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Study and development of compressed air driven vehicle

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Abstract-

Light utility vehicles are becoming very popular means of independent transportation for short distances. Cost and pollution with petrol and diesel are leading vehicle manufacturers to develop vehicles fueled by alternative energies.

Engineers are directing their efforts to make use of air as an energy source to run the light utility vehicles. The use of compressed air for storing energy is a method that is not only efficient and clean, but also economical.

The major problem with compressed air vehicle was the lack of torque produced by the "engines" and the cost of compressing the air. Recently several companies have started to develop compressed air vehicles with many advantages and still many serious bottlenecks to tackle.
This paper briefly summarize the principle of technology, latest developments, advantages and problems in using compressed air as a source of energy to run vehicles.
It is hard to believe that compressed air can be used to drive vehicles. However that is true, and the "air car", as it is popularly known, has caught the attention of researchers worldwide. It has zero emissions and is ideal for city driving conditions. Although it seems to be an environmentally-friendly solution, one must consider its well to wheel efficiency. The electricity requirement for compressing air has to be considered while computing overall efficiency. Nevertheless, the compressed air vehicle will contribute to reducing urban air pollution in the long run.

Key poin*ts*-Compressed air, Air Car, Environmental problem

Introduction: An air powered vehicle is the vehicle which completely runs on compressed air. There is no need of fuel or gasoline. It follows the first law of thermodynamics. When air is compressed it stores energy in the form of pressure this energy is converted into mechanical energy when air expands into the cylinder.
We are living in a very mobile society so light utility vehicles (LUV) like bikes and cars are becoming very popular means of independent transportation for short distances. Petrol and diesel which have been the main sources of fuel in the history of transportation are becoming more expensive and impractical (especially from an environmental standpoint). Such factors are leading vehicle manufacturers to develop vehicles fuelled by alternative energies. When at present level of technological development fuel-less flying (like birds) i.e., flying based on the use of bio-energy and air power in the atmosphere seems to be almost impossible for human beings then engineers are fascinated at least with the enormous power associated with the human friendly as well as tested source of energy (i.e., air) to make **air-powered vehicles** as one possible alternative. Engineers are directing their sincere efforts to make use of air as an energy source to run the LUVs which will make future bikes and light/small cars running with air power for daily routine distances and the travel will be free from pollution and cost effective. Compressed air for vehicle propulsion is already being explored and now air powered vehicles are being developed as a more fuel-efficient means of transportation. Some automobile companies are further exploring compressed air hybrids and compressed fluids to store energy for vehicles which might point the way for the development of a cost effective air powered vehicles design.

Technology of the Engine

The air-powered car runs on a pneumatic motor that is powered by compressed air stored onboard the vehicle. Once compressed air is transferred into the onboard storage tank, it is slowly released to power the car's pistons. The motor then converts the air power into mechanical power. That power is then transferred to the wheels and becomes the source of power for the car.

Under speeds of 35 mph, the air-powered car runs purely on compressed air through the previously stated process. Therefore it only emits cold air, making it emission free at speeds less than 35 mph.However, once the air-powered car accelerates beyond speeds of 35 mph, a small conventional engine kicks in to heat the air. This heating speeds the release of air to power the car's pistons, increasing the Cars speeds [4]. Since this process requires the use of a combustion engine and electricity to power the onboard air compressor, the air-powered cars emissions greater. This will be evaluated later in the paper.

The air-powered car is able to collect compressed air inits onboard storage tank in two ways. One way is the car can be electrically injected with compressed air directly into its thermoplastic and carbon fiber tank. For this method to be used, air stations similar to today's gas stations will be necessary. This process of refueling takes approximately three minutes [4].
While there are obviously no air stations available in today's market for air-powered car fueling, Shiva Vencat, Chief Executive of Zero Pollution Motor (ZPM), does not see this as a downside. He claims that the economic Invisible Hand will take care of that problem when the time is right and air stations will be on the market when they are needed [3].
The other method for refueling the air-powered car is by plugging the car into a wall outlet. This allows the car's onboard air compressor to pressurize air surrounding the car. This process takes approximately four hours [4].

Unlike gasoline, compressed air is not an energy source. Compressed air is an energy storage medium similar to an electric battery [1]. According to the authors of the article, "Compressed Air Vehicles," "Unlike other fuel types, which store energy within the chemical bonds of the fuel, compressed air derives its energy from the thermodynamic work done by an expanding gas" [1]. The thermodynamic work done by expanding gas in compressed air will be explained later in the paper.

Possible improvements

Compressed-air vehicles operate to a thermodynamic process as air cools down when expanding and heats up when being compressed. As it is not possible in practice to use a theoretically ideal process, losses occur and improvements may involve reducing these, e.g., by using large heat exchangers in order to use heat from the ambient air and at the same time provide air cooling in the passenger compartment. At the other end, the heat produced during compression can be stored in water systems, physical or chemical systems and reused later.
It may be possible to store compressed air at lower pressure using an absorption material within the tank. Absorption materials such as Activated carbon, or a metal organic framework is used to store compressed natural gas at 500 psi instead of 4500 psi, which amounts to a large energy saving.

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Figure-1

Typical compressed air engine uses one or more expander pistons or rotary expanders. Our project is to make the air powered vehicle so we required an air powered engine. To make air powered engine we required an expander piston. A four stroke petrol engine can be changed into air powered engine by making some modification in it. As we have a four stroke 97.22 cc petrol engine, and we are going to change it into air powered engine. The engine has four strokes which are suction stroke, compression stroke, power stroke and exhaust stroke. Air powered engine does not required all these strokes so we can change the number of strokes as we required. Air powered engine does not required compression stroke and suction stroke. In air powered engine air comes in cylinder at high pressure and creates a force on piston, which force is act to move the piston from TDC to BDC. So in air powered engine there will be only two strokes which is power stroke or expansion stroke and exhaust stroke.

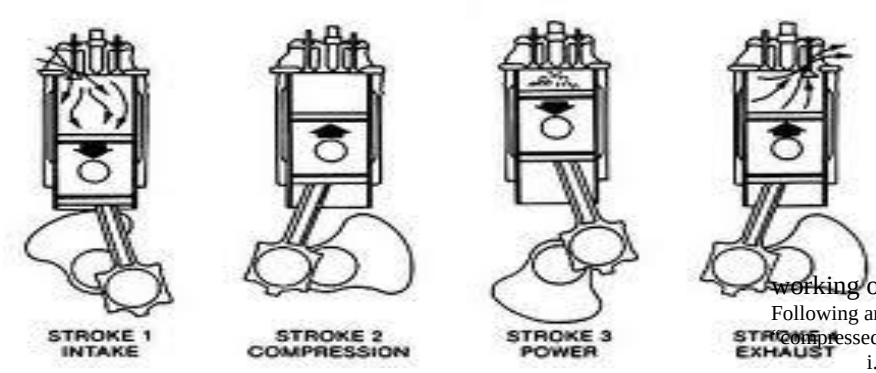

Figure 2 Four stroke SI engine

When air is squeezed at high pressure it stores energy in the form of pressure and this energy is used to move the piston from TDC to BDC. The engine has only two stroke cycle. When intake valve open air will push the piston in downward direction (due to the expansion of air) and we will get power at crank shaft. A fly wheel is mounted on the crankshaft which is used to store the fluctuation of energy. With the help of flywheel piston goes from BDC to TDC and exhaust valves open at this time. The air is exhausted in second stroke

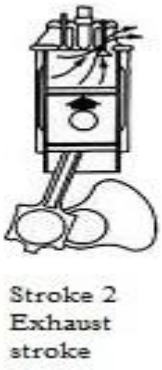

Figure 3

working of air powered engine

Following are the modifications made with four stroke petrol engine to run on "compressed air"

i. Changes with the intake port
ii. Changing valve timing
iii. Changes made with the timing chain
iv. Changing the angle of cam

Intake port

To use compressed air as input, intake port is to be change. Intake port should be in favour of air. Air comes from air storage tank through a pipe of 8 mm inner diameter. So there are some changes are done to take the air as input

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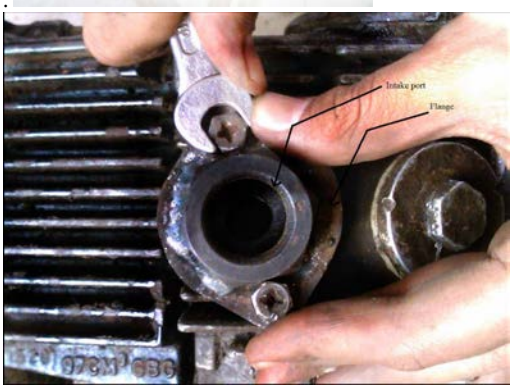

Figure 4

Valve timing diagram

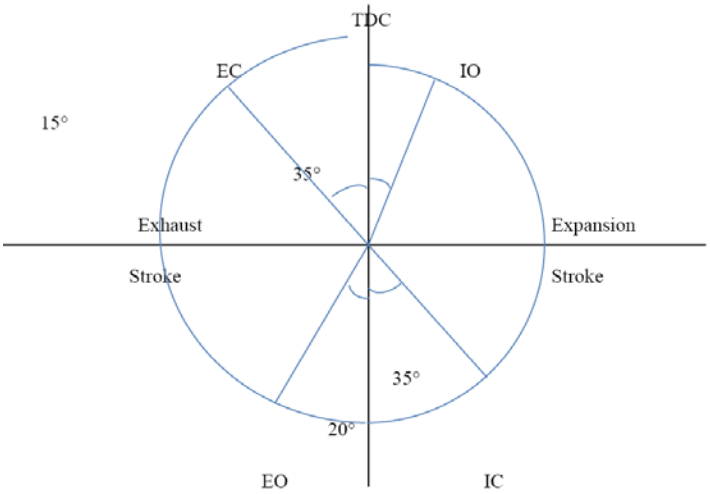

Figure 5

IO= Intake valve open TDC=Top dead Centre

EC= Exhaust Valve close IC= Inlet valve close

EO= Exhaust Valve Open

Timing chain

To maintain the gear ratio 1:1 for valve timing we have to reduce diameter of big sprocket equal to small sprocket. It means distance between end points of sprockets is reduced. So we have to cut the timing chain.

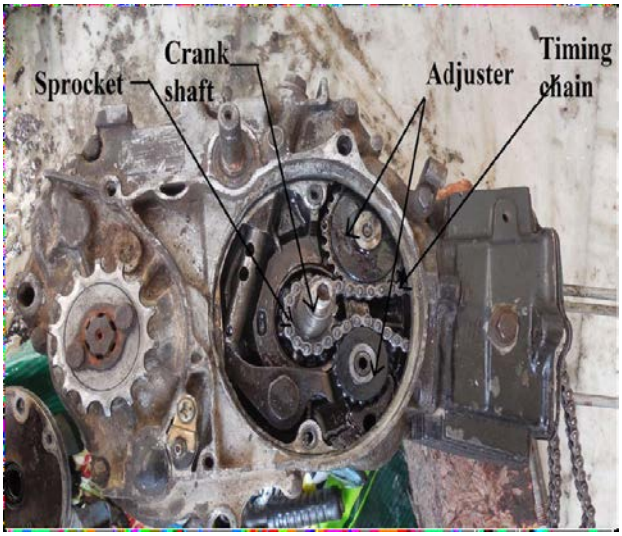

Figure 6

Cam shaft

Camshaft is use for opening and closing of valves. When piston goes down inlet valve should open, and when piston comes towards TDC exhaust valve should be open and inlet valve should be close. It means the angle of cam should be 180°, and should have same gear ratio.

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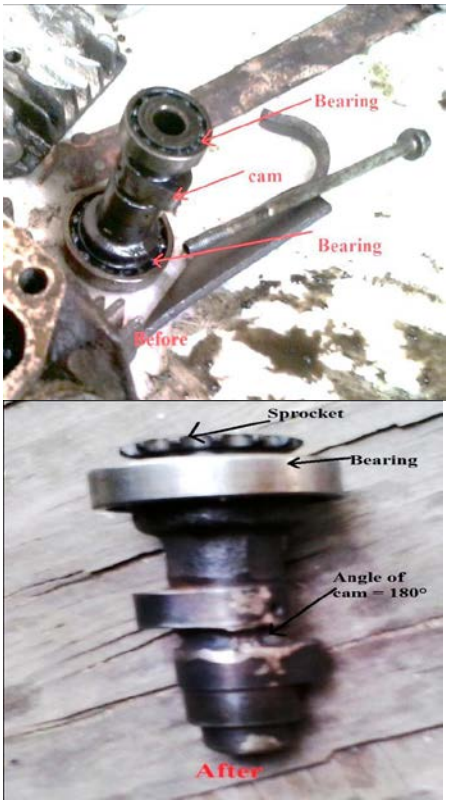

Figure 7 Changes made with the cam

For changing cam angle we did different process. First of all cam shaft is cut into two parts from the gap between cam, after that rotating cam at 180° and weld at that position. Welding used to join the camshaft is MIG (metal inert gas) welding shielded by argon. This welding is also called argon welding. It has high strength and temperature.

Mass of the body = 30 kg
Mass of air tank = 50 kg
Mass of engine = 20 kg
Mass of the human = 70 kg
Friction force
Since the project is made for use of single person. The vehicle is light utility vehicle.
The total mass of vehicle will be =170 kg
We can use this as 200 kg taking some factor.
Weight = mass × gravitational acceleration
= 200×10
= 2000 N
= 2 KN
This is the vertical force acting on the wheel in the direction of gravity

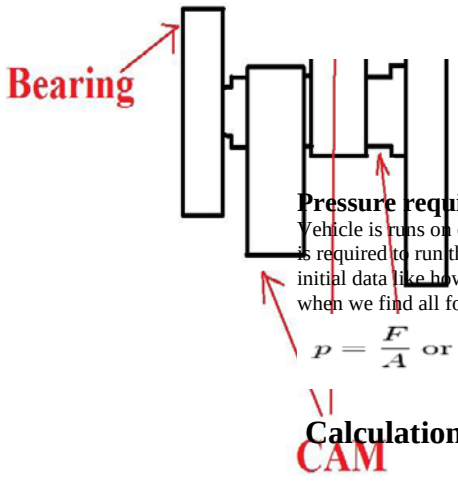

Figure 8 Camshaft

Working:-

Air powered vehicles run on compressed air instead of gasoline .Since the vehicle is working on air there is no pollution .A single cylinder compressed air engine powers the vehicle . The engine can run either on compressed air alone or act as an internal combustion engine, Compressed air is stored in fiber or glass fiber tank at a pressure of 4000 pounds per square inch. The air is fed through an air injector to the engine and flows into a small chamber, which expands the air. The air pushing down on the piston moves the crank shaft, which give the vehicle power.

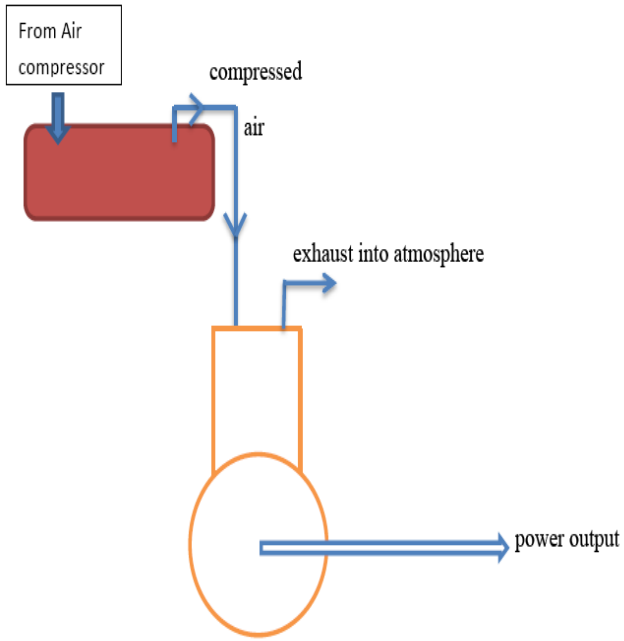

Figure 9 Block diagram of air powered vehicle

Pressure required to run the vehicle

Vehicle is runs on compressed air so we have to know that how much pressure is required to run the vehicle. For calculating the pressure we have to know all initial data like how much weight is to be manage, what should be torque etc. when we find all forces and torque, pressure can be calculated by the formula

$$p = \frac{F}{A} \text{ or } p = \frac{dF_n}{dA}$$

Calculation of load on the vehicle

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To rotate crank shaft 66 N-m torque is required. This torque can be balanced by the force applied by the piston Fp.
Fp = torque / radius of crank
Fp = 66/0.04
Fp = 1650 N
Pressure = Force /Area
Area of piston = (π/4) × d2
Area of piston = 2.29 × 10-3 m2
Pressure = 1650/2.29×10-3
= 720.524 KN/m2
Or = 7.205 bar
Or = 104.5 PSI
This is the minimum pressure required to run the vehicle having 2 KN weight. So we require the higher pressure than we calculated to run vehicle at high speed.

Figure 11 Air powered vehicle

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Figure 4.3 load on the wheel

4.1.2. Requirement of force to run the vehicle

Force required to run the vehicle should be greater than the resisting force on the wheel. This resisting force is the friction force between wheel and road surface. So we have to calculate this friction force on the wheel.
Friction force (F) = μ×N
Where μ is coefficient of friction
N is normal reaction force which is equal to the vertical force.
F = 0.3×2000
= 600 N

Torque required by engine

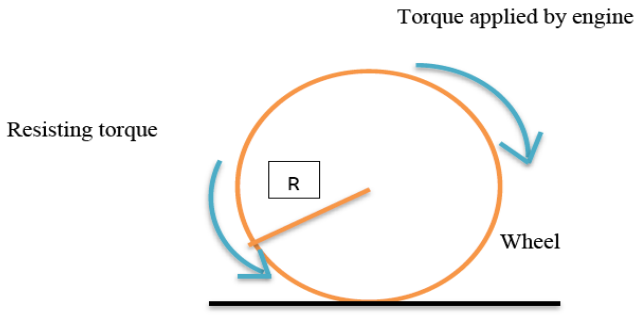

Figure 10

Relation between linear acceleration "α" and angular acceleration "α" for pure rolling movement is given by
α = α • R

Where R is the radius of the wheel
Resisting torque on wheel (τR) = *f • R*
The net torque causes angular acceleration on wheel (τ) = τe - τR
Where; τe is the torque applied by engine

$$\tau = I \bullet \alpha$$
$$\tau e - \tau R = I \bullet \alpha$$
$$\tau e = \tau R + I \bullet \alpha$$
$$= f \bullet R + \tfrac{1}{2} m R2 * f/mR \{\alpha = f/mR$$
$$\tau e = 3fR/2$$

We know that
f = 600 N
R = 200 mm = 0.2 m
τe = 3×600×0.2/2
= 180 N-m
We can take it as 200 N-m because there are many unnecessary forces which are acts in actual practice like friction force.
τe = 200 N-m
Gear ratio in first gear is 2.71, it means
Torque on output shaft of engine/torque on crank = 2.71
Torque on crank shaft = τe/2.71
= 180/2.71
= 66.4 ≈ 66 N-m

Calculation of pressure

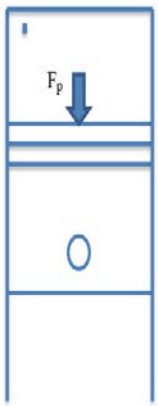

Figure 12

CONCLUSION

From all the disruption made one can say that by using air vehicle there is reduction in air pollution. The emission benefits of introducing this zero emission technology are obvious. Also, the aim of project is to cut cost. Also air vehicle provide an answer to the shortage of fuel and high of fuel.
With petrol and diesel prices going up and the price of oil subjected to fluctuation for motorist, this become headache, use of air powered engine is only the solution. All know that there will be shortage of gasoline in future, engine that run on compressed air is only the alternative for it.

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