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Design of Pneumatic Bicycle with Solar Charging

Mandar Patil [#1] Ashok Korane [#2]

[#1]Mechanical Department, Sinhgad College of Engineering [#2]Trendz Innovation

mpatild@hotmail.com

Abstract— Pneumatic bicycles can be the next generation self-powered vehicles for short distance urban travelling, a long lasting solution to the rising pollution levels & decreasing fossil fuel reserves. Currently electric powered vehicles with no emission of combustible products are gaining momentum as an alternative over petrol, diesel & gas engines. But with limited reserves & disposal challenges of Lithium-Ion, a major component in the electric vehicles batteries, and a huge maintenance cost, a more focused approach is required to the development technology of engines run by compressed air for mobility solutions which can be economical & everlasting. With abundant solar energy to run compressors for refueling, a 100% pollution free vehicle is very much possible. Motor Development International, a French company has already brought Compressed Air Engine operated cars in the market which are pollution free. The auto giant "TATA Motors" in India has signed a MOU with MDI to develop & manufacture CAE cars in India. In this paper an effort is made to review the challenges faced by the pneumatic bicycles as a mobility solution for short distance travelling & derive solutions on the same. Though challenging today, pneumatic bicycles can be the best solution towards global warming for short distance urban mobility.

Keywords— *Pneumatic Bike, Compressed Air Technology, Hybrid Bicycle, Alternative Energy*

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I. INTRODUCTION

The World Currently Is Under Tremendous Pressure With Its Fossil Fuels Reserves Depleting At A Highly Faster Rate. Such Factors Are Pressurizing Companies Dependent On Such Fuels To Invest Heavily On New & Sustainable Energy Sources Which Can Replace & Keep Continuing The Development Pace Of Its Nation. With The Atmosphere Being Harmed With The Pollutants From The Combustion Of These Fossil Fuels, Finding Alternative Mobility Solutions Is The Highest Need To Save This Beautiful Planet. With Air Available In Plenty, Everlasting & Nonpolluting, Which Can Be Easily Compressed To Higher Pressure At Low Cost, In Turn Can Be Used As A Replacement To Drive Engines For Mobility. Such Pneumatic Drives In Bicycles Can Be A Workable Solution To Travel On Roads And A Replacement To Electric Bicycles &I.C Engines Bikes Not Used For High Distance Travelling. These Type Of Pneumatic Bicycles Are Not New In The Market, But Are Currently Available In Complex Forms, Making Them Unsuitable & Heavy Over Electric Bicycles. The History Of Such Forms Of Transportation Dates Back To 1880, But Got Neglected After The Discoveries Of Heat Engines, Since The Later Had More Efficiency & Portability. Such Type Of Bicycle Can Be A Hybrid Form, Since It Can Also Be Peddled In Case Of Loss Of Power.

II. LITERATURE REVIEW

[1] Rixon K L, Irjet 2016 Vol: 3, Issue 3, "Fabrication Of Compressed Air Bike" Explains The History Of Compressed Air Vehicles & Makes An Overall Construction Of An Air Bike Using An Vaned Type Air Turbine, Compressed Air Tank, Connectors, Ball Valves & Frame To Convert Power Produced By The Compressed Air At 6 Bar, To Give An Output Power Of 4 Kw At The Wheel. The Output Power Is Achieved For A 30 Min Running And Maximum Pressure Of 200 – 300 Psi. The Constructed Model Looks Bulky With A Very Low Range, Hence Looks Unsuitable For Practical Use. The Author Concludes For A More Light Weight, Safe And An Economical Air Bike. [2] Devashish Tiwari, Shubhagy Sahu & Others, Ajer 2018, "Design & Fabrication Of Bicycle That Runs On Compressed Air' Discusses About Hybrid Bicycle Being Peddled Manually Or Propelled Using Compressed Air. The Author Aims To Design & Fabricate Such Type Of Bicycle For The Ease Of Cycling & Introduce A Technology For The Advancement Of Traditional Bicycles. In Their Design A Pneumatic Piston Is Used To Utilize The Mechanical Advantage, Whereas A Rack & Pinion Assembly Is Designed & Manufactured Along With Supporting Elements Like A Flow Regulator, A 3/2 Hand Operated D.C. Valve And A Gate Valve Are Used To Operate, Control And Complete The Cycle. The Paper Does Not Discuss About The Actual Results After Fabrication & Operation Of The Bicycle & Hence Can Be Assumed Unsuitable For Practical Purposes. The Author Concludes This Technology To Be A Distant Dream With Environment Conscious Attitude & Looks For Better Designs, Which Needs To Be Lighter & Cost Effective. [3] Mihai Simon, Science Direct 2017, "Pneumatic Vehicle, Research & Design" Describes The Research, Design & Construction Of A Viable Experimental Pneumatic Driven Vehicle, The Main Goal Being Environmental Friendly Solution For Mobility. The Paper Presents The Best Results After Designing, Building & Testing Five Tricycle Experimental Configuration Of Compressed Air/Gas. It Is Also Designed With A Secondary Transmission Of Chain & Sprocket With Changing Gear Speeds. A Double Acting Cylinder, Used With A Ratchet & Pinion Arrangement,

Comprises The Main Engine Incorporated In The Main Structure Of The Chassis. Transmission For Forward & Backward Movements Along With Speed Gear Changer Are Developed. The Frame & The Body Structure Are Fabricated From Aluminum To Keep The Weight To The Minimum. The Author Concludes The Vehicle's Feasibility And Cost Effectiveness For Common Urban, Non-Polluting Mobility.[4] Chaman Meena, Tarun & Others, Undergraduate Students Of Mechanical, In Their Paper "Design Of Pneumatic Operated Vehicle By Inversion Of Single Slider Crank Mechanism" Have An Eco-Friendly Approach For Mobility & Want To Use Air, Which Is Easily Available As A Best Option Over Fossil Fuels. Via Their Research Through Many Papers, It Is Noticed That The Major Problem With Air Operated Bicycles Is The Low Torque Generation. To Improve The Torque, The Authors Use Two Pneumatic Cylinders & Inverse The Single Cylinder Crank Chain Mechanism To Make The Oscillating Cylinder Engine Mechanism In Which The Reciprocating Motion Is Converted In To Rotary Motion. The Author Concludes To Develop An Air Operated Pneumatic Bicycle On Their Research. [5] S.S. Verma In His Paper "Air Powered Vehicles" Describes Air To Be The Most Efficient Fuel For Mobility On Light Utility Vehicles. Technologies Being Used In Such Bikes, The Recent Developments In These Areas, Then The Advantages Of Using Air As A Fuel And The Advantages Of Pneumatic Vehicles Over Battery Operated Vehicles Are Covered In This Paper. The Author Describes The Current Bottlenecks In The Development Of Such Mobility Options & Concludes With Some Solutions Opted By Companies In The Development Of Air Powered Vehicles.

III. Methodology

As per the papers reviewed, the main focus in this paper is to designe &derive solutions to the problems highlighted in them leading to the development of pneumatic air bicycles.

Table 1 Identification of Problems

Problem	Solution
Overall weight	Frame of the bicycle is designed & fabricated using aluminum Air tank is fabricated from carbon fiber for weight reduction Nitrogen is used in both tires instead of air
Low starting torque	Weight reduction/Optimization Double acting cylinder with spring arrangement Nozzle at the inlet of the pump, to increase the pressure
Range	Weight reduction Light weight air tanks to be fitted on both sides of the bicycle to increase tank capacity

Layout of the full system:

The below layout shows the flow of compressed air from the tank, to the cylinder through the control valves & conversion in to useful work to drive the free wheel or the sprocket. The exhaust air is further used to drive the dynamo before being passed to the atmosphere through the silencer.

Pneumatic Circuit Components:

- 5/2 Directional control solenoid valve
- Throttle assembly
- FRL unit
- Double acting cylinder
- Quick exhaust valve
- Silencer

Working:

The above layout can be explained as follows. The compressed air at 6 bar pressure will be filled in to the tanks at the charging station. These stations will be solar or electricity powered. The tanks can be filled in few minutes. Once the tanks are fully filled by the indication in the indicator, the cut off valve will automatically cut the supply, to prevent overfilling or bursting of the tank. The pneumatic cycle is now ready. The ignition switch to be switched on by the key, which will On the solenoid valve. Once the lever is engaged and the accelerator is given, the compressed air flow will start, which will enter the cylinder & push the piston from TDC to BDC & in connection the sprocket & rear wheel, which will give motion to the bicycle.

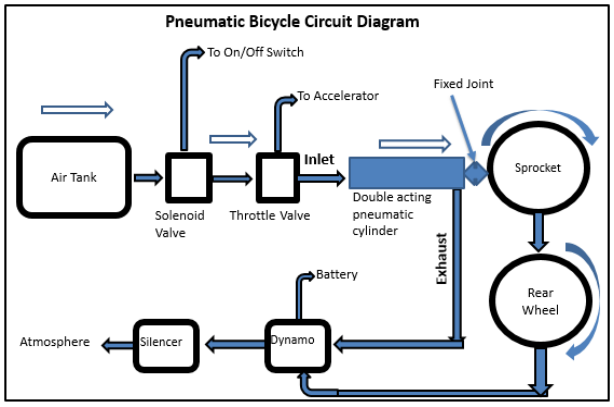

Figure 1 Pneumatic Bicycle Circuit Diagram

The compressed air will pass through a converging diverging nozzle, which will further increase its pressure. The above cycle will keep on repeating. Once the accelerator is reduced or closed, the supply will get cut off & the engine will stop. The throttle is connected to the accelerator by a mechanical linkage cable. The above arrangement will ensure that there is no energy wasted during temporary stops of the bicycle at signals or in traffic. A 12V battery will ensure current for the switches and the led. The battery will be

continuously charged by the dynamo which will run by the outgoing exhaust air. Provision will be made to couple it with the rear wheel for more power requirements.

Advantage of the designed technology:

1. The air intake will be during only backward stroke of the piston, which will draw less air from the tank, increasing the range of the bicycle
2. Less space is occupied by the above arrangement, by which the bicycle can be made hybrid, i.e. driving manually as well on pneumatic
3. An external spring will ensure retardation of the piston as per designed force, by which energy will not be lost in compression of the internal spring
4. Force will be generated during only one stroke of the piston, similar to the working of an SI or CI engine, which will ensure maximum power

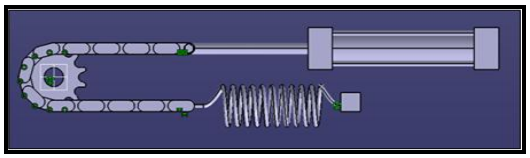

Figure 2 Working Technology of the Bicycle

Table 2 Bill of Material

Sr. No.	Component	Type	Dimension	Material	Qty
1	Total Frame	Fabricated	1095 X 500	Aluminum hollow tubes	1
	Top Tube		570 X 6		
	Down Tube		613 X 6		
	Seat Tube		420 X 6		
	Chain Stays		450 X 6		
	Seat stays		470 X 6		
	Head tube		120 X 6		
2	Sprocket	Bought out			3
3	Pneumatic Cylinder	Bought out	25 mm dia bore X 200 mm stroke	Aluminum	1
4	Chain	Bought out			2
5	Tires	Bought out	29 inch		2
6	Spring	Manufactured		Spring Steel	1
7	Pneumatic Tank	Manufactured	10 Liters	Carbon Fiber	2

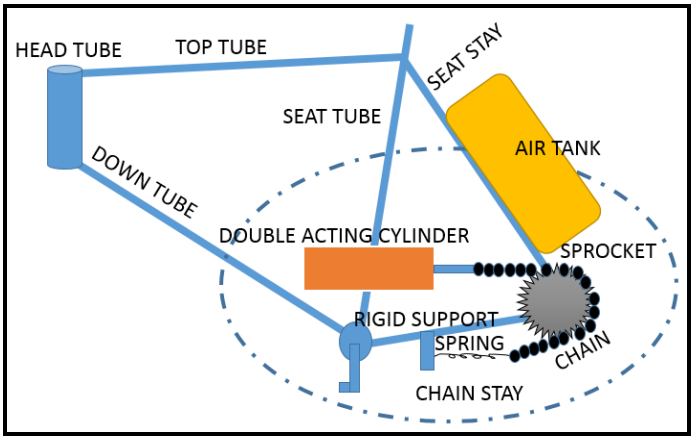

Figure 3 Bicycle Structure with pneumatic technology

Solar Charging

Solar roof panels at charging stations are used to run the compressor to compress the air to be filled in the tanks. A battery backup can be provided to store solar energy, or an electricity supply can be given as a backup.

IV. Result & Discussion

Problems discussed in the papers reviewed was the main objective in this paper. The new design can be advantageous in the following manner:

1. The design is simple & robust, with less no of moving parts
2. Direct drive is given from the cylinder to the sprocket, which overcomes any mechanical losses in the reviewed designs
3. Fully aluminium & other light weight material used, helps in reduction of weight, thereby reducing the starting torque for the bicycle
4. Carbon fiber tanks can further reduce the weight of the vehicle, without compromising on its strength
5. Designed nozzles at the intake stroke of the cylinder can help improving the speed as well as the power generated during the power stroke
6. Low maintenance & manufacturing cost as well as easy maintenance

The overall performance that are obtained on calculations are as follows:

- Average weight handled is 70 to 95 kg
- Top speed at average weight of 50 to 55 km/hr
- Average speed of 45 km/hr
- Range covered of 20 to 25 km by 10 litres of tank at 6 bar
- Cost of running comparably on a very lower side to its electrical partner

The bicycle if tested can give an output range of 20 to 25 km on a 10 liters air tank. The cost per km for running this bicycle should be less than one rupee. With less no of mechanical parts, the maintenance cost would also be very low for this vehicle. Such type of low cost solution for short distance travelling can be the biggest solution for increasing pollution & reducing fossil fuel reserves.

V. Conclusion

The designed bicycle is a concept mobility solution for short distance urban travelling that runs on a pure green energy which uses air as an intake & gives back air as an exhaust. Such forms of engines, though not in current usage but holds lots of promise due to their environmental friendly nature. With current pollution challenges & global warming because of fossil fuels, there is a wide scope for research on environmental friendly vehicles. Though initially at a higher cost can work towards a greener climate. Such solutions over current fossil powered engines might not be that easy to use, but over a period of time may find compulsion solutions.

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