

Mechanical Energy Harvesting Using a See-Saw-Based Regenerative Power Setup

Amit Kumar, Rakesh Yadav*

Department of Mechanical Engineering, Indian Institute of Technology Delhi, New Delhi, India

ABSTRACT

Research related to electrical vehicles is gaining importance due to the energy crisis. Using regenerative braking when braking, improves the efficiency of an electric vehicle as it recovers energy that could go to waste if mechanical brakes were used. A novel regenerative braking system for neighborhood electric vehicles was designed, prototyped and tested. The proposed system utilizes a seesaw system to capture energy whereas the conventional systems regenerate to the batteries. The user has direct control over the amount of current regenerated and hence the amount of negative torque applied for braking. The research has shown that the proposed regenerative braking system is significantly better in recovering energy and slowing the vehicle compared to a commercially available regenerative braking system. Regenerative Braking System (RBS) is an efficient system to reduce vehicle emission and fuel consumption. RBS is a system which converts mechanical energy to electrical energy during braking action. It will become an important system for future vehicle such as hybrid and electric car. The important components used in RBS will be determined such as electric motor, motor controller and battery. To produce a RBS model, a seesaw conversion system has been made in college and a dynamo was selected to be installed in the model. The results and calculations show that device can function properly, that means device can form recovery energy to charge battery during braking. During the recovery energy working, brake effects are formed to decelerate the bike. In addition this RBS model can be used for future study.

KEYWORDS: See Saw

Introduction

When a conventional vehicle applies its brakes, kinetic energy is converted to heat as friction between the brake pads and wheels. This heat is carries away in the airstream and the energy is effectively wasted. The total amount of energy lost in this way depends on how often, how hard and for how long the brakes are applied. Regenerative braking refers to a process in which a portion of the kinetic energy of the vehicle is stored by a short term storage system. Energy normally dissipated in the brakes is directed by a power transmission system to the energy store during deceleration. That energy is held until required again by the vehicle, whereby it is converted back into kinetic energy and used to accelerate the vehicle. The magnitude of the portion available for energy storage varies according to the type of storage, drive train efficiency, and drive cycle and inertia weight. City centre driving involves many more braking events representing a much higher energy loss with greater potential savings. With buses, taxis, delivery vans and so on there is even more potential for economy. Since regenerative braking results in an increase in energy output for a given energy input to a vehicle, the efficiency is improved the amount of work done by the engine of the vehicle is reduced, in turn reducing the amount of prime energy required to propel the vehicle. In order for a regenerative braking system to be cost effective the prime energy saved over a specified lifetime must offset the initial cost, size and weight penalties of the system. The energy storage unit must be compact, durable and capable of handling high power levels efficiently, and any auxiliary energy transfer or energy conversion equipment must be efficient, compact and of reasonable cost.

CHARACTERSTICS OF IDEAL REGENERATIVE BRAKING SYSTEM

To be successful a regenerative braking system should ideally have the following properties:

- Efficient energy conversion
- An energy store with a high capacity per unit weight and volume
- A high power rating so large amounts of energy can flow in a short space of time
- Not require over complicated control systems to link it with the vehicle transmission
- Smooth delivery of power from the regenerative system
- Absorb and store braking energy in direct proportion to braking, with the least delay and loss over
- A wide range of road speeds and wheel torques.

LITERATURE REVIEW

Yimin Gao and Mehrdad Ehsani, 2001

In this methodology for designing a RBS has been described. Three RBS's were built and tested, first using a HIL test bed and then installed on an operation hybrid electric city bus. For the serial RBS, a key problem of how to adjust the

friction braking force has been solved. Some factors have been taken into account for increasing the energy regeneration efficiency. How the RBS reacts with the ABS has been analyzed to ensure the vehicle's longitudinal stability. The results indicate that the serial RBS has high energy regeneration efficiency while retaining acceptable vehicle drivability and stability needed to ensure passenger safety.

Y. Hori, 2004

This paper presents a bilateral robot system, which is driven by the static friction-free drive system and implemented on the real-time network structure. The goal is to realize a force reflecting bilateral teleportation with haptic impression transmission over computer networks. The paper considers two subjects relating to the bilateral robot. The first is static friction, which degrades the performance of manipulation and results in a poor haptic impression.

A new transmission mechanism named twin drive system developed by the authors resolves this problem. The transmission mechanism, which resembles the differential gear of automobiles, is essentially free of static friction. This static-friction-free motion greatly contributes to the broad range of motion control applications. The second subject is the time delay of the network, which may cause serious problems such as instability of the feedback system. To avoid such delay, the authors developed a new real-time network protocol stack (RTNP). The detailed mechanism of the twin drive system and architecture of the RTNP are presented, and the control scheme and experimental results are also shown.

John M. Miller, 2004

This paper has explored the various types of power split e-CVTs now used or being planned for near term use. The e-CVT, as such systems are generically known, offer smooth and seamless driveability during all modes of operation. The e-CVT is also more efficient than mechanical CVTs, especially as the transmission ratio coverage approaches 6:1. This paper has developed the dynamics of the e-CVT and has shown the similarity of the various types and their major differences

COMPONENTS REQUIRED FOR SEE SAW MODEL

1. Wheel
2. Self constructed see saw bend
3. 2 Big and 2 small pulleys
4. Belt
5. Chain
6. Footpad as clutch
7. DC Motor
8. Dynamo
9. Rectifier
10. Transformer

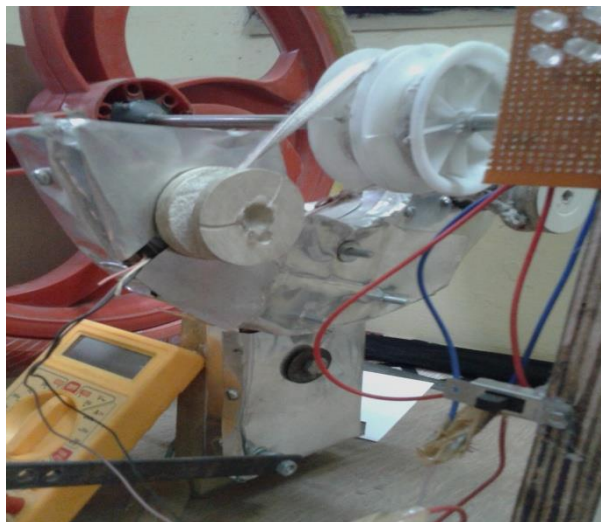


Figure 1RPS

PULMONOLOGY

Different components are assembled on a self constructed see saw as per drawing.



Figure 2RP

A footpad like mechanism is connected with see saw to provide movement to the module. A DC motor is attached on one side of the module and on the other side of the module a dynamo is connected. Both are connected with a wheel shaft pulley.

WORKING OF SEE SAW SYSTEM

When the DC motor is switched on, the wheel starts rotating along with rod. This also makes the pulleys fixed on the rod to rotate. At this moment, the pulleys fixed on the rod rotates along with the pulley on the see saw. This means one of the pulleys on the see saw is engaged with the main pulleys.

Now when the footpad is pressed, the brake is applied. This leads to the stopping of one of the pulleys on see saw as the pulleys which was moving earlier gets disengaged and stops rotating. The other pulley which was at rest earlier gets engaged and rotate for a very short period, nearly 3 to 4 rounds and stops after that. This is because of the braking effect of the vehicle.

The first output comes from the first rotating pulley. When the pulley is rotating, the output voltage may be measured by the multimeter. This is produced because of the dynamo. This is used to charge the vehicle's battery. The second pulley while braking produces a small amount of current which may be measured by a VU meter or may be indicated by the LED lights. This is used to charge the battery while braking of the vehicle. When the footpad is released, the system goes back to the initial state and starts rotating as earlier. The whole process continues repeatedly so as to charge the vehicle's battery.

IMPLICATION OF FINAL DESIGN

With all of these considerations taken into account, the mass of the flywheel should be as small as possible and should be distributed as much as possible on the outer radius, then the radius should be made as large as can fit on the bike, and the rest of the energy will be in the rotational speed, which hopefully is not too high to get significant friction losses.

First, the problem of how much energy will be stored in the flywheel will be solved without the complication of friction between the road and the bike. This means the angular momentum of the flywheel, the crank, and the two bike wheels will be analyzed for the two different gear ratios. The initial gear ratio between the flywheel and the crank is 3:2, so the relative angular speed of the flywheel will be two thirds of the crank. Since the angular speeds of the two parts are fixed relative to each other, the ratio of their angular momentum can be written as.

CONCLUSION

See Saw regenerative braking system is basically a modification in regenerative braking technique. Traditionally regenerative braking system is basically a setup which gives or converts kinetic energy of a vehicle into electrical

energy which is further used to charge the battery of a car but after implementing seesaw into this system we are doing two main things, first by the help of engaging & disengaging structure we are allowing 'battery' to get disengage from the system for some time because over charging a battery will ultimately lead it to lose its full charge capacity & the second thing is by disengaging the primary dynamo we are saving armature coil winding which will ultimately increase the life of primary dynamo or the main dynamo and further our modification at this small scale can give us a maximum of 9V voltage which can charge all the equipments. There are some more advantages too of using this modification in regenerative braking system, after using this modification fuel consumption of the vehicle can also be decreased up to a certain value which will ultimately save the money.

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. Future technologies in regenerative brakes will include new types of motors which will be more efficient as generators, new drive train designs which will be built with regenerative braking in mind, and electric systems which will be less prone to energy losses.

The world needs is a method or a technology that saves energy from getting wasted. Energy conservation is the hour of need. In case of automobiles, energy conservation can be done by using regenerative braking systems (RBS). When driving an automobile, a great amount of kinetic energy is wasted when brakes are applied, which then makes the start up fairly energy consuming. The main aim of this project was to develop a product that stores the energy which is normally lost during braking, and reuses it. The use of regenerative braking system in automobiles provides us the means to balance the kinetic energy of the vehicle to some extent which is lost during the process of braking. The authors of the paper have discussed and presented two methods of using the kinetic energy which generally gets wasted by converting it into either mechanical energy or into electrical energy. Flywheel is used for converting the kinetic energy to mechanical energy. Also, Electric Motor is used to convert Kinetic Energy into electrical energy. The regenerative braking system used in the vehicles satisfies the purpose of saving a part of the energy lost during braking. Also it can be operated at high temperature range and are efficient as compared to conventional braking system. The results from some of the test conducted show that around 30% of the energy delivered can be recovered by the system. Regenerative braking system has a wide scope for further development and the energy savings. The use of more efficient systems could lead to huge savings in the economy of any country.

REFERENCES

1. Yimin Gao and Mehrdad Ehsani. Electronic Braking System of EV And HEV—Integration of Regenerative Braking, Automatic Braking Force Control and ABS. SAE paper 2001
2. S. Kliuzovich, "Analysis of control systems for vehicle hybrid powertrains," *TRANSPORT VGTU*, vol. XXII, no. 2, 2007.
3. J. Zhang, X. Lu, J. Xue, and B. Li, "Regenerative braking system for series hybrid electric city bus," *The World Electric Vehicle Journal*, vol. 2, no. 4, 2008.
4. B. J. Varocky, "Combined control of a regenerative braking and antilock braking system for hybrid electric vehicles," *International Journal of Automotive Technology*, vol. 9, no. 6, 2011
5. S.J. Clegg *A Review of Regenerative Braking Systems*. Institute of Transport Studies, University of Leeds, Working Paper 471 2012
6. LOI WEI CHEONG, "A development and use of a regenerative braking model for a parallel hybrid electric vehicle," *SAE Technical Paper Series*, 2013.