ISBN 978-93-5156-328-0
International Conference of Advance Research and Innovation (ICARI-2014)

Pneumatically Actuated Vehicle as an Alter-Native

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Article Info

Article history:
Received 2 January 2014
Received in revised form
10 January 2014
Accepted 20 January 2014
Available online 1 February 2014

Keywords
Compressed Air;
Actuator;
Eco-Friendly,
Vehicle

Abstract

As we know, the world in which we live is facing energy crisis and all kinds of conventional sources of energy are on the verge of exhaustion and also causing pollution. Therefore, alternate sources of energies are being explored, one of which is air. Air is a natural resource which is found in bulk, yet we have hardly been able to tap its potential as an energy fuel. The authors of this paper present an idea to construct a vehicle that runs on compressed air, is a clean source of energy and economic too, if applied on a large scale. The paper explains various mechanisms involved in running the vehicle.

1. Introduction

The Air Car is recently being developed, and, eventually, manufactured by Motor Development International (MDI), founded by French inventor Guy Nègre[1].The air car is powered by an air engine, specifically tailored for the car. In January 2007, Tata Motors and Motor Development International (Luxembourg) signed a license agreement that enables Tata Motors to produce and sell compressed air cars using MDI technology in India. The agreement covered two phases of activity encompassing the technology transfer and proof of the technical concept in the first phase, and in the second phase completing detailed development of the compressed air engine into specific vehicle and stationary applications.

The first phase of this program - proof of the technical concept in Tata Motors vehicles - has now been successfully completed with the compressed air engine concept having been demonstrated in two Tata Motors vehicles.

In the second phase of the development, the two companies are working together to complete detailed development of the technology and required technical processes to industrialize a market ready product application over the coming years [2]

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Many more attempts have been made or are in progress [1] [3-8].

.As we were studying the air car concept, we stumbled upon another way of utilizing compressed air to drive a vehicle. Instead of using compressed air as a fuel for an air engine, we decided to use it to drive an actuator which we can connect to one of the wheels. Thus by using solenoid valves to regulate compressed air flow to the actuator, we converted translating motion of the actuator into rotary motion of the wheel connected to it.

2. Working Mechanism

The compressed air is first stored in an air tank up to a pressure of 8 bars having storage capacity of 30 liters. Stored air is discharged through a discharge valve, fitted on the air tank by a suitable knob opening and closing mechanism to control the air flow rate at the tank outlet. The output air passes through the solenoid spring controlled valve which is also called directional controlled valve having 5 ways 2 positions[9]. The solenoid valve is operated with a 12 V DC source. We have used a photodiode (sensitized by semi-circular shaped white paper pasted on the sprocket) which actuates the solenoid valve and in turn controls the movement of the actuator i.e..it eliminates the chance of backing of sprocket in the mid-way during its motion. This reciprocating motion of actuator is converted to rotary motion of the

sprocket whose shaft is welded to the rear part of the frame. With the help of chain and sprocket we are transmitting torque i.e. motion to the rear wheel which in turn pushes the vehicle forward.

3. Other Mechanisms Used

3.1 Steering Mechanism

Motion given by the motor is transmitted to worm and worm wheel and carried by gear train. So that a worm and worm wheel arrangement reduces the rotational speed and increases the torque which is required in steering mechanism and gear train further increases the torque. This torque with the help of two additional links and Scotch-Yoke mechanism transmitted to both front wheels for turning.

3.2 Braking System

As in this application one could usePneumatic actuating brakes which execute theretardation or stopping motion of the vehicle. Actuator used has a 20mm bore and stroke length of 80mm. Braking is applied at the rear wheel by wire actuating shoe brake.

3.3 Remote Control

ATMEGA Chip is used with light sensors for alternate actuating of Solenoid Valves of 12V rating. Presently experimental analysis was done by using a compatible 12V battery but in coming time solar panels can be installed for this purpose.

4. Observations

4.1 Costs per Refueling

Rated Power of the compressor = 2.2kw
Conversion of units in Joules
Power = 2.2kW= 2200 W = 2200 Joules/sec
Time required in filling the air reservoir
= 2min = 120 sec
Total Energy Consumption (Joules)
= 2200 W x 120 sec
= 264000 = 2.6 x Joules
Cost of 1kW-Hr unit
= Rs. 4.50(Domestic Cost)
1kW-Hr = 1000 x 3600 Joules
= 3.6 x Joules
Cost per refueling

$$= \frac{2640}{3.6 \times 1} \times 4.50 = \textbf{Rs.0.33}$$

4.2 Static Friction of Vehicle

Testing was required to check that weather the vehicle is able to overcome the static friction or not. So to understand this problem a set of basic calculations are shown.

Mass of the vehicle = 30 kg
Coefficient of static friction = 0.9
Force required overcoming static friction
= 30 x 0.9 x 9.81 N
Force required overcoming static friction
= **264.87 N**
Force applied by actuator at driving sprocket :
Full rated pressure
= 8 bar = 800 kN/m² = 8 x N/m²
Bore diameter of Actuator = 25mm = 0.025 m
Cross-sectional Area of bore

$$= A = = \frac{\pi (0.025)}{4} 4.908 \text{ x } 1 \text{ m}^2$$

Force given by actuator =
Full rated pressure x Cross-sectional Area
= 8 x N/m²x 4.908 x 1 m²
Force given by actuator = 392.64 N
Note: 392.64 N is greater than 264.87 N, means vehicle will be able to overcome the static frictional force and ready to move.

4.3 Pressure Vs Time graph

Pressure (bar g)	Time (min : sec : millisecond)
0-2	00:25:10
2-4	00:52:20
4-6	01:24:72
6-8	02:08:34

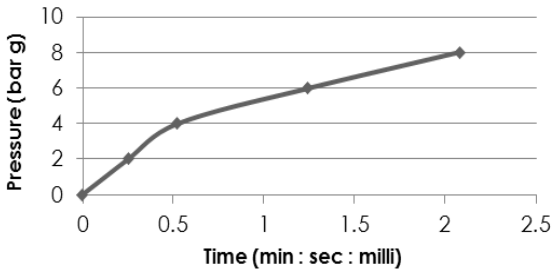

Fig: 1. Pressure Vs Time

As shown in Fig 1 graph it is clear that the slope is gradually decreasing while moving towards higher pressure range, reason is, compressor experience the back pressure and thus takes more time to refilling beyond 4 bars. This analysis was tentatively based on few observations and taken as average of all noted values.

5. Advantages

- Refueling can be done at home or at service stations. The energy required for compressing air is produced at large centralized plants, making it

- Less costly and more effective to manage carbon emissions than from individual vehicles [3].
- Compressed air technology reduces the cost of vehicle production by about 20%, because there is no need to build a cooling system, fuel tank, spark plugs or silencers [6].
- The rate of self-discharge is very low opposed to batteries that deplete their charge slowly over time. Therefore, the vehicle may be left unused for longer periods of time than electric cars [3].
- Compressed-air tanks can be disposed of or recycled with less pollution than batteries.
- Lighter vehicles would mean less abuse on roads, thus, resulting in longer lasting roads [6].
- As compared to the diesel or petrol run vehicles which emit a variety of pollutants like carbon monoxide, unburnt hydrocarbons, carbon dioxide and oxides of nitrogen , air car doesn't emit any pollutants and is eco-friendly, although the compressor emits a few pollutants[10].
- Low manufacturing costs when produced in mass as well as low maintenance costs.

6. Disadvantages

- The principal disadvantage is the indirect use of energy. For conventional combustion motor cars, the energy is lost when chemical energy in fossil fuels is converted to mechanical energy, most of which goes to waste as lost heat. For compressed-air cars, energy is lost when chemical energy is converted to electrical energy (if electricity is produced from chemical sources), when electrical energy is converted to compressed air, and when the compressed air is converted into mechanical energy [3, 10].
- Compressed air vehicles likely will be less robust than typical vehicles of today which poses a danger to users of compressed air vehicles sharing the road with larger, heavier and more rigid vehicles.
- Compressed air has a low energy density comparable to the values of electrochemical lead-acid batteries. While batteries can somewhat maintain their voltage throughout their discharge and chemical fuel tanks provide the same power densities from the first to the last litre, the pressure of compressed air tanks falls as air is drawn off[6].
- Cars powered alone by compressed air have a limited speed range but can have comparable speeds to present day vehicles by converting them into hybrid cars, for e.g. compressed air plus electric car [10].

7. Conclusion

Compressed air for vehicle propulsion is already being explored and now air powered cars are being developed as a more fuel-efficient means of transportation. Some automobile manufacturers are further exploring compressed air hybrids and compressed fluids to store energy for vehicles which might point the way for effective air powered vehicles design. Unfortunately there are still some serious problems to be sorted out, like lack of starting torque and cost of compressing air, before air powered vehicles become reality for common use but there is a hope that with the developments in science and technology which are also in agreement with the environment, air-powered vehicles will definitely see light of the day.

8. Acknowledgement

We owe a great thanks to many people who helped us during the execution of this project who graduated with us and we would also like to thank all those people who are currently associated with us in our respected Institutions and Organizations. Working as a team, gave us immense learnings about planning and management skills which are required to execute any project within a range of fixed budget and time.

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