Design and Development of Power Transmission Mechanism of Air Power Cycle

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***Abstract*: This paper is on Design & Fabrication of a Tri-cycle that runs on compressed air. The whole body looks like a complete tri-cycle except the manual operation is replaced by an automatic operation using pneumatic wrench as a power source for the tricycle. This tri-cycle can be used for handicapped people as well as industrial workers who need to travel short distances and to carry load and equipments. Only one person is allowed on this tri-cycle. This concept of compressed air tri-cycle in practice reduces the air pollution to large extend as its exhaust is nothing but air.**

***Keywords*: Tri-cycle, Compressed air, Automatic, Air pollution.**

1) INTRODUCTION

Nowadays the world is suffering from many environmental problems and depletion of conventional fuels. Automobile field works on a large amount of fossil fuels with somewhat lower efficiency. However the consumption of fossil fuels results and transforms in to many serious environmental problems. To reduce such environmental problem, the use of renewable energy sources like solar energy, wind emphasis on the use in automotive vehicle. As the conventional tricycle requires human strength and effort to be applied on the pedals to propel the vehicle. We intend to develop and fabricate an automated tricycle that uses compressed air pressure as a source of power. The pneumatic system deals with the use of air pressure along with its control system for moving things also provide clean system. Tricycle is an compressed air operated vehicle which has a one person capacity and are specially designed for the purpose of low mobility.

a) Problem Statement: While riding a tricycle human being wastes lots of energy in pedalling. Now-a-days environmental pollution is a major concern for all the countries. So this design of compressed air tricycle will reduce the human efforts and does not contribute to any environmental pollution problems.

b) Objectives:

- To Design and fabricate the pneumatic tricycle.
- To obtain maximum speed with maximum loading condition.
- To find the flow rate, compression ratio, and expansion.

c) Scope:

- This air compressed tricycle will be helpful for the handicapped people to travel with ease.
- We can make some new modifications in future to give this project a new direction towards eco-friendly vehicles.
- By using light weight air storage tank can further reduce the total load and can give more efficiency.
- For higher power output actuators which can work at higher pressures can be utilized

2) LITERATURE REVIEW

Andrew Papson et.al, studied the potential performance of CAVs in terms of fuel economy, driving range, carbon footprint, and fuel costs and examines their viability as a transportation option as compared with gasoline and electric vehicles. Subjects of analysis include energy density of compressed air, thermodynamic losses of expansion, CAV efficiency on a pump-to-wheels and well-to-wheels basis, and comparisons with gasoline and electric vehicles. Results show that although the CAV is a bold, unconventional solution for today's transportation challenges, it is ultimately not workable, and compares poorly with gasoline and electric vehicles in all environmental and economic metrics. Further, applications of the CAV are severely constrained because of its limited driving range. The results from this study, including the analysis of energy density and expansion losses, may be used to identify future opportunities for CAV applications. The pump-to-wheels and well-to-wheels methodology contained here establishes a framework for evaluating future CAV designs.

Saurabh Pathak et.al, did research on the heavy vehicles are known for producing a large amount of harmful gases like Co2, SO2etc., which act as the major source for global warming. So research is going on to find a light weight vehicle which does not pollute the environment. One of the alternatives is the use of compressed air to generate power to run an automobile. 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 paper an effort is made to study the extent of research done and the potential advantages and disadvantages of the compressed air technology. This paper explores the effective application of pneumatic power.

Rakesh P. Shende et.al, worked on a pneumatic vehicle, useful for handicapped people, equipped with pneumatic ratchet, pressure regulator, DC air compressor, air tank, chain sprocket transmission drive. The power transmission takes place from ratchet to rear wheel through chain drive. Only one person allowed on the Tricycle at any time. Modification by attach support is to make structure more strong at critical point. The materials, mild steel is choose as a main structure fastening by joint. Components of model attach by bolt and nut. Part by part create then be fabricate together. At the end of the project, the model tested by several people and their comment then being recorded and performed some tests.

Rahul Sharma et.al, studied on a pneumatic tricycle, which can be used for handicapped people as well as industrial workers who need to travel short distances and to carry load, equipped with pneumatic wrench, pressure regulator, Air compressor, air receiver tank, chain and sprocket transmission drive. It is an real wheel drive vehicle in which the power transmission takes place from pneumatic wrench to the rear wheel through a chain drive. Pneumatic tricycle is stable, operated quietly and is smooth, and gave users the feeling of being in control of the vehicle. The Ergonomic evaluation also demonstrated that Pneumatic tricycle is easy to use in normal use situations, including situations involving obstacles, for abroad cross section of users.

Rahul Jeughale et.al, Studied to design & fabricate vehicle running on air pressure for material handling in industries and reduce power consumption. It is rear wheel drive. He develop the concept of pneumatic vehicle from pedal operated tricycle. The vehicle looks like three wheeler in which manual operation is replaced by compressed air pressure. In this project a model of pneumatic vehicle is designed and manufactured. The load carrying capacity of pneumatic vehicle is 60 kg. The volume of air receiver tank is 6.3 lit. and is stored at pressure of 4 bar. Once the compressed air is filled in tank the vehicle can move upto a distance of 15 to 20 m.

3) THEORY

A compressed air is used in air powered tricycle for its operation. Now-a-days various industries are using compressed air power system for research and development of different drives for different operations. Storage of air by compression in the cylinder will store some energy. This stored energy can be of use in various aspects. The expansion of the compressed air releases energy within the system to do the work. So, this energy released during expansion is used to actuate the piston. This is the basic principle for a pneumatic system. As in the engine of compressed air driven cycle there is no combustion process. So, it is neither polluting nor harmful.

a) Type of Tricycle: There are two categories in which tricycle is divided.

1. Human powered tricycle
   - i. Upright Tricycle
   - ii. Recumbent delta
   - iii. Recumbent tadpole
2. Motorized tricycle
   - i. Motorized freight trikes
   - ii. Motorized scooter trike.

4) Use of Compressed Air Pneumatic System

In our pneumatic system, we have used air as a working fluid. Because air has the some advantages over the other gases. Properties of air are very suitable for pneumatic system. We used pneumatic system, as it has some advantages over the hydraulic system.

1) There is no need for fluid replenishment.
2) Light tubing/piping is sufficient.
3) There is no fire hazard.

5) Properties of Air

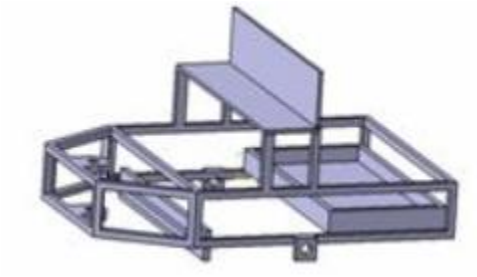
Air is a mixture of 78% nitrogen, 21% oxygen and 1% other inert gases with moisture by volume. Air exerts pressure at sea level of about 1.013 bar (14.7 psi) called atmospheric pressure. It is equivalent to 760 mm of Hg or 10.3 m of water pressure as measured by U-tube manometer.

Other physical properties of air are:

1) Molecular mass, M = 28.96 kg/kg mol.
2) Boiling point at 1 bar = -191º C to -194º C.
3) Freezing point at 1 bar = -212º C to -216 ºC.
4) Characteristic gas constant, R = 287 Nm/kg K

6) INTEGRATED PARTS

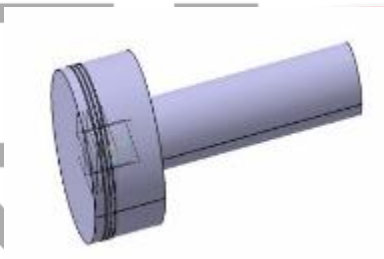
1) Frame: A frame is often a structural system that supports other components. The frame of a vehicle is basically chassis. It is the skeletal system of vehicle. To construct by fitting and uniting the part of a structure.



2) **Storage tank:** The air storage tank is used as a reservoir of compressed air. The air required for the circulation in the system is supplied from this tank. An air receiver tank is an integral and important part of compressed air system. The receiver tank acts as a reservoir of compressed air for peak.

3) **Wheel:** A circular object connected at the centre to a bar, used for making vehicle.

4) **Piston:** A piece of metal in an cylinder. That fits tightly inside the cylinder. The piston moves up and down in the cylinder.



7) DESIGN AND CALCULATION

1) Design of Chassis

Input data

1. Total weight = 70 kg

2. No of links = 4

1 and 4 links length = 915 mm

2 links length = 910 mm

3 links length = 300 mm

Applied Mass on Chassis = 70 kg

Weight = 70 × 9.81

Weight = 686 N

No of links = 4

Hence,

Force on each link = $\frac{700}{4}$ =175N

Considering the max value of FOS = 2

Buckling load on each link = 175 × 2=350N

Let,

t_1 = Thickness of link

b_1 = Width of link

Cross sectional area of link = $t_1 \times b_1$

Assuming width of the link = $3 \times t_1$

Hence,

$b_1 = 3 \times t_1$

Area = $3 \times t_1^2$

Moment of Inertia of link 1

$$I = \frac{1}{12} \times t_1.b_1$$

$$I = 2.25t_1$$

Let,

K = Radius of gyration

A = area

$$K = \left(\frac{I}{A}\right)^{\frac{1}{2}}$$

$$K = 0.75\ t_1$$

Link – 1

t_1= 300 mm

p_r= 500N

Rankin constant = a = $\frac{1}{7500}$

Crushing load (f_y) = 325 Mpa for M.S.

Now, buckling load

$$P_r = f_y.\frac{A}{1} + a\ \lambda$$

Where $\lambda = \frac{1}{K}$

$$Pr = fy.\frac{A}{1} + a\left(\frac{1}{K}\right)$$

$$975t_1 - 500t_1 - 7980 = 0$$

t_1 = 1.768 mm ≈ 2 mm

Similarly,

Calculating the thickness for link 2 and 3

t_2= 2.44 mm and t_3= 2.97 mm

Hence we take thickness, t = 3 mm

In automobile the chain is lubricated by oil and grease. But after some time the dust particle adhere on chain and goes in between roller and bushing and pins.

2) Design of Chain and Sprocket

Given:

Driving sprocket speed=80 rpm

Power =123.31 watt

According to standard design

ANSI chain no. is 40

Pitch (p) = 12.7 mm

Breaking strength for single strand

F_b=6670 N

Where,

P = pitch

D = pitch circle diameter of chain sprocket

α = pitch angle

$$\alpha = \frac{360}{18} = 20^0$$

Z= No. of teeth on Sprocket

Z_1, Z_2 = Number of teeth on driving and driven shaft.

$$\therefore \frac{\sin\alpha}{2} = \frac{\left(\frac{P}{2}\right)}{\left(\frac{D}{2}\right)}$$

$$D = \frac{p}{\frac{\sin\alpha}{2}}$$

$$D = \frac{12.70}{\frac{\sin 20}{2}}$$

D=73.13 mm ≅ 80

Average velocity of chain is,

$$V = \frac{\pi D 2}{6000}$$

$$V = \frac{\pi \times 80 \times 80}{6000}$$

V= 0.305 m/s

3) Design of Piston Cylinder

1. a) C 7 (UTS – 340 N / mm2)

   b) C 10 (UTS- 400N/mm 2)

2. Aluminium (UTS -200N/mm2)

4) Design of Cylinder

Let D_i be the internal diameter of cylinder, assuming operating pressure = 5 bar

$(142344 \times (D_i)2 \times 4 \times 105) = 5105$ N

D_i = 0.0637 m.

D_i = 63.7mm.

WE take,

D_i = 69.8 mm (From Pneumatic Handbook)

5) Thickness of Cylinder

Material C- 50, yield strength. Sy = 340 N/sq. m.

Considering the cylinder as thick.

Using "Clavarino" equation,

$$T = \left(\frac{Di}{2}\right) \times \{6 + \frac{Pi(1-2u)}{16} - Pi(1+u)\}$$

$$T = (34.9) \times \{6 + \frac{0.8(1-0.6)}{16} - 0.8(1+0.3)\}$$

T = 1.38 mm

By practical considerations, we take thickness of cylinder as, T= 3mm.

6) Design of Piston

Dia. of piston = I.D of cylinder

= 69.85mm

Considering the effective sealing and guiding the piston red inside the cylinder, we take length of piston in contact with cylinder =0.32 times diameter of piston. The length of step of Dia. 31.7 is taken equal to 12.5 , considering the size of " U" --- cup seal . Piston material is GOI 30 as its grains are small and soft. This helps in reducing wear of the cylinder and provides easy sliding it.

7) Design of Piston Rod

We design the piston rod for bucking .consider the condition fixed at both ends for piston rod.
According to Rankin's formula,

$W_{cr} = F_c \times A/1$: at L/K

Where,

W_{cr} = Crippling load .

F_c = Crushing stress = 320 N/ sq. m.

$$A = \frac{fc}{3.142\ x\ 3.142} \times \text{E. Rankine' s constant}$$

$$= \frac{1}{7500} \text{ for M.S.}$$

L = Equivalent length of column

= ½ for both ends fixed (by using Euler's theory)

= Least radius of gyration.

Thus putting the values in the above formula, we have

$$5105 = \frac{\left\{320 \times \left(\frac{3.142}{4}\right) \times D \times D\right\}}{\left\{1+\frac{1}{75010}\left[\frac{1}{15} \times \left(\frac{4}{D}\right)2\right]\right\}}$$

$$5105 = \frac{251.2 \times D}{D\,4 + 48.68}$$

Solving further we get,

$D_4 - 20.32\ D - 988.52 = 0$

D = 6.58

Considering the impact load coming on the piston rod , we take the diameter of piston rod as ,

D = 19.74 mm.

D = 20 mm.

(Applying a F.O.S. of 4/3)

T.D.C. – B.D.C.

= 135-85

= 50mm

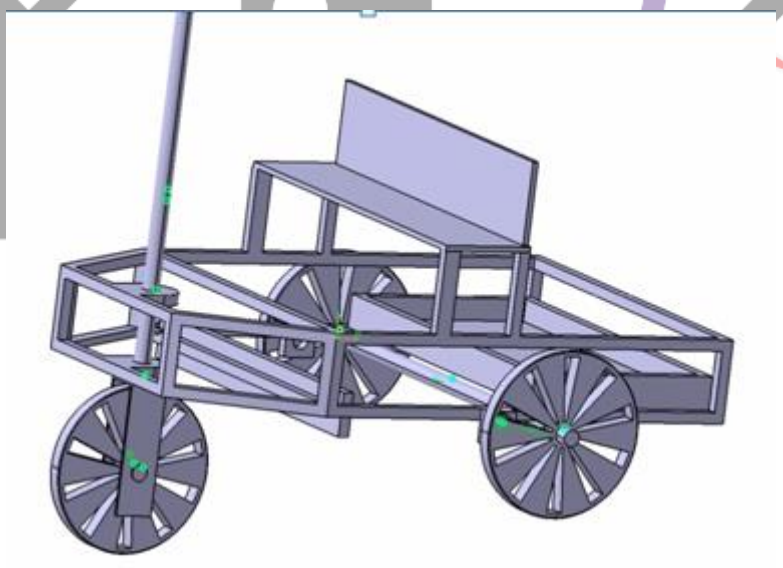
Volume of tank: - L = 300

D =140

$= (\frac{\pi}{4}) \times d^2 \times L = (\frac{\pi}{4}) \times (140^2 \times 300)$

$=6.031\ m^3$

8) Catia Model



9) Applications

Usually air at low pressures in the range of 5 to 7 bar is used in pneumatic systems. Compressed air systems are used for many industrial applications. Some of its applications are:

1. Mainly we took into consideration about to use of this tricycle for handicapped persons.
2. Then this device should be easy to work and easy to use by a handicapped persons.
3. There is no need of fuel to operate to it.

4. This brilliant idea can be used further in other vehicles with some more modifications.

5. It could be used in A.G.V. & in industries.

May be used for driving motor, turbine and other rotary equipment's

10) Conclusion

The vehicle is in early stage of development but it holds a lot of promise and provides scope for further research. The tricycle which we have designed and manufactured is eco-friendly and does not cause pollution. This tricycle will help in reducing the problems of global warming. It uses non-conventional energy source i.e. atmospheric air. This will help to save the non-renewable source of energy. Pneumatic vehicle can prove solution to depleting natural resources and can be the technology of tomorrow.

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