Asian Journal of Applied Science and Technology (AJAST)

(Peer Reviewed Quarterly International Journal) Volume 3, Issue 3, Pages 53-56, July -September 2019

Generating Electricity using Regenerative Braking System

Syed Hasan Furqan[1], Arumugam Ganesan[2] & Mohammed Sameer Baig[3]

[1]*Student, International Diploma in Engineering Institute, Al Shabaka Technical Institute, UAE. Email: khansyed590@gmail.com*
[2]*Faculty In-Charge, Head of Engineering, Electrical and Electronic Engineering, Al Shabaka Technical Institute, UAE. Email: arumugam@astidubai.ac.ae*
[3]*Faculty In-Charge, Mechanical Engineering Department, Al Shabaka Technical Institute, UAE. Email: sameer@astidubai.ac.ae*

Article Received: 27 January 2019 Article Accepted: 13 May 2019 Article Published: 21 July 2019

ABSTRACT

In the present scenario, energy crisis is one of the major challenges to the existing world. The fossil-fuel resources are being depleted at a tremendous rate due to their disproportionate consumption. This has put forth the widespread assumption that if resources are being used at current rate, the time is no longer when all our resources will expire. Thus, there is a need to develop the technology that saves the energy from getting wasted. In case of automobiles, energy recuperation can be done by introducing Regenerative braking system. Whenever the brakes are applied, a significant amount of kinetic energy gets wasted in the form of heat energy as a result of friction between brake pads and rotor. Regenerative Braking System recovers kinetic energy as much as possible that is lost during the process of braking. It stores that energy and releases it under acceleration. This paper highlights the two different methods of recovering energy that generally gets wasted, by converting it into either electrical or mechanical energy. The kinetic energy gets converted into electrical energy with the help of electric motor whereas flywheel harnesses the kinetic energy by converting it into mechanical energy.

Keywords: *Batteries, Energy recovery system, Electric motor, Flywheel, Generator, Regenerative Braking.*

I. INTRODUCTION

A. Conventional Braking System

Braking is one of the key features of vehicle which implies producing force that opposes the motion of wheel, there-by reducing vehicle's speed or bringing it to a halt. When the brakes are applied, hydraulic pressure actuates in the master cylinder as a result of which brake pads under pressure rub against the surface of rotor. Thus, the friction comes into play and kinetic energy of rotor and eventually wheel gets hampered. In this process, kinetic energy gets converted heat energy which is dissipated to the surroundings. Hence, a part of energy extracted from engine gets wasted and further energy is required to accelerate the vehicle.

B. Regenerative Braking System

Regenerative braking system is an energy recovery system that recovers significant amount of kinetic energy of vehicle that unnecessarily gets wasted during braking. The recovered energy is stored in a suitable storage system (battery or flywheel). "Stop and go", "decelerate and accelerate", that's usually the scene of traffic in the city which results in a lot of braking. The kinetic energy of vehicle is given by equation:

$$E = \frac{1}{2}mv^2 \quad (1)$$

Where, E=kinetic energy of vehicle, m=mass of vehicle and v=velocity of vehicle

Ideally, this is the amount of energy which is available for recuperation when brakes are applied. This energy which usually gets wasted on the application of conventional brakes can be recovered with the help of regenerative braking. The efficiency of regenerative braking mainly depends on the type of energy storage system and drive train. Energy storage system should be good enough to store the energy and should also be capable to release the stored energy or power. The transmission system should be efficient to transmit the power to the driving wheels to

propel the vehicle. The amount of work done by engine is reduced and thus the fuel consumption is reduced. Hence the fuel economy and overall efficiency gets improved. Regenerative braking not only improves the efficiency by saving the energy but also improves the performance of vehicle by boosting the acceleration of vehicle.

II. REGENERATIVE BRAKING USING ELECTRIC MOTOR

Electric vehicles and Hybrid vehicles use electric motor as a source to propel themselves. As known, when motor is made to run in reverse direction it behaves as a generator. Similar concept or principle is utilized for regenerative braking. When braking has to be done, motor switches to generator mode. The generator captures the kinetic energy of wheel via drivetrain. Thus, it transforms the kinetic energy into electrical energy which is stored in a battery for further use. On the other hand, generator resistance produced from the electricity created, slows the vehicle. The bigger the power of Motor/Generator in generator mode, the larger amount of kinetic energy would be recuperated. The capacity of battery to store the energy is also a factor that affects the amount of energy recovered. When the torque generated by the generator is less as compared to the required braking torque, it is supplemented by friction brake.

III. REGENERATIVE BRAKING USING FLYWHEEL

Flywheel is a heavy rotating mass that stores the kinetic energy or the mechanical energy of rotating wheel in the same form (rotational energy). This process of recovering energy is more efficient. The losses involved during energy transformation are avoided, because the energy is being transmitted in the mechanical form throughout the cycle. In case of recovering the energy through motor/generator and battery system, energy losses occur as mechanical energy is being transformed into electrical energy while charging the battery and during discharging electrical energy gets converted into mechanical form.

$$E = \frac{1}{2} I w^2 \quad (2)$$

Where, E=rotational energy of flywheel, I=moment of inertia of flywheel, w=angular velocity of flywheel

The amount of energy stored by flywheel depends upon its mass, radius and rotational velocity. Thus, the maximum energy stored by flywheel can be enhanced by increasing moment of inertia and angular velocity of flywheel. In order to recover energy or to initiate energy transfer through flywheel, angular momentum must be varied. For varying angular momentum, angular velocity or moment of inertia must be varied continuously. Thus, a Continuous Variable System (CVT) is used to transmit the power. A CVT consist of two pulleys which are connected through belt. One Pulley is called driving pulley whereas the other called driven pulley. The continuous movement of the sheaves of pulley changes the effective diameter of belt and hence gear ratio. Flywheel is connected to one end of the CVT whereas it's another end is linked to driving axle (wheel). The continuously variable transmission changes the angular velocity of the flywheel establishing different gear ratio between flywheel and wheel. The range of CVT determines the maximum angular velocity achieved by flywheel. In the normal mode, vehicle is powered by Engine by engaging the clutch between engine and variable transmission. In regenerative braking mode, flywheel is engaged to the transmission while the engine clutch is disengaged. The

variable transmission continuously varies gear ratio so as to speed up the flywheel. The angular velocity of wheel gets reduced and that of flywheel increases. Thus, the energy is stored in flywheel. In energy recovery mode or accelerating mode, flywheel clutch is engaged by establishing suitable gear ratio between flywheel and wheel. The gear ratio varies continuously so as to speed up the wheels. Thus, the vehicle is powered by flywheel by shutting down the engine. In this way, energy recuperation is done with the flywheel assisted regenerative braking system. Flywheels have high specific power as compared to the conventional battery and thus prove to be a better energy storage system.

IV. ADVANTAGES OF REGENERATIVEBRAKING

1. Fuel economy is improved as it lowers the fuel consumption.

2. Reduce the carbon footprint and thus environment friendly.

3. Improved vehicle performance as it boosts the acceleration instantly.

4. Regenerative braking system reduces the overall work done by the engine and therefore reduces the wear of engine parts.

5. Regenerative braking supplements the frictional braking and thus reduces the wear and tear of brake assembly parts.

V. FLYWHEELS: A BETTER ALTERNATIVE TO BATTERIES

1. Flywheel has comparatively better efficiency as compared to battery as the losses do not occur during energy transformation.

2. It has higher specific power and thus can deliver energy at high rate.

3. They are less sensitive to the temperature variation whereas conventional batteries experiences power fade at high temperatures.

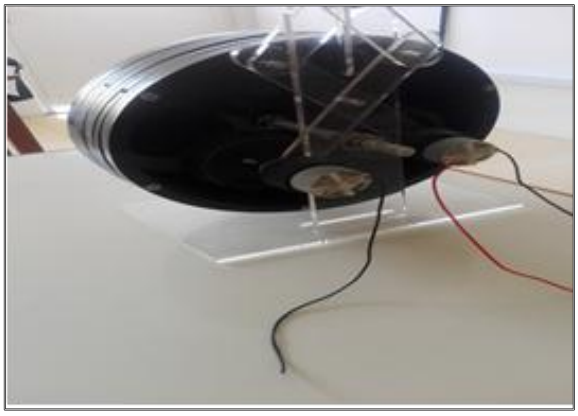
4. The operating life or cyclic age of flywheel is more as compared to battery.

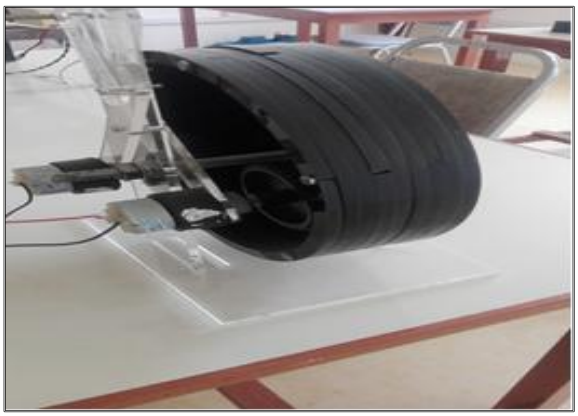
5. They have comparatively less impact on the environment and are easy to recycle.

VI. CONCLUSION

Regenerative braking is one of the effective and emerging technologies which can serve the purpose of capturing and reusing energy lost while braking. The above discussed storage system proves flywheel as a better energy storage system. There is always scope for improvement in terms of technology. Thus, the effort should be made to layout an appropriate design of flywheel which can bear a large amount of the stress developed in flywheel. Also, the research should be made to incorporate such a material for the flywheel which have good strength and comparatively less weight so that they can be feasible for the practical aspects of vehicle. Some modern flywheels are made of carbon-composite materials and are proved to be more reliable and feasible. Introducing an efficient transmission system would also increase the overall efficiency of regenerative braking. Further research could help in making this technology more efficient and reliable.

Figures





REFERENCES

1) https://www.irjet.net/archives/V4/i4/IRJET-V4I4595.pdf

2) https://www.researchgate.net/.../255670979_Regenerative_Braking_System_for_Series_...

3) https://www.irjet.net/archives/V4/i4/IRJET4I4595.pdf

4) iraj.in/journal/journal_file/journal_pdf/2-56-140048604775-78.pdf

5) https://www.mdpi.com/2032-6653/2/4/363/pdf

6) https://www.omicsonline.org/.../regenerative-brakingmethods-to-efficiently-use-regen..

7) https://www.tandfonline.com/doi/abs/10.1080/09720502.2018.1498047

8) www.ijsrd.com/articles/IJSRDV4I10597.pdf

9) large.stanford.edu/courses/2017/ph240/leis- pretto1/

10) https://acadpubl.eu/hub/2018-119-12/articles/4/878.pdf