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Research Article

Performance Analysis of an Air Driven Engine Modified from SI Engine

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Abstract

In the present scenario, the population of vehicles run by the fossil fuels is increasing tremendously in each year. These fossil fuel resources are at fast depleting trend and they may exhaust by 2050. The combustion products of these fuels are causing peak environmental pollution. The mismatch between the demand and supply of fossil fuels and the associated pollution problems is directing the world to shift towards renewable energy resources. With the usage of the renewable energy sources the dependency on fossils fuels and the environmental pollution can be minimized. In order to bridge the gap between the demand and supply of the fossil fuels, the automobile sector is depending on the bio diesel and solar power for some extent. In the view of economic and pollution aspects usage of compressed air to run the engine is very interesting, as the concept of pneumatics is known to men for several centuries. The air driven engine uses the air as fuel which is available abundantly in eliminates the use of fossil fuels. The another beauty of this technology is that the pollution is negligible The basic two stroke petrol engine is converted into an air driven engine with slight modifications, and it is provided with solenoid valve, Valve activation system including valve timing disc and the electronic circuit. The engine is cranked by the kicker. So that, the crank shaft along with the valve timing disk will rotate in the clockwise direction. The valve of the compressor tank is opened gradually to the maximum under the no load condition. When the engine attains the speed the performance test is conducted at different load conditions within the pressure range of 1 to 9 bar. In Air Driven Engine, the speed is bound to increase with increase in the inlet pressure. The brake power is also increased with increase in the inlet pressure

Keywords: *ODC (outer dead centre), Electronic circuit, Torque, Brake power.*

1. Introduction

The fossil fuels such as petroleum, diesel, natural gas and coal are being depleted rapidly. The fuel with World oil demand is 100 million barrels/ day. This has been spurred on by the fact that the world's current crude oil reserves are set to run out in the next 40 to 50 years. Among the alternative fuels believed to be the solution of the energy and the environmental crisis, Bio diesel and Alcohol fuels were feasible fuels and much devotion was given to them. Since this time, a lot of researches have been conducted by different scientists of the globe and of course attractive and appreciable results have come out. These two fuels can be used as pure as well as blended with the fossil origin fuel in any concentration in existing diesel engines with little or no modification. But combustion of the fuels is causing environmental problems.

As far as air pollution is concerned, with increases in population exponentially, our technological activities have an increasing impact on the environment. In urban areas, vehicle account for over 50% of the air pollution emitted. The targeted emissions from diesel operated vehicles are: NOx, carbon monoxide (CO), Particulate Matters (PM) and air toxics. This high level greenhouse gas emission cause an increase in ground level ozone. Ground level ozone can cause aching lungs, wheezing, coughing and headaches. Serious health problem also arises for those people suffering from Asthma, emphysema and chronic bronchitis. Children appear to be at particular risk like 10% to 15% lung function. In half of the world's cities, tail pipe emissions from gasoline and diesel powered vehicles are the single largest source of air pollution. Worldwide automobiles account for half of the oil consumed and a fifth of the greenhouse gas emitted. This situation is not expected to be improved in near future.

Air driven engine is one of the alternate technologies. As air is freely and abundantly available in the nature and as it is non pollutant, on the basis of fuel economy and environmental pollution, running the engine with air is a very positive sign. The science of air is known to men for several centuries and it has been long proven. The air operated and gadgets and tools such as Air motors, pneumatic actuators and others are common sight in industry. Compressed air was also used in some vehicle for boosting the initial torque. Turbo charging has one of the popular techniques to enhance power and improve the efficiencies of the automotive engine that completely runs

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on compressed air. An Air driven engine makes use of compressed air technology for its operation.

During the Second World War under the tremendous shortage of war commodities and technical man power the concept of pneumatics is widely spreader. Compressed Air Technology is now widely preferred for research by different industries for developing different drives for different purposes. Today the air operated tools and other retrofits are common sight in industries. The compressed air holding some energy can do the useful work when it is expanded. So this energy in compressed air can also be utilized to run the engine. This is the basic working principle of air driven engine. So, an air driven engine is especially a pneumatic actuator that creates useful work by expansion of the air. This work provided by compressed air is utilized to supply power to the crank shaft of the engine. As the engine is driven by the compressed air there will not be any combustion taking place within the engine so it is non polluting and less dangerous. It requires lighter metal only as there is no need of withstanding higher temperatures. Since there is no combustion taking place, there is no need of mixing fuel and air. Here the compressed air is the fuel and it is directly fed into the piston cylinder arrangement. It simply expands inside and does the useful work. In addition turbo charging has become one of popular techniques to enhance torque and improve efficiencies of the automotive engine that completely runs on the compressed air.

2. Engine specifications

The basic engine that we have used in the project is a normal two stroke petrol engine. The details of the engine are as follows:

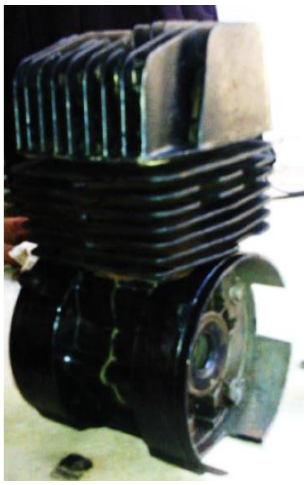


Fig. 1: Selected two stroke engine

Make: TVS
Displacement: 60 c.c.
Number of cylinders: 1
Stroke Length: 42 mm
Bore diameter: 38 mm

Specifications of testing apparatus

Diameter of brake drum; D = 0.07 m
Diameter of rope; d = 0.004 m
Gravitational constant g = 9.81 m/s2

3. Engine Modifications

A normal two stroke engine contained several ports and it also had the spark plug which we didn't require. So, several modifications had to be done on the engine to suit our purpose.

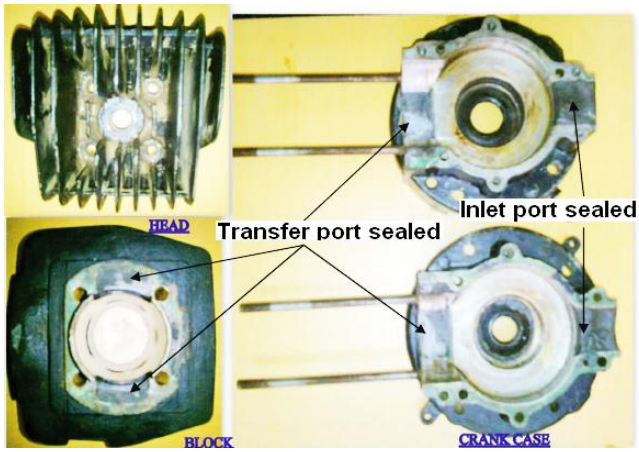


Fig. 2: Modifications of the engine

The modifications comprised of:
• Closing the transfer port
• Closing the inlet port
• Removing the spark plug from the cylinder head
• Providing an inlet at the place of the spark plug

The transfer port was to be sealed to provide maximum sealing of the piston cylinder arrangement Shown in Fig. 2. So that the chances of escape of air from the cylinder can be avoided. We made use of m-seal and araldite to seal off the transfer port. First a fine quantity of m-seal was filled in the transfer port fully except for a small clearance to apply araldite. Then the m-seal was allowed to solidify. After that araldite was applied in another layer and was allowed to solidify. Thus the transfer port was closed with the help of the adhesives.

The inlet port also was required to be closed to avoid mild chances of leakage. It was much easier to close the inlet port. The inlet port contains a Reed valve at its start. This valve is basically a non-return valve. So if we screw it tightly there wouldn't be chances of escape of air through the inlet port. This was carried out to close the inlet port. There is no combustion taking place in an Air Driven Engine. So naturally there is no need for the spark plug. So the spark plug is removed from its respective position that is on the top of cylinder head. It would be great if we provide the inlet for compressed air at the position of the spark plug as it is better to let the air enter from the top of the piston. So the connector which is used

to connect the pipe from the compressed air tank has to be fixed at the position of the spark plug. The connector contains an R1/2 thread of BSPT standard. So we tapped the same thread on the cylinder head at the position of the spark plug. Then the suitable connector was fixed on the cylinder head.

4. Engine components

The engine is modified and consists of the following components

4.1. Engine

The engine that is modified is brought and compressed air is now used as the fuel to run the engine *Fig : 1*.shows the engine

4.2. Solenoid valve:

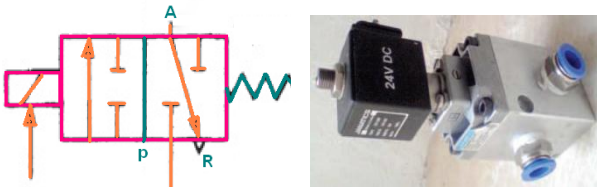


Fig. 3: Solenoid valve

A solenoid valve shown in *Fig. 3* is an electromechanical controlled by an electric current through a solenoid coil. Here a 3/2 pilot operated valve is used with the following specifications :

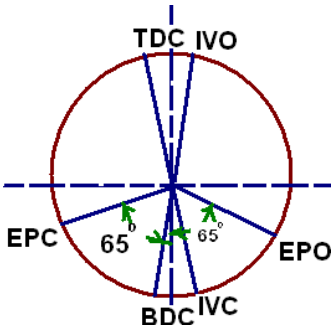
Orifice Diameter: 12 mm
Operating pressure range: 2-10bar
Flow rate : 3000Litres/minute
Coil width: 32 mm,
Voltage: 24V DC,
Duty cycle: Continuous

4.3. Valve timing disc and Valve activation system:

The valve activation system is designed to actuate the solenoid valve at appropriate period of time. In the traditional two stroke SI engine compression stroke and power stroke are available .The exhaust and compression takes place in one stroke and the power and suction takes place in other stroke But in this compressed air driven engine the pressurized air enters into the engine cylinder and causes power stroke there will not be any compression stroke, it is the exhaust stroke.

The amount of compressed air sent to the engine cylinder is regulated by the designed timing disc shown in Fig ; 5. The circular disc is being cut from a sheet metal of radius 6 cm and a sector portion of an angle of 175^0. So that fuel(compressed air) is being sent to the engine cylinder at this particular time period. So that , the amount of pressurized air is sufficient for the piston to invert its direction of reciprocation from downward to upward and complete the cycle. In this, compressed air driven engine

Similar to IC engine the inlet valve is opened at the point of time that the piston moves down from TDC and the valve is closed at correct point of time before BDC such that the incoming air should not obstruct the piston movement further when started back from BDC to complete the next half revolution and finally to complete the cycle



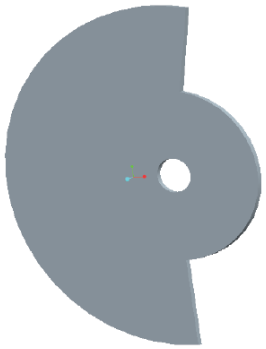


Fig.4: VTD **Fig.5**: Valve timing disc

If the angle of sector is less than the 175^0 then the amount of compressed air allowed is not sufficient to push the piston and to use the same stroke for further revolution that is to distribute the power in next exhaust stroke If the angle is greater than the 175^0 it will oppose the compression stroke. Thus the required supply of the compressed air is obtained by using the solenoid valve an electronic circuit is used to 'make and break' the supply to the solenoid valve according to the angle of the disc In this (modified two stroke engine) the location of the spark plug acts as inlet as the transfer port and inlet port the original engine is sealed .In the diagram (Fig: 4) the circle top point is the Top dead centre (TDC) and the bottom point is the Bottom dead centre (BDC).The diagram indicates Inlet valve opening as IVO and at this point of time the solenoid valve operates and the compressed air is allowed into the cylinder. As the piston moves downward the exhaust port itself opens as it is on the wall of cylinder. Air is admitted up to the IVC (Inlet valve closing) .During this period of time the air is allowed and power is developed at the crank shaft and thus the piston moves downward to BDC and reverses its motion upward using the power produced in the later stroke. The next line indicates the closing of the exhaust port and represented as EPC. As calculated from the diagram the idle time of the piston at TDC is for an angle of 200 and BDC is 100.

4.3. Piping system with connectors and the pressure gauge

It is used to connect the cylinder to the solenoid valve solenoid valve to the cylinder head. Here polyurethane pipes are used of diameter of 12mm and length of 2m. The type of connector used is one touch male connector which has an internal hexagonal socket. The specification of the thread is BSPT R1/2 (British standard piping thread). The outer diameter is 21.5mm and the inner diameter is 12mm. The pressure gauge is connected to the inlet of the solenoid valve. This helps to measure the pressure inlet to the solenoid valve A ' T ' shaped female connector is used

to hold the pressure gauge at position.

5. Electronic circuit

The purpose of the electronic circuit is to make and break the supply of the solenoid valve according to the valve timing disc.

5.1 Components of the electronic circuit

The main components of the electronic circuit are as follows:
1. Infrared pair 2. Power supply 3. Voltage regulators 4. Resistors 5. Capacitor 6. Transistor 7. Comparator 8. 555 IC Timer
Infrared pair: The infrared pair Shown in *Fig 6* mainly consists of an infrared emitter and an infrared sensor. The emitter emits the rays to the sensor. Both the emitter and the sensor are led's of same rating. They are placed in correct position face to face and are aligned in a straight line. They are also placed close together and are enclosed by a covering with an opening for the rays to pass. This helps to increase the accuracy of the sensing of the sensor to its maximum.

Fig.6: IR Pair

Fig.7: Batteries

Power supply: The power supply here used is a 24V DC.*Fig.7* supply by two batteries each of 12V and 2.5A rating which are connected in series.
Voltage regulator: These voltage regulators shown in Fig.8 have three terminals namely Reference or common, Input and Output terminal respectively. The voltage regulator used here are RG 7812 and RG 7805 In the case of RG 7812 the reference is grounded and the input terminal is provided with 24 V DC current supply. The voltage regulator steps down the voltage 12 V DC .The output is now supplied to the regulator RG 7805 voltage regulator further steps down the voltage to 5 V and this will be supplied to the IR pair through a series of resistors in the circuit.

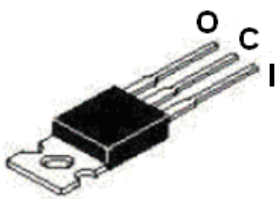


Fig.8: Voltage Regulator (7805)

Fig.9:: Resistors

Resistors: The resistors *Fig.9* are used to step down the current from the main supply. The main resistors used here are 18 Ω, 330 Ω, 1K Ω, 10K Ω, 22K Ω and Preset 500K Ω .The Preset resistor is used to tune the signals from the IR pair.
Capacitor: The capacitor Fig.10, is constructed with two or more alternating layers of ceramic and a metal layer. The ceramic material acts as the dielectric and the alternate layers of ceramic and metal layer acts as the electrodes. In the circuit two disc capacitors of 0.01µ farad and 0.001µ farad are used

Fig.10: Capacitors

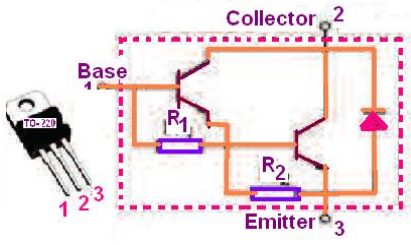


Fig.11: NPN Darlington Transistor (TIP 122)

Transistors: The transistor TIP122 Fig. 11 is used as a switching device to switch the 5V to the solenoid valve. It consists of three terminals. The emitter is grounded. The base is connected to the output terminal (1) of the comparator and the collector terminal of the transistor is connected to the solenoid valve
Comparator: The used comparator LM 741 Fig.12 is a general purpose operational amplifiers which have improved performance than the industrial amplifiers like LM709,LM 712 etc.., It mainly consists of 8 terminals out of which 5 terminals are in use. The negative terminal is connected to the voltage divider and the positive terminal is connected to the sensor. The output is taken from the output terminal to the transistor which acts as a switching device.

Fig.12: Comparator

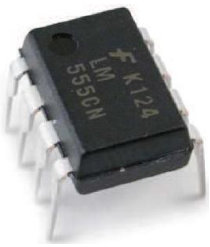


Fig.13: 555 Timer IC

555 timers IC: The LM555 *Fig.13* is a highly stable device for generating accurate time delays or oscillation. Additional terminals are provided for triggering or resetting if desired. The time is precisely controlled by one external resistor and capacitor. Two external resistors and one capacitor are used in the time delay mode of operation. For a stable operation as an oscillator, the free running frequency and duty cycle are accurately controlled with

5.2: Design of electronic circuit

The electronic circuit is to make and break the supply of

solenoid valve according to the valve timing disc. In this circuit IR pair is used along with the disc between them. The portion removed on the disc for the make of the circuit and remaining opaque sector portion of the disc for break of the circuit. The circuit is designed and tested on breadboard and then it is soldered on a PCB (Printed Circuit Board) without loose connections in the circuit. The following Fig.14 shows the connections made on breadboard and PCB.

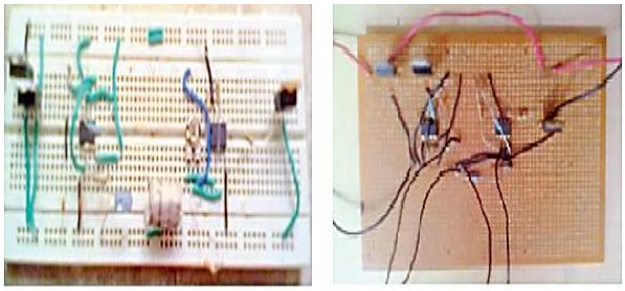


Fig.14: connections made on breadboard and PCB.

5.2.1: Working of the electronic circuit

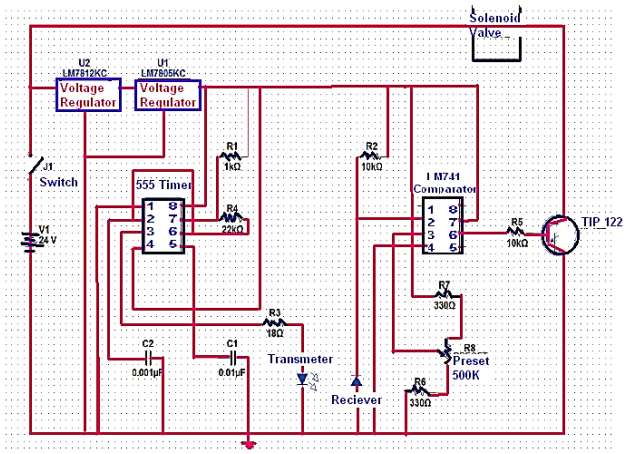


Fig.15: Electronic circuit

The 24 V DC is supplied to the voltage regulator shown in *Fig.15* RG7812 where the voltage is stepped down to 12 V. The reference terminal is grounded. The regulator RG7805 will further steps down the voltage to 5 V DC. Then the 5 V DC is passed to a series of resistors and then to the transmitter. When the transmitter receives the voltage it gets energized and emits the signal to the receiver section. The receiver receives the signal and passes on it to the comparator. The 5V is now given on to the comparator LM741input terminal (terminal 2).The same voltage comes out from the output terminal(terminal6).The output terminal is connected to the transistor base. The emitter of the transistor (TIP122) is grounded and collector terminal is connected to the solenoid valve. When the designed disc comes in between the IR pair, the supply to the transistors is cut-off and the collector gets grounded. When the disc gets back, solenoid valve is energized by passage of voltage through the collector and actuates the valve. This lets the compressed air to flow into the engine cylinder.

6. Working of the air driven engine

The difference between the IC engine and the air driven engine is that, in an IC engine; the energy required to move the piston is evolved by burning the fuel, while in an air engine the energy for moving piston is acquired from the supplied compressed air. The Fig.16 shows the connections of air driven engine

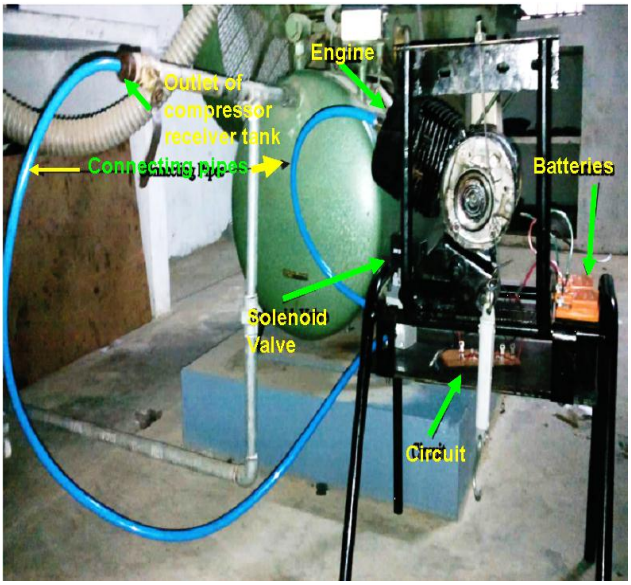


Fig.16: Connections of air driven engine

The complete assembly of our air engine consists of an IC engine with slight modifications, valve timing disc attached to the flywheel of the engine, sensor controlled valve mechanism, piping system, gauge system, air compressor and air tank. The purpose of the sensor controlled valve mechanism is for precise the proper and continues working of the engine by regulating the compressed air with timing. The valve timing disc is made to precise operation of valve. For that ODC is marked on timing disc also the point just before the exhaust port opening(EPO) is marked on the disk with the help of a cross sectional change.

For starting; the engine is cranked by the kicker. So that, the crankshaft along with the valve timing disk will rotate in the clockwise direction. During this rotation the ODC of the disc cuts the IR beam first and followed by the EPO When the IR beam is first cut by ODC region, the circuit activates the solenoid valve by electric signal. At the moment the valve gets opened and allows the flow of compressed air into the cylinder from the tank. The region from the point of ODC to EPO on the disk is opaque and does not allow the IR beam. So the circuit maintains the solenoid valve open by supplying a continuous supply of electric current to the valve. At the same time the compressed air entering the cylinder will push the piston towards the BDC. But to increase the fuel efficiency the fuel supply should be cut-off before reaching the EPO. So when the EPO region of the valve timing disc sweeps past away from between the IR sensors, the IR beam will make

connection again. This will cut the supply to the solenoid valve there by closing the valve. This will prevent the valve from being open at the same time of EPO; increasing efficiency. When the disc rotates further, the valve remains closed throughout the area from the EPO to the ODC as the IR beam is closed and this cycle continue.

7. Performance analysis of air driven engine

The specifications of the testing apparatus are as follows and the Fig.17, shows the Brake Drum and Spring Balance Assembly

Specifications of testing apparatus

Diameter of brake drum; D = 0.07 m
Diameter of rope; d = 0.004 m
Gravitational constant g = 9.81 m/s^2

Fig.17: Brake Drum and Spring Balance Assembly

A load test is conducted on the air driven engine. The testing apparatus consists of brake drum, spring balance, rope and holding frame. The brake drum of our testing apparatus was made by slightly modifying the Clutch disc of our engine itself and coupled it to the crankshaft. The spring balance is held in place to the main frame through a hole drilled into it. The rope is then tied to the hook of the spring balance. The other end of the rope is circled over the brake drum by a single loop in clockwise direction. The weight placing base is attached to the loose end of the rope. Extra care is taken in order to make sure that the spring balance, the rope and the weights are in straight line.

Procedure: The tank is filled up to the required pressure by running the compressor. The electrical circuit is turned on by closing the connection. The valve of the compressor tank is opened gradually to the maximum under the no load condition. The engine is cranked with the kicker. When the engine is gained speed at no load readings of pressure in the engine and the speed of the brake drum is noted down. This process is repeated for different values of pressure ranging between 1bar and 9 bar and the corresponding are noted. The readings thus obtained are tabulated

8. Performance characteristics.

The performance characteristics are represented in the form of graph by the values obtained from the load testing of the engine.

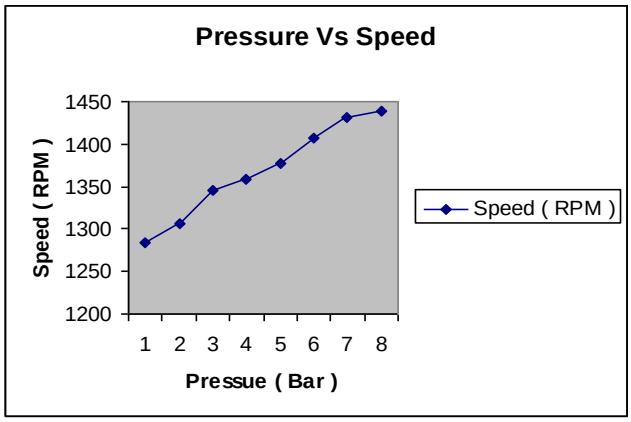


Fig.18: Pressure Vs Speed

In Air Driven Engine, the speed is bound to increase with increase in the inlet pressure.

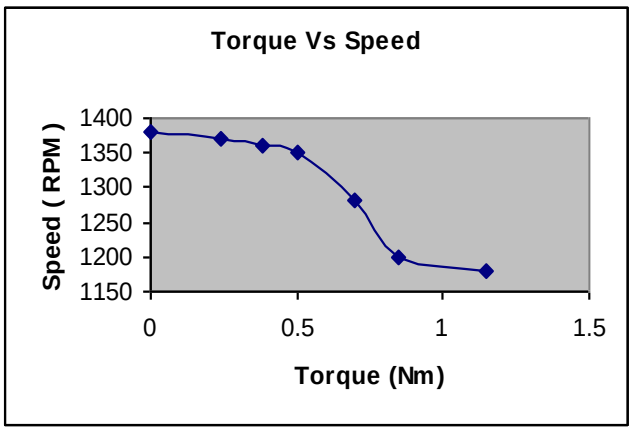


Fig.19: Torque Vs Speed

The speed versus torque characteristics shows a negative linear variation.

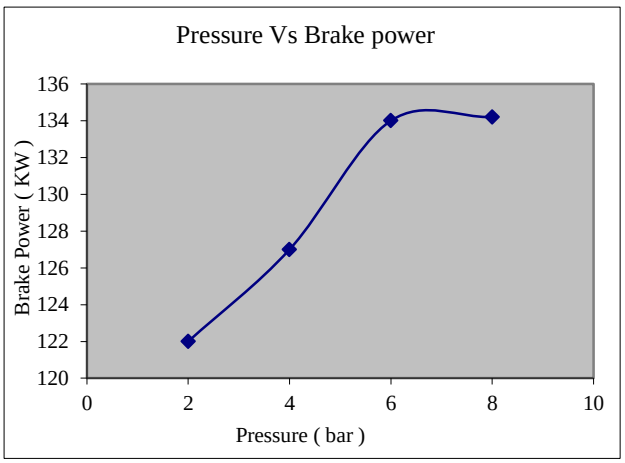


Fig.20: Brake Power Vs Pressure

The brake power is observed to increase with increase in the inlet pressure.

9. Advantages of an air driven engine

The following are the some of the advantages of the air driven engine

• Simple in construction, small in size and less costly
• The air engine is an emission-free engine
• Easy to maintain and repair and low maintenance costs
• The engine runs on cold or warm air
• Comparatively the operation cost is less.
• Light in weight and easy to handle.
• Compressed-air tanks can be disposed or recycled
• The price of filling air tanks is significantly cheaper
• Quick response is achieved.
• The engine temperature is less than the ambient
• Smooth working of due to very less wear and tear
• There is no possibility of knocking._
• No need of cooling and spark plugs or fuel injection
• No use of fossil fuels
• The cost of manufacturing is less as the no of components are less

10. Results and discussions

From the results obtained from the performance tests on engine the speed of the engine has increased drastically and the engine is working efficiently even at low pressures. The engine when operated at high pressures it is working almost nearer to the efficiencies of normal two stroke petrol engine. The output of the engine is increased with the increase in inlet pressure

Conclusion

The required modifications are successfully completed to convert the selected SI engine to Air Driven Engine. The Air Driven Engine provides an effective method for power production and transmission. Also the pollution free operation is an encouraging aspect Even though its applications are limited currently, further research could provide wider applications.

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