Regenerative braking power system

V. Sivamaran, A. Guru Pradeep, A. Manojkumar, A. Sujan, N. Balavenkatesh, N. Vamsi

Audisankara College of Engineering & Technology, Gudur, Andhra Pradesh, India

ABSTRACT

KEYWORDS

Regenerative Braking,
Kinetic Energy,
Braking System.

As the basic law of Physics says, "energy can neither be created nor be destroyed it can only be converted from one form to another". During huge amount of energy is lost to atmosphere as heat. It will be good if we could store this energy somehow which is otherwise getting wasted out and reuse it next time we started to accelerate. Regenerative braking refers to a system in which the kinetic energy of the vehicle is stored temporarily, as an accumulative energy, during deceleration, and is reused as kinetic energy during acceleration or running. Regenerative braking is a small, yet very important, step toward our eventual independence from fossil fuels. These kinds of brakes allow batteries to be used for longer periods of time without the need to be plugged into an external charger. These types of brakes also extend the driving range of fully electric vehicles. Regenerative braking is a way to extend range of the electric vehicles. In many hybrid vehicles cases, this system is also applied hybrid vehicles to improve fuel economy.

1. Introduction

A brake is a mechanical device that inhibits motion by absorbing energy from a moving system. It is used for slowing or stopping a moving vehicle, wheel, axle, or to prevent its motion, most often accomplished by means of friction. The term 'Braking' in a moving vehicle means the application of the brakes to reduce its speed or stop its movement, usually by depressing a pedal. The braking distance is the distance between the time the brakes are applied and the time the vehicle comes to a complete stop. 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.

Braking method in which the mechanical energy forms the load is converted into electric energy and Regenerated back into the line is shown as Regenerative Braking, the motor operates as generator over a car that only has friction brakes. In low-speed, stop- and-go traffic where little deceleration is required; the regenerative braking system can provide most of the total braking force. This vastly improves fuel economy with a vehicle, and further enhances the attractiveness of vehicles using regenerative braking for city driving.

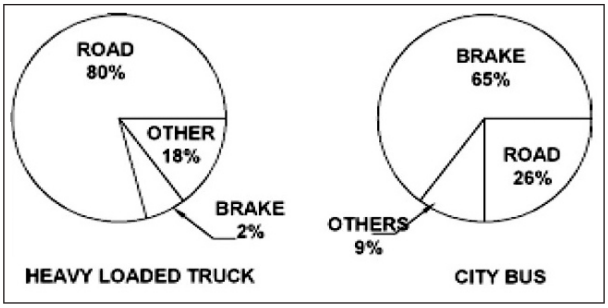

Fig. 1. Graphical representation of energy usage of vehicle.

Fig.1 shows the schematic representation of energy usage in vehicles. The regenerative braking system delivers a number of significant advantages over a car that only has friction brakes. In low-speed, stop-and-go traffic where little deceleration is required; the regenerative braking system can provide the majority of the total braking force. This vastly improves fuel economy with a vehicle, and further enhances the attractiveness of vehicles using regenerative braking for city driving. At higher speeds,

*Corresponding author,
E-mail: sivamaranv@gmail.com

too, regenerative braking has been shown to contribute to improved fuel economy – by as much as 20%.

Guney and Kilic (2016) revealed that the Regenerative Braking Systems (RBS) are an effective method of recovering the energy released and at the same time reducing the exhaust and brake emissions of vehicles. This method is based on the principle of converting the kinetic energy created by the mechanical energy of the motor into electrical energy. The converted electrical energy is stored in the battery for later use. This braking system must meet maximum energy recovery criteria by performing its function safely within the shortest braking distance. This study was conducted to provide comprehensive information about regenerative energy systems. These systems provide economic benefits via fuel savings and prevention of material loss. Their use also contributes to a clean environment and renewable energy sources, which are among the most important issues on the global agenda. It is clear that more comprehensive studies should be carried out in this area.

Vignesh and Benin (2020) proposed that, it is one of the best methods of braking system in electric vehicle which is proposed. The regenerative braking is used to drive the vehicle with more efficient and in effective way. The regenerative braking plays a vital part to maintain the vehicle's strength and getting better energy. Electric ATV vehicles use mechanical brake to increase the roughness of wheel for the deceleration purpose. From the point of view of saving energy, mechanical brake increases 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. The process of Regenerative braking system is the useful method and rise above the disadvantages. The main purpose is that has been concentrate on the released heat energy from brakes which is regenerated into energy is usable are discussed.

Yanan (2016) attempted to improve driving ability of electric vehicle, a braking regenerative energy recovery of electric vehicle was designed and the structure of it was introduced, the energy recovery efficiency of whole system was defined and a highly efficient control strategy was put forward, then it was embedded into the simulation of ADVISOR2002. The recovery efficiency of the system was up to 60%, the electric vehicle energy recovery efficiency was effectively improved.

Hence from the extensive literature review it was concluded that the 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.

The main aim of this investigation is to change in the magnetic field of a coil of wire will cause an emf to be induced in the coil. This emf induced is called induced emf and if the conductor circuit is closed, the current will also circulate through the circuit and this current is called induced current.

2. Materials and Methods

2.1 Construction and working

Fig. 2 shows the model of regenerative braking system and its components. When the wheel is in running condition, some gap between motors & wheel. These two motors are placed on break shaft. So, this motors work as a break. Now wheel is in running condition, but when break is applied, then motors work as break. Due to these motors start rotating. So, the power is produced in it. Multi meter relates to the motors. So, the reading is display in multi meter. About 15 voltage is generated in this system. Motor runs at 500 rpm. We also can store this power in a battery. We can also use this power in our required application. For Example, we can use this power in headlight of vehicle.

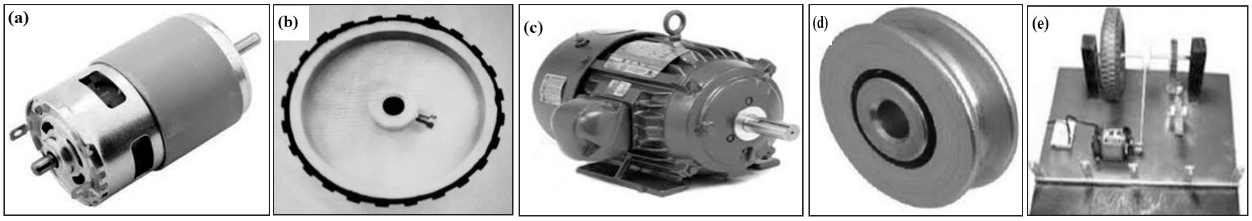

Fig. 2. Model of regenerative braking
(a) 3.1DC Gearing motors - (Nos-2) (b) Driving wheels - (Nos-2) (c) Motor (d) Pulley (e) Final model.

Table 1
Process variables of components.

Voltage Rating	15VOLT
Speed	500RPM

3. Design Calculations

3.1 Design of shaft

Shaft is designed based on consideration that shaft is subjected to combined twisting moment and bending moment.

Let τ = Shear stress
T = twisting moment
M = bending moment
Te = equivalent twisting moment

- Te = $\sqrt{(M2 + T2)}$, According to maximum shear stress theory, the maximum shear stress in the shaft,

- Total load on the Shaft = 3.5x9.8=34.3N,
- Length of the Shaft =90.0
- Maximum Bending Moment = 2572.5N-mm
- Power=2xπNxT/60=2x3.14x250xT/60= .5x1000
- Torque = 23885 N-mm
- Te = √ (M2 +T2)
- √ (2572.52 +238852)
- = 24023.13
- Te = (3.14/16) xτxd3
- Diameter = 14.5mm
- Therefore, desired diameter of shaft is 16mm.

3.2 Design of belt

- (T1/T2) =e (μxθxcosecβ)
- Sin(α) =(r2/r1)/x =(100-50)/(2x60)
- α =24.60deg
- Angle of lap(θ)= 180-2α = 180-2x24.6
- θ = 130 deg=2.268rad.
- Groove Angle =30 deg.
- T1=e(.3x2.268x2)
- T2 =3.9T2 T1-T2=955.4
- T1 =1284.4
- T2 =329.4
- 2x3.14xN2 (T1-T2) x(100/2) = .5x1000x1000
- N2 =100rpm,
- Length of belt, L=3.14x(r2-r1)+2X+((r2-r1)/X)2 = 1.435mm

3.3 D.C. Motor

- Capacity: 12V
- RPM: 200
- Wheel Dia: 50mm

3.4 Stepper Motor

- Output: 6V
- RPM: 125
- Base plate: 660x360x25mm3
- Shaft: 16mm Dia.,
- Length-900mm
- Motor wheel: 50 mm Dia.
- Pulley: 100mm Dia.
- Main Wheel: 400mm Dia.
- Brake Wheel: 220mm Dia.
- Gen. Wheel: 80mm Dia.
- Spring (K): 50N/m

4. Results and Discussions

- Output voltage ranges from 5.5 to 6.0 volt
- Output current ranges from 90 to 100 MA
- Time taken to full stop from maximum speed to zero is 28 to 40 second
- Average output voltage (V) = (5.5 +6.0) / 2= 5.75 V
- Average output current (I)= (90+100) / 2 = 95 Ma

- Average time taken to full stop (t) = (28 + 40) / 2=34 sec
- Electrical energy stored (E)= V * (Ii - If) / 2 * t = 5.75 * (95 – 0) / 2 * 10* 34 (If = 0 and 1 m =10-3 A) = 9.23 J
- Mass of one wheel (M) =1250 gm = 1.250 kg
- Radius of wheel (R) = 200 mm= 0.2 m
- Maximum Average speed (N) = 325 rpm
- Speed ranges, before braking, from 300 to 350 rpm
- Angular velocity (ω) = 2πN/ 60=34 rad / sec
- Moment of inertia of two wheel = 2* MR2 (taking wheel as a ring) = 2*1.250*0.22 = 0.1 kg/ m^2
- Rotational kinetic energy (K) = ½ I ω^2 = ½ 0.1 * 34^2 = 57.80 J

- It should store energy while braking which is its primary objective
- It should return the stored energy whenever required easily
- It should be compact and easy to install
- It should provide adequate stopping/braking force to the vehicle
- When used in conjunction with conventional braking systems, it should easily switch as per requirement
- Its design should be flexible so that it can cater to the needs of a wide variety of vehicles

Some of the advantages of this model are;

- Better fuel economy.
- Reduced CO2 emissions
- Approximately 30% saving in fuel consumption
- Improved Performance
- The lower operating and environment cost of the vehicle with regenerative Braking System
- Reduction in Engine wears.

5. Conclusions

Already automakers are moving toward alternative energy carriers, such as electric batteries, hydrogen fuel and even compressed air. Regenerative braking is a small, yet very important, step toward our eventual independence from fossil fuels. These kinds of brakes allow batteries to be used for longer periods of time without the need to be plugged into an external charger. These types of brakes also extend the driving range of fully electric vehicles. When we think about the energy losses incurred by battery-electric hybrid systems, it seems plausible to reason that efficient flywheel hybrids would soon become the norm. Further analysis shows that a combination of battery-electric and flywheel energy storage is probably the ideal solution for hybrid vehicles.

As designers and engineers perfect regenerative braking systems, they will become more and more common. All vehicles in motion can benefit from utilizing regeneration to recapture energy that would otherwise be lost

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Dr. V. Sivamaran is working as an Assistant Professor in Department of Mechanical Engineering at Audisankara College of Engineering & Technology, Nellore, Andhra Pradesh, India. He completed his B.E (Automobile Engineering) from Vel Tech Engineering College, Anna University, Chennai and obtained his M.E (Nano Materials & Surface Engineering) from Annamalai University. He has 6 years of experience in research with more than 10 publications in reputed international journals. His area of interest are Nano Materials, Surface Engineering.

A. Guru Pradeep is currently working as Assistant Professor in the Department of Mechanical Engineering at Audisankara College of Engineering & Technology, Nellore, Andhra Pradesh, India. He has completed B.Tech (Mechanical Engineering) from Chadalawada Ramanamma Engineering College, Tirupati, JNTUA University and M.Tech (Machine Design) from NIST, Vijayawada. He has 5 years of teaching experience. (E-mail: agurupradeep@gmail.com)

Alimili Manoj Kumar is studying third year B.Tech in Mechanical Engineering at Audisankara College of Engineering & Technology, Nellore, Andhra Pradesh, India. (E-mail: alimilimanoj kumar@gmail.com)

Arava Srujan is studying third year B.Tech in Mechanical Engineering at Audisankara College of Engineering & Technology, Nellore, Andhra Pradesh, India. (E-mail: srujanraj03@gmail.com)

Navuru Balavenkatesh is studying third year B.Tech in Mechanical Engineering at Audisankara College of Engineering & Technology, Nellore, Andhra Pradesh, India. (E-mail: balavenkatesh@gmail.com)

Nellore Vamsi is studying third year B.Tech in Mechanical Engineering at Audisankara College of Engineering & Technology, Nellore, Andhra Pradesh, India. (E-mail: nellorevamsi123@gmail.com)