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DESIGNING AND FABRICATION OF POLLUTION FREE CAR

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ABSTRACT

It was very difficult to think that a can be derived by using compressed air. Now a days however it is being popular and has been used to take interest of researchers having nil emissions and is feasible for city driving situations. The air car currently being designed, developed, manufactured and then powered by an air engine, specifically it was for the savings of fossil fuel and air pollution. Although it seemed to be an environmental-friendly solution, it must be considered that it is good for wheel drive in specific range. As the world is hard pressed with the vitality and fuel emergencies, intensified by contamination of numerous types, any innovation that brought out the answer for this problem was a blessing. In one of such new advances, was the improvement of another engine called as "compressed Air Engine", which did not oblige any of the known powers like petrol, diesel, CNG, LPG, hydrogen and so forth this worked utilizing just compacted air and it supplanted different sorts of known energizes furthermore permanently solved the issue of contamination, since its fumes was clean and fresh air. Experimental investigation were completed on this changed motor to discover its execution qualities like brake force, mechanical effectiveness, general productivity, aerial proportion and expense examination and so on. The basic principle involved in this project was that the compressed air was capable enough to provide sufficient thrust which in turn can propel the car instead of using fuels to get the thrust in the engines. Weight of the car is 80kg and it runs on 60km/h and its efficiency is14-18%.

Keywords: *Design, fabrication, improvements, compressed air engine.*

1) INTRODUCTION

The number of motor vehicles has been estimated to be more than 800 million worldwide and is increasing almost everywhere at higher rates than human population, and road traffic is growing even more rapidly. The number private cars worldwide rose to 500 million in 1990 from 50 million in 1950 (Kamerman and OECD, 2003). Fossil powers (i.e., petroleum, diesel, characteristic gas and coal), meet the majority of the world's vitality request today, are definitely diminishing. Their burning items are likewise bringing about worldwide problems, such as ozone layer consumption, corrosive downpours and contamination and the greenhouse effect, which are posturing extraordinary threat for our surroundings, and ultimately, for the aggregate life on our planet. These factors lead vehicles producers to create autos which are pushed by option energies. Hybrid autos, Fuel cell controlled autos, Hydrogen energized autos will be soon into the business as a consequence of it (Gary 1982). One conceivable option is the air-fuelled auto. Air, which is richly accessible and is free from contamination, can be compacted to higher pressure at very low charge, one of the best choices following far all the endeavours made to kill the contamination has diminished it, yet finish destruction is still thoroughly sought after. Compacted air use in the pneumatic applications has been long demonstrated. Air compressor, pneumatic motors, actuators and other gear are being utilized now days for distinctive purposes in everyday life. Compressed air was likewise utilized as a part of a percentage of the vehicle for boosting the beginning torque. Compressed air has been utilized following the nineteenth century to power mine locomotives, and was already the premise of naval torpedo propulsion (Aleklett et al., 2003). The mechanical configuration of the Compressor was uncomplicated and strong.

The tanks used in an air compressed car could be discarded or recycled with less contamination than batteries. The tanks utilized as a part of a compressed air auto had a more extended lifespan in correlation with batteries, which, before long experience suffer of a lessening in performance (David et al., 2009). Refueling could be possible at home, utilizing an air compressor or at service stations. Decreased vehicle weight ought to be the principle proficiency component of compacted air car.

The rate of discharge is low restricted to batteries that drain their charge gradually after some time. Accordingly, the vehicle may be left unused for longer periods of time than electric autos. Compressed air car has lower initial cost than the cost of the battery electric vehicles when power is generated to run the vehicle. Compressed air is not subject to fuel tax. Lighter vehicles would bring about less wear on roads (Selig et al., 2004). The cost of filling air fueled vehicles may be fundamentally less expensive than current fuels.

Keeping in view the above introduction the following objective of the project was selected (Singh et al., 2010). There has been increasing demand for research on travel time reliability, leading to a large number of studies on the subject, because preliminary research suggested that the benefits of improving the reliability of transport system may be substantial (Tseng, 2008). So there is great need in to find the more reliable transport system. (Eliasson, 2009; Li et al., 2010a; Hjorth, 2011).

2) MATERIALS AND METHODS

2.1) Working on Compressed air Engine

This Engine worked as a diesel engine. Toward the end of pressure stroke, a high-pressure air at room temperature was infused into the barrel. Infusion of air by the routine infusion framework was represented by the movement of rocker arm and reed valve settled in the ports of 2-stroke petrol Engine. High pressure air was entered into the engine that pushed the piston and showed a movement in the crankshaft because of the association of shaft with connecting rod which was further associated with the piston (Figure 1). The atmospheric temperature was utilized to warm the engine and amplify the road coverage and only pressure of the air was increased in this way. The compressed air system made use of the environmental air getting rid of other costly fuels. After the fabrication of such compressed air system, no pollution was observed; Lubricating oil change was kept necessary.

Due to the stay gave by the extraordinary associating rod assembly, the diesel motor chips away at constant volume cycle rather than constant pressure cycle. Through this constant volume, air was infused by the infusion framework into the engine cylinder.

As in the chamber hot and compressed air blended with the externally infused generally cool and compacted air, infused at moderately higher pressure than the internal pressure, the mixture tries to achieve a balance temperature.

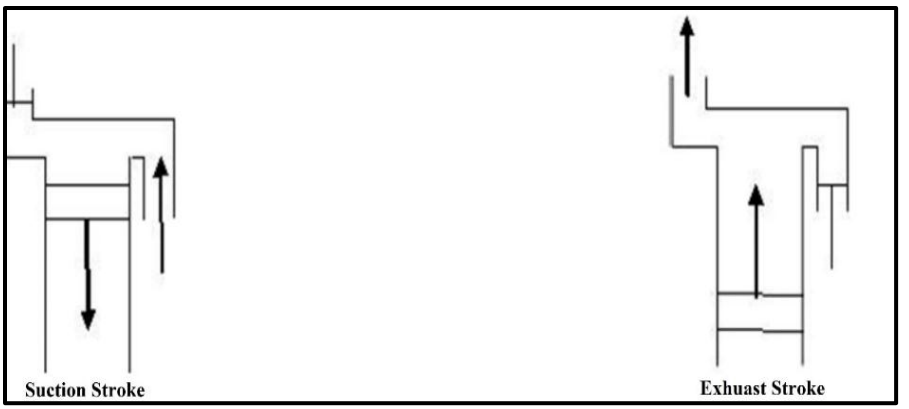

Figure 1: Compressed Air Engine

2.2) Techniques for compressing the air

Design and advancement in compressed air engine for of single cylinder which was made to operate by the compressed air. Current two strokes single cylinder motor was used to run on the compressed air with a couple of adjustments that were the primary goal of the study. Compressed air filled by power utilized a compressor. The power necessities for compressing air must be considered while registering general effectiveness. All things considered the compressed air vehicle needed to help for lessening air contamination and watch out for zero contamination level and advancing environment. Primary playing point of this engine was that no hydrocarbon fuel obliged it implies that no burning procedure needed to happen. Air was considered as a sustainable renewable energy resource and an emission free was analyzed for better and sustainable energy future in this project. As per the present vitality situation the fossil fuels which are quick draining and their burning items are bringing on worldwide ecological issues. So it was unavoidable to move towards the utilization of renewable energy assets which thusly needed to decrease contamination and to spare fossil fuels. Air Powered Engine is an option which uses compressed air to run the motor and subsequently kills the utilization of fossil fuels (Haum et al., 2003).

Fuel compressed air can be suitably utilized for running air engines and has many advantages being emission free and environment friendly (Haisheng Chen 2010). Air was stored after compressing it to desired pressure ranging from 4-40 bars according to the design. This was put away at high pressure and was held without any misfortune after omission or with passage of time. Compressed air is generally feasible. It has no volatility or temperature or much climate impact. When compacted air is put away through compressor, it will be accessible whenever without any loss of pressure. Therefore supportability of compressed air is much better contrasted with other accessible exchange of fossil fuel. Battery needs consistent upkeep actually for charging and discharging cycle. Hydrogen Cell is immoderate because of its capacity issues. Wind Mills, Photo Cells additionally require some stockpiling gadgets may be of high bank capacitors or batteries, which will require consistent and repeating consumptions on its upkeep.

2.3) Emission from compressed air car

Emissions from an individual auto are low, with respect to the smokestack picture and numerous individuals are connected with air contamination. Compressed air car has to emit air then there is not a danger for pollution from emission. The emission of air from its intake was carried out thoroughly, and with perfection. As it has been studied that exhaust is emitted directly and it influences environment through a complex set of compound responses including hydrocarbons, oxides of nitrogen and sun light (Baumann, et al., 1997).

2.4) Fabrication of Compressed air car

Firstly, in engine, major changes were made in the engine and tested it. Then fabricated the frame of the car and set the steering system and tires mechanism. After that set the engine on the frame and gave the power of the engine to the back tire shaft with chain and then tested it. The detail of the changes that occurred in the engine and the frame of the car were following (Table 1).

Table 1: Technical specifications of a Compressed air car

Parameters	Units	Specification details
Length	Meter	1.32
Width	meter	0.99
Height	meter	0.10
Number of seats	-	2.00
Weight	Kg	85.0
Engine	-	Single Cylinder 2 stroke
Power	KW	2.169
Max. speed	Km/h	30.0
CO_2 emission in urban use	g/Km	00
CO_2 emission in non-urban use	g/Km	0
Price (from) taxes included	Pak. Rs	75,000

2.5) Compressed Air Engine

Single cylinder with low speed model engine was changed and made to run on air. Rather than an ordinary connecting rod, a kinematic connection was utilized which has the procurement of staying at the top dead centre. Different speeds were noted for Compressed air engine (Table 2).

Table 2 Specifications of Compressed Air Car Engine

Idle speed	120 rpm
When connected to wheel	100 rpm
On load speed	60 rpm
Weight	80 kg

Air, which is liberally accessible and free from contamination, was compressed to higher pressure at cheap rates, and it was one of the prime choice since environmental contamination for all time annihilated (Amir et al., 2011). Engine was run utilizing the compressed air and compressed air car also included air motors, pneumatic actuators and other various pneumatic equipment. Compressed air was used to deliver motive power to an engine at full pressure or expansively, or somewhere in between partial expansion. For working at full pressure the air was admitted to the cylinder all through the whole length of stroke, that was, without cutoff

so that almost a cylinder filled with air at gauge pressure was depleted at each one stroke.

The air had to be entered to the chamber through just a fraction of the stroke, and needed to cut off and the stroke finished by expansion of the air. For working thusly some balancing operators, for example, the flywheel, was fundamental, and generally speaking a higher starting pressure was utilized that worked under full pressure all through the stroke. It was important to recognize complete and half expansion. Air utilized for full expansion, the operation in the cylinder was the opposite of adiabatic compression in a compressor; the last pressure was equivalent to that of the environmental pressure. However, air does not undergo condensation, the lowest terminal pressure in the cylinder was above environmental pressure to deliver a appropriate exhaust, and to conquer the friction of the engine toward the end of the stroke. Therefore, it was not practical to attempt truly to complete expansion.

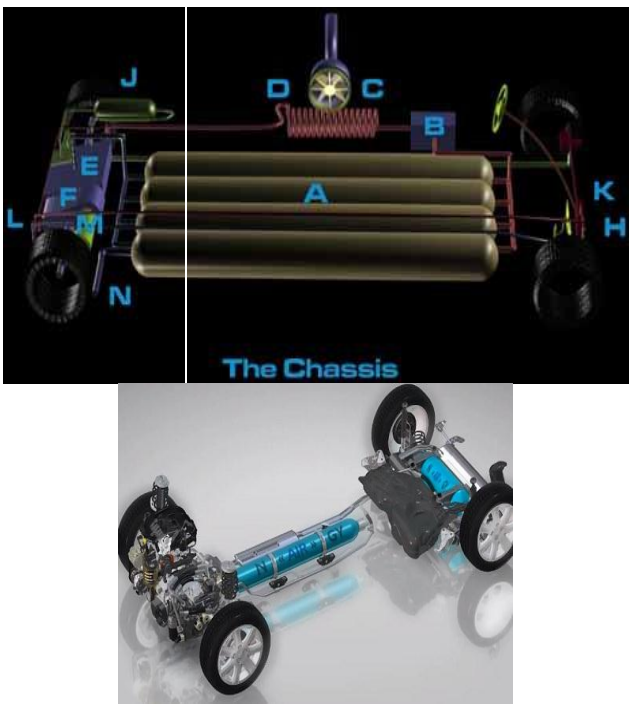

Figure 2: Fabrication details Chassis of Air Powered Car

Compressed air was used for boosting the initial torque. Turbo charging which is the popular technique was also used to upgrade control and

enhance the proficiency of the automotive engines. It was also studied to develop a reciprocating automotive engine that completed runs on compressed air. This assembly was divided in three links A, B, C. The A reciprocates, link B oscillates and the link C rotates (Figure 2) and transmitted the rotation of the engine to the other parts. One end of link B was attached to the link A, and was fixed at the other end at point 1.

The end was also fixed at point 2 and 3. It was fixed at the piston in the cylinder attached to the link A, dwells at the top dead centre for a rotation of 45 degrees of crank angle, while when fixed at 2, the dwell changed to 60 degrees and for point 3, it changed to 80 degrees of crank rotation. A practical constant volume was obtained when the piston dwelled for any angle at TDC. The swept volume inside the cylinder was changed when the other end of link B was fixed at points 2 & 3.

Compressed air at 300 bars was put away in the carbon fiber tanks as indicated in Figure 2. The air was discharged through the principle line firstly to an alternator B where the first phase of decompression occurred. The now cool air passed through a high temperature exchanger C which added heat energy to the air and gave an advantageous chance for air conditioning D. The warmed compressed air now was gone to the Engine E. where two more phases of decompression and re-warming occurred. The Engine drove the back axle G through the transmission F. Control of engine pace was through a customary accelerator pedal H controlling a valve inside the engine.

An energy recycler J was under test which utilized motor braking K to recompress air during braking into an secondary storage space, giving extra energy to restart and acceleration. Ordinary hydraulic braking L was supplied. The vehicle was refilled by utilizing the compressor or by refilling the tank at any air station at N. A compacted air driven engine offered tremendous profits to the auto designer. Due to its little size and weight, and the evacuation of a host of devices and parts not needed, the designer has free rein to enhance his materials and space to give a simple platform for the vehicle.

2.6) Modifications in injection system

Instead of conventional fuel injection system, an electro – mechanical injection system was used for air injection. This consisted of an externally

operating cam with a roller follower; solenoid valve was connected to a non-returnable valve assembly, which was fitted in the engine cylinder. Cam was so designed that it provided the dwell of 45 degrees as required by the link when it was fixed. The cam through the follower triggered the air injection into the engine cylinder for the period equal to its dwell, during which the piston also dwelled. The air injection through cam dwell was synchronized with the piston dwell.

2.7) Experimental Procedure

Before starting the experiment, the electric supply to control the flow through the solenoid, was switched "ON". The pressure regulating valve was opened and an operating pressure of around 6 bars was initially given. The engine was then given an initial torque to set it in motion. The cam through the follower triggered the solenoid valve with high pressure air which was injected in to the cylinder. As the air entered in, while the piston was dwelling as explained in the engine operation, expansion took place and the engine moved slowly. Amount of air flowing in the cylinder was noted directly by the air flow meter and the operating or the injection pressures were noted from the pressure gauge. Initial RPM was noted down, and load was applied on the brake drum. Speed decreased when load was applied, inlet pressure was increased for constant speed. All the tests were carried out at constant speed of 80 rpm. The complete line diagram was shown in Figure3.

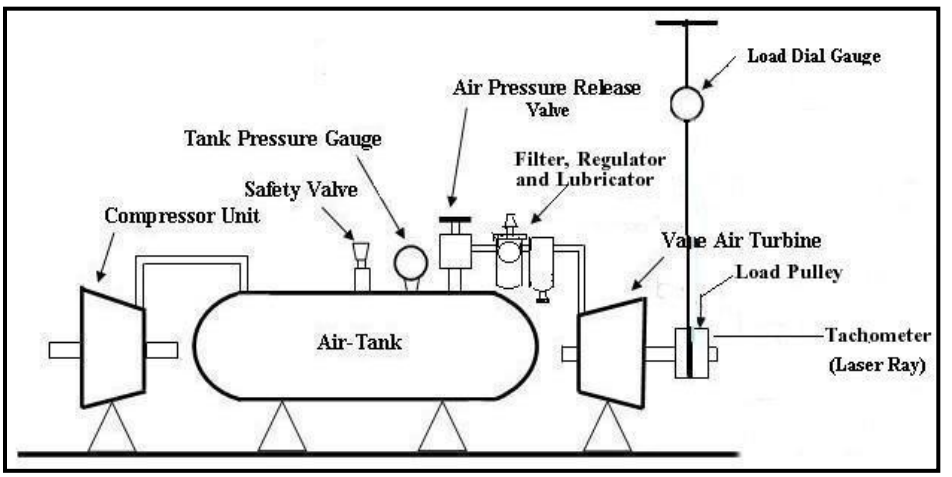

Figure 3: Experimental Test Setup

2.8) How Compressed Air can drive a Car

Compressing a gas into a little space was intricate to store energy. At the point when the gas extended once more, energy was discharged to do work. That was the fundamental standard behind which auto moved (Figure 4).

Figure 4: Assembled Compressed Air Car

The compressor used air from atmosphere to refill the compressed air tank. The thought of compressed air auto, on the base of air refuelling stations which are accessible at customary corners, where the tank can be refilled considerably all the more quickly with air. Filling the tank probably takes about two minutes (Figure 5).Air Car propelled with this engine that was based on compressed air of pressure to about 10.03 bar Pressure.

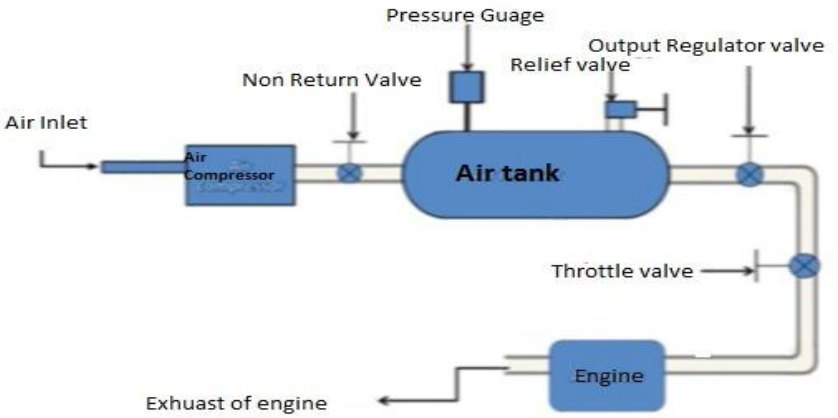

Figure 5: Line Diagram of Compressed Air Car

Its accelerator worked a valve mounted on its tank that permitted air to be discharged into the hoses and afterward into the engine indicated in Figure 5, where the pressure of the air's expansion was pushed against the vanes and turned the rotor. That produced enough power for speeds of about 10-50 kilometres per hour.

2.9) Work Division into Sub-Assemblies

The entire work was categorized into 5 phases. Each phase consisted of series of operations followed by the next phase. Several changes were made in the design depending upon the physical stability of the car.

a) Sub Assembly 1

In sub-assembly 1 firstly, the parts of engine and car were manufactured. Then it was decided to inspect all components of the engine and car. After inspection, engine was made able to run by compress air for test or pre-processing.

b) Sub Assembly 2

After pre-processing of the engine, engine was mounted to the frame of the car. Then prepared the design of the car and finalized the inspection of car frame.

c) Sub Assembly 3

In sub-assembly 3, after completing the fabrication of car and engine, mounted it to the frame of the car. Then completed the finishing of the frame, Painting was of black colour and after paint it was decided to test the car.

d) Sub Assembly 4

After running of the car evaluated it according to the requirements and then finalized it in every aspect.

2.10) Description of Mechanical Components

Various main Mechanical parts used in car were assembled to make it in running conditions according to the requirements. The parts are given below (Figure 6).

- Seat
- Compressed air tank
- Pressure gauge
- Engine
- Tires
- Triangular iron bar
- Spotting wood
- Air hose
- Head lights
- Protection seats
- Horn buttons
- Steering
- Accelerator.

Figure 6: Basic components of Car

Various Mechanical parts used in Engine were taken for assembly (Figure 7).

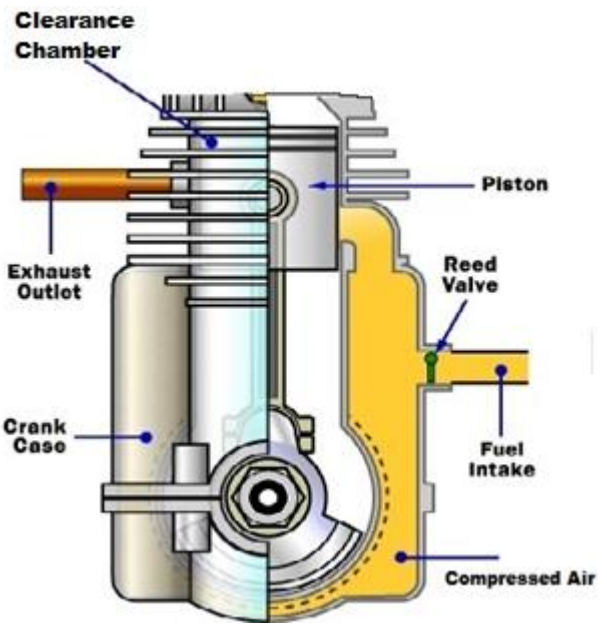

Figure 7: Basic Components of two-stroke Engine

a) Crank Shaft
b) Connecting Rod
c) Piston Cylinder
d) Reed Valve
e) Bearings
f) Rolling Bearing
g) Cam Shaft

2.11) Description of Electronic Components

Various electronic parts were used as given below.

a) Resistance
b) Three way button
c) Wire Hose
d) Relay
e) Wires
f) Current Divider
g) Integrated Circuit
h) Battery
i) Horn
j) Indicator
k) Pressure Indicator
l) Front Light

3) DESIGN OF COMPRESSED AIR CAR

3.1) Chassis Design Parameters

Chassis was made by Rectangular, square incorporating arc welding at various sections. It includes:

1) Lap joint welds 2) Butt welds 3) T Joint welds.

The end joints were butt welded and some internal angular sections were lap welded. The steering column support was given by welding with a hollow shaft and with a T weld to the front frame of the chassis.

3.2) Wheel Mounting

After the completion of chassis, wheels were mounted; two on the front side and twoon the rear side. Inclination was provided between the front and rear side of the chassis frame for steering compensation.

3.3) Rear Wheel Settings

The priority was given to rear wheels because of drive and braking system given to these wheels. The wheels spindle was aligned with the wheels center. This was given supports on either side of the wheels. The

spindle was extended on either side of the wheels. One side was for power transmission compensation and the other side was for brake setup compensation. Rests of the components were mounted on the chassis at the requisite positions according to the design parameters (Figure 8). A number of modifications were done in the design during the tests performed after installation of each and every module.

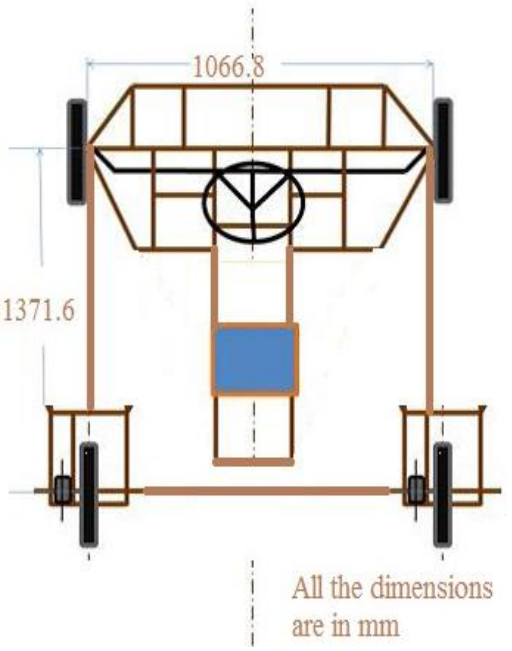

Figure 8: Frame Model of Compressed Air Car

3.4) Pressure Cut off Switch

This was a gadget intended to screen a pressure and gave output when a set pressure (set point) was arrived. A pressure switch did this by applying the process pressure to a piston to generate an energy which was contrasted with that of pre-compressed range spring.

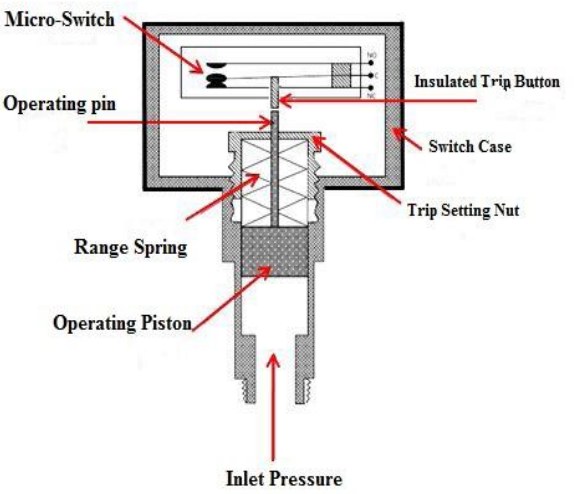

Figure 9 Sectional view of Pressure Switch.

A pressure switch was utilized to locate the vicinity of fluid pressure. Mostly pressure switches utilized a howl as the sensing component (Figure 9). The movement of this sensing component was utilized to impel one or more switch contacts to show a caution or start a control activity. Pressure switches had distinctive plans with diverse sensing components.

3.5) Steering System

Like most things in an auto, the idea of guiding is simple -you turn the controlling wheel, the front wheels turn likewise, and the auto alters course. How that happens however is not exactly so straightforward. So for our project Compressed Air Car we used Rack And Pinion type Steering System as shown in figure 11. In a rack and pinion System, each end was attached to toothed bar with tie rods.

On the end of the guiding segment there was a basic pinion gear that work with the rack. When you turn the guiding wheel, the pinion gear turns, and moved the rack from left to right. Changing the extent of the pinion apparatus adjusts the directing proportion. This steering mechanism followed the Ackerman's Steering Principle which was very best suited for our project to eliminate the weight of the vehicle because of the simple construction of the steering mechanism.

Figure 10 Steering linkages

4) RESULTS AND DISCUSSION

After manufacturing of compressed air car, the energy saving accessories including the engine and its piping system were installed, its structure was aligned according to the proper dimensions in the heart of the whole structure of the compressed air car reducing the weight of engine. The location of the compressed air tank was also manufactured at its back side of the structure. Different specifications for this car were noted as given below (Table 3).

Table 3: Different Specifications of Compressed air car

Data	Petrol Engine	Compressed Air Engine
Fuel Type	Petrol	Compressed Air
Rpm	470	125
Distance covered in 1 liter (km)	8-14	6-8
Cost of fuel Rs	115	30
Refilling time	1.5 minute	Less than 1 min
Efficiency	25-30%	14-18%

As it had to run the engine at normal speed and to provide required pressure for engine, so its proper location was set. Comparison of several types of compressed air cars with basic characteristics was studied and observation and analysis for new manufactured compressed air cars were carried out. It was decided to perform different kinds of tests and took the reading and then analyzed. In order to compare the total efficiencies with respect to total energy requirement, considered the mechanical, flow and

grid transmission losses which took place in between the stages from where the primary energy was obtained to the power transmitted on the wheel (Table 4).

Table 4: Comparison of several types of Green Car

Comparison of several types of Compressed air cars basic characteristics (Values are overall for vehicles in current production and may differ between types)				
Type of vehicle/ power train	**Fuel economy (mpg equivalent)**	**Range mil**	**Production cost for given Range**	**Reduction in CO2 compared to conventional**
Conventional ICE	10-78	Long (400-600)	Low	0%
Biodiesel	18-71	Long (360-540)	Low	100%
All-electric	battery	Shorter (73-150)	High	varies
Compressed Air	30-60	380	Medium	100%

5) TESTING AND PERFORMANCE

After fabrication, it was decided to perform following different tests for analysis. First of all road testing was carried out according to the standard parameters. Car was tested at various pressures of compressed air keeping the vehicle dynamics into consideration. Maximum permissible load was tested and the result depicted fair values. Brake tests were conducted and the joint efficiencies were observed. They withstood the impacts and found to resist the jerks (Table 5).

Table 5: Distance covered by car at different Pressure

Serial	**Pressure Bars**	**Time Sec**	**Distance m**
1	6	21.8	17.06
2	7	19.06	29.6
3	8	16.89	47.9

5.1) Leak Testing for compressed air car

Leak testing was required prior to initial operation and each piping system was tested to ensure leak tightness. The normally a hydrostatic

leak test was used to analyze leakage from the piping. There are several other types of testing depending on service fluid and there were two different testing methods that were used at most construction sites.

1) Hydrostatic testing which used water under pressure
2) Pneumatic testing which used gas or air under pressure.

a) Pneumatic Leak Testing

The fluid medium used for pneumatic testing was either compressed air. The test pressure was usually 1.1 times the design line pressure. Pneumatic testing involved the potential hazard of releasing energy stored in the compressed gas. Care was taken by gradually increasing pressure in steps upto the test pressure, holding it as long as the code required, then reducing to the design pressure for inspection of the joints. The inspection of joints was done utilizing a soapy water mix that bubbles when air was escaping.

b) Soap solution test

This was one of the simplest and cheapest methods to spot the leakage in a pneumatic circuit. A soap solution was prepared and was applied at all the joints, fixtures of the hoses, valves, reservoir connections and other sensitive parts. This solution was applied after the tanks were filled to a rated level.

6) THERMODYNAMIC ANALYSIS OF COMPRESSED AIR

At 20°c, 22 liter tank loaded with air at 8 bar used just 15.6 W of vitality. Under perfect reversible isothermal conditions, this vitality was totally changed over to mechanical work. Then again, under isentropic conditions (no heat was traded with the environment)that's the reason 15 W get to be valuable. The consequences of this examination were appeared to show that the effectiveness of the single stage expansion process was worthy, while even a one -stage air compression was associated with noteworthy misfortunes. Nonetheless, the general vitality use was increased on the grounds that the waste high temperature produced during the air compression process was utilized for household water and space warming.

6.1) Compression of Air for Compressed Air Car

The compression process was treated as Polytrophic process (a compression or expansion of a gas in which the amount pvn is held consistent, where P is the pressure and V is the volume of the gas, and n was constant). The compression to introductory air volume V1 to the last tank volume V` is trailed by high temperature evacuation at constant tank volume.

There were also some reference conditions for the compressed air car, including normal pressure Po=0.101325 MPa and Normal temperature T0=0°C=273.15 K with air density at NTP ρo as 1.2922 kg/m^3. There were also some initial conditions for the ambient temperature T1 at 20°C, with air density ρ1 as 1.1883 kg/m^3, ambient pressure P1 as 0.1 MPa, original volume V1 which was same as 0.22 m^3, air 0.261 kg was applied to the compressed air car engine. After accomplishment of the initial conditions for compressed air car, final conditions were applied including tank volume 22 liters or 0.022 m^3, Air density ρ2 as 11.88 kg/m3, Air temp T2=T1=20°C=293.15 K, Pressure in tank P2 = 10 bar = 1MPa, Compressed air M3 = V3 * ρ2 as 0.261 kg which will be equal to the mass M1. When expansion was done then the final conditions were as followed, Air pressure P3 as 0.1 MPa with single stage compression.

6.2) Isothermal Compression of Air

Through the idealized reversible isothermal compression process the temperature was considered to stay unaltered.

$$Wt_{1\text{-}3} = P1 * V1 * \ln\frac{P_2}{P_1} \quad (1)$$

$$Wt_{1\text{-}3} = P1 * V1 * \ln\frac{V_1}{V_2} \quad (2)$$

6.3) Polytrophic Compression of Air

The polytrophic change of state according to the isentropic laws, although, the isentropic coefficient (1.4 for air) was replaced by polytrophic coefficient i.e. 1.4 for isentropic and 1.0 for isothermal process.

$$Wt_{1\text{-}2} = m * C_p * (T_2 - T_1) = P_1 * V_1 * \frac{n}{n-1} * \left[\left(\frac{V_1}{V_2}\right)^{\frac{n-1}{n}} - 1\right] \quad (3)$$

At long last, a thermodynamic productivity of compression was computed as the degree of helpful vitality in the tank to the aggregate specialized work needed to fill the tank with compressed air.

$$\dot{\eta}_{th} = \frac{Wt\ 1-3}{Wt\ 1-2} \quad (4)$$

6.4) Expansion of Compressed Air

While on account of compression the thermodynamic change of state was identified with the change of volume, it was identified with the change of pressure for the instance of expansion. For a summed up polytrophic expansion from the starting conditions (P_3 = 1MPa and T_3 = 20°C = 293K) to P4 = 0.1 MPa = 1 bar.

$$(P_3V_3 = P_1V_1) \quad (5)$$

The technical work recovered was given by

$$Wt\ 3\text{-}4 = m * C_p * (T_4 - T_3) = P_1 * V_1 * \frac{n}{n-1} * \left[\left(\frac{P_3}{P_4}\right)^{\frac{n-1}{n}} - 1\right] \quad (6)$$

Finally, the overall thermodynamic efficiency was determined using the following formulae. The helpful specialized work yield of the expansion engine Wt3-4 was identified with the specialized work input for compression Wt1-2.

$$\dot{\eta}_{th} = \frac{Wt\ 3-4}{Wt\ 1-2} \quad (7)$$

After calculating the overall thermodynamic efficiency 65% with following results it represented a single-stage Polytrophic expansion of air from tank conditions P3 = 1MPa and T3 = 20°C. All mathematical statements for work or vitality yield negative results as work was carried out by the system. All specifications calculated values were given in the following Table 3 (Different Specifications of Compressed air car).

7) COST COMPARISON

In Pakistan, cost prices compare with the prices of electricity in our project and for comparison also petrol price could be calculated. For this purpose we used some formulas and calculation to find the finally price per Km, Indicated Power, Input power and efficiency. Now a day's price of Petrol is approximately 110 rupees per liter and price of electricity is 10 rupees per unit (Table 7).

7.1) Comparison with Other Fuels

Table 7: Comparison between Compressed air and Electric Car

Comparison Chart	**Altra EV Nissan**	**Ravi 4EV Toyota**	**City C.A.T**
Fuel Type	Electric	Electric	Compressed Air
MPG average	123	104	198
Annual greenhouse emissions	3.5	4.1	Less than 1
Engine Characteristics	0.62 KW	0.50 KW	1.342 KW
Recharged Time	5 Hours	6.75 Hours	4 hours
Price of Car	6,00,000 Rs	4,00,000 Rs	2,50,000 Rs
Range	129 m	126 m	86

8) RESULTS AND ANALYSIS OF THE PROJECT

During the first phase of project, design parameters are considered and components are collected, processed and upgraded. During the second phase of project, research has been done and the prototype was brought to present stage by performing the above functions and the dimensions for the manufactured engine were given as (Table 8).

Table 8: Overall Dimensions of Compressed Air Car

Components	**Dimension, mm**	**Components**	**Dimensions, mm**
Wheel rim diameter	280	Ground clearance	100
Front Wheel diameter	200	Tank thickness	6
Front Wheel width	40	Tank Length	500
Back Wheel diameter	300	Tank Diameter	237.5
Back Wheel width	40	Bearing OD	35
Front track length	990	Bearing ID	15
Side Length	1320	Bearing thickness	10

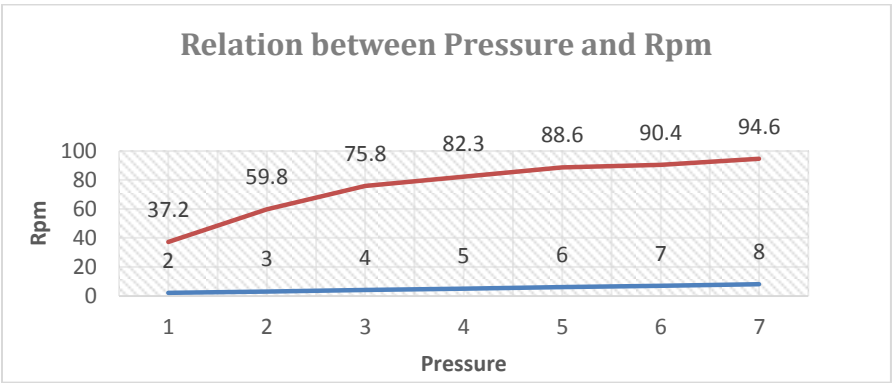

Figure 11: Graph between Pressure and rpm

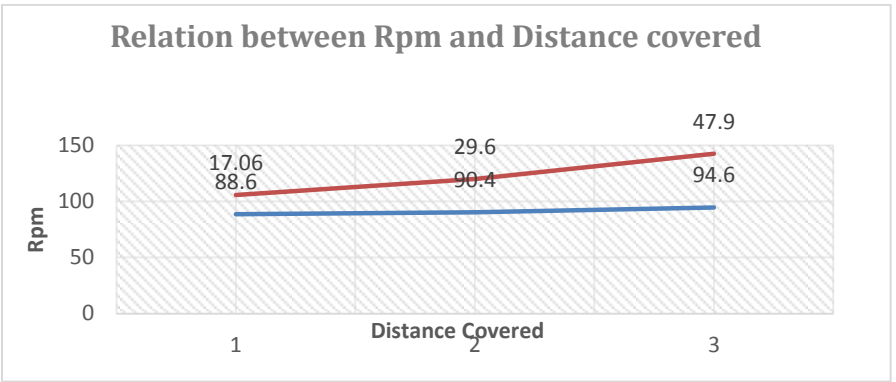

Figure 12: Graph between rpm and distance

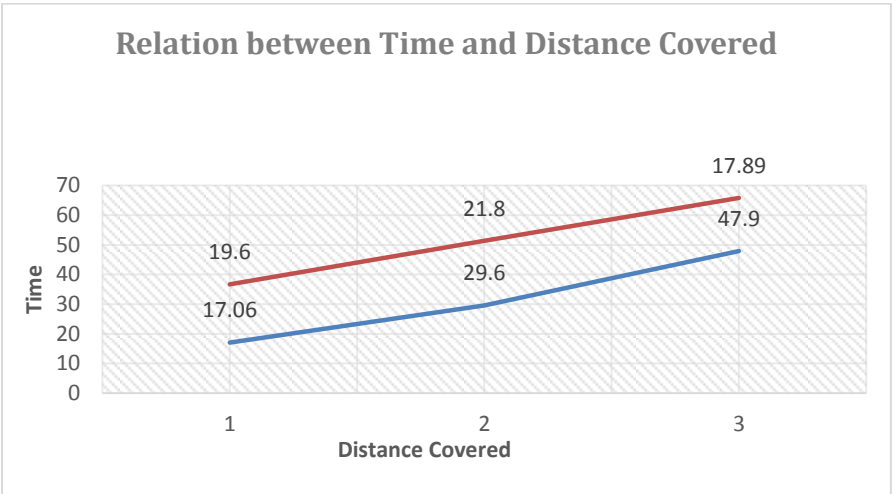

Figure 13: Graph between Time and Distance

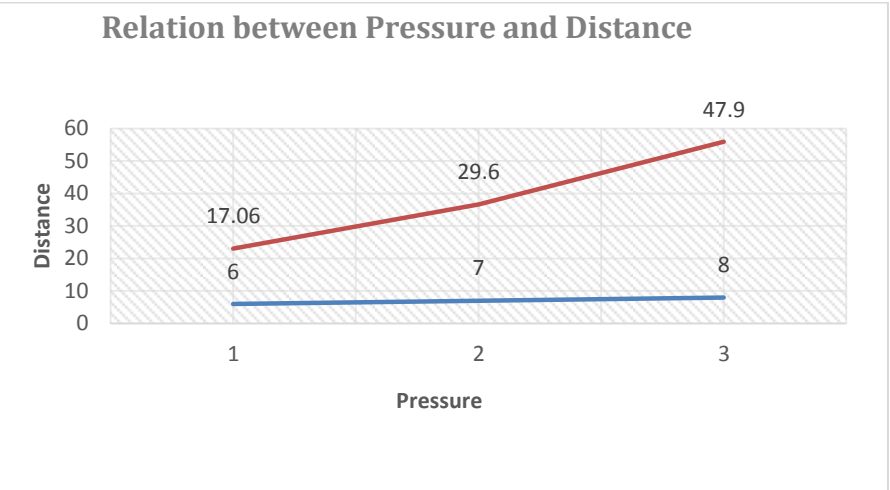

Figure 14: Graph between pressure and distance

Analysis Results for Pressure and RPM, RPM and distance, time and distance, pressure and distance

In this section, different parameters were analyzed with the different pressures, rpm, distance, time etc. and then drew the graphs and found the relationship between them. The graph between pressure and rpm shows that as the pressure increases the rpm also increases gradually. The relationship between rpm and distance has also been shown in the graphs along with the relationship of time and displacement. In the last graph, it was shown that the pressure gradually decreased as the distance was covered.

Characteristics of compressed air car

- Zero discharge vehicles.
- No fossil fuel needed.
- Working cost 75% less as contrast with the fuel motors.
- Cost is additionally short of what a large portion of the electric vehicles.
- The recharging time is considerably more short of what EV.
- The recharging of tank could be possible at house.
- It can't give much higher pace.
- Recharging stations easily available.

9) SUMMARY AND CONCLUSIONS

The technology of compressed air car was new to the manufacturers and fabricators, and it took the perfect attention for manufacturing of engine having capability to carry the load with use of compressed air only.

In fact, Compressed air technology allowed engine that was both nonpolluting and economical some provisions either to run it by compressed air or fuel.

Compressed air car was not expensive as electric or hydrogen powered vehicles, it was in the range of the local manufacturers.

It was affordable with proper performance rate whose power to weight ratio was 0.0373kW/kg. For arriving at a fair power to weight ratio and balanced the weight of car, possible factors which would result to minimize the weight of the car were adopted and thoroughly studied. The entire chassis was structured and manufactured with 1 inch angular frames. Unlike conventional transmission systems which include clutch, counter shaft, fly wheel, propeller shaft, and differential.

The Pneumatic motor was coupled to the rear wheel with intermediate gear box which greatly reduced the transmission losses and weight of the vehicle. It also occupied lesser space compared to a four wheeler. This car gave an economy of about Rs. 0.300 Per kilometer.

Exhaust temperature of it was somewhat short of what environmental temperature (i.e. 20-25°c) and therefore helped in controlling a worldwide temperature alteration and diminishing temperature climb brought on because of different means. As we are going to change over the effectively existing traditional motor into an air fueled one, this new innovation is not difficult to adjust. An alternate advantage is that it uses air as fuel which is accessible liberally in atmosphere.

At the same time the surface to wheel efficiency of the vehicle was needed to be improved. This was a progressive design which was not just natural benevolent, contamination free, but on the other hand is extremely economical. This tended to both the issues of fuel emergency and contamination. However unnecessary examination was required for

complete demonstrate of this innovation in Pakistan for both its business and specialized suitability.

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