Optimization in Compressed Air Vehicle

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Abstract— To meet the increasing demand for the fossil fuel consumption with increasing population and automobiles, various advancements such as hybrid electric vehicles, solar vehicles, hydrogen fuel cell powered vehicles are being attained in automobile sector. Also the increasing level of automobile pollutants and global warming due to increase in the percentage of CO2 demands a cleaner technology like Compressed Air Technology (C.A.T). The C.A.T which aims at using compressed air as a fuel for running the automobiles has been in development for so many years. It derives its principle from steam engine in which the potential energy of steam is converted into kinetic energy. Here air substitutes steam. This aims at overcoming all the above cited constraints and applying the technology to take the automotive world one step forward. This paper is all about converting an existing two stroke petrol engine into an engine which is powered only by a single source, namely compressed air. The air engine besides being an effective renewable alternative energy, it also aids to minimize the pollution level (eco-friendly) since exhaust of which contains nothing but cold air. This qualifies it to be a zero pollution vehicle.

Key words: Compressed Air Technology (C.A.T), Zero Pollution Vehicle, Effective Renewable Alternative Energy

I. INTRODUCTION

Many research have been carried out in the field of automotive sector to find a fuel which best suits the requirements. Though hydrogen, liquid nitrogen etc. proved to be good alternatives the environmental degradation also demanded a cleaner fuel. This led to the development of air engine in the middle of 19th century by Andraud and Tessie' Du Motay in Paris.

The air engine is the one which uses compressed air as a fuel. Here the pressure energy of the compressed air is converted into kinetic energy. Because it is devoid of combustion the exhaust consists nothing but cold air thus making it a zero pollution engine.

A. Need for CAV

With the exponential population hike, the usage of automobiles has also increased. The nature of the fuels (gasoline and diesel) used today is nonrenewable, expensive, highly polluting and fast depleting. This nature yields so many problems like poor economic growth, atmospheric degradation such as ozone layer depletion, acid rain etc... Motor vehicles also emit large amounts of carbon dioxide, which has potential to trap the Earth's heat and cause global warning.

Moreover the emissions like COx, NOx, SOx, CO, particulate matters cause various health hazards. In urban areas, motor vehicles are responsible for as much as 90 percent of CO in the air.

Fig. 1:

In this regards substituting gasoline and diesel with air can promote economic growth, reduce atmospheric degradation etc... in short means taking the world of automobiles one step ahead.

B. Significance

Many firms have developed engines that run on compressed air. But the technology of these engines is very advanced and this pushes the cost beyond the reach of common people. This idea aims to find a simpler solution to control compressed air thereby reducing the cost of the technology and does not copy the ideas of other firms but merely seeks to adopt their concept of running an engine on compressed air. This is evident in the fact that here a modified version of an existing engine is used whereas the technology developed by MDI of France and others use the engines that were specially designed to handle compressed air. This technology is still under research stage but constant experimentation and new ideas are needed if advancements are expected to be made.

C. Objective

The main objectives are,

- To find an effective alternative fuel for the future
- To develop a zero pollution vehicle and hence contribute to the act of reducing global warming.
- To make automobile common for a common man.
- To formulate economic way of transportation.
- To minimize the usage of fast depleting non-renewable resources especially gasoline and diesel.

D. Definition

The CAV is one which uses compressed air as a fuel. This specially designed vehicle consists of an air storage tank, from which the air is made to expand inside the cylinder. Here the pressure energy of air is getting converted into kinetic energy. The compressed air vehicle is a ZERO POLLUTION VEHICLE because of the absence of combustion. CAV is the vehicle of the future generation when optimized.

E. Principle

The principle of the air engine is derived from the steam engine in which the pressure energy of steam is converted to kinetic energy. The air engine uses compressed air instead of steam. The compressed air has pressure which on expansion moves the piston (linear motion) which is converted to rotary motion through crank and connecting rod mechanism.

F. Pressure Energy --> Kinetic Energy

1) Working

In the compressed air engine, the cycle of operation gets completed with two strokes of the piston or one revolution of the crank. The two strokes are,

1) Expansion or Power stroke.
2) Exhaust stroke.

II. NOVEL DEVICE FOR HARNESSING & STORING OF SOLAR ENERGY

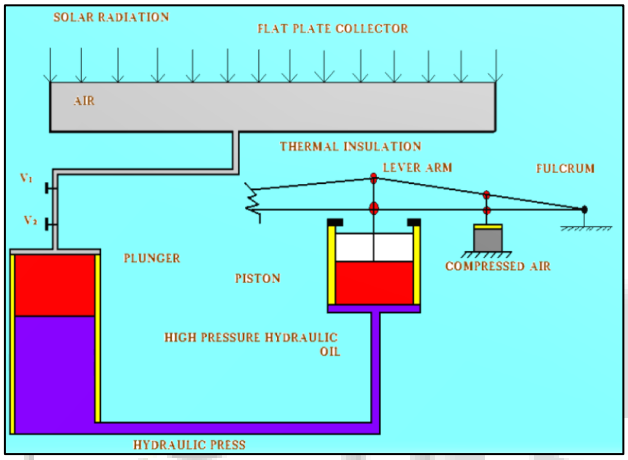

Fig. 2:

A. Mode of Operation

This device consists of 3main parts namely solar collector, Hydraulic press & Air compressors. The flat plate collector (made of steel/aluminum/copper possessing high thermal conductivity) gets heated by solar radiation falling upon the plate collector and the heat in turn in the plate is transmitted to the air in the roomy chamber underneath it. The air expands and gets pressure. The pressure acting upon the plunger is then gradually transmitted to the high pressure hydraulic oil which in turn acts upon the bottom of the heavy ram to lift up. The piston of the air compressors connected to the ram by lever arms also reach the top level of the compression chamber. Then by operating valves V1 and V2, the air under pressure above plunger escapes reducing the pressure of the hydraulic oil. Now the ram goes down by gravity, plunger goes up and thereby the pistons go down gradually, compressing the air to the required pressure in the compression chamber. The compressed air under pressure is then taken to the storage tank or container. Thus, by sequence of operations the solar energy is converted and stored in the form of pneumatic energy.

Fig. 3:

B. Expansion or Power Stroke

S. NO.	STROKE	EVENT	POSITION w.r.to TDC/BDC	CRANK ANGLE (in degrees)
1	EXPANSION OR POWER	IVO	After TDC	11
2	EXHAUST 1	IVC EVeO	After TDC Before BDC	127 45
3	EXHAUST 2	EVO EVeC EVC	After BDC After BDC Before TDC	14 45 7

Table 1:

During this stroke the piston moves from the TDC to BDC. At the beginning of this stroke the inlet valve is opened and allows the compressed air stored in the tank to expand inside the cylinder. This moves the piston down as pressure energy of air gets converted into kinetic energy thus producing a power stroke.

Just before reaching BDC the specially designed cam mechanism closes the inlet valve and the piston uncovers an exhaust vent through which the expanded gas escapes to the atmosphere. This reduces the load on the piston by reducing the amount of air present inside the cylinder during return stroke.

1) Exhaust Stroke

During this stroke piston moves from BDC to TDC. Initially the piston covers the exhaust vent and the cam mechanism opens the exhaust valve. The remaining air trapped inside the cylinder is expelled to the atmosphere through the exhaust valve and the cycle continues.

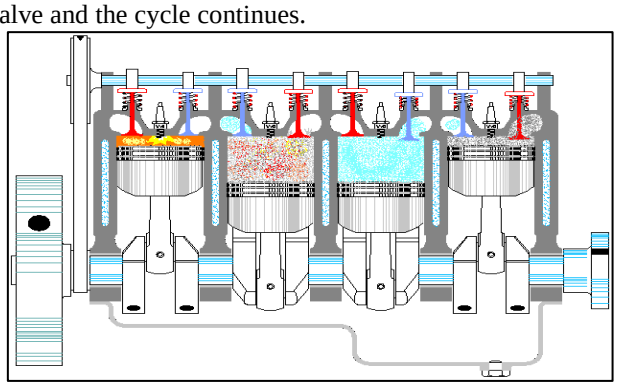

Fig. 4:

2) Valve Timing for Compressed Air Engine

As mentioned earlier, air engine requires two strokes of piston or one crank revolution to complete one cycle. During the first stroke, just 11 degree after TDC, the inlet valve opens to allow air from the cylinder to expand inside the cylinder. This causes the piston to move downward (pressure energy converted to kinetic energy). This timing avoids reversing of the engine. Then after 116 degree of crank revolution, inlet valve closes and cuts off the air supply.

Then after 8 degree of crank revolution, the exhaust vent opens to allow major part of the expanded air to escape to the atmosphere. Both these timings are given in such a way that the former prevents useful air from escaping out and the latter reduces the resistance on the piston during return stroke. The crank rotates another 45 degree to take the piston to BDC, thus completing the first stroke.

During the second stroke the piston starts moving from BDC to TDC. After 14 degree of crank revolution from BDC, the exhaust valve opens which facilitates the remaining part of expanded air trapped inside the cylinder to escape to the atmosphere.

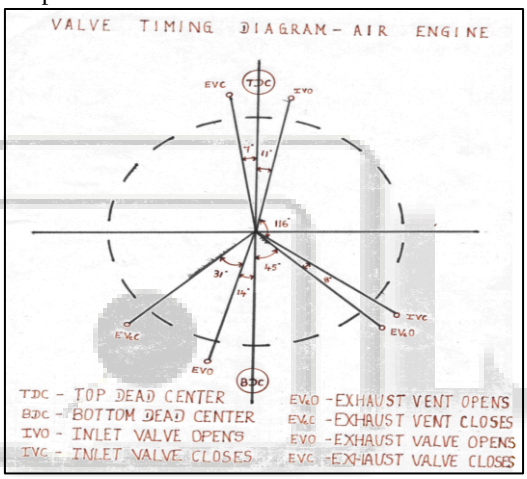

Fig. 5:

After 45 degree of crank revolution from BDC, the exhaust vent closes. At the same time the expanded air continues to escape through the exhaust valve. After this just 7 degree before TDC, the exhaust valve closes and the piston reaches TDC after 7 degree of crank revolution, thus completing the second stroke.

3) Modifications Done

Since the existing two stroke engines cannot be used as such to work as an air engine, certain modifications has to be carried out to serve the purpose. The following are the various modifications done on the existing engine to convert it into a compressed air engine.

- The ports (inlet, exhaust and transfer) in the existing engine were sealed by inserting a sleeve.
- The spark plug was eliminated as no spark is required because of the absence of combustion.
- Specially designed upper and lower valve plates were mounted in the space of cylinder head.
- Two actuators to actuate the inlet and exhaust valves were designed and mounted.
- A special cam like mechanism was designed and mounted on the flywheel to open and close the valves at required timings.

4) Detailed Information

The detailed information of the design and modifications of various components are as explained below.

1) Cylinder

In two stroke engines, the cylinder consists of ports like inlet and transfer ports to allow air or air fuel mixture inside the cylinder and crankcase. The exhaust ports are used to expel the burnt gases.

In compressed air engine, the ports in the cylinder are sealed. First the cylinder is bored to a diameter of 54 mm from 50 mm and 5 mm aluminum sleeve is inserted using hydraulic press and the was finished to 4 mm making the net diameter as 50 mm thus sealing the ports. An exhaust vent is made at the bottom of the cylinder to allow major part of the expanded gas to escape to the atmosphere.

2) Valve Plates

Two valve plates are specially designed to take air in and out of the cylinder. The cylinder head and spark plug assembly is removed and replaced by the valve plates.

3) Lower Valve Plate

The lower valve plate contains a specially designed groove which acts as cylinder head. It also contains inlet and exhaust openings and some holes for clamping.

4) Upper Valve Plate

Upper valve plate contains an opening which leads to the exhaust valve. It has a projection by its side which accepts the tube from the compressed air tank. It also contains holes for clamping. It is clamped over the lower valve plate rigidly.

5) Valve Actuators

To actuate the inlet and exhaust valves special actuators are designed. It is designed in such a way that one end continuously roll over the flywheel and this end has a bearing to reduce friction. The other end is clamped to the disc behind the flywheel. On operation the actuators lift a loosely inserted actuator rod to unseat the inlet and exhaust valve pins.

6) Flywheel

Flywheel is a wheel mounted on a crank shaft which stores excess energy during the power stroke and returns that energy during the other strokes and maintains a fairly constant output torque on the crankshaft (reduces cyclic variation of speed).

The specially designed cam like mechanism is mounted on the flywheel with regard to the valve timings. The cam is just like a projection over which the valve actuators come in contact during respective valve openings. The projection is given a slope on either side to facilitate smooth operation of the inlet and exhaust actuators.

7) Valve

The valve controls the admission of compressed air into the cylinder. When the valve pin is unseated, the hole in the valve comes in line with the inlet opening provided on the lower plate. This allows compressed air to enter into the cylinder to move the piston downward.

8) Valve Pin

The valve pin seated in the valve is lifted up while the actuator rises up according to the cam mechanism in the flywheel, thus admitting the inlet of compressed air into the cylinder piston arrangement. And similar functioning is done by the exhaust valve pin to expel the expanded air inside the cylinder to the atmosphere.

9) Actuator Rod

The connecting rod is used to lift the valve pins in the valve according to the valve actuators. These rods are loosely fixed above the actuators.

10) Actuator Holding Disc

The inlet and exhaust valve actuators are fixed at one end and the other end consists of the bearing. The fixed end is screwed to the disc placed behind the flywheel.

11) Chassis

Chassis is the body of a vehicle in which the total weight of the vehicle acts upon. All the parts of the vehicle are mounted on the chassis. In the compressed air engine a separate chassis as per requirements is designed in order to mount the engine and other parts.

12) Components Assembly

The various components are assembled together as fixed in the engine. The various assemblies are as follows.

– Valve assembly

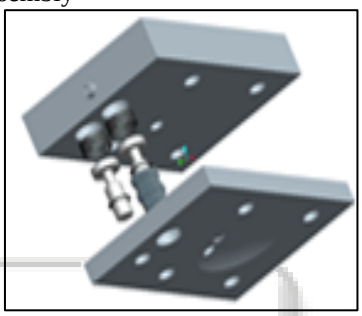

Fig. 6:

– Flywheel assembly

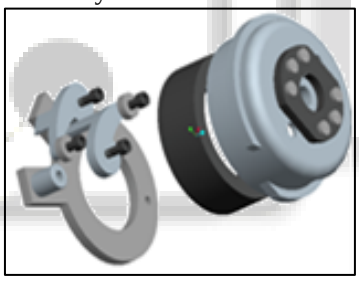

Fig. 7:

III. ADVANTAGES

The following are the important merits of compressed air engine.

– It Serves as an Alternate Fuel

Since compressed air has the potential to move the piston by virtue of its pressure energy, it can be served as an alternate fuel.

– Reduced Fuel Cost Compared to Gasoline and Diesel Engines

Cost of compressed air per km to run the vehicle is less compared to that of using gasoline or diesel due to their increase in demand and cost in the market.

– Reduced Emission as Compared to Present Vehicles (Eco-friendly)

Since the air engine is devoid of combustion there are no harmful gases in their exhaust. The exhaust contains nothing but the expanded cold air.

– The Fuel used is a Renewable One

The air engine uses compressed air as fuel. Atmospheric air is a renewable source of energy which can be compressed by means of a compressor which when running on electric current generated by renewable energy source becomes a zero polluting engine.

– Low Exhaust Temperature

Compressed air on expansion loses its temperature. This reduction in temperature is directly proportional to the initial pressure of air stored in the tank. This chilled air can be used for air conditioning of the vehicle.

– Very Less Lubrication is Required

Due to the absence of combustion in the engine its working temperature is reduced considerably. The heat generated in the engine is only due to the friction of moving parts. So very less lubrication is required.

IV. CONCLUSION

From this paper we infer that compressed air stored in a tank can be used as a substitute fuel for diesel and gasoline. The future of gasoline and diesel is at risk due to fast depletion of fossil fuels. More over these diesel and gasoline engines emit considerable quantities of noxious gases into the ambience resulting in the increase in percentage of greenhouse gases and thus enhancing global warming.

An effort such as the compressed air vehicle is one such measure to stop air pollution and thereby using the large quantities of air available in the atmosphere to a maximum profitable extent. The vehicle becomes a purely zero polluting vehicle if the compressor for compressing the air is run on current generated by renewable energy source.

More over the cost to run the air engine is less compared to gasoline and diesel engines giving an extra edge over those engines. If the design is further optimized for mass production of these vehicles then it will create a revolution in automotive sector thereby giving its users an ecofriendly vehicle for the future.

The significance of the project lies-the data obtained can be made use for future research in this field.

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