A SEMINAR REPORT ON REGENERATIVE BRAKING SYSTEM

- SUBMITTED BY

GUIDED BY: -

ABSTRACT

- Regenerative Braking System is the way of slowing vehicle by using the motors as brakes
- Instead of the surplus energy of the vehicle being wasted as unwanted heat, the motors act as generators and return some of it to the overhead wires as electricity.
- The vehicle is primarily powered from the electrical energy generated from the generator, which burns gasoline.
- This energy is stored in a large battery, and used by an electric motor that provides motive force to the wheels.
- The regenerative barking taking place on the vehicle is a way to obtain more efficiency; instead of converting kinetic energy to thermal energy through frictional braking, the vehicle can convert a good fraction of its kinetic energy back into charge in the battery, using the same principle as an alternator.

CHAPTER 1: INTRODUCTION

- **Brake:-**
- A brake is a machine element and its principle object is to absorb energy during deceleration. In vehicle brakes are used to absorb kinetic energy whereas in hoists or elevators brakes are also used to absorb potential energy. By connecting the moving member to stationary frame, normally brake converts kinetic energy to heat energy. This causes wastage of energy and also wearing of frictional lining material.

Regenerative Braking System:-

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Definition:

- Braking method in which the mechanical energy from the load is converted into electric energy and regenerated back into the line is known as Regenerative Braking. The Motor operates as generator.

Regenerative Braking For Hybrid Vehicle:

- In most electric and hybrid electric vehicles on the road today, this is accomplished by operating the traction motor as a generator, providing braking torque to the wheels and recharging the traction batteries.

CHAPTER 2: *NECESSITY OF THE SYSTEM*

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

Energy Conservation

- The flywheel absorbs energy when braking via a clutch system slowing the car down and speeding up the wheel. To accelerate, another clutch system connects the flywheel to the drive train, speeding up the car and slowing down the flywheel. Energy is therefore conserved rather than wasted as heat and light which is what normally happens in the contemporary shoe/disc system.

Wear Reduction:

- An electric drive train also allows for regenerative breaking which increases Efficiency and reduces wear on the vehicle brakes. In regenerative raking, when the motor is not receiving power from the battery pack, it resists the turning of the wheels, capturing some of the energy of motion as if it were a generator and returning that energy to the battery pack. In mechanical brakes; lessening wear and extending brake life is not possible. This reduces the use of use the brake.

Fuel Consumption:

- The fuel consumption of the conventional vehicles and regenerative braking system vehicles was evaluated over a course of various fixed urban driving schedules. The results are compared as shown in figure. Representing the significant cost saying to its owner, it has been proved the regenerative braking is very fuel-efficient.

Braking is not total loss

- Conventional brakes apply friction to convert a vehicle's kinetic energy into heat. In energy terms, therefore, braking is a total loss: once heat is generated, it is very difficult to reuse. The regenerative braking system, however, slows a vehicle down in a different way.

Regenerative brake

- A **regenerative brake** is an apparatus, a device or system which allows a vehicle to recapture and store part of the kinetic energy that would otherwise be 'lost' to heat when braking.

The IMA operating principle

- This system is especially effective due to the fact that acceleration requires a significantly higher power than needed for cruising on a level road (where vehicles spend most of their time). An engine more powerful than needed has to work under low load most of the time, condition where its efficiency is lower than under high loads, thus worsening the vehicle's fuel economy..

- The electric motor-generator positioned between the engine and transmission assists the engine when accelerating and recovers energy to store in batteries when braking or decelerating (regenerative braking), allowing it to operate independently without the need for a grid power supply.
- When the Civic Hybrid is coasting or its brakes are applied, its electric motor becomes a generator, converting forward momentum (kinetic energy) into electrical energy, instead of wasting it as heat during conventional braking. Energy is stored in a battery pack located behind the rear seat in the trunk. If the state of charge of the batteries is low, the motor-generator will also recharge them while the Civic Hybrid is cruising.

ELEMENTS OF THE SYSTEM

- **1.**Energy Storage Unit (ESU):
- The ESU performs two primary functions
- 1.TO recover & store braking energy
- 2. TO absorb excess engine energy during light load operation
- The selection criteria for an effective energy storage includes
- 1. High specific energy storage density
- 2. High energy transfer rate
- 3. Small space requirement
- The energy recaptured by regenerative braking might be stored in one of three devices: an electrochemical battery, a flywheel, in a regenerative fuel cell.

Regen and Batteries:

- With this system, the electric motor of a car becomes a generator when the brake pedal is applied. The kinetic energy of the car is used to generate electricity that is then used to recharge the batteries. With this system, traditional friction brakes must also be used to ensure that the car slows down as much as necessary
- The Honda Insight is another vehicle in addition to the Prius that is on the market and currently uses regenerative braking. In the Insight there are two deceleration modes: When the throttle is engaged, but the brake pedal is not, the vehicle slows down gradually, and the battery receives a partial charge.
- When the brake pedal is depressed, the battery receives a higher charge, which slows the vehicle down faster. The further the brake pedal is depressed, the more the conventional friction brakes are employed.

Regen and Flywheels:

- In this system, the translational energy of the vehicle is transferred into rotational energy in the flywheel, which stores the energy until it is needed to accelerate the vehicle.
- The benefit of using flywheel technology is that more of the forward inertial energy of the car can be captured than in batteries, because the flywheel can be engaged even during relatively short intervals of braking and acceleration. In the case of batteries, they are not able to accept charge at these rapid intervals, and thus more energy is lost to friction.

. Continuously Variable Transmission (CVT):

- The energy storage unit requires a transmission that can handle torque and speed demands in a steeples manner and smoothly control energy flow to and from the vehicle wheels. For the flywheel the continuously variable transmission and vehicle because flywheel rotational speed increases when vehicle speed decreases and vice versa.

Control System:

- An “ON-OFF” engine control system is used. That means that the engine is “ON” until the energy storage unit has been reached the desired charge capacity and then is decoupled and stopped until the energy storage unit charge fall below its minimum requirement

DESCRIPTION & OPERATION

- **How regenerative braking system works?**
- Regenerative (or Dynamic Braking) occurs when the vehicle is in motion, such as coasting, traveling downhill or braking
- And the accelerator pedal is not being depressed. During “Regent,” the motor becomes a generator and sends energy back to the batteries.
- There are two deceleration modes:
- 1. Foot off throttle but not on brake pedal – in this mode, the charge/assist gauge will show partial charge, and the vehicle will slow down gradually.
- 2. Foot on brake pedal - In this mode, a higher amount of regeneration will be allowed, and the vehicle will slow more rapidly

EXAMPLE

- The Mercury Mariner Hybrid offers a uniquely satisfying transportation choice for an ever-increasing segment of the population concerned about the environment. It's a stylish, upscale sport-utility vehicle with nimble handling and impressive performance, as well as ample cargo and towing capacity. In addition, it's an environmentally conscious SUV with remarkable fuel economy – an estimated 33 miles per gallon (mpg) city, 29 mpg highway – and is expected to meet the cleanest emissions rating achievable by a fossil-fuel vehicle
- Regenerative braking uses the traction motor to assist the four-wheel disc brakes in slowing Mariner Hybrid while simultaneously generating electricity for charging the battery.

Regenerative braking of Toyota Prius:

- Toyota realized that one way to achieve longer vehicle range was to conserve and reuse some of the energy that a vehicle normally loses as heat caused by braking friction. This idea led engineers to apply the principles of regenerative braking.
- the regenerative braking system, the regenerative brake is only responsible for a part of the deceleration necessary to stop the vehicle.
- To maximize fuel economy, of course, the regenerative braking system is made to do as much of the braking work as possible.

Component Used in Toyota Prius for Regenerative Braking System:

- ***Brake Pedal:***

It is used to apply braking force by the driver.

- ***Hydraulic Booster Unit:***

It is composed of the master cylinder and the regulator, responds in two steps. First it signals electronically to the brake ECU that braking force has been demanded. Next, the master cylinder exerts hydraulic pressure on the pedal stroke simulator, and the regulator feeds hydraulic fluid to the hydraulic pressure control unit.

Brake ECU:

The brake ECU senses the braking demand and sends a fraction of this demand to the THSECU for regenerative braking.

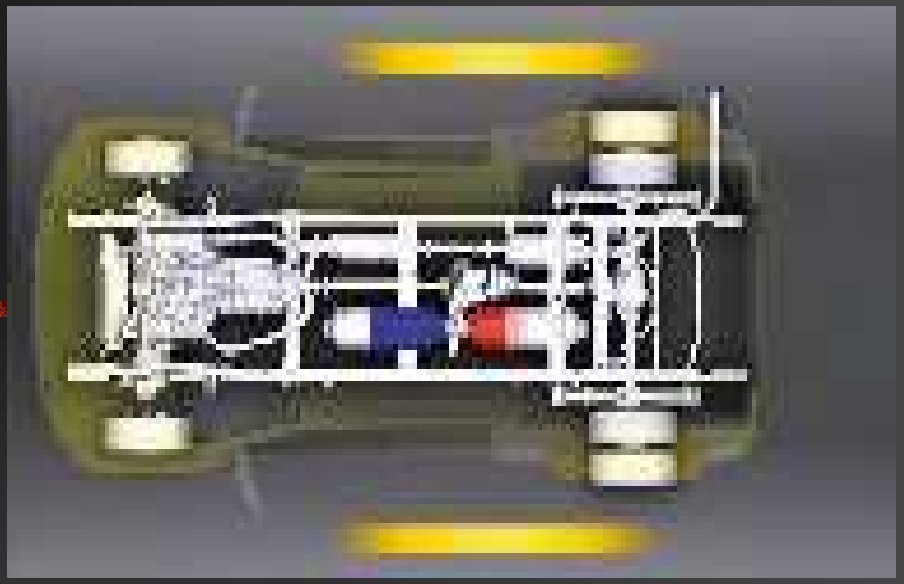
It also calculates the force necessary to fulfill remaining braking demand and instruct the hydraulic pressure control unit to pass on a corresponding amount of hydraulic fluid

- ***Pedal Stroke Simulator:***
- It absorbs an amount of hydraulic pressure from master cylinder that corresponds to the amount of braking force applied by the regenerative braking system.
- As hydraulic pressure is fed back to the pedal, the pedal, the pedal stroke simulator feeds back to the master cylinder.
- ***THS (Toyota Hybrid System) ECU:***
- It induces regenerative braking, and returns a signal that indicates braking force output back to the brake ECU.
- ***Hydraulic Pressure Control Unit:***
- It passes on a corresponding amount of hydraulic fluid to a four way cylinder.

A hydraulic regenerative braking system improves the fuel economy of Ford's F-350 Tonka 25-35% during stop-and-go driving. The system provides power during initial acceleration when demand peaks.

The HLA system consists of a reversible hydraulic pump/motor from Eaton's Fluid Power Group (Eden Prairie, MN) coupled to the drive shaft through a clutch and two accumulators. As the driver steps on the brake, the pump/motor forces hydraulic fluid out of a low-pressure accumulator and into a high-pressure accumulator, increasing the pressure of nitrogen gas stored there to 5,000 psi.

- During acceleration, the HLA system switches from the pump mode to the motor mode, the nitrogen gas forces the hydraulic fluid back into the low-pressure accumulator, and the pump/motor applies torque to the driveshaft through the clutch. If quick acceleration is required, the F-350's diesel engine works with the HLA system



- *The hydraulic launch assist system in the F-350 Tonka functions as a secondary source of energy during peak power demand. It consists of a low-pressure accumulator in blue, and a high-pressure accumulator in red. The system captures energy normally dissipated as heat during breaking, stores it, and uses it later during periods of peak power demand.*

Inertia, Force and Mass

- Everything has inertia; if it has a mass, it has inertia. A hybrid reclaims energy through the fundamentals of physics
- You apply a force to move an object. The equation for this is:
  - F=ma

  "F" being the force, "m" being the mass and
  "a" being the acceleration
- The faster you want an object to accelerate, the more force you have to apply.
- Let's just look at the electric motor for now. Energy from the battery (Watts) is applied to the coil windings in the motor. These windings then produce a magnetic force on the rotor of the motor, which produces torque on the output shaft. This torque is then applied to the wheels of the car via a coupling of gears and shafts. When the wheel turns, it applies a force to the ground, which due to friction between the wheel and the ground causes the vehicle to move along the surface.

Friction in Hybrids

- There is friction everywhere in the hybrid system. There is electrical friction between the atoms and electrons moving in the wires between the battery and the motor and through the motor itself.
- There is magnetic friction in the metal laminations that make up the magnetic circuit of the motor, as well as in the magnets again on the atomic level
- Then, there is mechanical friction between every moving part, such as the bearings, seals, gears, chains and so on. The by-product of friction is heat

- **Frictional Losses in Conventional Cars**
  A standard car generates torque to move the wheels to drive the vehicle down the road. During this time, it is generating friction and losses.
- **Transferring Torque Back to the Motor**
  This inertia is the fundamental property of physics that is used to reclaim energy from the vehicle. Instead of using 100% of the foundation brakes of the vehicle, which are the friction brakes, we now let the linkages back to the motor such as the drive shafts, chains, and gears transfer the torque from the wheels back into the motor shaft

- One of the unique things about most electric motors is that electrical energy can be transferred into mechanical energy and also mechanical energy can be transferred back into electrical energy. In both cases, this can be done very efficiently

- Thus, through the technology of the motor and motor controller, the force at the wheels becomes torque on the electric motor shaft. The magnets on the shaft of the motor (called the rotor—the moving part of the motor) move past the electric coils on the stator (the stationary part of the motor) passing the magnetic fields of the magnets through the coils producing electricity. This electricity becomes electrical energy, which is pumped back to the battery. This, in turn, charges the hybrid battery pack. This is where the comment “regeneration” or “reclaiming energy” comes from.

CONCLUSION

- Theoretical investigations of a regenerative braking system show about 25% saving in fuel consumption.
- The lower operating and environment costs of a vehicle with regenerative braking system should make it more attractive than a conventional one. The traditional cost of the system could be recovered in the few years only.
- The exhaust emission of vehicle using the regenerative braking concept would be much less than equivalent conventional vehicles as less fuel are used for consumption.
- These systems are particularly suitable in developing countries such as India where buses are the preferred means of transportation within the cities.

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Thanks for listening