type of connecting link. The pin and link plate are slip fit in the connecting link for ease of assembly. This type of connecting link is 20 percent lower in fatigue strength than the chain itself. There are also some special connecting links which have the same strength as the chain itself. (See Figure 1.2)

Tap Fit Connecting Link

In this link, the pin and the tap fit connecting link plate are press fit. It has fatigue strength almost equal to that of the chain itself. (See Figure 1.2)

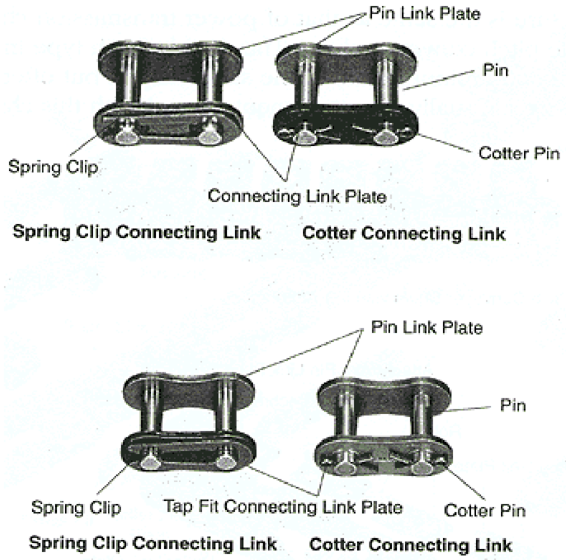

Figure 1.2 Standard Connecting Link (top) and Tap Fit Connecting Link (bottom)

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Offset Link:

An offset link is used when an odd number of chain links is required. It is 35 percent lower in fatigue strength than the chain itself. The pin and two plates are slip fit. There is also a two-pitch offset link available that has fatigue strength as great as the chain itself. (See Figure 1.3)

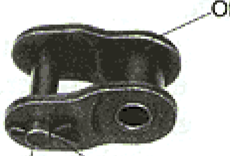

Figure 1.3 Offset Link

COMPRESSED AIR ENGINE PRINCIPLE

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. 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. ENGINE:

A Compressed-air engine is a pneumatic actuator that creates useful work by expanding compressed air. They have existed in many forms over the past two centuries, ranging in size from hand held turbines up to several hundred horsepower. 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 can buy the vehicle with the engine or buy an engine to be installed in the vehicle. Typical air engines use one or more expander pistons. In some applications it is advantageous to heat the air, or the engine, to increase the range or power.

2. TANKS:

The tanks must be designed to safety standards appropriate for a pressure vessel, such as ISO 11439.
The storage tank may be made of:

- steel,
- aluminium ,
- carbon fiber,
- Kevlar,
- Other materials or combinations of the above.

The fiber materials are considerably lighter than metals but generally more expensive. Metal tanks can withstand a large number of pressure cycles, but must be checked for corrosion periodically. One company stores air in tanks at 4,500 pounds per square inch (about 30 MPa) and hold nearly 3,200 cubic feet (around 90 cubic metres) of air.
The tanks may be refilled at a service station equipped with heat exchangers, or in a few hours at home or in parking lots, plugging the car into the electrical grid via an on-board compressor.

3. COMPRESSED AIR:

Compressed air has a low energy density. In 300 bar containers, about 0.1 MJ/L and 0.1 MJ/kg is achievable, comparable to the values of electrochemical lead-acid batteries. While batteries can somewhat maintain their voltage throughout their discharge and chemical fuel tanks provide the same power densities from the first to the last litre, the pressure of compressed air tanks falls as air is drawn off.

A consumer-automobile of conventional size and shape typically consumes 0.3-0.5 kWh (1.1-1.8 MJ) at the drive shaft per mile of use, though unconventional sizes may perform with significantly less.

4. EMISSION OUTPUT:

Like other non-combustion energy storage technologies, an air vehicle displaces the emission source from the vehicle's tail pipe to the central electrical generating plant. Where emissions-free sources are available, net production of pollutants can be reduced. Emission control measures at a central generating plant may be more effective and less costly than treating the emissions of widely-dispersed vehicles.

Since the compressed air is filtered to protect the compressor machinery, the air discharged has less suspended dust in it, though there may be carry-over of lubricants used in the engine.

WORKING PRINCIPLE

Today, internal combustion engines in cars, trucks, motorcycles, aircraft, construction machinery and many others, most commonly use a four-stroke cycle. The four strokes refer to intake, compression, combustion (power), and exhaust strokes that occur during two crankshaft rotations per working cycle of the gasoline engine and diesel engine.

The cycle begins at Top Dead Center (TDC), when the piston is farthest away from the axis of the crankshaft. A stroke refers to the full travel of the piston from Top Dead Center (TDC) to Bottom Dead Center (BDC).

1. INTAKE stroke:

On the intake or induction stroke of the piston , the piston descends from the top of the cylinder to the bottom of the cylinder, reducing the pressure inside the cylinder. A mixture of fuel and air is forced by atmospheric (or greater) pressure into the cylinder through the intake port. The intake valve(s) then close.

2. COMPRESSION stroke:

With both intake and exhaust valves closed, the piston returns to the top of the cylinder compressing the fuel-air mixture. This is known as the compression stroke.

3. POWER stroke:

While the piston is close to Top Dead Center, the compressed air–fuel mixture is ignited, usually by a spark plug (for a gasoline or Otto cycle engine) or by the heat and pressure of compression (for a diesel cycle or compression ignition engine). The resulting massive pressure from the combustion of the compressed fuel-air mixture drives the piston back down toward bottom dead center with tremendous force. This is known as the power stroke, which is the main source of the engine's torque and power.

4. EXHAUST stroke:

During the exhaust stroke, the piston once again returns to top dead center while the exhaust valve is open. This action evacuates the products of combustion from the cylinder by pushing the spent fuel-air mixture through the exhaust valve(s).

In our project we have to modified these four strokes into totally two stoke with the help of inner CAM alteration. In air engine we can design a new CAM which is operate only Inlet stroke and exhaust stroke. Actually in four stroke engine the inlet and exhaust valve opens only one time to complete the total full cycle. In that time the piston moving from top dead center to bottom dead center for two times. A stroke refers to the full travel of the piston from Top Dead Center (TDC) to Bottom Dead Center (BDC).
In our air engine project, we have to open inlet and exhaust valve in each and every stroke of the engine so that it will convert the four st

DESIGN:

1. DESIGN OF BALL BEARING

Bearing No. 6202

Outer Diameter of Bearing (D)   = 35 mm
Thickness of Bearing (B) = 12 mm
Inner Diameter of the Bearing (d) =15 mm

r_1 = Corner radii on shaft and housing
r_1 = 1 (From design data book)
Maximum Speed = 14,000 rpm (From design data book)
Mean Diameter (d_m) = $(D+d)/2$
= $(35+15)/2$
d_m = 25 mm

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1. ENGINE DESIGN CALCULATIONS:-

DESIGN AND ANYLSIS ON TEMPERATURE DISTRIBUTION FOR TWO-STROKE ENGINE COMPONENT USING FINITE ELEMENT METHOD:

SPECIFICATION OF FOUR STROKE PETROL ENGINE:

Type	:	four strokes
Cooling System	:	Air Cooled
Bore/Stroke	:	50 x 50 mm
Piston Displacement	:	98.2 cc
Compression Ratio	:	6.6: 1
Maximum Torque	:	0.98 kg-m at 5,500RPM

CALCULATION:

Compression ratio = (Swept Volume + Clearance Volume)/ Clearance Volume

Here,

Compression ratio = 6.6:1

∴ 6.6 = (98.2 + Vc)/Vc

Vc = 19.64

Assumption:

1. The component gases and the mixture behave like ideal gases.
2. Mixture obeys the Gibbs-Dalton law

Pressure exerted on the walls of the cylinder by air is P_1

P_1 = $(M_1RT)/V$

Here,

M_1 = m/M = (Mass of the gas or air)/(Molecular Weight)

R = Universal gas constant = 8.314 KJ/Kg mole K.

T_1 = 303 ºK

V_1 = V = $253.28 \times 10^{-6}\ m^3$

Molecular weight of air = Density of air x V mole

Here,

Density of air at 303ºK = 1.165 kg/m³

V mole = 22.4 m³/Kg-mole for all gases.

∴Molecular weight of air = 1.165 x 22.4

∴P_1 = $\{[(m_1/(1.165 \times 22.4)] \times 8.314 \times 303\}/253.28 \times 10^{-6}$

P_1 = $381134.1\ m_1$

Let Pressure exerted by the fuel is P_2

P_2 = $(N_2\ R\ T)/V$

Density of petrol = 800 Kg/m³

∴P_2 = $\{[(M_2)/(800 \times 22.4)] \times 8.314 \times 303\}/(253.28 \times 10^{-6}$

P_2 = $555.02\ m_2$

Therefore Total pressure inside the cylinder

P_T = $P_1 + P_2$

= 1.01325 x 100 KN/m²

∴$381134.1\ m_1 + 555.02\ m_2$ = 1.01325 x 100 ----------------------- (1)

Calculation of air fuel ratio:

Carbon = 86%

Hydrogen = 14%

We know that,

1Kg of carbon requires 8/3 Kg of oxygen for the complete combustion.

1Kg of carbon sulphur requires 1 Kg of Oxygen for its complete combustion.

(From Heat Power Engineering- Balasundrrum)

Therefore,

The total oxygen requires for complete combustion of 1 Kg of fuel

= $[(8/3c) + (3H_2) + S]$ Kg

Little of oxygen may already present in the fuel, then the total oxygen required for complete combustion of Kg of fuel

= $\{[(8/3c) + (8H_2) + S] - O_2\}$ Kg

As air contains 23% by weight of Oxygen for obtain of oxygen amount of air required

= 100/23 Kg

∴Minimum air required for complete combustion of 1 Kg of fuel

= $(100/23)\{[(8/3c) + H_2 + S] - O_2\}$ Kg

So for petrol 1Kg of fuel requires = $(100/23)\{[(8/3c) \times 0.86 + (8 \times 0.14)]\}$

= 14.84 Kg of air

∴Air fuel ratio = m_1/m_2 = 14.84/1

= 14.84

∴m_1 = $14.84\ m_2$--------------------- (2)

Substitute (2) in (1)

1.01325 x 100 = $3.81134\,(14.84\ m_2) + 555.02\ m_2$

∴m_2 = 1.791×10^{-3} Kg/Cycle

Mass of fuel flow per cycle = 1.791×10^{-3} Kg cycle

Therefore,

Mass flow rate of the fuel for 2500 RPM

= $[(1.791 \times 10^{-3})/3600] \times (2500/2) \times 60$

= 3.731×10^{-4} Kg/sec

Calculation of calorific value:

By Delong's formula,

Higher Calorific Value = $33800\ C + 144000\ H_2 + 9270\ S$

= $(33800 \times 0.86) + (144000 \times 0.14) + 0$

HCV = 49228 KJ/Kg

Lower Calorific Value = $HCV - (9H_2 \times 2442)$

= $49228 - [(9 \times 0.14) \times 2442]$

= 46151.08 KJ/Kg

LCV = 46.151 MJ/Kg

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Finding cp and cv for the mixture:

We know that,

Air contains 77% N_2 and 23% O_2 by weight

But total mass inside the cylinder = $m_1 + m_2$

= $2.65 \times 10^{-4} + 1.791 \times 10^{-5}$ Kg

= 2.8291×10^{-4} Kg

(1) Weight of nitrogen present = 77% = 0.77 Kg in 1 Kg of air

∴In 2.65×10^{-4} Kg of air contains,

= $0.77 \times 2.65 \times 10^{-4}$ Kg of

= 2.0405×10^{-4} Kg

Percent of N_2 present in the total mass

= $(2.0405 \times 10^{-4} / 2.8291 \times 10^{-4})$

= 72.125 %

(1) Percentage of oxygen present in 1 Kg of air is 23%

Percentage of oxygen present in total mass

= $(0.23 \times 2.65 \times 10^{-4}) / (2.8291 \times 10^{-4})$

= 21.54 %

(2) Percentage of carbon present in 1 Kg of fuel 86%

Percentage of carbon present in total mass

= $(0.866 \times 1.791 \times 10^{-5}) / (2.8291 \times 10^{-4})$

= 5.444%

(3) Percentage of Hydrogen present in 1 Kg of fuel 14%

Percentage of Hydrogen present in total mass

= $(0.14 \times 1.791 \times 10^{-5}) / (2.8291 \times 10^{-4})$

= 0.886 %

Total Cp of the mixture is = ∑msi Cpi

Cp = $(0.72125 \times 1.043) + (0.2154 \times 0.913) + (0.54444 \times 0.7) + (8.86 \times 10^{-3} \times 14.257)$

Cp = 1.1138 KJ/Kg.K

Cv = ∑msi Cvi

= $(0.72125 \times 0.745) + (0.2154 \times 0.653) + (0.05444 \times 0.5486) + (8.86 \times 10^{-3} \times 10.1333)$

= 0.8 KJ/Kg.K

(All Cvi, Cpi values of corresponding components are taken from clerks table)

n For the mixture = (Cp/Cv)

= 1.11/0.8

n = 1.38

Pressure and temperature at various PH:

P_1 = 1.01325 x 100 bar

= 1.01325 bar

T_1 = 30°C = 303 K

$P_2/P_1 = (r)^{n-1}$

Where,

P_1 = 1.01325 bar

r = 6.6

n = 1.38

∴P_2 = 13.698 bar

$T_2 = (r)^{n-1} \times T_1$

Where,

T_1 = 303 K

∴T_2 = 620.68

Heat Supplied by the fuel per cycle

Q = MCv

= $1.79 \times 10^{-5} \times 46151.08$

Q = 0.8265 KJ/Cycle

0.8265 = $MCv (T_3 - T_2)$

T_3 = 4272.45 K

$(P_2 V_2) / T_2 = (P_3 V_3) / T_3$

Where,

$V_2 = V_3$

∴$P_3 = (T_3 \times P_2)/T_2$

Where,

P_3 = 94.27 bar

$P_4 = P_3 / (r)^n$

∴P_4 = 6.973 bar

$T_4 = T_3 / (r)^{n-1}$

= 2086.15 K

POINT POSITION	PRESSURE (bar)	TEMPERATURE	
POINT-1	1.01325	30°C	303 K
POINT-2	13.698	347.68°C	620.68K
POINT-3	94.27	3999.45°C	4272.45 K
POINT-4	6.973	1813.15°C	2086.15 K

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DESIGN OF ENGINE PISTON:

We know diameter of the piston which is equal to 50 mm

Thickness of piston:

The thickness of the piston head is calculated from flat-plate theory

Where,

t = D (3/16 x P/f)½

Here,

P - Maximum combustion pressure = 100 bar

f - Permissible stress in tension = 34.66 N/mm²

Piston material is Aluminium alloy.

∴t = 0.050 (3/16 x 100/34.66 x $10^6/10^5$)½ x 1000

= 12 mm

Number of Piston Rings:

No. of piston rings = 2 x D½

Here,

D - Should be in Inches = 1.968 inches

∴ No. of rings = 2.805

We adopt 3 compression rings and 1 oil rings

Thickness of the ring:

Thickness of the ring = D/32

= 50/32

= 1.5625 mm

Width of the ring:

Width of the ring = D/20

= 2.5 mm

The distance of the first ring from top of the piston equals

= 0.1 x D

= 5 mm

Width of the piston lands between rings

= 0.75 x width of ring = 1.875 mm

Length of the piston:

Length of the piston = 1.625 x D

Length of the piston = 81.25 mm

Length of the piston skirt = Total length – Distance of first ring from top of The first ring (No. of landing between rings x Width of land) – (No. of compression ring x Width of ring)

= 81.25 – 5 – 2 x 1.875 – 3 x 2.5

= 65 mm

Other parameter:

Centre of piston pin above the centre of the skirt = 0.02 x D

= 65 mm

The distance from the bottom of the piston to the Centre of the piston pin = ½ x 65 + 1

= 33.5 mm

Thickness of the piston walls at open ends = ½ x 12

= 6 mm

The bearing area provided by piston skirt = 65 x 50

= 3250 mm²

3 DESIGN OF CHAIN SPROCKET DRIVE:

DESIGN OF CHAIN DRIVE:

STEP 1: DETERMINATION OF TRANSMISSION RATIO

n_1 = 20

n_2 = 16

Transmission ratio, (i) = z_2/z_1 = n_1/n_2

= 20/16 = 1.26 1.25 (approx)

STEP 2: SELECTION OF NO. OF TEETH ON DRIVER SPROCKET

z_1 = 15

z_2 = i z_1

= 1.25 x 15 = 19

STEP 3: CENTER DISTANCE

a = (30 to 50)p

a = 150 mm

p max = a/30 = 150/30 = 5 mm

P min = a/50 = 150/50 = 3 mm

P = 9.525 is chosen

STEP 4: SELECTION OF CHAIN

Assume the chain to be Duplex

From table 7.72

For duplex DR 50

10 A-Z DR 50 is chosen

STEP 5 : TOTAL LOAD ON THE DRIVING SIDE CHAIN

Σp = pt + pc + ps

pt = 102 x 0.75/0.0476 =160.71 kgf

v = No. of teeth on driver sprocket x pitch x rpm/60 x 1000

= 15 x 9.525 x 20/60 x 1000 = 47.62 mm/sec

pt = 102 x 0.75 /0.0476 = 160.71 kgf

pc = wv²/g (From page 7.72) for duplex DR 50 (P.No. 7.72)

w = 1.78 kg/m

pc = 1.78 x (0.0476)²/9.81 =4.8 kgf

Tension due to staging by chain,

ps = 6 x1.78 x 0.5 = 5.34 kgf

Σ_1p = 5.34 +4.8+160.71 = 170.85 kgf

STEP 6: DESIGN LOAD

Design load = Ks x Σp

Ks = $k_1k_2k_3k_4k_5k_6$

k_1 = Load factor = 1.25

k_2 = 1 for adjustable supports

k_3 = 1 for a = 30 to 50 p

k_4 = 1 for horizontal drives (P.no. 7.76)

k_5 = 1 for drop lubrication

k_6 = 1.25 x 1 x 1 x 1 x 1 x 1.25

∴k = 1.5625

Design load = 1.5625 x 170.85

= 266.95 kgf

STEP 7: FACTOR OF SAFETY

FOS = Breaking load/Total load = [b]

For DR 50

Breaking load = 4440 kgf

FOS = 4440/170.85 = 25.98

(Page no. 7.77)

n =11 for pitch is 20 and 16 rpm

[11.26]

Design is safe

STEP 8: BEARING STRESS ON ROLLERS

Induced stress (σ) =pc x ks /A

A = 1.4 cm²= 140 mm

Σ = 160.71 x 1.5625/140

= 1.79 kgf/mm²

STEP 9: ALLOWABLE BEARING STRESS (σ)

σ = 2.24 kgf/mm²

σ = 1.79 < 2.24

Design is safe.

STEP 10: LENGTH OF THE CHAIN

Lp = $2a_p + (z_1+z_3)/2 + ((z_2-z_1)/2\pi)\pi^2/a_p$

Ap = a_0/p = 150/150875 = 11.44

Lp = 15 links

Length of chain (l) = Lp x p

= 15 x 0.043 = 66.55

STEP 11: CORRECTED CENTRE DISTANCE

a = (e + √(e²-8m))/4

Where,

e = lp-((z_1+z_2)/2)

m = ((z_2-z_1)2π)²

= 162.5 mm

STEP 12: SPROCKET DIAMETER

d1 = (p/sin (180/Z_1))

= 66.5 mm

d_2 = (p/sin (180/Z_2))

= 85 mm

SPECIFICATIONS:

1) Type of chain = A-Z DR 50 roller chain
2) Center distance =162.5 mm
3) No. of teeth on the pinion sprocket = 15
4) No. of teeth on the wheel sprocket = 19
5) Length of the chain = 62.5 mm
6) Diameter of piston sprocket = 66.55 mm
7) Diameter of wheel sprocket = 85 mm

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DESIGN OF RATCHET AND PAWL:

STEP 1:

Module (m) = D/Z

= 130/28

= 64 mm

P = 2N4/D (Page 7.85)

P = 75 (Assume)

75 = 2 Mt/130

Mt = 4875

STEP 2:

B = ψm

Ψ = 1.5 (Assume)

B = 1.5 x 4.64

= 6.96

STEP 3:

m = $2 \times \sqrt[3]{Mt/z\psi [\sigma h]}$

= $2 \times \sqrt[3]{(875/28 \times 6.96 \times 300)}$

= 2 x 0.4368 = 0.873

STEP 4:

Diameter of the pawl pins:

d = $2.71 \times \sqrt[3]{p/2[\sigma h](b/2+a_1)}$

= $2.71 \times \sqrt[3]{(5/600x(6.96/2 \times 15))}$

= 55 mm

STEP 5:

SPECIFICATIONS:

- Diameter of the ratchet = 130 mm
- Width of the ratchet = 15 mm
- No. of teeth of the ratchet = 28 Teeth

LIST OF MATERIALS

Sl. No.	PARTS	Qty.	Material
i.	Frame Stand	1	Mild Steel
ii.	Air Tank	1	M.S
iii.	Gate Valve	1	M.S
iv.	Bearing with Bearing Cap	1	M.S
v.	Engine	1	100 Cc
vi	Chain with Sprocket	1	M.S
viii.	Connecting Tube	1 meter	Plastic
ix.	Bolt and Nut	-	M.S
x	Wheel Arrangement	1	-

COST ESTIMATION

Sl. No.	PARTS	Qty.	Material	Amount (Rs)
i.	Frame Stand	1	Mild Steel	
ii.	Air Tank	1	M.S	
iii.	Gate Valve	1	M.S	
iv.	Bearing with Bearing Cap	1	M.S	
v.	Engine	1	100 Cc	
vi	Chain with Sprocket	1	M.S	
viii.	Connecting Tube	1 meter	Plastic	
ix.	Bolt and Nut	-	M.S	
x	Wheel Arrangement	1	-	

TOTAL =

2. LABOUR COST

LATHE, DRILLING, WELDING, GRINDING, POWER HACKSAW, GAS CUTTING:

Cost =

3. OVERHEAD CHARGES

The overhead charges are arrived by "Manufacturing cost"

Manufacturing Cost = Material Cost + Labour cost

=

=

Overhead Charges = 20% of the manufacturing cost

=

TOTAL COST

Total cost = Material Cost + Labor cost + Overhead Charges

=

=

Total cost for this project =

ADVANTAGES, APPLICATIONS AND DISADVANTAGES

ADVANTAGES:

1. Zero emission vehicles.
2. No fossil fuel required.
3. Operating cost 75% less as compare to the gasoline engines.
4. Price is also less than half of the electric vehicles.
5. The recharging time is much more less than EV.
6. The recharging of tank can be done at house.
7. Refueling can be done at home using an air compressor.
8. The rate of self-discharge is very low opposed to batteries that deplete their charge slowly over time. Therefore, the vehicle may be left unused for longer periods of time than electric cars.

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APPLICATIONS

1. Two wheeler Application
2. Four wheeler Applications

DISADVANTAGES

1. It can't give much higher speed.
2. The recharging stations are not available.
3. Tanks get very hot when filled rapidly. It very dangers it sometime bloused

CONCLUSION

This project work has provided us an excellent opportunity and experience, to use our limited knowledge. We gained a lot of practical knowledge regarding, planning, purchasing, assembling and machining while doing this project work. We feel that the project work is a good solution to bridge the gates between institution and industries.

We are proud that we have completed the work with the limited time successfully. The AIR ENGINE is working with satisfactory conditions. We are able to understand the difficulties in maintaining the tolerances and also quality. We have done to our ability and skill making maximum use of available facilities.

In conclusion remarks of our project work, let us add a few more lines about our impression project work. Thus we have developed an "AIR ENGINE" which helps to know how to achieve compressed air vehicle. The application of pneumatics produces smooth operation. By using more techniques, they can be modified and developed according to the applications.

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