Regenerative Braking

Braking using Regenerative systems in Automobiles

Shreyash Jadhav
Department of Electronics
Vivekanand Education Society's Institute of Technology

Prof. Ameya Jadhav
Department of Electronics
Atharva College of Engineering

***Abstract*- Energy has become a largest question nowadays.Today as the sources of fossil fuels such as petrol, diesels are decreasing and so their cost is rising. Hence there is a need to find an alternative energy which can be used in automobile for transport purposes. So the car companies have started developing hybrid electrical vehicles [HEV]. But manufacturing of such cars is costly as compared to internal combustion engines [ICE] vehicles. So the use the electrical vehicles is limited due their cost. The other problem of electrical vehicle is that as the battery drives the vehicle so the battery requires lot of charging to run for longer distances. So the other emphasis was on generating the electrical energy/current from the vehicle itself to store in the battery itself to be used later. So that some amount of energy can be saved. There are two mechanism by which we can generate the electric energy/current using the braking system of the hybrid electric vehicle [EV] that will be explained below.**

Keywords- Regenerative Brakes, Flywheel.

I. INTRODUCTION

In an electrical vehicle, the most important thing is charging of the battery to drive the motor of the vehicle. The battery have to be charged in order to run the vehicle.
As the charging is required more for longer distances. We can constantly stop the car and charge the car from the outer source. Every time instead of using external charging source, we can employ the regenerative braking system. This system generates the electric energy from the vehicle itself. There are two regenerative braking system discussed in the paper. The regenerative brakes and the Flywheel.

II. METHOD ONE - REGENERATIVE BRAKES

Regenerative brakes work by saving energy. As a car stops all the momentum the car built up using precious gas or electricity is wasted using friction based brakes. With regenerative brakes some of that energy can be reused basically the motor that makes the car move is put in reverse to slow the wheels down. In this process the motor acts as a generator recharging the batteries as an electrical current runs the opposite way through the motor that gave the vehicle the power inthe first place. So instead of theenergy becoming heat and leaving into the atmosphere, itcan be used once again to get the car up to speed. This can over time help with the fuel efficiency of you vehicle ormake the electric motor last longer.

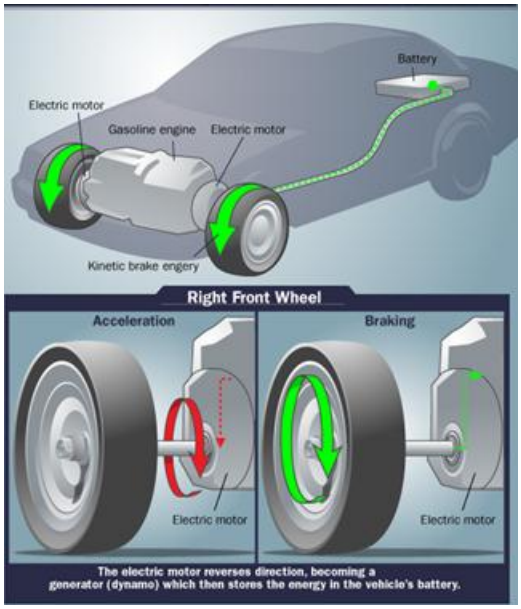

Fig. 1 How Regenerative Brakes works

III.WORKING

The physics behind the regenerative braking system goes back to a fundamental law of physics. The conservation of energy law states that energy cannot be destroyed or created but only transformed into different types on energy. When braking the car the regenerative brakes take the kinetic energy of the spinning tires and turn it into mechanical energy by turning the motor. The motor turns the mechanical energy into electrical energy that charges the batteries and supply the motor with electricity so the cycle starts over [8].None of the energy is destroyed but transformed. To calculate the energy saved we must use several equations.

$$Energy=0.5MV^2 \quad (1)$$

Where M is mass and V is initial velocity. From this we must take away the force of friction.

$$Friction= (MG) (Nf) \quad (2)$$

Where M is Mass, G is gravity, andNf is the normal force. Once we find the energy we then subtract the force of friction. This leaves us with the amount of energy left over to recover. Since regenerative brakes can only recover about 40% of the energy we take the recoverable energy and multiply by .4. This gives us the amount of energy recovered and put back into the batteries.

Now we need to look at just how effective regenerative brakes really are. They do have the potential to absorb 40% of energy used for braking. However, this system does have some flaws. The regenerative brakes do not have the power to bring the car to a full stop so some friction brakes must still be applied in every stop. Also the faster stop that is needed the more friction based brakes need to be used because regenerative brakes only have so much stopping power. In order to store the energy saved each vehicle must have a highly efficient battery system. This means large batteries that add weight and cost to each vehicle. Batteries also decrease in performance as the temperature goes down, so in the winter regenerative brakes do not seem worthwhile. Another downside to batteries is over time they lose their ability to fully charge. This means less driving distance, less energy absorption, and more battery replacement. However, it is still thought that regenerative breaks can save up to 800 dollars every year. Which mean less gas and less CO2 emissions.

IV. METHOD TWO - FLYWHEEL

Another form of energy saving is called the flywheel. The flywheel is actually not a new concept. It has been used in century old machines like the potter's wheel and many others. In the 1950's flywheels were starting to be used in trams and busses to help with gas mileage. However the technology was still very new and the flywheels could weigh as much as 500kg and spin at about 2000 rpm [1]. This weight would make it impossible to be used in everyday vehicles. The problem experts faced was how do you make the fly wheel light enough for a car yet have the same amount power?

VI.WORKING

The concept of the flywheel is actually very easy to understand. It is a wheel that spins to retain energy. As the wheel speeds up it has more kinetic energy [7]. That energy can then be harnessed for use. This is useful in cars as energy can be stored in the flywheel as the car slows down. Instead of the energy being wasted as friction, the energy is used to spin the flywheel. The flywheel continues to spin until you need to speed up and that saved energy can be used to supply more power [3]. The heavier the wheel the more energy it takes to make it spin, but then it has more inertia. A smaller wheel takes much less energy to spin yet has less inertia. The idea is to not waste all the energy when slowing down because it can be harnessed and used again. The flywheels in these new cars are put in vacuums and suspended by magnets to reduce air resistance and friction. This allows the most energy containment as possible [2]. The problem is still the size of the wheel which can be explained by the calculations and physics behind them. There are several equations used for rotational energy. One is

$$\text{Kinetic energy}=0.5(KMR^2)(W^2) \qquad (3)$$

K is the inertial constant, which is dependent on the shape of the wheel, M is the mass of the wheel, R is the radius, and W is rotational velocity. A uniform solid disk has a K of .5. As you can see from this equation as mass, represented by M, increases the kinetic energy increases linearly. As the rotational speed, represented by W, increases the kinetic energy increase exponentially because it is squared. This means that it is much more important to have rotational speed than mass. So to fix the problem with the size of the flywheels it quite simple. The flywheel just needed to be smaller, but with a much higher rotational velocity. So why car didn't companies just do this? The reason is because of centrifugal force. This is the force that makes the object in a circular motion move outward, which can tear apart the wheel itself.

$$\text{Centrifugal force}= M (W^2) R \qquad (4)$$

This means once again that as rotational speed increases the centrifugal force will increase exponentially. So the solution to this problem is the material used for the wheel needs to have little mass and high tensile strength. Tensile strength is the amount of force it takes to pull something apart. So engineers had to design a wheel that was light strong and had a very high rotational speed. With the use of composite materials they were able to create a 5kg flywheel that has a rotational speed of 60,000 rpm [2]. This is 30 times faster than original flywheels. This allows for much higher energy absorption.

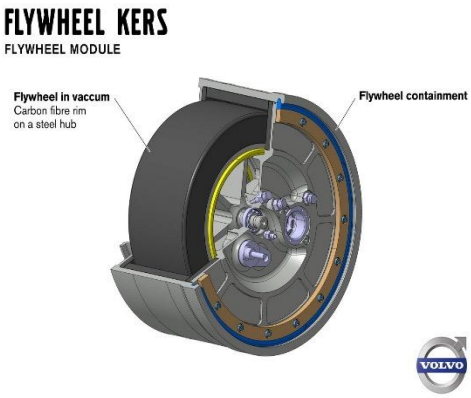

Fig. 2 Diagram of Flywheel

Now that there is a feasible flywheel, how efficient is it? Test show that flywheels have the potential to have up to a maximum of 80% energy return [4]. This means of the energy that is stored in them 80% is reusable. Experts also believe that the flywheel could provide as much as 60 kW of energy. This could give the car and extra 80 hp or improve fuel efficiency by 20%. It is also thought it has the chance to lower CO2 emissions by 30% [1]. So the flywheel has a pretty good chance of affecting our car's gas mileage and CO2 emissions in the very near future.

It is easy to see that the use of flywheels can be affective in everyday cars, but can they feasibly be produced on a large scale. The reality of the situation is that the flywheel is half the weight of the battery systems. This means half the material and less cost [1]. It is thought that the flywheels can be mass produced for a quarter of the price of battery systems already in use today. Jaguar is even planning on having a model with the flywheel in production in the year 2013 [9].

Now the question is which system is better? The flywheel system can reuse up to 80% more energy than the battery system [4]. The wheel also has half the weight and a quarter of the cost compared to the battery system [1]. Batteries also wear out over time and cannot perform well in cold climates [1]. Whereas the flywheel does not wear out and performs in all temperatures. The flywheel can also store more energy more efficiently. Until a battery system is created that has a long life, performs well in cold temperatures, is efficient, and is smaller than the flywheel it seems like the better system for energy saving is the flywheel [1]. It seems to have every edge in every aspects of energy saving.

VII. CONCLUSION

From the regenerative braking systems discussed above, both the systems have their own advantages and disadvantages .Both the systems are useful, they can be used by the requirement of the user.
But we can say that by means of energy saving these systems are useful.

REFRENCES

[1] Everett, Michael. "Ultra caps "Brakes" Wasteful Energy Habits." Design Solution 4 Nov. 2010: 65-66.
[2] "Flywheel Hybrid." Automotive Engineering October 2009, pg.48.
[3] "Flywheel hybrid car shows class." Professional Engineer 22 Sept. 2010, pg. 10.
[4] "Flywheels and Energy Storage." The Electronic Universe Project. September 23,2011 http://zebu.uoregn.edu/1996 /ph162/l10a.html
[5] Honeywill, Tristan. "Hybrids hit the brakes. "Automotive Engineer Nov. 2007, pg. 22-23
[6] Oxford Dictionary of Sports Science & Medicine. "Centrifugal Force." September 23, 2011 http://www.answers.com/top ic/centrifugal-force
[7] Polar Power "Power Storage Technology." September 23, 2011h://polarpower.org/technologies/power_storage/index. html
[8] Simpson, JT and Stuebing, Jamie. "Regenerative Braking." May 22,2011.Sept.24 2011 http://sjam4uphysics.pbworks.com/w/page/38936885/ Regenerative/20Braking.html
[9] U.S. hybrid market historical sales. Chart. May 13, 2008. September 23, 2011 www.hybridcars.com/marketdashboard/april-2008-hybrids-defy-recession.html
[10] "Welcome to the GARAGe flywheel demo page." September 23, 2011 http://garage.cse.msu.edu/demos/index.html