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Compressed Liquid Air Propelled Engine

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Abstract:- The main objective of this project is to design, develop, test and evaluate the compressed liquid air propelled engine that works with compressed liquid air as the fuel. In this system modifications are done to four stroke engine. In this engine, the fuel and exhaust is in the form of air or its components. The compressible air engine is an alternative for running light vehicles, which results in reducing the use of fossil fuel, hence it is an alternative for IC engines. On comparing with the existing air compression engine, the refilling of fuel is much simpler since the air is sucked in and compressed by the components fit around to the automobiles. The development of compressed air engine results in the reduction of environmental problem that are created by the conventional engines. 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.

Keywords—Air Engineg;Compressors;GI pipes;Non-return valve;Grinding machine;Design)

I. INTRODUCTION

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. (1) 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 available are solar, electric, atmospheric air etc. Air acts like a blanket for the earth. It is the mixture of gases, 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.

A.HISTORY

The history of Compressed Air Technology (CAT) is not new to industries. Pneumatic pressure stored in tanks with the use of CAT has been used to drive many pneumatic based devices in industries. The use of CAT did not remain to just industrial application but has been also applied for driving the vehicle. CAT was first used for running a vehicle in 18thcentury . The energy from the CAE was used to power a train by Tramway de Nantes in France. The use of CAT to power an engine did not earn much audience due to some technological disadvantages and the easy availability of gasoline. However, Charles B. Hodges not only invented a car to be powered by a compressed air engine but also achieved success in finding great use for commercial industries . work on CAE brought a possibility to use CAE in small cars. In 2002 an engine with two stage was developed by Motor Development International (MDI) to easily fit inside a commercial car . This engine overcame many disadvantages of early CAE engines and was more efficient in working. The engine developed by MDI also has a greater value of torque when compared with early CAE engine. Further, the Indian motor giant TATA announced to manufacture CAE powered car, with hopes of offering it directly to consumers, in 2018 . The work on the current CAE still need to overcome some disadvantages of recharging the compressed air tank. Big carmakers are still waiting for some major development in the CAE based car before putting their hand in the production of such car .Hence, the co-development by MDI and TATA give the new possibility of powering a car with CAE.

B.OBJECTIVES

The main objective is to develop compressed air engine which can be run by the compressed air. A four stroke single cylinder conventional engine can be run on compressed air with a few modifications. Main advantage of compressed air engine is that no hydrocarbon fuel required means no combustion process. Our environment must be protected against various contaminations produced by vehicles driven on I.C. engine which produces some of most adverse environment effects. For example, Nitrogen oxide (NOX) after oxidation forming nitric acid, contributes to acid rain which causes severe damage to environment. Nevertheless,

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the compressed air technology will contribute to reduce air pollution and tend to zero pollution level and promoting great environment. This is because in compressed air engine air is used as fuel and exhaust is also in the form of air. There are several technical benefits of using this engine, like as no combustion inside cylinder, working temperature of engine is very close to ambient temperature. This in turn results in smooth working of engine, less wear and tear of engine components. There is one more technical benefit that there will not be any need for installing cooling system or complex fuel injection system, etc. These benefits result simple design, simple construction and less weight. Thus compressed air technology satisfies present demand and can prove to be future transport medium

C.PROBLEM STATEMENT

A compressed air engine, using compressed air, which is stored in a tank, then through the pressure relief valve and buffer tank, it enters the compressed air engine, in which the compressed air pushes the piston to do work and output mechanical energy. Instead of mixing fuel with air and burning it in engine to drive pistons with hot expanding gases, compressed air engine uses the expansion of compressed air to drive their pistons. The compressed air engine is the core dynamic system of air powered vehicles. It is a kind of power device which converts the compressed air energy into mechanical energy by expanding. The piston converts the compressed air into mechanical energy, which is then transferred to the wheels by means of chain sprocket mechanism and used to operate the vehicle. There are several technical benefits of using this engine, like as no combustion inside cylinder, working temperature of engine is very close to ambient temperature. This in turn results in smooth working of engine, less wear and tear of engine components. There is one more technical benefit that there will not be any need for installing cooling system or complex fuel injection system, etc. These benefits result simple design, simple construction and less weight

D.METHODOLOGY ADOPTED

Problem identification: Automobiles consume a large number of fossil fuels and has brought many serious environmental problems, such as global warming, ozone layer depletion and fine particulate matter. To avoid such environmental problems, renewable energy has been applied to automobiles.

Idea screening: In order to reduce adverse effects caused by usage of fossil fuels various methods can be adopted : Usage of electric vehicles. Usage of compressed air engine(CAE).

Usage of biogas engine. Due the various limitations like toxic substances produced from battery in an electric vehicle and lack of availability to satisfy the working of every vehicle the best idea is to use a CAE

Brainstorming: A liquefaction plant is made as the separate unit and supplies the liquid air to the fuel tank of vehicle slight modifications are done on the normal four stroke engine.A two stroke engine has to be used instead of modifying the four stroke engine. The exhaust from the engine is in the form of air. So it can be reused .

Solutions: 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 project an effort is made to study the extent of research done and the potential advantages and disadvantages of the compressed air technology.

Design phase : The design of CAE consists of compressed air tank, throttling valve, piston engine and exhaust tail. A compressed air tank is very important part of CAE. A compressed air tank is a container where highly pressurized compressed air is stored. Thus, a compressed air tank act like a powerhouse for the CAE and is responsible for driving the piston engine. Compressed air tank is made of GI (galvanized iron) pipes. Valve timing of the engine is adjusted by replacing cam wheel by sprocket wheel. There are two sprocket wheels. So engine works in 1:1 ratio and thus working of the engine is adjusted according to our needs.

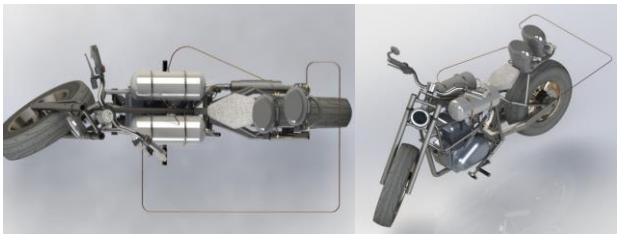

Fig:A Isometric and Top views of cad model

Obtaining of materials : the components required for this project is compressors (2 nos) GI pipes (2 nos) non return valves (2 nos) sprocket wheel (1 nos) copper tubes (5 metres). Here the compressors are used to compress the atmospheric air and this compressed air gets stored in the fuel tank. The fuel tank here used is made up of GI pipes. The compressors are worked by external power source. Non return valves are placed between compressor and tank and between tank and engine for the unidirectional flow of air. Copper tubes are used to connect all the components and which passes the compressed air.

Fabrication and Assembly : Different processes like grinding, gas welding, drilling was done for the perfect fit. Engine was disassembled, cam wheel has been changed to sprocket wheel. Fuel tank was replaced by gas tank made of GI pipes. Engine re-assembled, Connection between air tank, compressors and non-return valve is done with the help of copper tubes.

Final prototype : The working model of final protype is made by making the modifications in the fuel tank and also changing the sprocket wheel connected with the camshaft of the engine to adjust the valve timing of the engine, as shown in figure B

Fig:B Final prototype

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II. EXPERIMENTAL DETAILS

The detailed description of the equipment's used and the different components used has been shown in the sub part of the section.

A.EQUIPMENT DISCRIPTION

The equipment's needed for machining process of the prototype are:

Welding Machine **:** The welding machine was used to weld the copper tubes from the engine to the compressors and from the storage tanks(GI Pipes) to the compressors. Also the copper tubing which is used to connect both the storage tanks is connected using the welding process. The storage tanks are fixed and held rigidly onto the vehicle by supports which are welded onto the chassis.

1. Arc Welding : Arc welding is a welding process that is used to join metal to metal by using electricity to create enough heat to melt metal, and the melted metals when cool result in a binding of the metals. It is a type of welding that uses a welding power supply to create an electric arc between a metal stick and the base material to melt the metals at the point of contact. Arc welders can use either direct (DC) or altering (AC) current, and consumable or non-consumable electrodes.

2.Gas Welding : Gas welding is a most important type of welding process. It is done by burning of fuel gases with the help of oxygen which forms a concentrated flame of high temperature. This flame directly strikes the weld area and melts the weld surface and filler material. The melted part of welding plates diffused in one another and create a weld joint after cooling. This welding method can be used to join most of common metals used in daily life.

Drilling Machine **:** The drilling machine is used to make holes on the storage tanks so that the copper tubes can be joined on to it. The hole diameter is corrected with respect to the diameter of the copper tubes. Three holes are made by the help of the drilling machine. The grinding machine was used in order to fit in a 2mm copper tube of 3m length.

Grinding Machine **:** After cutting the GI Pipes into the required dimensions it was found out that the surface of the pipes were irregular including the two ends. The surface as well as the ends of the pipes were finished and made regular with the help of the grinding tool. The copper plates enclosing the two ends of the pipes had irregular surfaces after the welding process and these irregularities/burrs were removed by finishing process or by the grinding process

B.COMPONENTS USED

1. Storage Tank : In order to use compressed air engine in vehicles for transportation purpose, high pressure storage cylinder is used to store the compressed air. Therefore, the storage system must be compact and lightweight. Generally, the cylinder is fitted with stop valve. The valve also includes a pressure relief device. In this case, GI pipes are used to make the storage tanks for storing air under high pressure. Since they are cheaper, light weight and easy to handle.

2. Copper Tubes : Copper tubes are used to connect the storage tank to the engine in order for the air pressure transfer. The minimum length of the copper tubes used in this case is 3 metres and the diameter of the tube is 2mm. It is used for the transfer of compressed air from the storage tank to the engine, where it is used to run the vehicle. Copper tubes are used because it can with stand high pressure without any leakage problem.

3 Compressors : Two compressors are used to increase the pressure of the incoming air in order to generate enough power in the engine to drive the vehicle forward. As gases are compressible, the compressor also reduces the volume of a gas.

4. Air Engine : A 4-stroke convention IC engine of 100cc is converted in compressed air engine is used after the modifications. The major modifications done on the engine is the changing of sprocket wheel connected with the cam shaft and replace it with the sprocket wheel of same size connected at the other end od timing chain to make the valve timing ratio 1 : 1.

5. Non-Return Valve :Two non-return valves are used in this project. They are used for the uni-directional flow of compressed air through the copper tube. A non-return valve is place in between the compressor and the storage tank to direct the compressed air to the storage tank. Another non return valve is placed in between the engine and tank to direct the flow of compressed air to the engine.

6.100cc Bike(HEROHONDA CD DAWN) : It is structure on which all other components will be installed. For this purpose, a 100cc bike is used. This should have simple and easy construction. Here we use Hero Honda CD Dawn as the frame of the project. All the parts get assembled on it. Engine specification of conventional engine is 4-stroke I.C engine without any modification is given below in the table 1.

Table1. Engine specification of CD Dawn 100cc bike

Engine Displacement	97.2 CC
Engine Type	Air cooled, 4 Stroke
Number Of Cylinders	1
Valves Per Cylinder	2
Fuel Type	Petrol
Starter	Kick
Number of Stroke	4 Stroke
Transmission Type	Manual
Number Of Speed Gears	4

Compressed air engine is modified engine which is converted from conventional 4-stroke engine after modification. In this type of engine old sprocket wheel connected which camshaft is replaced with new sprocket wheel as same size as connected at other end of timing chain and valve timing is arranged according to new sprocket wheel .So in both case specification of engine is same

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C. EXPERIMENTAL PROCEEDURE

Different processes like grinding, gas welding, drilling was done for the perfect fit. Engine was disassembled, cam wheel has been changed to sprocket wheel. Fuel tank was replaced by gas tank made of GI pipes. Engine re-assembled. Connection between air tank, compressors and non-return valve is done with the help of copper tubes. The product with modification in place of fuel tank and cam wheel was done. A working model was made. Air is stored in the form of air-liquid mixture in the storage tanks. Two tanks of same dimensions are made out of GI pipes. Since atmospheric air is a mixture of different gases such as oxygen, nitrogen, hydrogen, carbon dioxide, and other gases no reaction occurs with the walls of the storage tank as it is made up of Galvanised Iron.

Fig:C. Storage tanks mounted on two sides of the chassis.

Two compressors are used to compress the atmospheric air and transfer it to the air-tank. The compressors used are of the type semi-hermetically sealed compressors. In these type of compressors, the compressor and motor driving the compressor are integrated, and is made to operate within the pressurized gas envelope of the system. A semi-hermetic uses a large cast metal shell with gasketed covers and with screws that can be opened to replace motor and compressor. The figure is shown below as D.

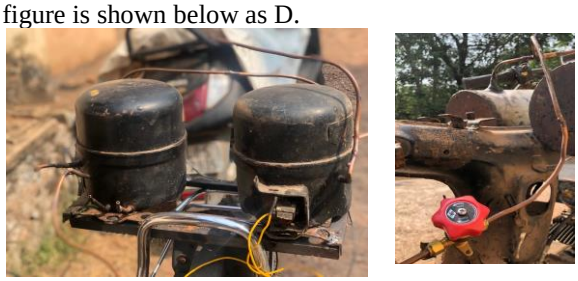

Fig:D. Compressors and Control valve

Air stored in the tank is supplied to the engine via the 2 copper tubes. Copper offers a high level of corrosion resistance but is becoming very costly. The type of copper tubing used in this case is Soft Copper Tubing. Soft Copper Tubing Soft (or ductile) copper tubing can be bent easily to travel around obstacles in the path of the tubing. As the engine that is used in this case is a 4-stroke engine, the entire process is completed in the 4 strokes of the piston like any normal 4-stroke engine, but the valve timing is different. In the case of a normal 4-stroke engine, the valve timing occurs in a 2:1 ratio. But in this air engine we have adjusted the valve timing ratio to 1:1 in order to obtain the required amount of power from the pressurised air to drive the engine. This 1:1 aspect ratio is obtained by replacing the cam wheel by a sprocket wheel in the gearbox. Hence, a 2-stroke power is obtained from a 4-stroke engine as the valve timing is altered, i.e., the inlet stroke itself is the power stroke and the compression stroke itself is the exhaust stroke. This 1:1 aspect ratio is obtained by replacing the cam wheel by a sprocket wheel in the gearbox. Hence, a 2-stroke power is obtained from a 4-stroke engine as the valve timing is altered, i.e., the inlet stroke itself is the power stroke and the compression stroke itself is the exhaust stroke. Working of CAE is shown in figure E.

D. WORKING OF CAE (Compressed Air Engine)

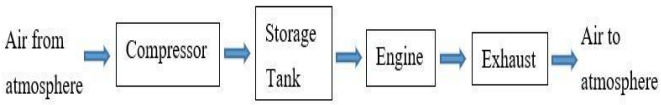

Fig:E. Working diagram

1. Power Stroke: Power stroke is suction stroke or Intake Stroke, in this stroke when the piston is at the top position (TDC) its spindle opens the inlet valve, the compressed air fills the space of cylinder. The air expands and exerts pressure on the surface of piston, causing its movement down to BDC.

2. Exhaust Stroke: In exhaust stroke of CAE, air escape from cylinder through exhaust valve and inlet valve get closed. One interesting benefit is that the exhaust air temperature of CAE measured practically as low as 17.6°C is less than atmospheric temperature, helps in reducing the temperature and controlling global warming rise caused by I.C engines or due to other means. In the cylinder are small amounts of air, so the piston moves upwards until it will again open the ball valve and the cycle repeats.

E. TEST CONDUCTED

The tests conducted on the vehicles parts are explained by the different test given below,

1. Leakage Test : Here in this process the test for the leakage of fuel tank, leakage of copper tubing is done. For this operation the tank is filled with the air and immersed in the water. The leakage of the fuel tank is identified by the air bubbles coming from the tank and also for the copper tubing, the both ends are connected with the tube for supplying the air through the copper tubing and these are also immersed in the water. The presence of air bubble from the tubing or tank shows the presence of leakage. The leakage of the tank and tubes are rectified by welding operations.

2. Power Test : The power outputs from the modified air engine were measured at air pressure ranging from 1 to 5 bar. . In this experiment, it has been found that if the sprocket

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wheel of the cam shaft changes to the same size of the sprocket wheel connected at the other end of timing chain and timing valve ratio is changed then the conventional engine can be converted into air engine. Thus the performance of CAE mainly influenced by air supply pressure. The prototype of CAE has good performance under low speed. Air powered vehicle is a realization of latest technology in automobile field tend to healthier environment. From the above graph we conclude that the speed of vehicle depends on pressure I.e., if pressure increases then speed increases and vice-versa but maximum pressure should not exceed 8 bar and for precaution we should not increase pressure more than 5 bar.

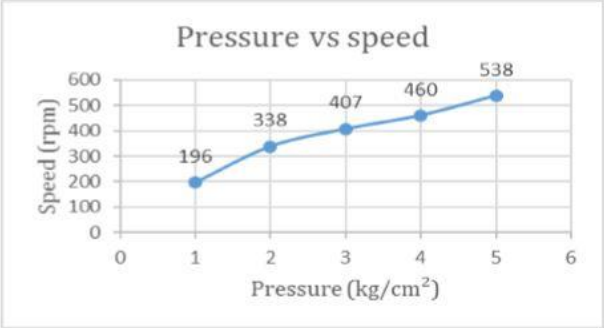

Fig:F. Pressure vs Speed curve

3. Performance Test : A Compressed-air engine is a pneumatic actuator that does work by expanding compressed air which is stored in the tank. An air driven vehicle is powered by an air engine, using compressed air, which is stored in a tank as shown in figure D. Compressed air vehicles (CAV) use the expansion of compressed air to drive their pistons. The engine is runned by considering the various valve conditions. The three different valve conditions is full open, 3/4th open and half open. By connecting tachometer to the wheel, speed of the engine for the three different valves is calculated. Table 1 gives the details of speed, velocity, acceleration, force required to pull the vehicle, total force and power for the full open, 3/4th open and half open valve condition. Traction force and power required on uphill climb is given in the table 2. Time taken to reach a distance of 10m is tested by applying three different loads of 30, 60 and 90 kg for the full open, 3/4th open and half open valve conditions is shown in table 2. Results The speed of the air driven vehicle increased from half open valve to full open valve condition. The corresponding total force and power were plotted with respect to speed. As speed increases total force and power of the air driven vehicle also increases respectively as shown in figure 4. It is observed that the power is greater in the full open valve when compared to the 3/4th open and half open valve. The performance evaluation of the air driven vehicle is evaluated for the three different loads at three different valve conditions. From figure F it noted that as load increased in the air driven vehicle time taken to reach 10m distance also increases. It is observed that the time taken to reach 10m distance when the valve is half open is lesser in comparison to the valve is full open. When the valve is 3/4th open time taken to reach 10m distance will be lesser as compared with the full open valve and higher.

Table2. Power Calculation of the model

Condition of the valve	Speed N (rpm)	Velocity V (m/s)	Acceleration A (m/s^2)	F_v (N)	F_t (N)	Power P_t (W)
Half open	395	6.2	1.24	111.6	124.8	773.76
3/4th open	421	6.61	1.32	118.8	132	872.52
Full open	535	8.4	1.68	151.2	164.4	1380.96

Table3. Result of performance evaluation of air driven

Condition of the valve	Load (Kg)	Time taken to reach 10m distance (s)
Half open	30	8.80
	60	9.40
	90	11.70
3/4th open	30	6.98
	60	7.13
	90	10.17
Full open	30	5.77
	60	6.33
	90	9.81

F. DESIGN ANALYSIS

1. Structural Analysis of Vehicle Frame : Considering the vehicle base frame, analysis is conducted to determine the load bearing capacity of the frame at various points and its behaviour when subjected to bending loads. Pulling force is calculated using the equation below

2. Pulling Force Calculation for Piston

$$F = \left[\frac{P \times (D_1^2 - D_2^2)}{4}\right]$$

Where, D_1 = Bore Diameter = 63mm, D_2 = Piston Rod Diameter = 20mm.

P = Air pressure, F = Pulling force

3. Cylinder Thrust **:** The Thrust developed in the cylinder that is the piston power is a function of piston diameter, operating air pressure and the frictional resistance. Cylinder thrust can be calculated by using the formula

$$F = \left[\frac{\pi \times d^2}{4}\right] P_a$$

For double acting cylinder, Piston Diameter d=63 mm, P_a = 0.6 MPa. The cylinder thrust developed will be 1870.4 N.

4. Air Consumption by Pneumatic Cylinder : It is the amount of air required to actuate the pneumatic cylinder. Considering cylinder specifications and various parameters such as pressure, stroke, stroke length, etc it is substituted in equation 4.4 and values are obtained to determine the size of reservoir in litters.

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Bore Diameter, D=63mm, Rod Diameter, d= 20mm
Pressure, P = 6bar, Stroke, S = 127 strokes/min
Stroke length, L =6 cm.
Air consumption by cylinder in forward and reverse stroke is calculated using the formula and respectively.

$$A_{cf} = \frac{\pi \times (D^2)}{4} \times l \times P \times s$$

$$A_{cr} = \frac{\pi \times (D^2 - d^2)}{4} \times l \times P \times s$$

Air consumption by cylinder in forward and reverse stroke is 142.52 liters/min and 128.15 liters/min. Total air consumption is 270.67 liters/min.

5. Power Calculations : The speed for full, 3/4th and half open of the valve is noted by connecting a tachometer to the wheel is 535, 420 and 395 rpm. The diameter of the wheel, d=300 mm, the velocity for various speed is calculated by the equation

$$V = \frac{\pi dN}{60000}$$

Velocity of full, 3/4th and half open valve is 8.4, 6.6 and 6.2 m/s. The time taken to reach the top speed is 5sec and acceleration is 1.24 m/s^2. Mass of the vehicle is 90kg. Force required for moving the vehicle is 111.6 N.

6. Rolling Resistance : Rolling resistance, sometimes called rolling friction or rolling drag, is the force resisting the motion when a body rolls on a surface. The rolling resistance of the wheel is calculated using the equation and coefficient of friction is 0.015.

$$F_r = \mu \; m \; g$$

7. Force Calculations : Assuming incline angle, θ=10° and weight of the vehicle, W=882.9N. Force required on incline is calculated using the formula and F_g is found to be 153.3N

$$F_g = W \times \sin\theta$$

Total force required to overcome inertia is found out using the equation and F_i is found to be 278.14N.

8.Power Required for Uphill Climb *:* Velocity is 1m/s for uphill climb and power required is calculated using the equation .

$$P_i = F_i \times V$$

Power required for uphill climb is 278.14W.

III. RESULT AND DISCUSSION

The power outputs from the modified air engine were measured at air pressure ranging from 1 to 5 bar. It has been found that if sprocket wheel connected with cam shaft in conventional engine of 4stroke engine is modified and timing valve ratio is changed then the conventional engine can be converted into air engine. Thus the performance of CAE mainly influenced by air supply pressure. The prototype of CAE has good performance under low speed. Air powered vehicle is a realization of latest technology in automobile field tend to healthier environment. From the above experiments we conclude that the speed of vehicle depends on pressure I.e., if pressure increases then speed increases and vice-versa but maximum pressure should not exceed 8 bar and for precaution we should not increase pressure more than 5 bar.

The speed of the air driven vehicle increased from half open valve to full open valve condition. The corresponding total force and power were plotted with respect to speed. As speed increases total force and power of the air driven vehicle also increases respectively as shown in figure F. It is observed that the power is greater in the full open valve when compared to the 3/4th open and half open valve.

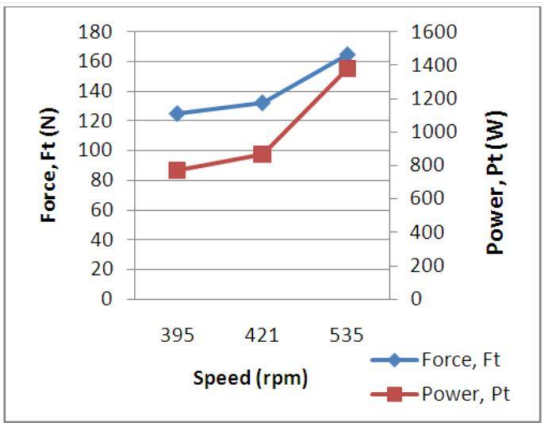

Fig: G Speed Vs Force, Power plot

The performance evaluation of the air driven vehicle is evaluated for the three different loads at three different valve conditions. From figure F it noted that as load increased in the air driven vehicle time taken to reach 10m distance also increases. It is observed that the time taken to reach 10m distance when the valve is half open is lesser in comparison to the valve is full open. When the valve is 3/4th open time taken to reach 10m distance will be lesser as compared with the full open valve and higher with the half open valve.

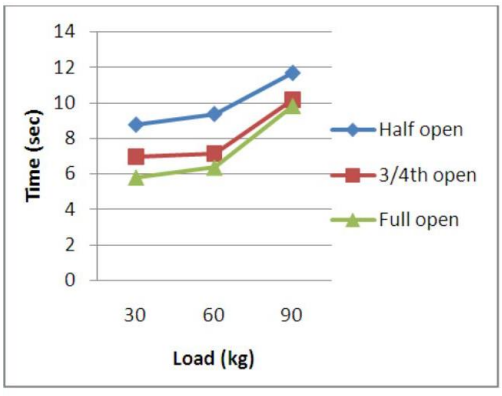

Fig: H Load Vs Time plot

IV.CONCLUSION

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

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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 refuelling 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. The air driven vehicle is designed and developed which runs with the help of compressed air as the fuel. The pneumatic three wheeler reduces the environmental pollution and is beneficial for handicapped people and old age people for easy transportation. The vehicle is operated in three different valve conditions. The result of the performance test revealed that out of three different valve conditions, the optimum power generated and transmitted by the engine took place at full open valve condition and the time taken to reach 10 meters distance for the full open valve is lesser in comparison with the 3/4th and half open valve.

V.FUTURE SCOPE

Further study is to be done to improve the performance parameters like output and efficiency. Compressed Air Engine will be make revolution in automobile industry. This engine having many advantages than the conventional engines. With some modifications it will give better performance than the conventional engines. This engine having minimum disadvantages. It is cheaper than any other technology. So in future compressed air engine will be give the better option for the conventional engines

Few advancements in this presented project can be taken up by doing some ideal methods like:

- The automobile can be brought more compact by removing the compression unit from the tank and setting it up as a refuelling plant or station, thereby increasing the use of vehicles with compressed air engines mounted on it on a large scale in the near future.
- If this system is applied to four wheel automobiles, the compressed air that is used as fuel will be having low temperature so this can be used to cool the cabin of the vehicle when it is not running.
- Installing of external heater to heat inlet air before entering the engine can improve the efficiency.
- Develop cylinders with lesser weight and less volume and a capacity to store high pressure.
- Making the chassis light weight by selecting proper materials can also greatly affect the efficiency of CAV.
- The use of the compressed air engine can result in reduction of the pollution level and can be brought up as a companion for e-vehicle in the near future.

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