Performance of Air Power Engine Powered with Compressed Air and Engine Exhaust Gas

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Abstract—Now-a-days people are concentrating mainly on alternate fuels as there is shortage of non-renewable energy sources and some of the alternate fuels which are available are found to cause some of the problems like difficult to store, proved to be less efficient and non-economical. So we have to find the solution to these three crises of shortage in fuel, hike in fuel prices and pollution to environment caused by the combustion of fuels. To achieve this we have to modify the existing I.C. Engine or Compressor into an Air Powered Engine to run the vehicles. We chose the compressor and we modified it as our main objective is to develop an efficient, economical and which runs on clean fuel with almost zero emissions i.e. air and we named it as air powered engine. At the initial stage compressed air is used as fuel for the engine, this lead to the idea of using Exhaust to run the engine and hence it is termed as Exhaust Gas Engine. The fuel used in Exhaust Gas Engine is the Exhaust evolved from CI or SI Engines. Industries releases exhaust gases in to atmosphere, using of these exhaust in a productive manner, results in development of a most economical engine. Hence, exhaust gas as a fuel can be considered as one among the best alternative sources of energy.

Index Terms—CAE, Compressed Air Power Engine, Green Engine, Experimental Air power Engine, Compressed Air Fuel, Exhaust Gas Fuel.

I. INTRODUCTION

Air, which is abundantly available and is free from pollution, can be compressed to higher pressures at a very low cost, is one of the most considerable option since atmospheric pollution can be permanently wiped out. Whereas so far all the attempts made to eliminate the pollution has however reduced it, but complete eradication is still rigorously pursued. Compressed air utilization in the pneumatic applications has been in use for long time. Air motors, pneumatic actuators and other various such pneumatic equipment are in use. Compressed air was also used in some of the vehicle for boosting the initial torque. Turbo charging has become one of the popular techniques to enhance power and to improve the efficiencies of the automotive engines.

The concept of micro or mini compressed air engine can be one of the best alternatives for light vehicles, if it runs using air alone and thus causing no pollution. It was also under study to develop a reciprocating automotive engine that completely runs on compressed air. There are too many ongoing projects that are developing a new type of car that will run only on compressed air. Similar attempt has been made but to modify the existing engine and to test on compressed air.

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. Instead of mixing fuel with air and burning it in the engine to drive pistons with hot expanding gases, compressed air engine use the expansion of compressed air to drive their pistons. Actually all engines work with compressed air. Most engines suck it in, heat it up, it pressurizes and it pushes on a piston. The future of power production will soon be whooshing down the houses in the form of an unparalleled “green” earth-friendly technology that
everyone will want to get their hands on as soon as they can: The Compressed Air Engine. It is hard to believe that compressed air can be used to produce power or drive vehicles. However that is true with the “Compressed air Engine”.

II. PRINCIPLE AND WORKING OF AIR POWER ENGINE

In compressed air engine there will only be two strokes. Engine will be supplied with the mean effective pressure which will directly push the piston in downward direction hence giving the piston power to drive the engine. But as soon as the piston comes up the exhaust valve will have to be opened so that the compressed air driving the piston may go out and piston may cover its distance in the upward direction without any hurdle. Now to minimize forces on the head of the piston the intake valve will also have to be closed while piston is coming up. As the basic idea has been grasped now the amendments will have to be made in the engine.

A. Stroke I:

In the first stroke the intake valve will open and the compressed air will make impact with the piston. As a result the piston will go down from the top dead centre to the bottom dead centre. Hence the intake stroke will also act as power stroke as well. Therefore, there will be no need of extra power stroke.

B. Stroke 2:

In the second stroke the exhaust valve is opened and the compressed air which gave its energy to piston in the last stroke to make it move goes out as the pressure of the ambient is even lower.
III. FABRICATION OF AIR POWER ENGINE

Two air guns are employed to the conventional compressor out of which one controls the inflow of the compressed air and the another controls the out flow of the air from compressor i.e. one acts as inlet valve and other as outlet valve and hence complete cycle is controlled.

In order to avoid back pressure and to maintain required pressure, two way manifold is used. Where, one valve of Two Way Manifold is opened to atmosphere and the other is connected to Exhaust Gas Engine. When the valve connected to Exhaust Gas Engine opens, the exhaust enters in to the engine by Inlet Air Gun.
IV. EXPERIMENTAL SETUP

A. Specifications of Air Power Engine

Make : Bosch
Type : Reciprocating Type
Acting : Single Acting
Stage : Single Stage
Cylinder : Single Cylinder
Bore : 70 mm
Stroke Length : 40 mm
No Of Strokes : 2 Strokes
Lubrication : Splash Type
Heating : Air Heating
Belt : A Type Belt
Flywheel : 6 Kg 10 Inch
Max Speed : 120 Rpm at 5 bar
Range : Works efficiently between 2.5 To 4.5 bar
Mechanism : Actuation of Compressed Air by Air Guns

Valve Timing Diagram of Air Powered Engine

![Valve Timing Diagram of Air Powered Engine](image)

**Fig 8:** Valve Timing Diagram of Air Powered Engine

At TDC - Exhaust valve closes 5˚
After TDC - Inlet valve opens 85˚
Before BDC - Inlet valve closes
At BDC - Exhaust valve opens

Here both the valves are controlled by the movement of fly wheel i.e. crank rotation

Inlet Valve Opens for 90˚ from 5˚ after TDC and exhaust valve opens for 180˚ from BDC

Usually there are many researches going on this type of engine there are many projects related to this engines which involves the conversion of conventional engines to compressed air engine. In most of the cases 4- stroke engine is converted to this type or a new designed engine for this type but we took a conventional compressor and we converted into a compressed air engine by removing delivery valves, closing suction valve and we made two external valves by using two air guns of a size of quarter inch diameter and we also changed the pulley (in case for an engine it is called as fly wheel) given with the compressor to another pulley which has more weight than the original one to get higher moment of inertia such that it is capable of maintaining some torque in the stroke other than power stroke.

B. Engine Fuelled with Exhaust Gas

![Experiment set up for compressed air fuel to the air power engine](image)

**Fig 9:** Experiment set up for compressed air fuel to the air power engine

![Two way manifold is connected to the diesel engine exhaust manifold](image)

**Fig 10:** Two way manifold is connected to the diesel engine exhaust manifold

The fuel used in Exhaust Gas Engine is the Exhaust evolved from CI or SI Engines. At the initial stage compressed air is used as fuel for the engine, this lead to the idea of using Exhaust to run the engine and hence it is termed as Exhaust Gas Engine. Industries
releases exhaust gases into atmosphere, using of these exhaust in a productive manner, results in development of a most economical engine. Hence, exhaust gas as a fuel can be considered as one among the best alternative sources of energy.

Working of Exhaust Gas Engine: Pressure required for Exhaust Gas Engine ranges from 2.5 to 4.5 bar, the required pressure is extracted from engine manifold. In order to avoid back pressure and to maintain required pressure, two way manifold is used. Where, one valve of Two Way Manifold is opened to atmosphere and the other is connected to Exhaust Gas Engine. When the valve connected to Exhaust Gas Engine opens, the exhaust enters into the engine by Inlet Air Gun.

When the pressurized air strikes the piston, piston moves from TDC to BDC thus expansion occurs. This results in the rotation of flywheel and then piston moves from BDC to TDC, facilitating the release of Exhaust gases from the engine with the help of Outlet Air Gun.

- Supply of compressed air from air power engine to the diesel engine

A compressor is connected to the flywheel of Exhaust Gas Engine, this results to develop 3-4 bars pressure. This compressed air is connected to the Diesel Engine Inlet, which refers to supercharging.

V. RESULTS AND DISCUSSION

![Graph showing the variation of indicated power with pressure](image1.png)

**Fig 12. Statistical data of Indicated power varying with pressure**

The indicated power is varying with the pressure as shown in the above figure. When the pressure increases, the indicated power increases. The indicated power developed by compressed air engine is high compared to the exhaust gas engine. Only a minimal variation is observed among output produced by using Compressed air and Exhaust Gas. Where, Compressed air is generated by using electrical energy and Exhaust gas is obtained at free of cost.

![Graph showing the variation of speed with pressure](image2.png)

**Fig 13. Statistical data of Speed varying with pressure**

As the compressed air supplied to the Air power Engine, it results in change of speed as shown in above fig. When the input pressure increases, speed .maximum speed obtained 128 rpm at 4.5 bar. The
exhaust gas supplied to the air power engine gets maximum speed obtained 116 rpm at 4.5 bar.

variations is observed among output produced by using Compressed air and Exhaust Gas. Where, Compressed air is generated by using electrical energy and Exhaust gas is obtained at free of cost.

**Fig 14. Statistical data of brake power varying with load**

The load is varying with the brake power as shown in figure14. When the load increases the brake power increases. The compressed air engine is developed the brake power is high compared to the exhaust gas engine. Only a minimal variation is observed among output produced by using Compressed air and Exhaust Gas. Where, Compressed air is generated by using electrical energy and Exhaust gas is obtained at free of cost.

**Fig 15. Statistical data of brake power vary with different pressures**

The pressure is varying with changing of the brake power as shown in figure15. When the pressure increases the brake power increases. The compressed air engine is developed the brake power is high compared to the exhaust gas engine. Only a minimal variation is observed among output produced by using Compressed air and Exhaust Gas. Where, Compressed air is generated by using electrical energy and Exhaust gas is obtained at free of cost.

**Fig 16. Statistical data of Speed varying with load**

The load is varying with changing of the speed as shown in figure16. The load increases with the increasing of the speed. The Brake Power developed by Compressed air engine is high compared to the exhaust gas engine. Only a minimal variation is observed among output produced by using Compressed air and Exhaust Gas. Where, Compressed air is generated by using electrical energy and Exhaust gas is obtained at free of cost.

**Fig 17. Statistical data of Torque varying with load**

The load is varying with changing of the torque as shown in figure17. Increasing of the load results in increasing of the torque. The compressed air engine torque is equal to the exhaust gas engine because of the same loads.
The load is varying with changing of the friction power as shown in figure 18. The load increases with the increasing of the friction power. The friction power developed by compressed air engine is high compared to the exhaust gas engine because of the difference in density of exhaust gases.

The load is varying with the mechanical efficiency as shown in figure 19. When the load increases the mechanical efficiency increases. Mechanical efficiency developed by compressed air engine is high compared to the exhaust gas engine. Only a minimal variation is observed among output produced by using Compressed air and Exhaust Gas. Where, Compressed air is generated by using electrical energy and Exhaust gas is obtained at free of cost.

As the compressed air supplied to the diesel Engine from air power engine, it results in change of brake thermal efficiency. As shown below fig20. maximum brake power obtained 3.85kW. Which refers to supercharging and this facilitates improved brake thermal efficiency by 2% of Diesel Engine.

As the Compressed air supplied to the diesel Engine from air power engine, it results in change of volumetric efficiency. As shown below fig21. maximum brake power obtained 3.85kW. Which refers to supercharging and this facilitates improved volumetric efficiency by 5% of Diesel Engine.
VI. CONCLUSION

From the above discussion it can be concluded that when the input pressure increases the speed of the engine as well as indicated power increases and maximum indicated power at 4.5 bar is 128 rpm. For maximum load of 4kg Brake power and mechanical efficiency obtained is 0.123kW, 80.29% respectively. For exhaust gas used as a fuel in an air powered engine then the maximum indicated power and speed obtained is 0.141 kW, 116 rpm at 4.5 bar. For maximum load of 4kg Brake power and mechanical efficiency for exhaust gas powered engine obtained is 0.113kW, 80.14% respectively. Finally we can say that the compressed air and exhaust gas powered engine get the nearly same results but the exhaust gas powered engine has less mechanical efficiency due to waste gases. A compressor is connected to the flywheel of Exhaust Gas Engine, resulting in development of pressure. This compressed air is connected to the Diesel Engine Inlet, which refers to supercharging and this facilitates improved volumetric efficiency by 5% and brake thermal efficiency by 2% of Diesel Engine.

REFERENCES


