

PNEUMATIC AND ELECTRIC ENERGY GENERATION USING SPRING BACK MECHANISM

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Abstract - The said research consist of generation of pneumatic energy from the speed breaker using spring back mechanism. The speed breaker is connected with the pneumatic cylinder which acts as pump to generate air pressure. By using the principals of hydraulics and pneumatics a model is developed to store the energy generated by pump. Later this generated energy is partially converted into electrical energy for various electrical applications, while rest is used for free air filling point for tyres.

Key Words: Spring, Pneumatic energy, air storage, speed breaker, pump, electric energy

1. INTRODUCTION

Energy sources may broadly be classified into two major categories that are: conventional energy sources and renewable energy sources. Conventional energy sources have been utilized for power generation and industrialization for centuries. These energy sources are mainly dependent on fossil fuels namely: coal, oil and natural gas. Renewable energy sources are the ones that are inexhaustible, clean, pollution free, and environmental friendly. These energy sources include: hydro power (water energy), wind energy, geothermal energy, solar power and tidal energy. Energy exists in various forms, example mechanical, thermal, electrical etc., but has one thing in common [1]. On road vehicles waste a tremendous amount of energy on speed breakers, where there is a necessity to provided speed breaker to control the speed of the vehicles. There is tremendous vehicular growth in year by year. The increasing traffic and number speed breakers on roads motivate to manufacture an innovative device which can channelize the energy of vehicles that is wasted on speed breakers to some useful work. In this practical manufacturing processes and steps of speed breaker device for generation of compressed are described which can be used to generate compresses air on highways in remote areas [9].

At the present time, it appears that shortages of conventional forms of energy, particularly oil, have become critical. Much effort has been devoted to finding alternate sources of energy. Most energy sources suffer from drawbacks. Some are limited as to the amounts available, and when a particular material has been used it is gone forever. They are not available to all nations. Some have created ecological problems [6]. There exist numerous prior devices which have attempted to harness the potential energy contained in moving vehicles. Typically, these devices convert the potential energy into kinetic energy for providing useful work by means of pneumatic and/or mechanical means which can be used to run a generator [4].

2. FLOWCHART:

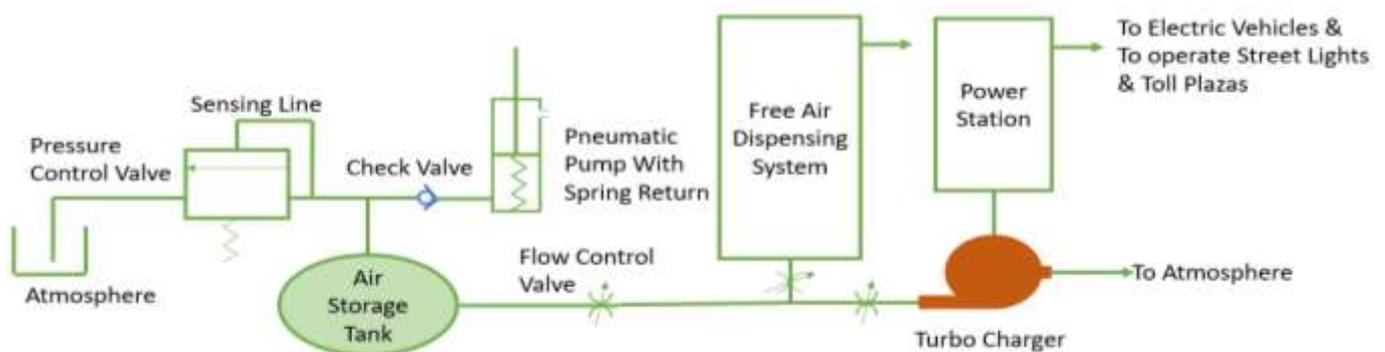


Figure 1: Electronics Flowchart Robot Side

The system is comprises of pneumatic cylinder to generate the air pressure. This cylinder is connected to check valve which is also called as unidirectional valve used in order to avoid the reverse flow of air from tank to pneumatic cylinder. This check valve is coupled to air storage tank which stores the air volume and distributed whenever needed. This tank consist of flow

control valve, with which we could control the amount of flow or velocity and pressure from tank to rest of the system. This line then connects the individual flow control valve of the turbo charger or generator and the free air dispensing unit. This systems allows to operate the system individually or a combine operation can be performed. After flow control valve this line is connected to turbo charger and another line is connected to free air dispensing unit. The free air dispensing unit is used to inflate the flat tyre and the turbo charger generates the electrical energy used for charging units for electric cars and street light.

3. MODEL:

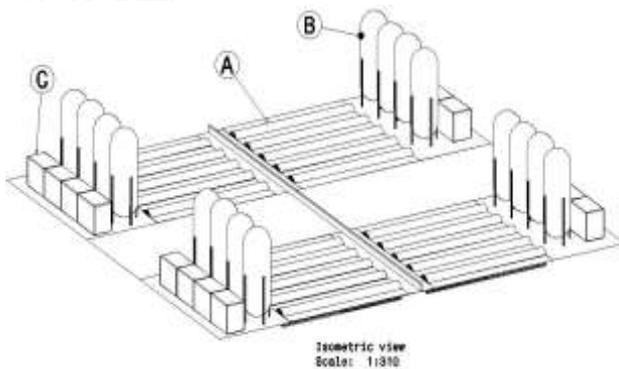


Figure 2: Isometric View

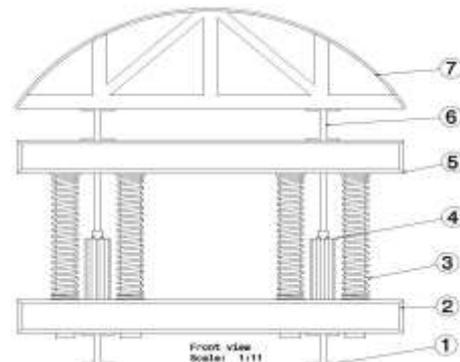


Figure 3: Top & Bottom View

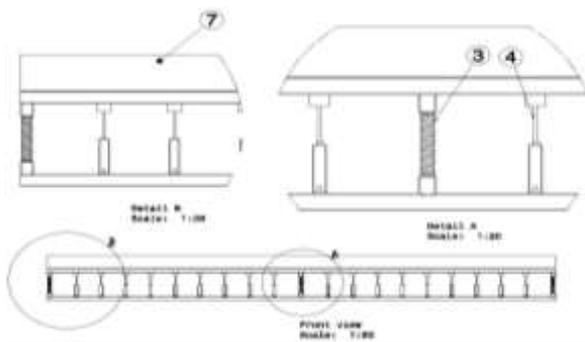


Figure 4: Sectional View

4. PARTS DESCRIPTION:

Part A ‘Speed Breaker System’ system is used to form mechanism which helps in generating the energy.

Part B ‘Pneumatic Reservoir’: system is used to generate the air pressure.

Part C ‘Power Generator’: system is used to generate the power

Part 1: Lower Base Support I Shaped Beam: I shaped horizontal beam is used as a supporting element to hold the whole speed breaker structure. The beam are two in number run’s perpendicular to road. Each beam is a complete uniform structure without any joints. This element is coupled between the part 2 and ground.

Part 2: Lower Perpendicular Secondary Support Structure: This structure is used to hold the spring back mechanism part 3. This structure allows the part 3 solid shaft to pass through it without allowing the spring to pass through it. This structure is a solid rectangular beam runs parallel to road and perpendicular to part 1. They are 3 in numbers. This element is coupled between the part 1, part 3 and part 4 using bolting joints.

Part 3: Spring Support Mechanism: this mechanism is also called as spring back mechanism designed to reduce the force from the piston shaft. They are six in numbers, coupled in a pair at the both right and left side along with one pair at the center. This structure is generally a solid shaft with the helical spring mounted across it. The limits are given to this mechanism for compression in order to avoid the damage of the piston cylinders. The spring could be compressed 98 percent of the compression stroke of the piston to avoid the damage to the piston. This element is coupled between the part 5 and part 2 using press fit along with journal bearing.

Part 4: Pneumatic Pump with Spring Return Mechanism: A single acting spring return pneumatic cylinder is used as actuator to generate the air pressure. A cushioning is provided to absorb shock for safety reasons. On one of the side of the piston, from top direction a hole is been drilled to suck the air the piston at the top position and closes during the compression stroke. There are

numerous pistons coupled at either sides of speed breaker across the part 6 to generate as much air pressure as it could be. This element is coupled between the part 6 and part 1 using bolting joints.

Part 5: Upper Perpendicular Secondary Support Structure: This structure is used to hold the 'I' shaped beam part 6. This structure reduces the load from the piston shaft and divides equally around the structure. This structure is a solid rectangular beam runs parallel to road and perpendicular to part 6. They are 3 in numbers. This element is coupled between the part 6, part 4 and part 3 using bolting joints.

Part 6: Upper Base Support I Shaped Beam: I shaped horizontal beam is used as a supporting element to hold the speed breaker structure. The beam are two in number run's perpendicular to road. Each beam is a complete uniform structure without any joints. This element is coupled between the part 7 and part 5 using bolting joints.

Part 7: Speed Breaker Structure: Speed breaker is designed using the angel structure in order to avoid the failure and this part is coupled with the part 6 using the bolting joints. Inverse U structure is made using the sheet metal and angel structure is designed using the weld joints.

5. CALCULATION:

I. Design of Helical Spring: [2]

Maximum spring force = P

deflection of spring = δ

Ultimate Tensile Strength = S_{ut}

Permissible Shear Stress = τ

Torsional Yield Stress = S_{sy}

factor of safety = f_{os}

Outside Coil Diameter = D_o

Minimum Inside Diameter = D_i

Stiffness = K

Wire Diameter = d

Mean Coil Diameter = D

Modulus of rigidity = G

Total Number of Coils = N_1

Pitch of coil = p

Load Stress Equation

$$\tau = K \left(\frac{8PD}{\pi d^3} \right) \quad (1)$$

Permissible Shear Stress Equation by factor of safety

$$\tau = \frac{S_{sy}}{f_{os}} \quad (2)$$

$$\tau = 0.3 S_{ut} \quad (3)$$

Wahl Factor

$$K = \frac{4C-1}{4C-4} + \frac{0.615}{C} \quad (4)$$

Mean Coil Diameter

$$D = Cd \quad (5)$$

Number of Active Coil

$$\delta = \frac{8PD^3 N}{G d^4} \quad (6)$$

Solid Length of Spring

$$\text{Solid Length} = N_1 d \quad (7)$$

Actual Deflection of Spring

$$\delta = \frac{8PD^3 N}{G d^4} \quad (8)$$

Total Axial Gap between coils is given by,

$$\text{Total gap} = (N_1 - 1) \times \text{gap between two adjacent coil} \quad (9)$$

Free Length

$$\text{free length} = \text{solid length} + \text{total gap} + \delta \quad (10)$$

Pitch of the coil

$$p = \frac{\text{free length}}{(N_1 - 1)} \tag{11}$$

Rate of spring

$$k = \frac{G d^4}{8 D^3 N} \tag{12}$$

Requirement of Guide

$$\frac{\text{free length}}{\text{mean coil diameter}} \leq 2.6 \dots \dots \dots \text{Guide Not necessary} \tag{13}$$

$$\frac{\text{free length}}{\text{mean coil diameter}} > 2.6 \dots \dots \dots \text{Guide required} \tag{14}$$

II. Buckling Load Calculation For Part 3 & 4 [10]

$$F = \frac{\pi^2 E I}{L^2} \tag{15}$$

$L = \frac{l}{2}$ As the both the ends are fixed

$F =$ Buckling Load

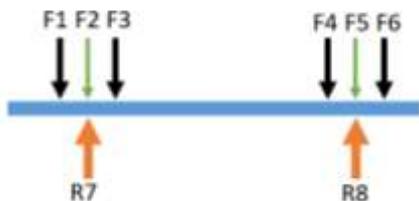
$I =$ Moment of inertia

$E =$ Youngs Modulus Or modulus of elasticity

$l =$ Length of the Coloumn

III. Free Body Diagram And Force Calculation for bending of Beam [10]

Free Body Diagram Of Part 2



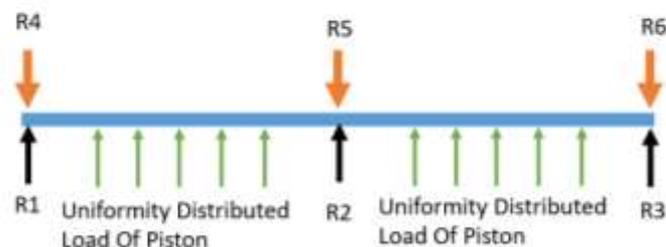
$F 1, 3, 4, 6 =$ Force Exerted by part 3
 $F 2, 5 =$ Force Exerted by part 4
 $R 7, 8 =$ Reaction Force Develop by part 1

Free Body Diagram Of Part 5



$F 1, 3, 4, 6 =$ Force Exerted by part 3
 $F 2, 5 =$ Force Exerted by part 4
 $F 7, 8 =$ Force Exerted by part 6

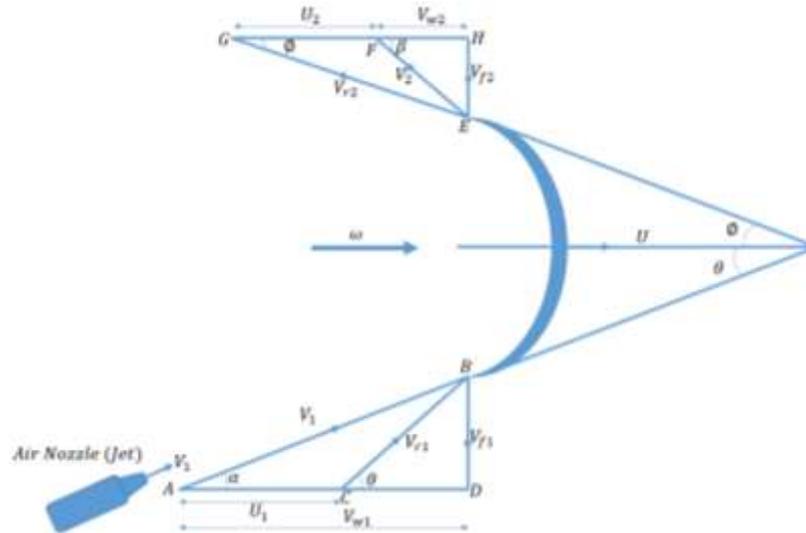
Free Body Diagram Of Part 6



$R 1, 2, 3 =$ Reaction Force Exerted by part 3
 $R 4, 5, 6 =$ Reaction Force Exerted by part 7

Uniformly distributed Load is load exerted by the part 4

IV. Jet Velocity and velocity of turbine Calculation



V_1 = absolute velocity of jet
 u = Vane velocity at inlet of vane
 α = exit angle of moving vane
 θ = inlet angle of moving vane
 ϕ = exit angle of moving vane
 β = angle at which the jet leaves the vane
 V_{r1} = relative velocity at inlet
 V_2 = absolute velocity of jet at outlet
 V_{r2} = relative velocity at outlet of vane
 V_w & V_f are the component of absolute velocity in the direction of motion of vane and normal to it respectively. V_w is called velocity of whirl or tangential velocity and V_f is called velocity of flow therefore,

V_{w1} = velocity of whirl at inlet
 V_{w2} = velocity of whirl at outlet
 V_{f1} = velocity of flow at inlet
 V_{f2} = velocity of flow at outlet

R_1 = radius of wheel at inlet
 R_2 = radius of wheel at outlet
 A = area of cross section of jet in m^2
 ρ = density of air $\frac{m}{s}$

Q = volume flow rate

\dot{m} = mass flow rate

η = efficiency of jet

W = force X distance moved by vane in direction of force per second

$$W = \dot{m} (V_{w1} + V_{w2}) \times u \quad \frac{Nm}{s} \tag{16}$$

$$W = \rho A V_{r1} (V_{w1} + V_{w2}) u \tag{17}$$

$$\eta = \frac{\text{Output}}{\text{Input}} = \frac{\rho A V_{r1} (V_{w1} + V_{w2}) U}{\left(\frac{1}{2} \rho A V_1^2\right)} \quad \text{for single vane} \tag{18}$$

$$\eta = \frac{2(V_{w1} + V_{w2})U}{V_1^2} \quad \text{for series of curved vanes} \tag{19}$$

For multiple Vanes in Series

$$\text{Angular velocity of wheel } \omega = \frac{2 \pi N}{60} \frac{\text{rad}}{\text{s}} \tag{20}$$

$$\text{Blade velocity at inlet } U_1 = \omega R_1 \tag{21}$$

$$\text{Blade velocity at outlet } U_2 = \omega R_2 \tag{22}$$

$$\text{Mass of air striking the series of vanes per second } \dot{m} = \rho A V_1 \tag{23}$$

$$\text{Rate of angular momentum of jet at inlet } = \dot{m} V_{w1} R_1 = \rho A V_1 X V_{w1} X R_1 \tag{24}$$

$$\text{Rate of angular momentum of jet at outlet } = \dot{m} V_{w2} R_2 = \rho A V_1 X V_{w2} X R_2 \tag{25}$$

$$\text{Torque on wheel } T = \text{rate of angular momentum at inlet} - \text{rate of angular momentum at outlet}$$

$$T = \rho A V_1 (V_{w1} R_1 + V_{w2} R_2) \tag{26}$$

$$\text{Workdone per second, } W = T \omega = \rho A V_1 (V_{w1} U_1 + V_{w2} U_2) \tag{27}$$

$$\text{Blade Velocity coefficient or friction factor } K = \frac{V_{r2}}{V_{r1}} \tag{28}$$

$$\text{Axial thrust on wheel } F_a = \dot{m} (V_{f1} - V_{f2})$$

$$F_a = \rho A V_1 (V_{f1} - V_{f2}) \tag{29}$$

V. Power Calculation [1]

$$\text{Work Done} = \text{Force} \times \text{Distance} \tag{30}$$

$$\text{Force} = \text{Mass} \times \text{Acceleration due to gravity} \tag{31}$$

$$\text{Power} = \frac{\text{Workdone}}{\text{Time}} \tag{32}$$

$$\text{Power} = \text{Voltage} \times \text{Current} \tag{33}$$

$$\text{Emf} = -\text{Number of Turns} \times \frac{\text{Change in Flux}}{\text{Change in Time}} = -N \frac{\Delta\phi}{\Delta t} \tag{34}$$

$$\text{Emf} = B l v \sin(\theta)$$

$$\text{Total Emf around the loop} = 2 B l v \sin(\theta)$$

$$\theta = \omega t$$

$$\text{Emf} = 2 B l v \sin(\omega t)$$

$$v = r \omega \quad \& \quad r = \frac{\omega}{2} \quad \& \quad v = \left(\frac{\omega}{2}\right) \omega \quad \& \quad A = l \omega \dots \dots \dots \text{Allowing for } N \text{ number of loops}$$

$$\text{Emf} = 2 B l \left(\frac{\omega}{2}\right) \omega \sin(\omega t) = N A B \omega \sin(\omega t)$$

$$\text{Emf generated as function of time} = N A B \omega \sin(\omega t) \tag{35}$$

A = area of loop

B = Strength of electromagnetic field

ω = Angular Velocity of Turbine

t = time for which coil is rotated

6. SELECTION OF MATERIAL:

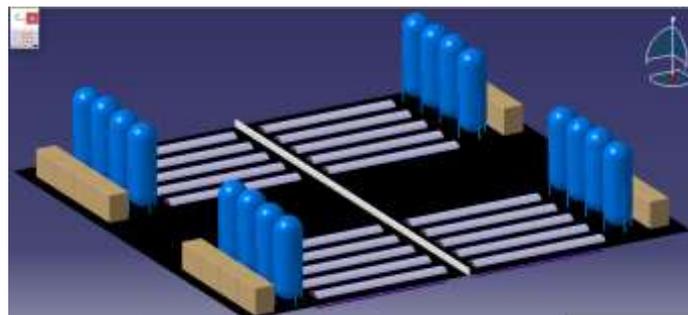


Figure 5: Catia Model

SR. NO	COMPONENT	MATERIAL
1	Lower Base Support I Shaped Beam Part 1	A709M Grade 345 W Structure steel
2	Lower Perpendicular Secondary Support Structure Part 2	AISI 4130 alloy
3	Piston part 4	C-40 EN34 with coating hard
4	Cylinder part 4	C-40 Cast iron
5	Piston rod part 4	C-40 Plain carbon steel
6	Upper Perpendicular Secondary Support Structure Part 5	AISI 4130 alloy
7	Upper Base Support I Shaped Beam Part 6	AISI 4130 alloy
8	Angles for part 7	C-25 Plain carbon steel
9	Rack part 3	C-30 Plain carbon steel
10	Reservoir tank	C-40 EN8
11	Spring part 3	C-40 Spring Steel
12	Nut bolts	C-25 Plain carbon steel
13	Washer	C-25 Plain carbon steel

Table 1: Material for Each Component [9]-[11]

7. DISSCUSIONS

- With the help of spring back mechanism it becomes easier to extend and retract the piston cylinder without having much load on piston shaft.
- Unidirectional valve is used to obstruct the flow in reverse direction from reservoir to piston cylinder.
- The free air dispensing system is been installed to inflate the flat tyre during emergency situation.
- The pneumatic energy is converted into electrical energy with the help of turbo charger.
- The generated energy can be used for charging points for the electrical cars and during night times for street lights, etc.

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