COMPRESSED AIR VEHICLE: A REVIEW

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Abstract: The latest trend in the automotive industry is to develop light weight vehicles. Every automotive industry is looking to reduce the weight of the vehicle as it helps in the better handling of the vehicle and increases the efficiency of the vehicle. Today, the heavy vehicles are known for producing a large amount of harmful gases like CO_2, SO_2 etc. which act as the major source for global warming. So research is going on to find a light weight vehicle which does not pollute the environment. One of the alternatives is the use of compressed air to generate power to run an automobile. Due to the unique and environmental friendly properties of air, it is considered as one of the future fuels which will run the vehicles. So in this paper an effort is made to study the extent of research done and the potential advantages and disadvantages of the compressed air technology.

Keywords: - Light Weight Vehicles, Compressed Air, Global Warming, Alternative Sources of Energy.

I. INTRODUCTION

The first compressed air vehicle was established in France by a Polish engineer Louis Mekarski in 1870. It was patented in 1872 and 1873 and was tested in Paris in 1876. The working principle of Mekarski's engine was the use of energy stored in compressed air to increase gas enthalpy of hot water when it is passed through hot water. Another application of the compressed air to drive vehicles comes from Uruguay in 1984, where Armando Regusci has been involved in constructing these machines. He constructed a four-wheeler with pneumatic engine which travelled 100 km on a single tank in 1992. The Air Car was developed by Luxembourg-based MDI Group founder and former Formula One engineer Guy Negre is which works on compressed air engine (CAE). He developed compressed air- 4- cylinders engine run on air and gasoline in 1998 which he claims to be zero pollution cars. It uses compressed air to push its pistons when running at speeds under 35 mph and at higher speeds of 96 mph, the compressed air was heated by a fuel (bio fuel, gasoline, or diesel),due to which the air expanded before entering the engine. A fuel efficiency of about 100 mpg was observed.

Light weight vehicles are the next advancement in the development of automobiles. Reducing the weight of the vehicle has many advantages as it increases the overall efficiency of the vehicle, helps in improving maneuverability, requires less energy to stop and run the vehicle. The latest researches are going on around the world in order to come up with innovative ideas. But global warming is also one of the problems which is affecting the man. The temperature of the earth is increasing drastically and this in turn is causing climatic changes. The fossil fuels are widely used as a source of energy in various different fields like power plants, internal & external combustion engines, as heat source in manufacturing industries, etc. But its stock is very limited and due to this tremendous use, fossil fuels are diminishing at faster rate. So, in this world of energy crisis, it is necessary to develop alternative technologies to use renewable energy sources, so that fossil fuels can be conserved. One of the major source of the pollution is the smoke coming out from the automobiles. So an alternative way of producing the running the vehicle must be made so that we can prevent further damage to the earth. The alternative sources of energy availableare solar, electric, atmospheric air etc. Air acts like a blanket for the earth. It is the mixture of gasses, which makes it neutral and non-polluting. It has the property to get compressed to a very high pressure and retain it for a long period of time. It is cheap and can be found abundantly in the atmosphere. So it can be used as an alternative fuel for the automobiles. Much research is going on in this field and scientists are trying to improve the effectiveness of this technology. It is experimentally found that the efficiency of the vehicle ranges from 72-95%. So this can be considered as one of the preferable choices to run the vehicle.

II. LITERATURE REVIEW

2.1 Air Powered Engine

Prof. B.S.Patel et al. tried to develop a compressed air engine by modifying an 4-stroke, single cylinder SI engine by replacing the spark plug with a pulsed pressure valve, and using compressed air as the working fluid. The working of the engine is explained theoretically and the cost analysis is made which shows that the compressed air engine is cheap when compared to the conventional SI engine.

2.2 Study of Compressed Air Storage System as Clean Potential Energy for 21st Century

Dr. Bharat Raj Singh and Dr. Onkar Singh conducted an experiment in which they used a vaned type novel air turbine as a prime mover for a motor bike. In this experiment they tried to gain an output of 6.50 to 7.20 HP for the starting torque requirements of 500 to 750 rpm at 4 to 6 bars air pressure to running speeds of 2000 to 3000 rpm using 2 to 3 bars air pressure. The test was conducted in HBTI Kanpur and below diagrams shows the test rig setup and its layout:

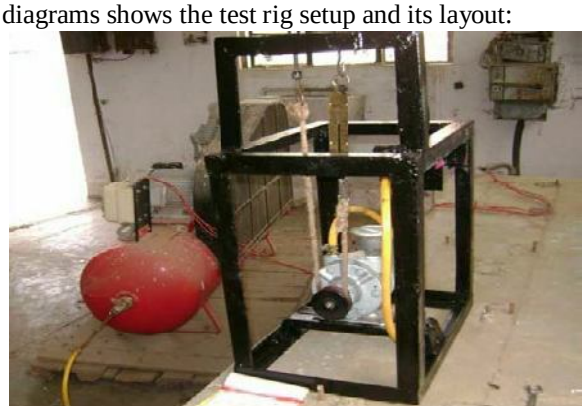

Fig:1 Actual Test Rig Setup

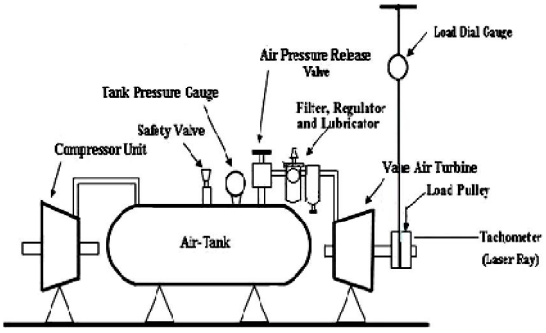

Fig: 2 Test Setup Layout

It consists of an air compressor which was used to produce and store 300 psi (21 bar approx.) air and use it to impact the compressed air on the vanes of the novel air turbine. The test was conducted at different inlet pressures and the efficiencies of the turbine was found to vary from 72 to 97 %. The turbine had d/D ratio of 0.7 and the results obtained were are follows:

- 93% to 99% with variation of 6%, at speed of rotation 500 rpm for injection pressure 20 psi to 100 psi.
- 81.8% to 89.8% with variation of 8%, at the speed of rotation 1000 rpm for injection pressure 20 psi to 100 psi.
- 70.8% to 84.3% with variation of 13.5%, at the speed of rotation 1500 rpm for injection pressure 20 psi to 100 psi.
- 64.4% to 79.8% with variation of 15.4%, at the speed of rotation 2000 rpm for injection pressure 20 psi to 100 psi.
- 59.5% to 76.5% with variation of 17%, at the speed of rotation 2500 rpm for injection pressure 20 psi to 100 psi.
- 56.2% to 72.9% with variation of 16.7%, at the speed of rotation 3000 rpm for injection pressure 20 psi to 100 psi.

A graph given below was drawn for comparing Actual power with respect to theoretical power and the Speed of rotation in rpm:

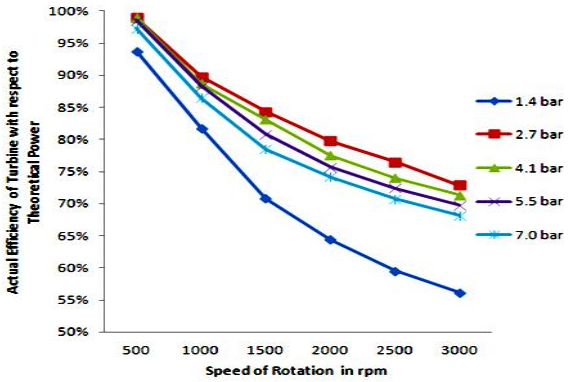

Fig: 3 A graph comparing Actual power with respect to theoretical power and the Speed of rotation in rpm

After conducting this research they have concluded that overall performance of air turbine for working pressure ranging from 2.7-6 bar is found varying from 72%-97%. This technology can be used in the future automotive industry.

2.3 Compressed Air Energy Storage System Based Engine for Running Light Vehicle

Dr. Bharat Raj Singh and Dr. Onkar Singh have used a vaned type turbine as the prime mover and have conducted three different experiments with different casing diameters of 50mm, 100mm, 150mm, with the constant injection angle of 60^0, 2500 rpm speed of rotation and 6bars air pressure.

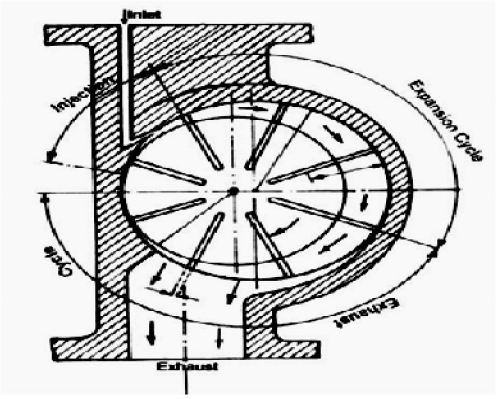

Fig: 4 Thevaned air turbine

The results obtained after experiments were conducted are:

1) When D=50mm :

0.19 kW- 0.72 kW, when rotor to casing diameter ratios is of 0.95-0.80 and vane angle is kept 30^o (vanes 12 nos.) and 0.87 kW- 1.0 kW, when rotor to casing diameter ratios are of

0.75-0.70 and vane angle is kept 36° (vanes nos. 10)

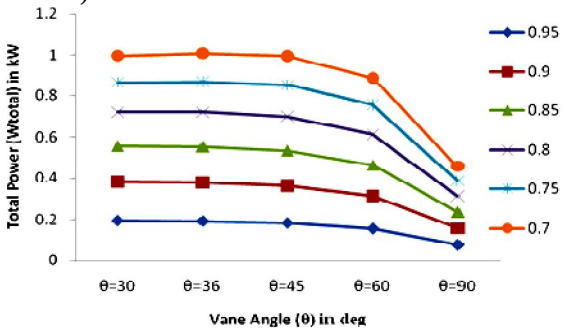

Fig: 5 Total power output (Wt) versus different Rotor / Casing ratio at different vane angle when D=50 mm

2) When D=100mm

0.8 kW- 2.9 kW, when rotor to casing diameter ratios are of 0.95-0.80 and vane angle is kept 30° (vanes nos. 12) and 3.5 kW- 4.0 kW, when rotor to casing diameter ratios are of 0.75-0.70 and vane angle is kept 36° (vanes nos. 10)

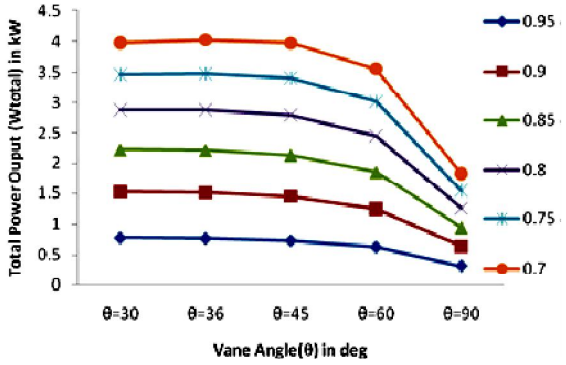

Fig: 6 Total power output (Wt) versus different Rotor / Casing ratioat different vane angle when D=100 mm

3) When D=150mm

1.9 kW- 6.5 kW, when rotor to casing diameter ratios are of 0.95-0.80 and vane angle is kept 30° (vanes nos. 12), and 7.8 kW- 9.0 kW, when rotor to casing diameter ratios are of 0.75-0.70 and vane angle is kept 36° (vanes nos. 10)

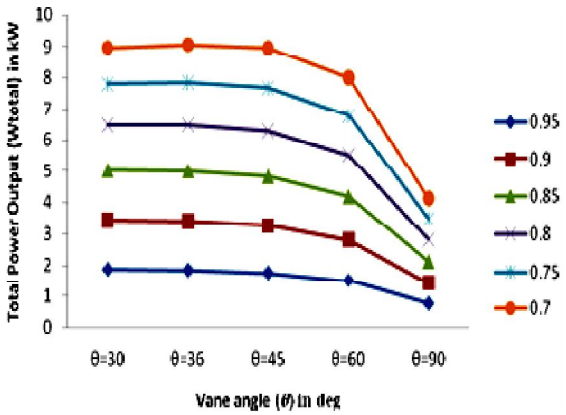

Fig: 7 Total power output (Wt) versus different Rotor /Casing ratio at different vane angle when D=150 mm

The comparison of all the test cases are done and the results are tabulated:

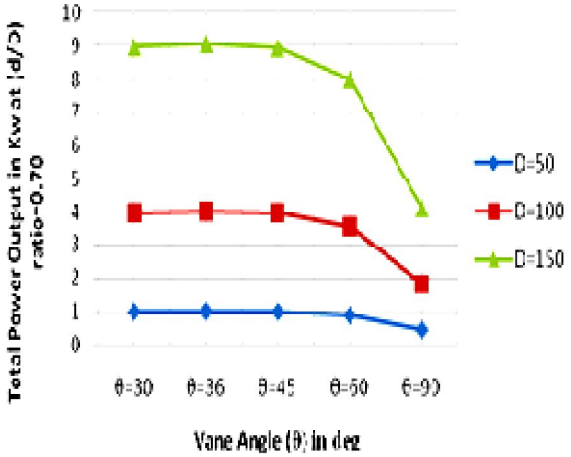

Fig: 8 Total power output (Wt) versus vane angles when rotor / casing diameter (d/D) ratio is 0.70 when D=50 mm, 100 mm, and 150 mm

Thus after this experiment it is concluded that optimum shaft power output of a novel vaned type air turbine is obtained when the design parameters for rotor diameter to casing diameter (d/D) ratios is kept between 0.70 to 0.75 and vane angle is 30-45° and the efficiency of the light weight vehicle would be around 75-97%.

2.4 Vehicle Operating On Compressed Air by Inversion of Slider Crank Mechanism

A.A.Keste et al. worked on the concept of inversed slider crank mechanism to utilize the compressed air to run a vehicle [20]. In this experiment a double acting pneumatic cylinder was used in which the piston attached to a pinion which generated rotation motion. The below diagram shows the test setup:

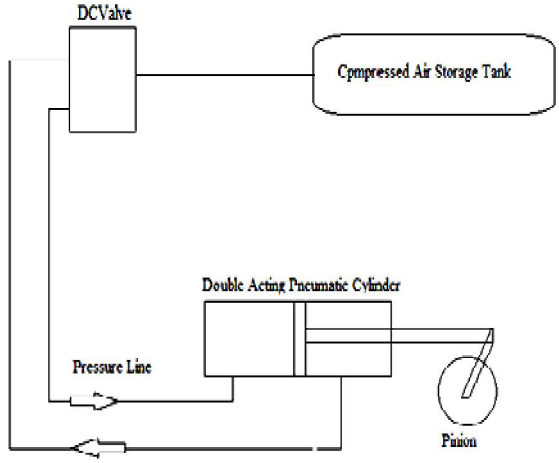

Fig: 9 Test Setup

A prototype working on this principle is made and then tested, after the test, it is found that for 12 litres of air the prototype vehicles travels 50mts. From this experiment, it can concluded that the this mechanism

can also be utilized for running a vehicle. The prototype built is given below:

Fig: 10 Prototype

2.5 Airpod – The Mini Car

AirPod is an alternative fuel vehicle which was developed by Motor Development International, in collaboration with India's Tata Motors and Paris-based Air France. It works on the compressed air. The AirPod's engine works with the help of two linked cylinders. Compressed air flows into the smaller cylinder first at a constant pressure of 20 bars. When the smaller piston bottoms out, the intake is closed, and the air in the small cylinder expands, flowing into the larger cylinder. Both pistons then move to exhaust the expanded air, and the cycle begins again. The 80 kg of compressed air in the AirPod's tank has the capacity of generating 11.2 kilowatt-hours of mechanical energy when fully expanded at constant temperature. The manufacturing plant has been setup in Sardinia, Italy and it would be available in market by summer 2014.

Fig: 11 The AirPod

III. RESULTS AND DISCUSSIONS

Compressed air technology allows engines that are both nonpolluting and economical. With the use of non-conventional energy sources such as compressed air engine we can set a milestone in the field of green technology because it is the demand of the time to adopt green technology.

3.1 Advantages of compressed air powered vehicle:

In comparison to petrol or diesel powered vehicles "air powered vehicles" have following advantages:

• Air, on its own, is non-flammable, abundant, economical, transportable, storable and, most importantly, nonpolluting.

• Compressed air technology reduces the cost of vehicle production by about 20%, because there is no need to build a cooling system, fuel tank, spark plugs or silencers.

• High torque for minimum volume.

• The mechanical design of the engine is simple and robust.

• Low manufacture and maintenance costs as well as easy maintenance.

• Lighter vehicles would mean less abuse on roads, thus, resulting in longer lasting roads.

• The price of fueling air powered vehicles will be significantly cheaper than current fuels.

• When the air is being compressed at reasonable speeds, it heats up. The heat given off during compression could be reclaimed for space heating or water heating, or used in a stirling engine.

• Transportation of the fuel would not be required due to drawing power off the electrical grid. This presents significant cost benefits. Pollution created during fuel transportation would be eliminated.

Compressed-air vehicles are comparable in many ways even to electric vehicles and their potential advantages over electric vehicles include:

• Compressed-air vehicles are unconstrained by the degradation problems associated with current battery systems.

• Much like electrical vehicles, air powered vehicles would ultimately be powered through the electrical grid which makes it easier to focus on reducing pollution from one source, as opposed to the millions of vehicles on the road.

• Compressed-air tanks can be disposed of or recycled with less pollution than batteries.

• The tank may be able to be refilled more often and in less time than batteries can be recharged, with refueling rates comparable to liquid fuels.

• The tanks used in a compressed air motor have a longer lifespan in comparison with batteries, which, after a while suffer from a reduction in performance.

CONCLUSIONS:

It's important to remember that while vehicles running on only compressed air might seem like a distant dream, but they still have public interest due to their environmental friendly nature. 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. This

paper explores the effective application of pneumatic power. Pneumatic vehicle will replace the battery operated vehicles used in industries. Pneumatic powered vehicle requires very less time for refueling as compared to battery operated vehicle.

On the whole, the technology is just about modifying the engine of any regular IC engine vehicle into an Air Powered Engine. The Air Powered Engine technology is cheaper in cost and maintenance, can be easily adapted by the masses and it doesn't cause any kind of harm to the environment. Instead, its wide spread use will help mankind in controlling the serious problem of global warming.

At the end of this review we conclude that the compressed air technology can be tested and developed using the Vaned Type Novel Air Turbine as there are minimal losses and practically their efficiency varies from 72-97% which is very high when compared to a conventional IC engine. Future developments can be made by designing an ideal vehicle for this kind of engine.

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