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AN ANALYSIS OF BRAKING ENERGY REGENERATION IN VEHICLE

PROF. S. L. BANKAR[1], TEJAS THAKARE[2], SARANG SOMANI[3], UTSAV BORSARE[4]

[1]Associate Professor, Department of Mechanical Engineering, Yeshwantrao Chavan College of Engineering, Nagpur, 441110
[2,3,4]Student, Department of Mechanical Engineering, Yeshwantrao Chavan College of Engineering, Nagpur, 441110

Abstract - *Climate change is the severe concerns for our generation and for upcoming generation. We are heading towards more polluted, unhealthy environment. The use of vehicle is drastically increasing day by day but the storage of natural resources is drastically decreasing. It is need of a time to save these natural resources as much as possible. In automobiles, energy is lost due friction in breaks in form of heat. As the first law of thermodynamics states that "Energy is always conserved, it cannot be created or destroyed, it can be converted from one form to another". We are going to discuss the Regenerative Braking System (RBS) in this paper. Regenerative braking is an energy recovery mechanism that slows a vehicle or object by converting its Kinetic Energy (K.E) into a form which will be either used immediately or stored until needed.*

Key Words: **Regenerative Braking, Hybrid vehicles, Kinetic energy recovery system (K.E.R.S.), Flywheel, Motor, Hydraulic Power Assist.**

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. In conventional braking systems, friction is used to counteract the forward momentum of a moving vehicle. When the brake applies pads rub against the wheels or a disc that is connected to the axles, excessive heat energy is created. Due to friction this energy dissipates into the air in the form of heat, wasting as much as 30 percent of the vehicle's generated power. Over the time, this cycle of friction and wasted heat energy reduces the vehicle's fuel efficiency.

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 problem is Regenerative Braking System. It is also known as energy recovery system. This is a new type of braking system recollect/recover kinetic energy wasted unnecessarily due to braking and convert it into electrical energy or mechanical energy. The energy so produced can then be stored as mechanical energy in flywheels or as electrical energy in the automobile battery which can be used again. This system helps to improve overall performance of vehicle. There are multiple methods of energy conversion in RBSs including electric motor, flywheel, electromagnetic and hydraulic.

2. REGENERATIVE BRAKING SYSTEM (RBS)

The main aim is to study existing regenerative braking system and to discover best system that is efficient, less bulky so as to increase performance and efficiency of vehicle. System used in vehicle is known as hybrid vehicle or electric vehicle. The use of hybrid vehicle is widely available since 1997 in Japan and vehicle was Toyota Prius followed by Honda Insight in 1999. But the Baku-Tbilisi-Batumi started applying RBS in railways in early 1930s. In 1967 American Motor Car company (AMC) created an electrical energy regeneration brake for their concept electric car, the AMC Amitron. Toyota was the first car manufacturer to commercialize RBS technology in their Prius series hybrid car. Since then, RBSs have to be used in almost all electric and hybrid cars as well as some gas-powered vehicles.

2.1 WORKING

In the normal driving condition, the electric motor or IC engine drives the transmission it generate torque and run the wheel. The direction of wheel is in the direction of torque. The direction of flow of energy is from battery to wheel as shown in fig.(a).

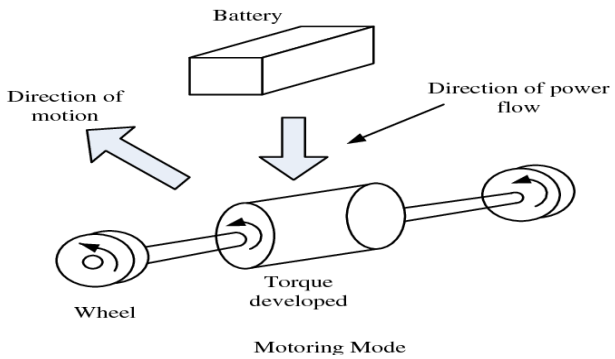


fig.(a) Driving Condition

When the brakes applied the RBSs activated it uses motor to generate the opposite torque it not only stops the vehicle but also generate the electric energy from the kinetic energy loss due to friction in brakes. In this condition the motor acts as generator and store this energy into batteries for further use. The flow of power is from wheels to motor, the direction of wheel is in opposite direction to torque as shown in fig.(b).

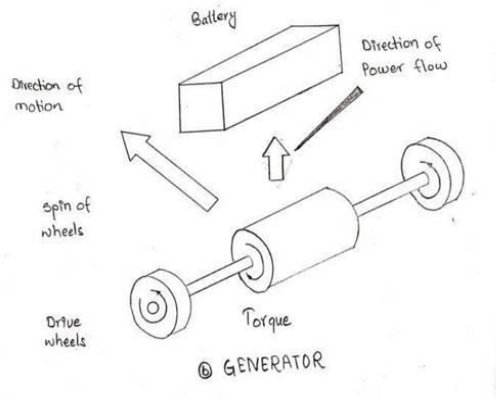
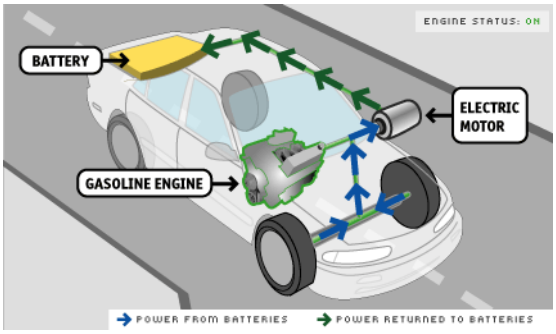


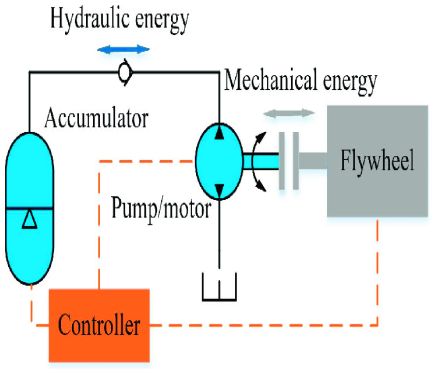
fig.(b) Regenerative Braking Action

2.2 TYPES OF REGENERATIVE BRAKING SYSTEM

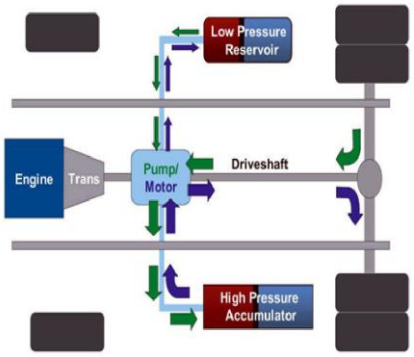
Electric motor (RBS) :- It involves using an electric motor as an electric generator. The working of the regenerative braking system depends upon the working principle of an electric motor. Electric motor gets activated when some electric current is passed through it. But, when some external force is applied to activate the motor (during the braking), then it behaves as a generator and generates electricity. This electricity is then used for recharging the battery.



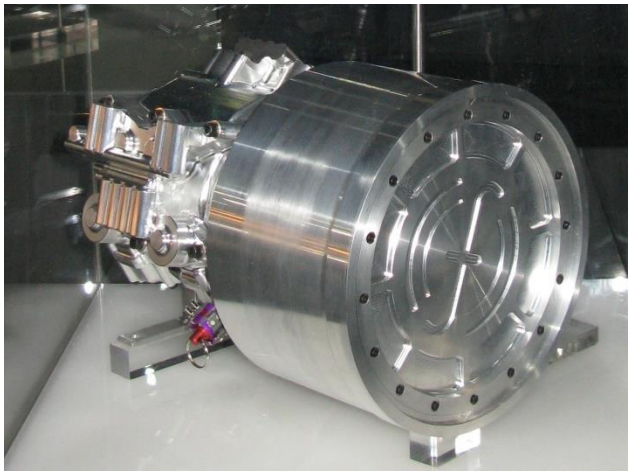
Flywheel (KERS):- In Flywheel Kinetic Energy Recovery System, the system collects the kinetic energy of the vehicle to spin a flywheel that is connected to the drive shaft through a transmission and gear box. The spinning flywheel can then provide torque to the drive shaft, giving the vehicle a power boost. As the energy is supplied instantly and efficiency is high, these types of systems are used in F-1 cars.



Hydraulic (RBS):- The Hydraulic Regenerative Braking System slows the vehicle by generating electricity which is then used to compress a fluid. Nitrogen gas is often chosen as the working fluid. Hydraulic Regenerative Braking Systems have the longest energy storage capability of any system, as 6 compressed fluid does not dissipate energy over time. However, compressing gas with a pump is a slow process and severely limits the power of the hydraulic Regenerative Braking System.



Electromagnatic flyweeel (RBS):- Electro flywheel regenerative brake is a hybrid model of electromagnetic basic power generation methods with the electromagnetic system; however, the energy is stored in a flywheel rather than in batteries. In this sense, the flywheel serves as a mechanical battery, where electrical energy can be stored and recovered. Due to the long life of flywheel batteries compared to lithium-ion batteries, electric flywheel Regenerative Braking System is the more cost-effective electricity storage method.



2.3 ADVANTAGES OF REGENERATIVE BRAKING SYSTEM

[1]Better Performance. [2]Cuts down on pollution related to supply generation. [3]Efficient Fuel Economy–The fuel consumption is reduced, dependent on the machine cycles, vehicle design, automation control plan, and the individual component's efficiency. [4]Reduced wear and tear of Engines. [5]Reduced Brake Wear– Cutting down the replacement brake linings cost, the cost of labour for installation, and machine downtime. [6]Reduced emissions– Cuts down on pollution related to power generation, engine decoupling reduces the total number of revolutions and thus engine emissions. [7]Smaller accessories – reducing fuel tank size and thus the weight of the vehicle.

2.4 PERFORMANCE IMPROVEMENT OF RBS

Optimization techniques of regenerative braking :- Cheng-Kuo Sung [1] experimented on four stroke air engines for regenerative braking & installation of buffer region, which revealed that after installing buffer region in RBS the cylinder pressure could be effectively regulated thus reducing the peak value of pressure. Kai Liu [2] The experiment shows analyses of the impact of road gradient on the electricity consumption OF EV's by combining GPS tracking data from EV's with road elevation information. Which gave them a result of 5% to 8% improvement. Jiaseng Ruan [3] experimented various braking testing maneuver which were used to test possible safety issues due to redistributing the braking force between the front/rear axles in a Regenerative braking.

Increasing recoverable energy and power battery efficiency:- Siddharth Mehta [4] in this paper, a cascaded bi-directional DC/DC buck-boost converter with dual control strategy during regenerative braking is used for a two-wheeler application. The average power stored by the battery is increased by 2.5 times and the vehicle comes to halt faster in comparison with the existing control strategy. Zhongyue Zou [5] in this paper they have used super-capacitors for their project. As the super capacitors has high power density and they are employed to withstand high current in the short time and essentially capture more regenerative energy. The result verifies the higher efficiency of energy regeneration system using super-capacitors and the effectiveness of the proposed measurement method.

3. CONCLUSION

Regenerative braking systems require further research and development to captures more energy and stop faster. With developed system application in vehicles 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, with more efficient battery to bear more frequent charging and discharging. 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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