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A Review on Novelty of Design and Development of Pneumatic Bicycle

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Abstract

In the current day scenario, the trend in the automotive industry is shifting towards the development of light weight vehicles. Amid the cut throat competition, the competitors are majorly aiming at reducing the weight of vehicle. This in turn tends to help in the better handing of the vehicle and increases the efficiency of vehicle compared to the existing models. Moreover, in the modern day scenario it is of major concern that heavy vehicles are known for producing a large amount of harmful gases like CO_2, SO_2, etc. which is the main reason for global warming. Hence, research has been under progress to find a light weight vehicle which does not pollute the environment. One such alternative that has been identified and tapped is the use of compressed air to generate power sufficient enough to run an automobile. Due to the abundance, unique and environmental friendly properties of air, it is considered as one of the future fuels which will drive the vehicles. In this purview, a complete review has been carried out to develop a design to implement pneumatics in bicycle and also incorporate Hall Effect sensors in the suggested design.

Keywords: *Re-fueling, compressed air, pneumatic, sensors, hall effect*

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INTRODUCTION

Today most of the world's energy demanded is from fossil fuels (i.e., petroleum, diesel, natural gas and coal) which is depleting rapidly and also tend to deteriorate slowly. The combustion and bi-products are causing global problems slowly yet heavily. The working medium in pneumatics is air which is compressed above atmospheric pressure to impart pressure energy to the molecules and the kinetic energy of molecules that has been imparted is used to power the system. The stored energy is converted to mechanical work through appropriate controlled sequence like valves, controllers and actuators. The system can process various conversion combinations of motions like rotary-rotary, linear-rotary and linear-linear. Due its simplicity in design, ease, durability and compactness pneumatic systems make them very effective and well suited for lots of applications.

Compressed air storage is a way to store energy, with high efficiency and environmental friendliness. It is regarded as fourth utility, after electricity, natural gas, water which facilitate in production activities of industries. Air that is tapped in this form is widely used for many applications such as cooling, drying, actuating and removing metal chips.

LITERATURE REVIEW

An extensive review of literature has been carried out to make a compilation of the advantages and disadvantages of the compressed air powered vehicles that will facilitate the research objectivity [1–5].

Advantages of compressed air powered vehicles

- Air is non-polluting when compared to diesel and petrol and also is non-flammable, easy to store, safe and less expensive.
- By using compressed air technology it can decrease the cost of vehicle around 20% and cooling system, fuel tank, spark plugs or silencers can be eliminated.
- The heating of the compressed air engines and weight are comparatively less when compared to petrol and diesel.

- Manufacturing costs and maintenance costs are less for air powered vehicles.
- The tanks can be used again and again for refueling air and refueling takes less time and it is cheaper.
- Due to low inertia the air has the tendency to accelerate and decelerate quickly.
- Compressed air vehicles can attain a suitable speed within less time.
- Air is non-combustible and it does not catch fire.
- Compressed powered vehicles have less vibration compared to petrol and diesel.

Limitations of compressed air powered vehicles are:

- Lower efficiency.
- Cannot handle high loads.
- Causes noise while operating.
- Compressed air has a low energy density. This means that, as the volume of air present inside the tank decreases the power output it provides also decreases proportionally. So complete air present inside the tank cannot be used for energy generation.

The research carried out on pneumatic powered vehicles by several researchers has given sufficient basis for dynamic applications and its subsequent use in overcoming the fuel resource requirements for powering the vehicles [6–9].

OBJECTIVES

The following objectives are to be met:

- To model and design a simple to construct mechanism that can be incorporated on any commercially available cycle.
- Implementing sensors to regulate the motion of the double acting cylinder.

MECHANISM

The design mechanism is one of the important aspects in achieving the functioning of system. The mechanism adopted is such that the linear motion of the pneumatic double acting cylinder is converted into rotary motion by connecting cylinder rod end of the cylinder with the help of a clamp. The clamp is bolted to a sheet metal welded on to a new sprocket on the other side of chain mechanism. The cylinder is connected such that, it gives a driving force due to compressed air and to and fro motion of cylinder. This is an effort to substitute and optimize the conventional design of the vehicle to simple and lighter construction. The vehicle is designed such that the weight is balanced and meets the efficient standards as per design. The optimal design and parameters that are chosen are done by calculations.

WORKING METHODOLOGY AND WORKING

The power system of conventional IC engine is replaced by pneumatic system. The principle of power generation in the system is by means of fluid power i.e., air and it is powered by continuous reciprocation of pneumatic double acting cylinder (Figure 1). The reciprocation is caused due to the compressed air supply. The linear reciprocation of cylinder is converted into a rotary motion.

In physical principle, the vehicle solely runs on the power produced by pedalling minimally and compressed air majorly. Air is the main source of supply that is sent in the pressurized form from the compressed tank to the pneumatic actuator. The fluid that is compressed in the rated pressure and depending on the output required, flow rate of air is left to flow for the actuation for desired power (Table 1).

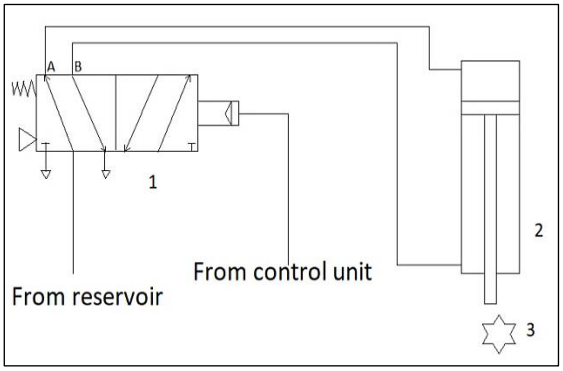

Fig. 1: *Layout Diagram.*

Table 1: *Part Designation.*

Part No.	Part Name
1	5/2 Solenoid Valve
2	Double Acting Cylinder
3	Sprocket

SENSING AND CONTROL

Hall Effect sensor (72x0H10) is used to determine the frequency of rotation of the bicycle wheel which can be viewed using the display connected to the control unit. The Hall Effect sensor also helps in regulating the frequency at which the solenoid valve is operated.

Two magnets are placed at the circumferential surface, with one facing its north pole outwards and the other with its south pole facing outwards. The difference in angle between the two magnets is 180 degrees. The Hall Effect sensor (72X0H10) is placed within the vicinity of the magnet such that the sensor is in the range of the magnetic field for every half rotation of the bicycle wheel (Figure 2). Every introduction of the sensor to a magnetic field creates an impulse signal which is fed back to the control unit such that the control unit regulates the on/off signal sent to the 5/2 solenoid valve. Due to this as the RPM of the bicycle wheel increases there will be decrease in the time taken for the solenoid valve to change from ON position to OFF position or vice versa.

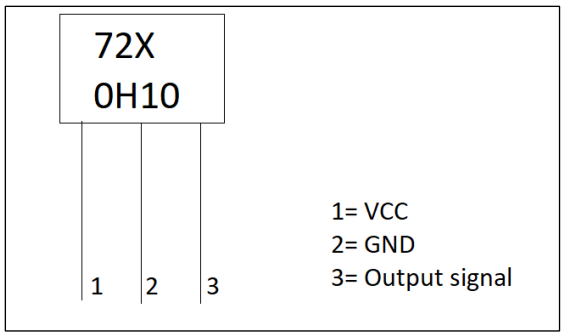

Fig. 2: *Hall Effect Sensor and its Connection.*

SPEED AND BRAKING

Speed is an important factor in vehicle aspects. Speed is regulated by using valves. In bicycle after reaching a particular rpm the mechanical motion is changed into a pneumatic motion with the help of magnetic sensors sensed with the help of arduino. While speed decelerates the system changes over from pneumatic to mechanical.

Braking is mainly used to stop the vehicle at particular instances. Same rim brakes of bicycles are mainly used. While braking, the pneumatic system is stagnated in its braking position and no further motion occurs.

MODELLING AND DESIGN

The modelling of the design is carried out in *Solid Works* as per dimensions.

The various parameters of the bicycle are as follows:

Double Acting Cylinder

From mathematical relation,

$$F_{piston}=P \times \frac{\pi}{4} d^2$$

where, F_{piston}, Force acting
P, Pressure

- Piston diameter d= 25 mm
- Stroke Length L= 250 mm

Reservoir

Commercially available reservoir specifications:

- Strong aluminium alloy cylinder
- Capacity = 170 litres
- Flow rate= 0.5 – 25 L/min
- Weight= 1.8 kg

Flow

Depending on the number of strokes/sec and its equivalent total running time, the below mentioned values were considered:

- The flow required from tank to the system is Q = 7.5 L/min
- Running time = 23.33 min

Force

The different forces that are considered for designing are as follows:
From mathematical relation,
Total force = Total Weight + Rolling Resistance (F_R) + Inertia Force (I)
where, F_R, m x g x c_r
$I = m \times r^2$

- Rolling Resistance (F_R)= 7.848 N
- Inertia Force (I)= 11.225 kg/m^2
- Total Force= 1019.1005 N
- FOS= 3

Torque

The calculated torque for factor of safety = 3 are:
From mathematical relation,

$$T = F \times r$$

where, F, Total force acting
r, Length of the lever

- T= 2.47 kN-m initial torque is overcome

Fig. 3: *Design of Mechanism.*

Thus looking into the above mentioned design parameters these indicate the utmost possibilities and also scope for improvement (Figure 3).

RESULTS AND DISCUSSION

Design and modelling of the suggested mechanism is successfully carried out.

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 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. Efforts should be to make them light, safe, cost effective and economical for deriving. There are still serious problems to be sorted out before air powered vehicles become a reality for common use but there is a hope that with the development in science and technology well supported by the environmental conscious attitude it will be possible.

CONCLUSION AND SCOPE FOR FUTURE WORK

- The exhaust air from the vehicle can be reused and passed to the compressor. So refueling of the air can be minimized.
- The further improvement can be made with stress analysis, thermodynamic analysis, and other minimized energy loses then the efficiency of the vehicle can be increased.
- High power motors and good suspension system can be used in pneumatic bicycle.
- Speed improvements can be done based on good design. So the pneumatic cycle can travel longer distances.
- The bicycle can be designed and modified according to person's aspects.
- The future trend of bicycles is based on airless tyres. Due to this trend vibration problems can be minimized.

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