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Power Generation at Speed Bumper by Pneumatic Mechanism

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Abstract - *As the need for power requirements are increasing by many folds, more studies on renewable energy sources are being made and innovative methods have been thought of to generate electricity by unconventional methods. In this regard, an attempt is made by us in harvesting energy absorbed during the vehicle movements over speed bumpers on roads.*

This work concentrates on extracting kinetic energy of vehicles that run on the streets and to generate power from the same. Even though, few mechanisms are available to tap the energy, pneumatic system appears to be the more feasible among all for power utilization. The arrangement consists of a flexible curved portion resembling a road hump that can be conveniently installed beneath the hump. As the vehicle movements exert pressure, the same is utilized to increase the pressure of air contained in a cylinder. The high pressure air is then made to impinge on turbine blades with a kinetic energy when passes through a nozzle. This develops mechanical rotational energy which in turn can be converted in to electrical energy.

The performance tests conducted after the installation has shown that power developed and thereby stored in battery is sufficient to run electrical appliances used for domestic purposes. The developed system is one of the innovative method of power generation by producing high pressure air, needs no fuel and power generation is possible out of energy which otherwise would go as waste.

***Key Words*: Power generation, Speed bumper, Pneumatics, Kinetic energy, High pressure**

1. INTRODUCTION

The demand for energy is skyrocketing day-by-day leading to energy crisis. This energy crisis has led to development of alternative solutions to generate power from the energy which is wasted. The existing [1] sources of energy are not adequate to meet the ever increasing energy demands and some innovative techniques of exploring non-conventional energy should be thought of. Now a days over-speeding has been found as the major cause of many fatal accidents because of which speed bumpers have become very crucial. A speed bumper is used to control the speed of the traffic and hence a number of speed bumpers are incorporated on roads. While considering a toll plaza, [2] nearly 15 vehicles passing per minute; the average kinetic force obtained from the vehicles is around 1000 N at speed bumper. Hence, the power produced from this mechanism is estimated around 500 Watts. There is wastage of good amount of energy on speed bumpers by the vehicles, which can be utilized in an effective manner to generate power. It is a small level power generation but if it is used in [3] proper way then we can generate larger amount of power. All vehicles [4] in motion can benefit from these systems by recapturing energy that would have been lost during compression and expansion of suspension. There is an enormous growth in number of vehicles during the past. There is a rise in the number of speed bumpers to slow down the traffic on roads which spark the implementation of some innovative ways which can tap the energy of vehicles wasted on speed bumpers to generate some amount of power. This generated power can be used to power street lights, public booths, a back-up power source, etc.

This electrical power can [5] be stored in battery in the day time and we can use it in the night time for highway illumination, signal system on the road, tollbooth or any other useful work. And compressed air can be used for cleaning purpose in tollbooth and refilling of air in tires. This paper helps for the conservation of natural resources.

2. EXPERIMENTAL PROCEDURE

The main aim behind the development of this project was to utilize wasted energy and to design a mechanism which can run without the use of fuel making it cost effective and a low maintenance system.

1.1 Block Diagram

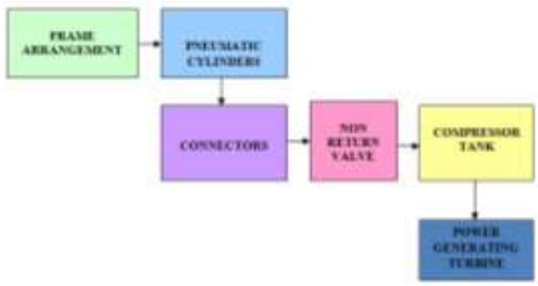

Fig -1: Block Diagram

1.2 Working Principle

The main components in this device are Pneumatic cylinder, spring, Air Tank, Speed bumper, Safety valve, Gate valve and Non-return valve. The Pneumatic cylinders are fixed at the bottom of the speed bumper with two springs. The speed bumper setup is mounted on the frame. When a vehicle crosses over the setup then the pneumatic cylinders start to pump the air because of its upward and downward movement. Due to this motion, compressed air is produced and stored in the tank. Non-return valves are used to control the direction of flow of the air to the tank and not allowing it to return back to the pneumatic cylinders. It runs on the principle of the reciprocating air compressor in which compressor compresses the air by decreasing the volume of air that has been isolated. This setup will be kept underground of road exactly below the speed bumper and the head of piston rod is brought up to the level of the road surface. The compressed air coming out of the pneumatic cylinders gets stored in the air tank and a non-return valve prevents the flow of the air back to the pneumatic cylinders. The nozzle, used at the outlet of the air tank, generates a high velocity flow of air which impinges on the turbine blades making it to run. The stepper motor, coupled with the turbine, transforms mechanical energy into electrical energy.

2. Materials and Methods

The design of speed breaker system includes primary components such as: Speed Breaker upon which the load is applied, two springs to bring back the speed breaker to its initial position when the load is removed, a modified single acting cylinder, an air tank, a mini turbine, a nozzle, a supporting frame to hold the entire assembly of speed breaker system.

2.1 Supporting Frame:

Supporting frame is used to support the entire assembly so the frame should possess adequate mechanical strength. Therefore mild steel was the material selected because of its great durability, good tensile & yield strength & resistance to corrosion.

2.2. Speed Breaker:

The speed breaker (Figure.2) should have good mechanical strength so that it can withstand continuous loading and unloading. Hence Cast Iron was used because of its low cost and shock absorbing property. The speed breaker was cut, machined and welded to the frame.

Figure 2: Speed Breaker.

2.3. Single Acting Pneumatic Cylinder

The single acting pneumatic cylinder (Figure.3) is used here to get the compressed air and to supple the air to the air tank. The air is getting suppressed when the vehicle passes over the hump and to get back in the original position, cylinder uses its spring. Some modification has been done as per our requirements to make it work in setup. The piston of the cylinder is welded with the speed beaker base and spring is also attached here.

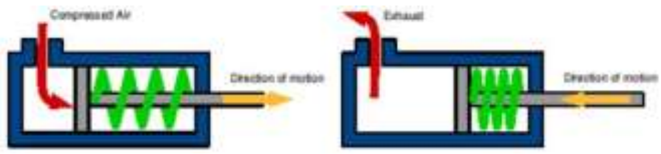

Figure 3: Single Acting Pneumatic Cylinder

2.4. Spring

The primary function of the spring (Figure.4) is to bring back the speed breaker to its initial position after the load has been removed. Stainless steel was selected as material for the spring because of its high tensile strength coupled with good corrosion resistance. The spring was welded to the dome shaped hump and also to the cylinder using electric arc welding method.

Figure 4: Spring

2.5. Air Tank

The air tank (Figure.5) is used to store compressed air coming out of cylinder. The material used for air tank is Mild Steel because of its high strength, low weight, durability, ductility and corrosive resistance. The air tank was welded to the frame at its base and was connected to the cylinders using a 3-way collar, valves and hose pipes.

Figure 5: Air Tank

2.6. Nozzle

Nozzle (Figure.6) is connected to the outlet of the air tank through a hose pipe & is fitted at an angle to the mini turbine blades so that it impinges compressed air directly onto the blades making it to rotate at high speed. The nozzle converts the low velocity compressed air into high velocity compressed air. The nozzle material selected is Brass and is welded to the frame using electric arc welding.

Figure 6: Nozzle

2.7. Mini Turbine

A mini turbine (Figure.7) connected with the stepper motor is used to tap the mechanical energy into electrical energy. The material used is Aluminium because of its low weight to power ratio, high strength to weight ratio & low corrosion rates. It was assembled with the frame by drilling and fastening of the screws and nuts using drilling machine, spanner and screw driver respectively.

Figure 7: Mini Turbine

2.8. Valves

Three types of valves are used namely Non return valve, Gate valve and Safety valve.

Non return valve - The function of non-return valve (Figure.8) is to allow the flow of fluid uni-directionally.

Figure 8: Non- Return Valve

Gate valve–Gate valves (Figure.9) allow or restrict the flow of fluids depending upon the requirement. Gate valves are primarily linear motion valves in which a closing element seizes the path of fluid causing a restriction to the flow stream to provide a block out.

Figure 9: Gate valve

Safety valves - Safety valves (Figure.10) open when the inner pressure rises to a pre-set pressure by lifting the disc, and closes when the pressure of the system drops to a safe value. Safety valves protect the equipment from the damage because of high pressure.

Figure 10: Safety valve

3. Figures and Tables

Figure 11: Working Model

Nozzle opening	Pressure in the air tank(Bar)	Time taken to empty the air tank (Secs)	Max. speed of turbine achieved (RPM)	Max. Voltage generated (Volts)
Half	2	28	521	7
Three fourth	2	24	545	11
Full	2	19	582	15

Table1: Experimental Reading

4. Equations:

DESIGN CALCULATION

1. PNEUMATIC CYLINDER
Design of Piston rod:
Load due to air Pressure
Diameter of the Piston (d) = 40 mm
Pressure acting (p) = 6Kgf/cm^2
Material used for rod = C 45
Yield stress (σ_y) = 36 Kgf/mm^2
Assuming factor of safety= 2

Force acting on the rod (P) = Pressure x Area
= p x (Πd^2 / 4) (1)
= 6 x {(Π x 4^2) / 4 }
= 73.36 Kgf

Design Stress(σ_y) = σ_y / F0S (2)
= 36 / 2
= 18 Kgf/mm^2

∴ d = √ 4 p / Π [σ_y]
= √ 4 x 73.36 / {Π x 18}
= √ 5.33
= 2.3 mm

∴ Minimum diameter of rod required for the load=2.3 mm
We assume diameter of the rod =15 mm

Length of piston rod:

Approach stroke = 160mm
Length of threads = 2 x 20
= 40mm

Extra length due to front cover = 12 mm
Extra length of accommodate head = 20 mm
Total length of the piston rod = 232 mm
By standardizing, length of the piston rod = 230 mm

Design of cylinder thickness:
Material used = Castiron
Assuming internal diameter of the cylinder= 40 mm
Ultimate tensile stress = 250 N/mm^2

= 2500 Kgf / mm^2
Working Stress = Ultimate tensile stress / factor of safety
Assuming factor of safety = 4
Working stress (ft) = 2500 / 4
= 625 Kgf /cm^2

According to 'LAMES EQUATION'

Minimum thickness of cylinder (t) =
ri {√ (ft + p) / (ft – p) -1} (3)
where,
ri = Inner radius of cylinder in cm.
ft = Working stress (Kgf / cm^2)
p = Working pressure in Kgf / cm^2

∴Substituting values we get,
t = 2.0 {√ (625 + 6) / (625 – 6) -1}
= 0.019 cm
= 0.19 mm

We assume thickness of cylinder = 2.5 mm
Inner diameter of barrel = 40 mm
Outer diameter of barrel = 40 + 2t
= 40 + (2 x 2.5)

= 45 mm

Compressed Air Production:-
Diameter of the cylinder = 40mm
= 4 cm
Stroke length = 170 mm
Pressure = Force/Area (4)
=100/(3.14 x4*4/4)
=100/12.56
=7.96 kg/cm2

5. Results and discussion

After conducting few trials, we get affirmative results. If the nozzle is fully opened then an average of 15 volt is being generated. The pressure in the air tank was set to 2 bar for the whole experiment. The advantage of the whole setup is that there is no fuel used and hence it is ecofriendly. It is the most reliable source of power generation compared to any other way of power generation from speed bumper. One of the dis-advantages of this setup is that continuous generation of power is not possible and the spring used here may lose its elastic property shortly due to continuous loading and unloading resulting in shorter life span of the spring.

6. Conclusions

1. The device designed and fabricated is environmental friendly and helps in generating power.

2. This setup can not only be used in speed bumper but also in school, colleges and parks to generate power.

3. The application can be extended to setup in parks, schools with few minor modifications.

4. The device utilizing pneumatic energy is feasible and can develop power sufficient to run household electrical appliances.

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