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Design and Development of Regenerative Braking System

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Abstract- The brakes are commonly use friction between two surfaces pressed together to convert the kinetic energy of the moving object into heat, though other methods of energy conversion may be employed as all the energy here is being distributed in the form of heat. Regenerative braking converts much of the energy to electrical energy, which may be stored for later use. We are also going to make a working model of regenerative braking to illustrate the process of conversion of energy from one form to another. Regenerative braking converts a fraction amount of total kinetic energy into mechanical or electrical energy but with further study and research in near future it can play a vital role in saving the non-renewable sources of energy.

Keywords- Regenerative Braking, Electric Vehicle, Motor, Generator, Friction.

I. INTRODUCTION

In braking systems on conventional vehicles, friction is used to counteract the forward momentum of a moving vehicle. As the brake pads rub against the wheels or a disc that is connected to the axles, excessive heat energy is created. This heat energy dissipates into the air wasting as much as 30 percent of the vehicle's generated power.

Over time, this cycle of friction and wasted heat energy reduces the vehicle's fuel efficiency. More energy from the engine is required to replace the energy that was lost by braking.

Most of it simply gets released in the form of heat and becomes useless. That energy, which could have been used to do work, is essentially wasted. The solution for this kind of this problem is Regenerative Braking System.

This is a new type of braking system that can recollect much of the car & kinetic energy and convert it into electrical energy or mechanical energy. The effect of regenerative brakes is less at lower speeds as compared to that at higher speeds of vehicle. So the friction brakes are needed in a situation of regenerative brake failure, to stop the vehicle completely.

II. REVIEW OF LITERATURE

1. Pratik Bhandari, Shubham Dubey:
Author has explained, Regenerative braking converts much of the energy to electrical energy, which may be stored for later use. Driving an automobile involves many braking events, due to which higher energy losses takes place, with greater potential savings. Regenerative braking converts a fraction amount of total kinetic energy into mechanical or electrical energy but with further study and research in near future it can play a vital role in saving the non-renewable sources of energy.

2. NPTEL – Electrical Engineering – Introduction to Hybrid and Electric Vehicles:
In this note the information given about, the electric motors in EVs and HEVs can be controlled to operate as generators to convert the kinetic or potential energy of the vehicle mass into electric energy that can be stored in the energy storage and reused.

A successfully designed braking system for a vehicle must always meet two distinct demands:

- In emergency braking, the braking system must bring the vehicle to rest in the shortest possible distance.
- The braking system must maintain control over the vehicle's direction, which requires braking force to be distributed equally on all the wheels.

3. Mr. S. N. Sidek and Mr. J. E. Salami:
Have published paper "Hardware implementation of intelligent braking system". In this paper it is concluded that, TMS320LF2407 is an efficient processor to handle the task to control the intelligent braking system. The on board peripherals reduce the cost of additional component and the architecture allows real time control. The performance of the processor can be enhanced if there is special fuzzy logic instruction set available in the software kernel of the processor.

4. Milind S.Deotale, Hrishikesh Shivankar:
Have published paper "Review on Intelligent Braking System". The have reviewed, Road accidents are a commonplace in today's scenario. Accident prevention has been one of the leading areas of research. In Indian scenario normally vehicles are equipped with ABS (Anti-Lock Braking System), traction control, brake assist etc. for driver's safety. This paper focuses on a system known as 'Intelligent braking system' (IBS) which employ several sensor to respond when emergency conditions occur.

The system includes an infrared wave emitter provided on the front portion of the car. An infrared receiver is also fitted to receive the signal. The reflected wave gives the distance between the obstacle and the vehicle. Then a microcontroller is used to detect the pulses and apply brakes to the vehicle.

5. G.V. Sairam, B. Suresh:
Have published paper "Intelligent Mechatronic Braking System" In this paper author has given, currently vehicles are often equipped with active safety systems to reduce the risk of accidents, many of which occur in the urban environments. The most popular include Antilock Braking Systems (ABS), Traction Control and Stability Control. All these systems employ different types of sensors to constantly monitor the conditions of the vehicle, and respond in an emergency situation.

In this paper the use of ultrasonic sensors in safety systems for controlling the speed of a vehicle is proposed. An ultrasonic receiver is also placed on the front portion of the car operatively receiving a reflective ultrasonic wave signal. The reflected wave (detected pulse) gives the distance between the obstacle and the vehicle. Then a microcontroller is used to control the speed of the vehicle based on the detection pulse information to push the brake pedal and apply brake to the car stupendously for safety purpose.

6. Soniya. K. Melodee, R H. Adware et al:
Published paper ''Investigation regenerative braking in EV'' Regenerative braking is a most excellent way for electric vehicle to expand their driving capabilities. The regenerative braking plays a vital part to maintain the vehicle's strength and getting better energy. Electric vehicle's use Regenerative Braking System to boost the roughness of wheel for the deceleration purpose. However from the point of view of saving energy, mechanical brake increase out much energy while the EV's kinetic energy is renewed into the thermal one. The braking system for a vehicle is based on hydraulic braking technology.

Thus, this traditional braking methodology causes a lot of wastage of energy since it produces unwanted heat during braking. Thus, the creation of regenerative braking has risen above these disadvantages in addition it helps in save energy and provide higher efficiency for a car. The main aim that has been focus on having influence on brake energy regeneration that is usable is discussed World today is heading towards the brink of energy crisis.

III. OBJECTIVE

While working towards this aim, it was necessary that certain objective need to be defined so that the reachability of the aim becomes easier & straight forward.

The objectives that we had defined are as follows:

- To design simple braking system.
- To save energy so that efficiency will get increase.
- To develop modifies system with low cost.

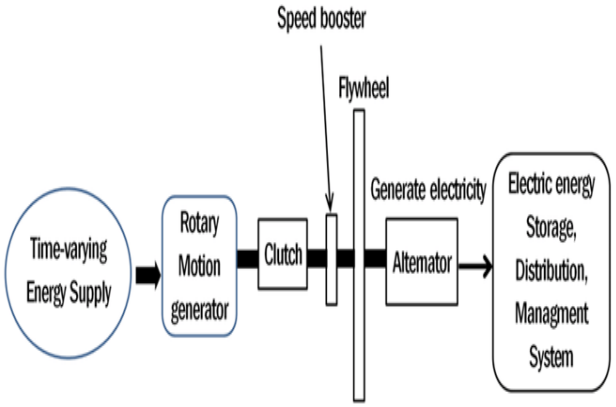


Fig 1. Proposed set up for regenerative braking system.

When driving motor will get start, wheel starts rotating in clockwise direction. This clockwise motion is also transferred to the second shaft through the timing pulley. We are using Timing pulley, the friction losses are neglected. Motion which is transmitted to the sprocket shaft is carried to flywheel is connected on shaft. Motion of the shaft is transmitted to the flywheel and it is connected with the dynamo.

The dynamo is used to convert the rotational energy to the mechanical energy. Basically its work is to store the energy. When we apply the brake the motor continues to work but the wheel gets stopped and thus the sprocket shaft also gets stopped but the flywheel keeps on rotating which stores the waste energy of the wheel lost due to friction or heat to the atmosphere.

Now this rotating mechanical energy is transferred to the dynamo from where battery or any equipment is connected which can work by taking this energy. Dynamo connected to the flywheel means of gear pair converts rotational mechanical energy to electrical energy. Potentiometer which regulates the voltage is used for varying the speed. By regulating the voltage, we can vary the input speed from which different readings are taken by connecting different load. Regenerative braking systems recapture some of the vehicle's kinetic energy when the brakes are

applied and store this energy so that it can be used to reduce the engine load when the vehicle accelerates. It is widely used in electric and hybrid electric vehicles that already have batteries to store the recaptured energy.

Regenerative braking has minimal impact on fuel economy during highway driving, but it can significantly improve the fuel economy of vehicles that are driven primarily in city traffic. In the event that the motor-generator cannot slow the vehicle fast enough, a torque coordinator module will apply traditional friction brakes to the extent necessary.

IV. DESIGN CONSIDERATIONS

- When designing our attachment, the following considerations were taken into account.
- The device should be suitable for local manufacturing capabilities.
- The attachment should employ low-cost materials and manufacturing methods.
- It should be accessible and affordable by low-income groups, and should fulfill their basic need for mechanical power
- It should be simple to manufacture, operate, maintain and repair.
- It should employ locally available materials and skills. Standard steel pieces such as steel plates, iron rods, angle iron, and flat stock that are locally available should be used. Standard tools used in machine shop such as hack saw, files, punches, taps & dies; medium duty welder; drill press; small lathe and milling machine should be adequate to fabricate the parts needed for the machine.
- Excessive weight should be avoided, as durability is a prime consideration

1. Design of hinge shaft for pedal:

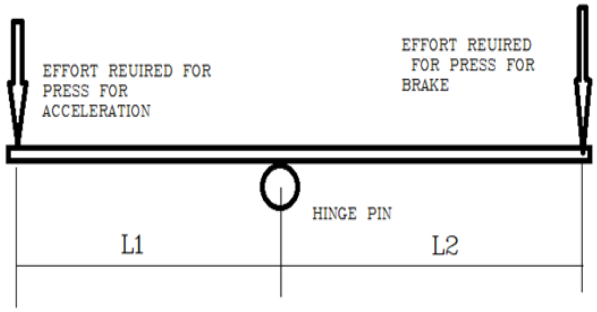


Fig 2.Arrangement of Hings shaft for Pedals.

In the proposed mechanism we have used arrangement as shown in fig,

Load on shaft considered= 10 kg = 100N
Considered speed of machine N =30 rpm
Maximum lever L 1 = L2 = 100mm

For design load considered = 25 kg = 250N
So Maximum Torque T = Effort x Lever arm
Total torque on sprocket shaft = 250x100 = 25000 N-m

To design of shaft we have considered three loading conditions:-

- Against tortional moment
- Against bending moment
- Against both combining tortional and bending moment.

Material selection is a step in the process of designing any physical object. In the context of product design the main goal of material selection is to minimize cost while meeting product performance goals. Systematic selection of the best material for a given application begins with properties and costs of candidate materials. Most of the times; failure arises due to improper selection of materials.

In design the material used for shaft we have to consider C40. The material selected for shaft is C40, as it is a popular grade.

Table 1. Chemical composition % of steel C40 (1.0511): EN 10277-2-2008.

Grade	Min	Max
Carbon (C)	0.37	0.44%
Manganese (Mn)	0.5	0.80%
Silicon (Si)	0.38	0.4%
Nickel (Ni)	0.38	0.4%
Molybdenum (Mo)	0.9	0.1
Chromium (Cr)	0.38	0.4%
Phosphorous(P)	0.42	0.45%

Ordinary transmission shafts are made of medium with carbon content ranging from 0.15 to 0.40% such as 30C8 or 40C8. These steels are commonly called as machinery steels. For shaft design, 40C8 is used [Machine design Data Book by V. B. Bhandari, McGraw Hill Education (India) Private Limited, pp. 2.13].

Sut = 630N/mm2,
Syt = 350N/mm2,
σ = 145 N/mm2

As per ASME code,
0.3 X Yield strength N/mm2
0.18 X ultimate strength N/mm2} which ever is smaller

0.3 x 330 = 99 N/mm2
…….(a)

0.18 x 580 = 104 N/mm2
……..(b)

From equation (a) & (b)
Allowable stress value will be 99 N/mm2

If key ways will provide to shaft then
τ = 99 x 0.75 = 74.25 N/mm2

Max torsional moment equation is given by

we know,

$$T_e = \frac{\pi}{16} d^3 \tau$$

Where T = 2500 N-mm

By using above equation drive shaft dia d = 8.02 mm ……A

We know that,
Max bending moment equation is given by

we know,

$$M = \frac{\pi}{32} d^3 \sigma$$

The Radial load at end point is considered maximum considered = 150 N

As per ergonomically consideration the one person can apply the radial load = p = 150N

P = 150 N

$$\sum F_Y = 0$$

As per consideration total load on wheel will be = 150N
RA =150 ……I

The length of stub shaft = L = 100 mm
Calculation of bending moment at loading point P,
BM at M = 150 x 100 = 15000 N-mm

we know,

$$M = \frac{\pi}{32} d^3 \sigma$$

σ = 145 N/ mm2 considering factor of safety = 4
By using above equation drive shaft dia d = 12.85mm ……..B

From equation A and B we have selected the diameter of shaft = 20mm considering extra jerk and for safe design.

According to maximum shear stress theory

Te = 16770 N-mm
Me = 23385N-mm

we know,

$$T_e = \frac{\pi}{16} d^3 \tau$$

> 10.67 = ζ

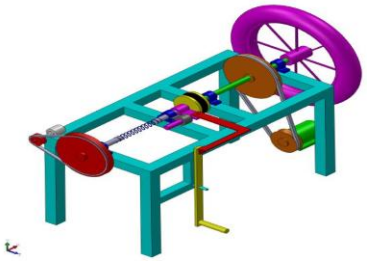
we know,

$$M = \frac{\pi}{32} d^3 \sigma$$

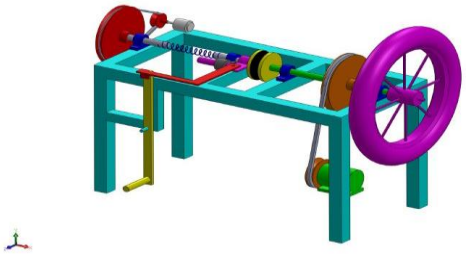
74 N/mm2 and
σ = 93.25< 145 N/mm2

We have selected the diameter of shaft = 20mm considering extra jerk and for safe design.

2. 3d Design:



(a)



(b)
Fig 3.3d Design.

V. CONCLUSION

The regenerative braking is on of the important system in electric vehicle generation. The research says that regenerative braking is already in used in many Electric Vehicles. The result says that torque driven by the vehicle is measured. Electric power generated by motor, generator and battery is very useful and hence it should be used in electric vehicle.

VI. FUTURE SCOPE

Regenerative braking systems require further research to develop a better system that captures more energy and stops faster. As the time passes, designers and engineers will perfect regenerative braking systems, so these systems will become more and more common. All vehicles in motion can benefit from these systems by recapturing energy that would have been lost during braking process

and thereby reducing fuel consumption and increased efficiency. Future technologies in regenerative brakes will include new types of motors which will be more efficient as generators, more powerful battery which can bear more frequent charging and discharging, new drive train designs which will be built with regenerative braking in mind, and electric systems which will be less prone to energy losses. Of course, problems are expected as any new technology is perfected, but few future technologies have more potential for improving vehicle efficiency than does regenerative braking

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REFERENCES

[1] Erik Coelinghetal, "Collision Warning with Autobrake", Sweden, ppn: 07-0450.
[2] Dr. Kripal Singh, "Automobile Engineering – Vol. 1", Standard Publishers Distributors New Delhi- 110 006
[3] S. P. Patil, "Mechanical System Design", Second Edition, JAICO Publishing House, Mumbai 400 001.
[4] Dr. Sanjiy. K.Bhatia, Dr. George.M.Lacy, "Infra- Red Sensor Simulation", Missouri, (2009)
[5] Dr. Eung Soo Kim,"Fabrication of Auto Braking System Using Sensor", International Journal Of control And Automation, Vol-2, and no1.
[6] Prof. Mujumdar: "Pneumatics – Study Material".
[7] Wang, J. T., H. S., "Actuator Mounting and Method for Motor Vehicle Bumper," U.S. Patent No. 6,834,898.
[8] International Research Journal of Engineering and Technology (IRJET) [1998].