Performance studies on compressed air driven modified commercial two stroke engine

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ABSTRACT

With gasoline prices soaring and fossil fuels depleting, the need for alternative propulsion systems becomes critical to sustain present level of mobility. Also there is a growing concern over the pollution caused by the harmful gases released from burning fossil fuels, leading to global warming, climatic change and health related complications. Transport sector is one of the major consumers of energy and contributors to emission. Any small improvement in the efficiency, use of renewable sources or new methods to reduce emissions will bring a tremendous impact on energy and environment. Reducing emissions even at specific locations like hospitals, crowded cities, etc will contribute positively to improve human health. To this purpose electric and pneumatic vehicles are widely used. In India, millions of vehicles that run in conventional fuel are used. Instead of making new electric and pneumatic operated vehicles, this project aims at remodeling an existing vehicle to operate on compressed air. An existing two stroke engine is redesigned which works on compressed air. An innovative inlet mechanism is designed for the purpose of allowing pressurized air to enter the cylinder and expand, thus exerting force on piston. A cam mechanism, coupled with the crankshaft through a chain drive, is used to control the action of the inlet, to allow compressed air to enter the cylinder when the piston is at top dead centre. Once the air forces the piston to the bottom dead centre, the inlet valve shuts off preventing the entry of compressed air into the cylinder, thus reducing the consumption of compressed air. This cycle continues to run the vehicle. In order to test the performance of the modified engine, a brake drum loaded with dynamometer is coupled with the engine crankshaft on test setup. For different load conditions and input pressures the performance of the engine was studied. Experimental analysis shows that the mechanical efficiency increases with increase in power output but decreases with increase in pressure. The overall efficiency is around 7% for a brake power of 0.16 kW at a pressure of 7 bar.

KEY WORDS: Two stroke engine, Compressed air driven engine.

1. INTRODUCTION

The various sources of energy for operating automobiles are petrol, diesel, natural gas, biogas, charcoal, solar energy, hydrogen, nitrogen and compressed air. The major contributor is the petrol and diesel powered engines. They contribute up to 85% of vehicles all over the world. Hence the emissions from these sources are inevitable. This greatly affects human health. To address this issue, renewable and greener fuel sources are being explored. Also electric and compressor driven vehicles are used to reduce pollution at least in critical locations like hospitals and crowded cities. The advantages of compressed air driven vehicles are: almost no fuel transportation and storage issues, lighter than conventional automobiles, low manufacturing and maintenance costs and importantly no harmful gases. Also refilling of compressed air tanks can be done at any place. As the engine operates at cold or warm conditions, it eliminates the need for cooling. This makes the engine less in weight thereby reducing the vehicle production cost. Compressed air tanks are less dangerous compared to H_2, LNG, CNG, LPG tanks. Though the energy to run a compressor must come from power plants, at least air driven vehicles move the pollution from its location to central power plants where emission control methods are far better and less costly than treating them at individual vehicles.

In early 19th century, compressed air was used to run trams in Paris. French companies like Motor Development International (MDI) and PSA Peugeot Citroen and Indian companies like TATA Motors are working to perfect the technology for compressed air driven cars. MDI reports that their air car weighing 907kg can run at 56 kmph. So compressed air driven vehicles can soon be witnessed on our roads.

Asia is still using its two stroke engines widely. Huge amount of common users are unable to put off them due to financial reasons. Instead of running them with conventional fuel, if we convert them to run on non-polluting sources, emissions can be reduced to a very large extent. So in Asian context, also for many similar countries of other continents, attempting greener fuel in existing engines is essential in order save the environment without pressuring the common man to invest in new vehicles. Few researchers like Maglub (2012), and Naveen Kumar (2013), have attempted conversing SI engines to run in compressed air. But they haven't reported their performance in details. Yuan (2014), and Nitin (2014), have studied the performance of compressor air driven four stroke engines. Apart from compressed air fuels many authors like Kirthivasan (2015), tried blended fuels also on existing vehicle engines with minor modifications in order to reduce emissions. Still an exhaustive experimental works needs to be done to make this technology viable on both technical and economic grounds. Hence, the present work attempts to adopt an existing two stroke engine to run on compressed air and study its performance.

2. EXPERIMENTAL

Design Modifications: In a conventional automobile engine (IC engine), combustion of fuel is used to supply energy. But here, compressed air replaces the conventional fuels. Hence changes are done to a two stroke conventional fuel engine. The layout of the engine and assembled view of the modified compressed air driven engine assembly are shown in Fig.1 and 2.

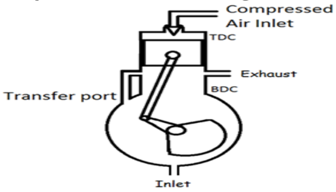

Fig.1. Layout of engine

Fig.2. Modified compressed air driven

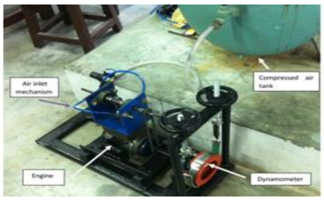

Fig.3 Modified compressor driven engine with test set up

The engine that is modified for this project is a two stroke TVS engine of 50 cc capacity. The spark plug is removed from the existing IC engine and is replaced by a novel inlet mechanism designed to allow compressed air into the cylinder over the piston head. A hollow cylinder rod is used with the same thread as the spark plug, so as to reduce work done in fixing the inlet mechanism. Two holes are drilled on the sides of the rod and flexible hoses are fixed to supply compressed air to the engine. A plunger is bored to provide opening and closing of ports and is controlled by cam. The cam shaft is powered by a chain drive that is connected to the crank shaft. The cam design is optimized such that the amount of compressed air that is used in the expansion phase inside the cylinder is minimum, so as to reduce energy consumption, and avoid wastage.

Working principle: Air at high pressure is stored in a tank. It is then sent in through the inlet mechanism. The high pressure air forces the piston down (which is the occurrence of the power stroke). Thus, output torque is obtained. The expanded air exits the cylinder through the exhaust port. A part of the engine output power is used to run the cam shaft, which controls the motion of the plunger in the inlet mechanism to allow the flow of compressed air into the cylinder only when required.

Test setup and procedure: To test the performance of the engine a test rig was built as shown in Fig.3. The testing setup consists of a frame upon which the engine is mounted and connected to a dynamometer. The dynamometer consists of a belt loaded-brake drum connected to the engine through a shaft, which is used to apply load on the engine. The engine was assembled on the testing setup fabricated. The testing setup is such that any engine can be mounted on the platform for testing purposes. Since an used engine was selected the maximum load applied was restricted to 2 kg. Also the available facilities restricted the compressed air pressure to 8 bar.

A compressor pressurizes air and stores in an air tank. The timing of the engine according to the inlet of compressed air is optimized, such that air is let into the engine only when the piston is at the TDC. When the piston is at the TDC, the flow valve is opened to allow flow of compressed air into the inlet mechanism, and the engine is set in motion. The operation of the cam controls the inlet mechanism to allow compressed air to enter the engine, only from the beginning of the TDC to the opening of the exhaust port. Load is applied to the engine using the dynamometer and engine RPM is noted using a tachometer. Inlet pressure is noted from the pressure gauge fitted to the pressure regulator just before the inlet mechanism of the engine. Manometer readings for air inlet are noted and the time taken for 3 revolutions of the energy meter is also noted.

Parameters selection: The primary objective was to test the application of air as an alternate propulsion system and test the modified two stroke engine and test the suitability of the novel inlet mechanism. The maximum compressed air pressure was only 8bar due to limitations in facilities available in our college. The engine selected was an old one which was in operation for many years; hence the maximum load for the selected pressures couldn't go beyond 2 kg. So results presented are being the lowest possible output from a two stroke engine. Table 1 shows the parameters varied and their range.

Table.1. List of parameters and their range

Description	Range
Load applied	0.5 – 2. kg
Compressed air pressure	3 – 8 bar

3. RESULTS AND DISCUSSIONS

It can be observed from Fig. 4 that the mechanical efficiency increases with increase in pressure as higher pressures have higher potential for work. Efficiency also increases with increase in load. This is because the driving potential in compressed air is better utilized at higher loads. Figure 5 shows that increase in pressure increases the speed of the engine almost linearly. For a pressure of 8 bar, the engine can run at 1000rpm for a load of 1.5kg. The mechanical efficiency of the various brake power and air pressure is shown in Fig 6. It can be observed that effect of pressure is better realized at higher break power than at lower break power. Figure 7 indicates that the mechanical efficiency decreases with increase in speed for various ranges of pressure.

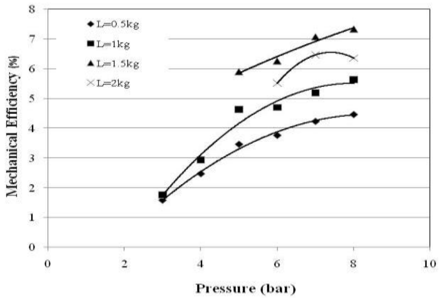

Fig.4. Effect of Pressure on Mechanical efficiency for various loads

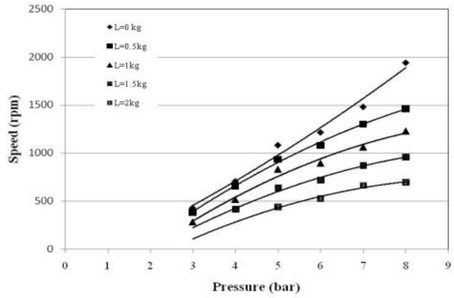

Fig.5. Effect of Pressure on Speed for various loads

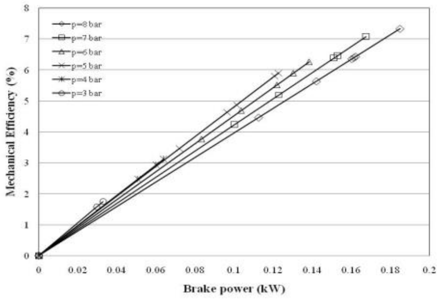

Fig.6. Effect of Brake Power on Mechanical Efficiency for various loads

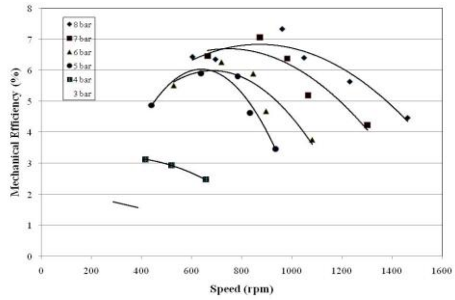

Fig.7. Effect of Speed on Mechanical Efficiency for various Pressure

4. CONCLUSIONS AND RECOMMENDATIONS

The compressed air engine is a device which is propelled by high pressure air, stored in a tank. The consumption of compressed air is controlled accurately by the use of the cam mechanism designed. By varying the pressure of compressed air supplied, the engine speed can be controlled. At 8 bar the engine produced an output of 0.184 kW (1.5 kg) and ran closer to 1000 RPM with a mechanical efficiency of 7.33%. The compressed air engine that has been demonstrated with the working model is the tip of the ice berg in terms of scope for development of alternate sources for powering engines. It has the capability to be extended to a large number of applications, and to become one of the major areas of research for alternate propulsion systems for auto manufacturers. One of the major areas of improvement is the installation of an inter-heater, in order to perform a multi-stage expansion process. There are three types of expansion processes; i) Isothermal, ii) Polytrophic, iii) Isentropic.

In the compressed air engine developed, polytrophic expansion process takes place. Maximum efficiency is obtained in an isothermal expansion process. But this cannot be realized as an isothermal expansion process is infinitesimally slow. Multi stage expansion brings the expansion process as close as possible to an isothermal process, which is performed by the use of an inter-heater.

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