# Brake System of Hybrid Vehicle

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***Abstract-*** **This article describes the design of the specific regenerative brake system (RBS) developed by Continental for different hybrid vehicles. The system layout and the components are shown Electric Vehicles offer the possibility of fuel saving by regenerative braking, where the electric motor is used as a generator which converts the kinetic energy of the moving vehicle into electric energy when decelerating the vehicle. Special brake systems are needed to entirely exploit the regenerative capability of these vehicles. Electric generator and brake pressure and are capable of regenerative blending between them. In order to improve the energy efficiency of intelligent vehicle equipped with drive-by- wire system and braking safety. The mechanical and electric braking system of intelligent vehicle is analyzed by the theory of vehicle braking stability.**

**Index Terms- Hybrid electric vehicle, regenerative braking, braking systems, fully electric brake system.**

## INTRODUCTION

Now a days the pollution is increasing day by day so the need of the hybrid electric vehicle is increasing. Recently, electric vehicles driven by electric power and the key technology such as control technology and integrative technology have been put into application. It can be foreseen that EV's future will lie on the development of electric, mechanical and control technology. The limitation of driving range is the key restriction for the development of electric vehicles &the technology of storage cells is not in practice and the cost is large, it becomes a checkpoint which restricts the application of Electric Vehicles. Regenerative braking method could increase EV's driving range by 8-25%.

## HYBRID ELECTRIC VEHICLE

Hybrid vehicle uses two or more distinct types of power, such as internal combustion engine to drive an electric generator that powers an electric motor. The basic principle with hybrid vehicles is that the different motors work better at different speeds; the electric motor is more efficient at producing torque, or turning power, and the combustion engine is better for maintaining high speed (better than typical electric motor). There are different types of hybrid vehicle power train configuration.

Hybrid vehicle power train configurations are given below

- Parallel hybrid
- Mid parallel hybrid
- Series- parallel hybrid
- Series hybrid
- Plug in hybrid electric vehicle Parallel hybrid vehicle

In a parallel hybrid vehicle an electric motor and an internal combustion engine are coupled. Most commonly the internal combustion engine, the electric motor and gear box are coupled by automatically controlled clutches. For electric driving the clutch between the internal combustion engine is open while the clutch to the gear box is engaged. While in combustion mode the engine and motor run at the same speed so they can power the vehicle either individually or together.

Mid parallel hybrid
These types use a generally compact electric motor (usually <20 kW) to provide auto- stop/start features and to provide extra power assist during the acceleration, and to generate on the deceleration phase

Series parallel hybrid
In this combustion engine act as generator for charging the batteries. In a power-split hybrid electric drive train there are two motors: a traction electric motor and an internal combustion engine. The power

from these two motors can be shared to drive the wheels via a power split device, which is a simple planetary gear set. The ratio can be from 100% for the combustion engine to 100% for the traction electric motor, or anything in between, such as40% for the electric motor and 60% for the combustion engine. fig 1.1 show the series parallel hybrid electric vehicle

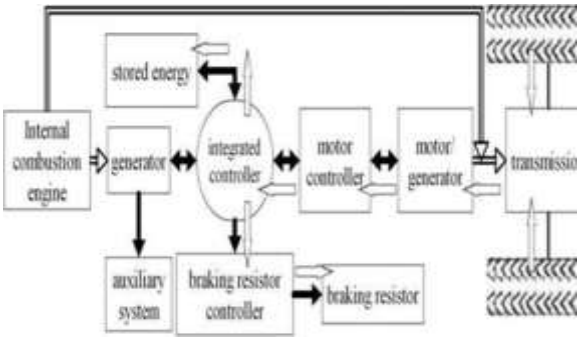



Figure 1.1the schematic of the electrical brake of series-parallel hybrid Electric vehicle.

Series hybrid

A series- or serial-hybrid vehicle is driven by an electric motor, functioning as an electric vehicle while the battery pack energy supply is sufficient, with an engine tuned for running as a generator when the battery pack is insufficient. There is typically no mechanical connection between the engine and the wheels, and the primary purpose of the range extender is to charge the battery.

Plug in hybrid electric vehicle (PHEV)

The plug-in hybrid is usually a general fuel- electric (parallel or serial) hybrid with increased energy storage capacity, usually through a lithium-ion battery,

REGENERATIVE BRAKING

Regenerative braking is an energy recovery mechanism which slows a vehicle or object by converting its kinetic energy into a form which can be either used immediately or stored until needed. In the regenerative braking system, the electronically controlled brake subsystem that directs the braking forces into four wheels independently is indispensable. The regenerative braking systemof the Hybrid Electric Vehicle (HEV) is a key technology that can improve fuel efficiency by 20~50%, depending on motor size.

DESIGN AND ANALYSIS OF REGENATIVE BRAKE

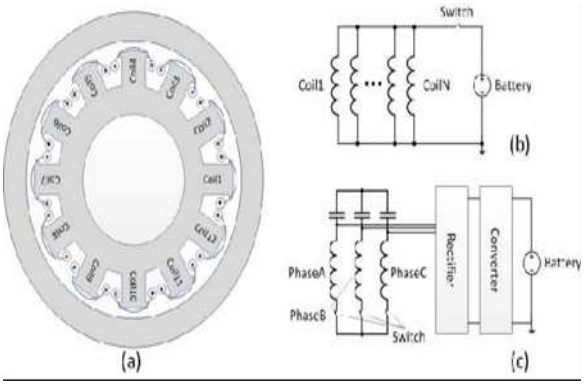
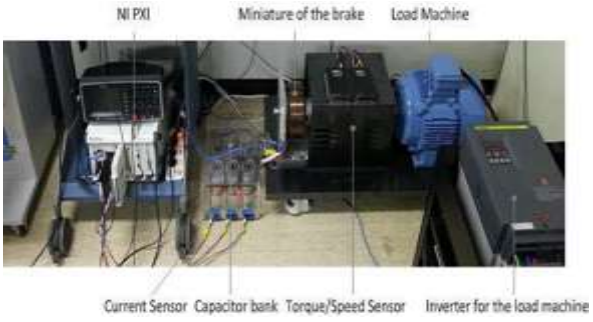



Fig. 1.2 Regenerative electromagnetic brakes. (a) Cross section. (b) Electric Circuit for conventional electromagnetic brakes. (c) Electric circuit for regenerative electromagnetic brakes.

These brakes have the same structure as conventional Electromagnetic brakes but different configurations of their electric circuits. The three-phase windings are Y- connected, and each winding is connected to a capacitor. In addition, ON/OFF switches exist between each winding and capacitor. For energy recovery, a rectifier and a converter are connected between the windings and a battery. The braking torque can be controlled by adjusting the recovered power or rectified voltage.

Fig. 2. Prototype of the miniature model (16 poles and 24 slots).

FIG 2.1 ROTOR




BRAKING SYSTEMS

A. Brake schematic of Series Parallel hybrid electric vehicle.

Depending on the operating conditions and work processes, the electrical brake of the series-parallel hybrid electric vehicle can be divided into two forms, regenerative brake and electric consuming brake. In the regenerative brake process, the electricity generated from the brake process is used to charge the battery. The regenerative brake strength is affected by many factors, such as the maximum allowed working current of motor in generating mode, the maximum charging current and voltage of battery and so on.

B. Operation of electric consuming brake

The electric consuming cooling system related to the electric consuming brake subsystem is designed as part of thermal management system. The schematic of thermal management system under electric consuming brake is shown as Figure 3. The red parts in the picture are the main heat source components in the brake process. In this self-adaptive thermal management system, electric pump and electric fan which can be continuous speed adjusted are applied in light of the system flexible control. Then the active-adjust of the thermal management system can be easily realized.

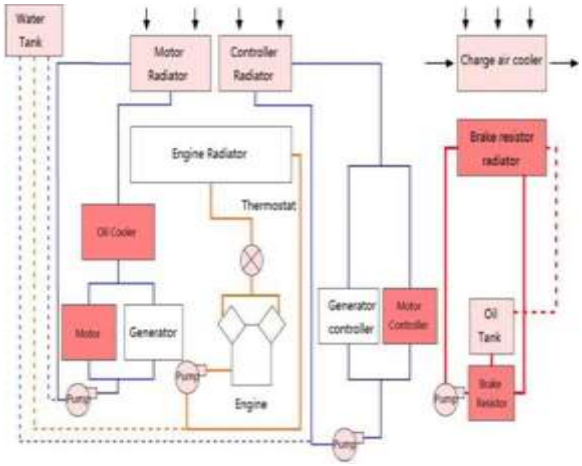



Figure 3. The schematic of the thermal management system with electric Consuming system in electric consuming brake process

In the brake process, when the voltage and SOC of the battery reach to their maximum limitations, the vehicle works in its electric consuming brake mode. In this situation, integrated brake system opens the operating switch to active the brake resistor. Then the brake resistor starts to be charged. The temperature of the brake resistor begins to go up. And then the electric consuming brake cooling system goes to work as the temperature going up. Before this process, the bus voltage of the vehicle should be checked. Then the signal is sent to the integrated controller of the vehicle through the voltage transducer. Compared to the estimated voltage maximum limitation, the integrator unit of the integrated controller should plus one continuously when the measured voltage value is bigger than the calculation value. When the accumulative value exceeds the set value, the brake resistor is active.

COMPOSITION OF FULLY ELECTRIC BRAKE SYSTEM

The braking system consists of the inverter, the Pulse-width modulation (PWM) control unit, the vector control unit, the drive control unit, the speed detection unit. The inverter control

The speed of the motor by converting the DC voltage to AC voltage input through a pantograph.

The PWM control unit makes the gate pulse of the inverter. The PWM control unit adjust the traction motor's input circuits voltage and frequency. The vector control unit receives the motor speed and current signals.

The vector control unit determines the inverter voltage inverter frequency. The drive control unit performs the operation command for acceleration, regeneration and braking.

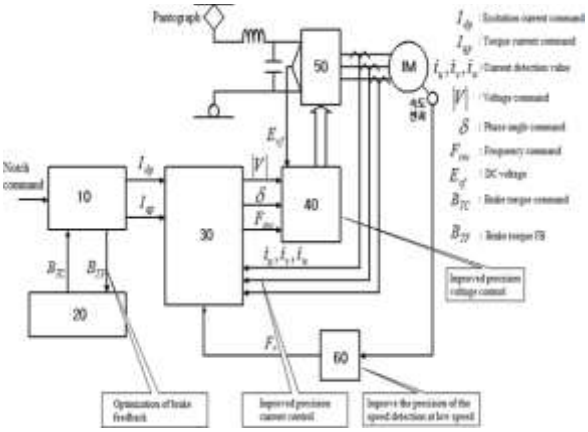



Figure 4. Vector control configuration

The vector control unit receives the motor current detection value and the speed in order to feedback traction power and the speed from the traction motor. And it adjusts the output of the pulse width modulation control unit. The vector control unit performs feedback control of Current and frequency as the vector control in order to respond the reference value of the drive control unit.

## CONCLUSION

The energy-saving, powertrain efficiency and braking stability performance of hybrid electric vehicles depends to a large extent on their regenerative braking strategy.

Regenerative brake is the good braking system use for electric hybrid vehicle and Regenerative braking method could increase EV's driving range by 8-25%.

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## REFERENCES

[1] Jo C, Ko J, Yeo T et al. Cooperative regenerative brake control algorithm for an automatic-transmission based hybrid electric vehicle during a downshift. Proc !MechE Part D: J Automobile Engineering 2012; 226(4): 457-466

[2] L. Wang and C.-H. Lee, "A novel analysis on the performance of an isolated self-excited induction generator," IEEE Trans. Energy Convers.,vol. 12, no. 2, pp. 109–117, Jun. 1997.

[3] Krueger E, Kidston K, Busack A. Reducing disturbances caused by reductions inregenerative brake torque. SAE Paper, 2011-01-0972.

[4] Gao, Y.M.; Chen, L.P.; Ehsani, M. Investigation of the effectiveness of regenerative braking for EV and HEV. SAETrans. 1999, 108, 3184–3190.