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Vehicle Operating on Compressed Air by Inversion of Slider Crank Mechanism

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ABSTRACT : *This paper describes the working of a vehicle which works on pneumatic power. A pneumatic vehicle uses compressed air as a source of energy for locomotion. In this system a double acting pneumatic cylinder is operated as a slider crank mechanism which converts the linear reciprocation of the cylinder piston rod into oscillatory motion of the driver crank about the pinion shaft. The battery operated vehicles used in all manufacturing industries has disadvantages like high weight, takes more time to charge the battery, critical connection of switches and relays and more maintenance. These stated problems in this paper are overcome by a pneumatically operated vehicle which has low weight, easy circuits, takes less time for refueling and requires less maintenance.*

Keywords -*Compressed Air Energy, Directional Control Valve, Pneumatic Power, Inversion of Slider Crank Mechanism, Eco-friendly.*

I. INTRODUCTION

In a pneumatic system, the working fluid is a gas (mostly air) which is compressed above atmospheric pressure to impart pressure energy to the molecules. This stored pressure potential is converted to a suitable mechanical work in an appropriate controlled sequence using control valves and actuators. Conversion of various combinations of motions like rotary-rotary, linear-rotary and linear-linear is possible. The simplicity in design, durability and compact size of pneumatic systems make them well suited for mobile applications. Pneumatic control system plays very important role in industrial system owing to the advantages of low cost, easy maintenance, cleanliness, readily available, and cheap source, etc. [1]. A particularly well suited application for vehicle operating on compressed air is material handling and for visitors in industry. Compressed air storage energy (CASE) is a promising method of energy storage, with high efficiency and environmental friendliness [2]. Compressed air is regarded as fourth utility, after electricity, natural gas, water and the facilitating production activities in industrial environment [3]. Unfortunately production of compressed air solely for pneumatic vehicle is not affordable but in manufacturing industries compressed air is widely used for many applications such as cooling, drying, actuating and removing metal chips. In addition, as a form of energy, compressed air represents no fire or explosion hazards; as the most natural substances, it is clean and safe and regarded as totally green [4]. The performance of air car is explain in [8] in which the importance of the impact of the fossil fuels in the present and future generations is explained which led them to design a new vehicle which runs by renewable energy sources. Compressed air vehicle are more suitable for low speed, short range and flammable environment [9, 10].An inventor, JemStansfield, has been able to convert a regular scooter to a compressed air moped [10]. The moped has top speed of about 18 mph and could go 7 miles before its air pressure ran out [10]. During literature survey it is observed that compressed air vehicles has many potential advantages over electric vehicles which includes no degradation problems of batteries, time required for refueling the tank, easy disposal of compressed air tank without causing any pollution as with the batteries [10].Hence in order to overcome the above stated problems there is a need of eco-friendly vehicles using compressed air as a working medium in future. In this work a sincere effort is made to develop Vehicle operating on compressed air by inversion of slider crank mechanism.

II. INVERSION OF SLIDER CRANK MECHANISM

The slider crank mechanism as shown in Fig.1 has a four links connected by three revolute joints and one prismatic joint of lower pair or surface contact. In this inversion the cylinder is fixed and piston inside reciprocates and this reciprocating motion is converted in to the rotary motion of crank[5].

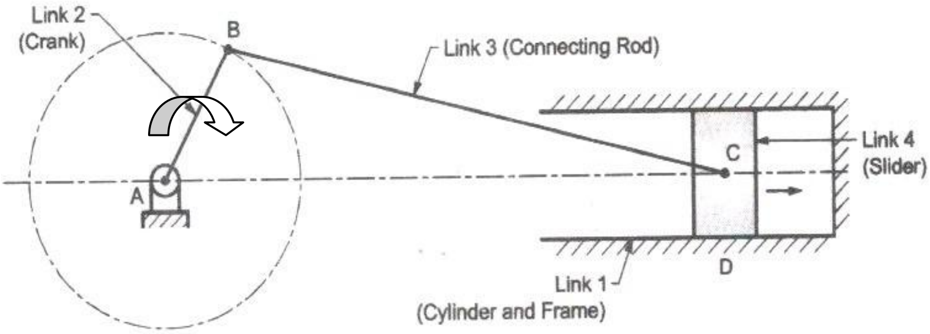

Fig.1 Inversion of slider crank mechanism[5]

In this system a double acting pneumatic cylinder operated as a slider crank mechanism that converts the linear reciprocation of the cylinder piston rod into oscillatory motion of the driver crank about the pinion shaft. The pinion shaft further drives the pinion, which will turn the gear wheel on the output shaft. The output shaft carries the system that converts the oscillatory motion of the gear into the single direction rotation of the chain vehicle by means of a unidirectional clutch arrangement. The pneumatic linear actuator as shown in Fig.2 supplies compressed air by means of an appropriate filter-regulator-lubricator (FRL) unit and a 5/2 foot operated pneumatic direction control valve. This system is capable of being driven to given intermittent as well as continuous motion to the chain vehicle system. The system uses pneumatic cylinder, which is fast actuation system, hence the vehicle has fast response. The system incorporates a provision to arrest the stroke of the actuator to a desired level there by deciding the length of travel of the vehicle thus making the system flexible enough to serve the needs of the flexible production system.

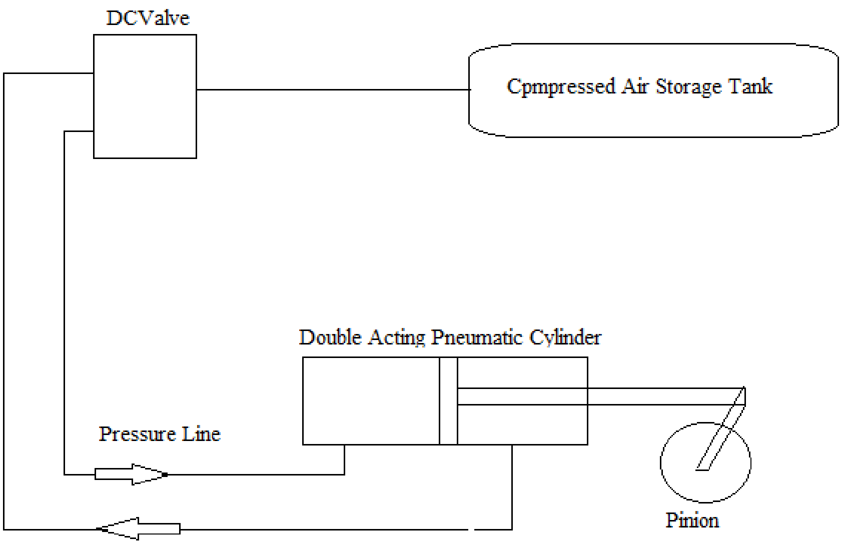

Fig.2 Assembly layout

III. WORKING OF DOUBLE ACTING PNEUMATIC CYLINDER

Pneumatic cylinders or air cylinders are mechanical devices which use the power of compressed air to produce a force in a reciprocating linear motion or cylinders which converts pneumatic power into mechanical power [11]. Compressed air forces the piston to move in the desired direction. As the operating fluid is air, leakage from a pneumatic cylinder will not drip out and contaminate the surroundings, making pneumatics more desirable where cleanliness is a requirement. Because air is expandable substance, it is dangerous to use pneumatic cylinder at high pressure so they are limited to 8 bar (gauge) pressure [6]. Consequently they are constructed from lighter material such as aluminium and brass. Because gas is compressible substance, the motion of pneumatic cylinder is hard to control precisely. The force exerted by the compressed air moves the piston in two directions in a double acting cylinder. These are used particularly when the piston is required to perform the work not only in the forward movement but also on the return. In principle, the stroke length is unlimited, although buckling and bending must be considered before we select particular size of piston diameter, rod length and stroke length.

3.1 Force

The fluid pushes against the face of the piston and produced force. The force produced is given by

$$F=PA \tag{1}$$

Where p= pressure in N/mm^2 and A= Area the pressure acts on it mm^2

$$F= 5x10^5 \text{ x } \frac{\pi}{4}\ x\ d^2 \ (2)$$

$$F = 981.74 \text{ N}$$

3.2 Speed

The speed of piston and rod depends upon the flow rate of fluid. The volume per second entering the cylinder must be the change in volume per second.

$$Q\ m^3/sec= \text{Area x distance moved per second} \tag{2}$$

$$Q\ m^3/sec= \text{Area x velocity (full side)} \tag{3}$$

$$Q\ m^3/sec= (A\text{-}a) \text{ x velocity (rod end side)} \tag{4}$$

3.2.2 Specification of Double Acting Pneumatic Cylinder

TABLE.1 Specification of Double Acting Cylinder

Model	**SC**
Structure	Piston Cylinder
Power	Pneumatic
Body Material	Aluminum
Bore Diameter	50mm
Stroke Length	100mm
Rod Diameter	25mm
Working Pressure	1.5-8 Bar

IV. 5/2 DIRECTIONAL CONTROL VALVE

To control the to and fro motion of a pneumatic cylinder, the air energy has to be regulated, controlled, and reversed with a predetermined sequence in a pneumatic system [7]. Similarly one has to control the quantity of pressure and flow rate to generate desired level of force and speed of actuation. To achieve these functions, valves are used to-(i) start and stop pneumatic energy, (ii)control the direction of flow of compressed air, (iii)control the flow rate of the compressed air and (iv) control the pressure rating of the compressed air. A direction control valve has two or three working positions generally. They are:

1. Neutral and zero position
2. Working position

4.1 Working of 5/2 DC Valve

First position **-** The pressurized air from port P is supplied to pneumatic cylinder from piston end which extends the piston as shown in Fig.3. This forward motion of the piston forces out the air present at rod end side through the port Q. During the extension of piston the port R is at hold position.

Second position **-** In second position as shown in Fig.4 the pressurized air is supplied to the piston rod end through port P, B causing the piston to retract. During the retraction the air present at the piston side is forced out through port Q.

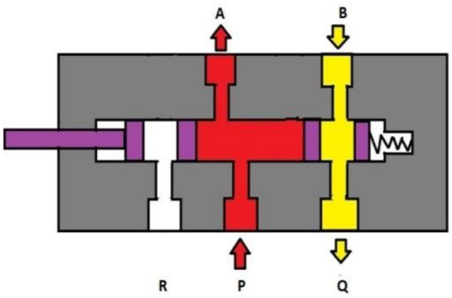

Fig.3 5/2 DC Valve in first position[7]

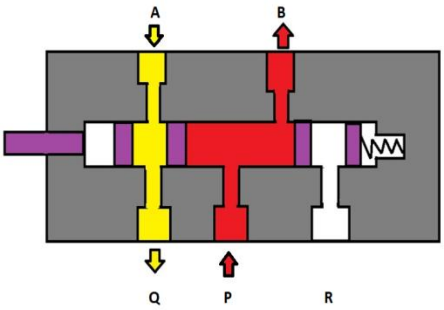

Fig.4 5/2 DC Valve in second position[7]

P = Pressure Port

A, B = Working Port

R, Q = Return Line

V. PROTOTYPE PARAMETERS

5.1 Dimension of Prototype vehicle**:** Fig. 5 shows prototype of pneumatic vehicle develop in the college workshop. TABLE.2 shows the dimensions of the prototype.

TABLE.2

Length	1240mm
Width	920mm
Height	400mm

Fig 5 Prototype pneumatic vehicle

5.2 Design: TABLE.3 shows the design parameters of prototype which is shown in Fig.2

TABLE.3

Material for Prototype frame	Mild Steel (L section)
Gear for transmission	Spur Gear
Bearing	Ball Bearing 6204
Steering system	Rack and Pinion
Load	100kg
Volume of compressed air tank	12 liter
Control valve	5/2 DC valve

5.3 Results & discussion: During the testing, it is observed that the time required to fill the compressed air tank is about 144seconds @ 4 bar pressure which is very less than battery operated vehicle. Also,it is observed that the prototype covers the distance of 50 meters in 12 liters.

TABLE.4

Time required to fill tank	144seconds@ 5bar pressure
Distance moved in 12 liters	50 meters

VI. CONCLUSION

The technology of compressed air vehicles is not new. In fact, it has been around for years. Compressed air technology allows engines that are both nonpolluting and economical. This paper explores the effective application of pneumatic power. Pneumatic vehicle will replace the battery operated vehicles used inindustries. Pneumatic powered vehicle requires very less time for refueling as compared to battery operated vehicle. This is totally clean, light weight circuit, can work in hazardous environment and requires less maintenance.

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