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Investigation of Regenerative Braking System of Several PMSM Motor with Vector Controller Applicability in HEV

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ABSTRACT: 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. This study will start with literature review about the Regenerative Braking System (RBS). The basic design and components used in the regenerative braking for current vehicles will also be reviewed. The important components used in RBS will be determined such as electric motor, motor controller and battery. To progress driving ability of electric vehicle, a braking regenerative energy improvement of electric vehicle was designed and the structure of it was introduced, the energy recovery efficiency of whole system was defined and a highly efficient control strategy was put forward. To produce a RBS model, an e-bike conversion kit has been bought from Hong Kong and an alternator was selected to be installed in the bicycle. The results and calculations show that both devices can function properly, that means both devices can form recovery energy to charge battery during braking. During the recovery energy working, brake effects are formed to decelerate the bike. The recovery energy during braking for both devices are taken and compared to found out which one can produce high recovery energy during braking.

Keywords: Energy management, energy storage, vehicles, energy recovery control strategy,

I. INTRODUCTION

As we all know it'll not be able to realize the dream of popularization of cars if only using limited petroleum resources. Therefore, the vital technique to resolve issues is to develop electrical vehicle and it's of great significance [1].

For electrical vehicle its power supply is batteries. The mileage remains a "curse" for development of electrical vehicle. Together of the most important factors to determine the driving mileage, the battery technology has created great development, however because of restriction of technology and economic factors; recently there'll be no big breakthrough. Thus another major issue to reduce energy consumption and improve driving mileage, the analysis of brake energy recovery technology has become standard and braking energy will be up to 500th of the entire energy to drive according to related literature. The driving mileage are increased if the a part of waste energy will be reused [2-4].

The system structure is introduced and therefore the energy recovery is researched, then the energy recovery control strategy is suggests. Finally, the control strategy is simulated in ADVISOR2002 simulation platform and therefore the result is evaluated.

A. General Structure of an Hybrid Electric Vehicle

An Electric vehicle can be operated by using only an electric source like battery or it can also have a structure of a combustion engine parallel to the electric motor. Such a type of vehicle is known as Hybrid Electric Vehicle. HEVs give us an option of switching between the conventional IC engine and the electric motor setup. Either the battery or the gasoline engine runs the transmission and operates the motors of the vehicle. An electric vehicle can have either ac or dc motors. For ac motors, an inverter changes dc voltage of the battery to ac voltage before giving it to the motor. The gear structure of an electric vehicle remains same as a conventional vehicle to provide both variable speed and variable torque to the vehicle. The battery is the power source for the electric vehicle and after using the vehicle, the battery is then charged at the end of the day. Charge in the battery determine the travelling distance and hence the mileage of the electric vehicle. The battery may take a few hours to charge but gives sufficient energy for our general day to day travelling needs. An ICE vehicle can also be converted into an electric vehicle.

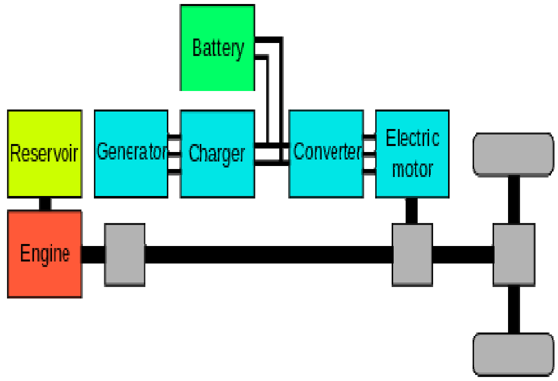

Fig. 1. General structure of HEV.

This involves changing the engine from ICE to an electric motor to run the vehicle. Though the initial conversion cost may be incurred, it is beneficial and cost effective to the user and better for the environment.

II. THEORY

A. Regenerative Braking Systems

Regenerative braking refers to a procedure in which a segment of the kinetic energy of the vehicle is store 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. A lorry on the momway could travel 100 miles between stops. This represents little saving even if the efficiency of the system is 100%. 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.

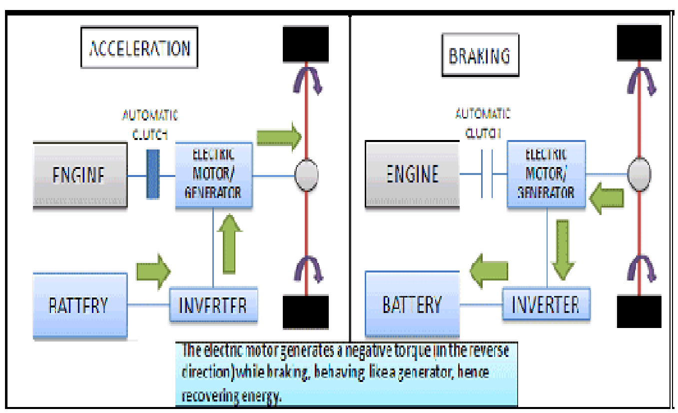

Fig. 2. Working of Regenerative Braking.

While regenerative braking outcome in an enhance 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.

B. Applications of Regenerative Braking Systems

- For recovering Kinetic energy of vehicle lost during braking process.
- One theoretical application of regenerative braking would be in a manufacturing plant that moves material from one workstation to another on a conveyer system that stops at each point.
- Regenerative braking is used in some elevator and crane hoist motors.
- Regenerative Braking Systems are also used in electric railway vehicle (London Underground & Virgin Trains).

III. METHOD

This HEV has 2 varieties of motive power sources: an electrical motor and an internal combustion engine (ICE), so as to extend the drive train efficiency and reduce pollution. It combines benefits| of the electrical motor drive (no pollution and high accessible power at low speed) and therefore the advantages of an internal combustion engine (high dynamic performance and low pollution at high speeds).

A. Electrical Subsystem

The electrical subsystem handles onboard circuitry, interfaces with sensors and the main processing board. The team adheres to certain norms while building these systems - including labeling of all parts, modularity of design (so that everything can be taken part and attached via a serial bus). This will serve two purposes - ease of understanding of the hardware (similar to the use of commenting in code) for an interested third party, and to ease future troubleshooting. All circuit diagrams shall be put on the site for scrutiny by third parties (unless MSI decides to protect it as IP, in which case it will be made public after necessary protection has been sought). We appreciate any comments and suggestions by interested parties.

The Electrical Subsystem is composed of four parts: The electrical motor, the generator, the battery, and the DC/DC converter.

- The electrical motor is a 500 Vdc, 50 kW interior Permanent Magnet Synchronous Machine (PMSM) with the associated drive (based on AC6 blocks of the Sim Power Systems Electric Drives library). This motor has 8 pole and the magnets are buried (salient rotor's type). A flux weakening vector control is used to achieve a maximum motor speed of 6 000 rpm.
- The generator is a 500 Vdc, 2 pole, 30 kW PMSM with the associated drive (based on AC6 blocks of the SimPowerSystems Electric Drives library). A vector control is used to achieve a maximum motor speed of 13000 rpm.
- The battery is a 6.5 Ah, 200 Vdc, 21 kW Nickel-Metal-Hydride battery.
- The DC/DC converter (boost type) is voltage-regulated. The DC/DC converter adapts the low voltage of the battery (200 V) to the DC bus which feeds the AC motor at a voltage of 500 V.

B. Vector-controller

The previous control strategies good steady-state but poor dynamic response oscillation resulted from the air gap flux. Vector control (field-oriented control) is related to the phasor control of the rotor flux. Vector control, also called field-oriented control (FOC), is a variable-frequency drive (VFD) control method in which the stator currents of a three-phase AC electric motor are identified as two orthogonal components that can be visualized with a vector. FOC is used to control AC synchronous and induction motors.

C. Planetary Gear Subsystem

The planetary gear scheme models the facility split device. It uses a planetary device that transmits the mechanical driver from the engine, the motor and also the generator by allocating and mixing them.

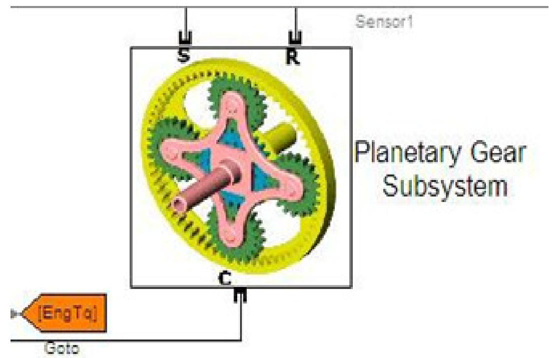

Fig. 3. Planetary Gear Subsystem.

D. Internal Combustion Engine

The Internal Combustion Engine scheme models a 57 kW @ 6000 revolutions per minute gas fuel engine with speed governor. The throttle signaling lies between zero and one and specifies the torque demanded from the engine as a fraction of the most potential torque. This signal additionally indirectly controls the engine speed. The engine model doesn't embody air-fuel combustion dynamics.

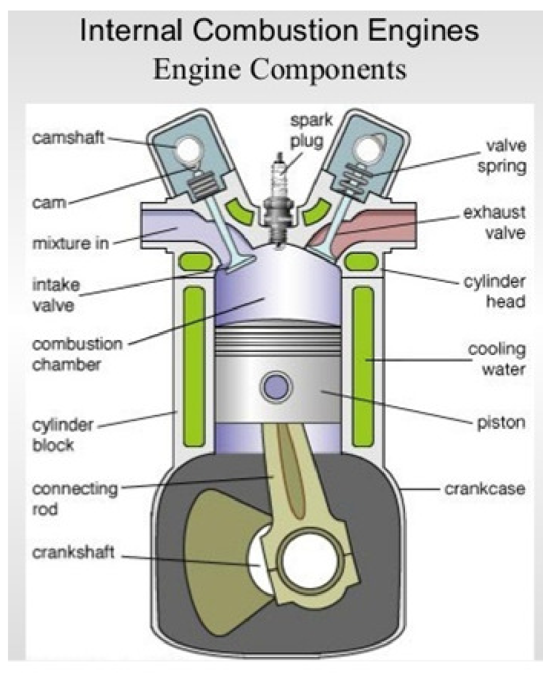

Fig. 4. Internal combustion engine.

The internal combustion engine is an engine within which the burning of a fuel happens during a confined house known as a combustion chamber.

This exothermic reaction of a fuel with an oxidizer creates gases of high temperature and pressure that are permissible to expand. The defining feature of an internal combustion engine is that useful work is performed by the increasing hot gases acting on to cause movement, as an example by performing on pistons, rotors, or maybe by pressing on and moving the whole engine itself.

IV. RESULT

The simulation results related to Hybrid Electrical Vehicle (HEV) and its related term is shown in the below figures, all the terms like speed, torque, power and accelerator is summarized in this chapter and represents relevant graph with it. In figure 5 display the car properties like accelerator and other vehicle dynamics like speed of car torque of drive in two forms one in reference form and another is measured form, and Electrical power of motor, Generator and battery. In above figure 6 Planetary Gear System shows its sub module of speed of different module like carrier speed of ICE, Ring Speed of motor, Sun speed of generator and Planet speed all speed should be measured in rad/s.

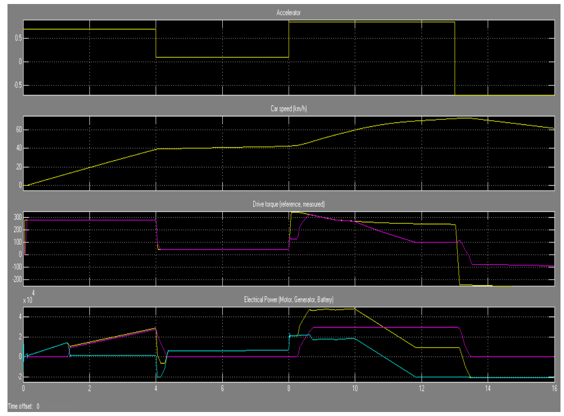

Fig. 5. Accelerator and power of motor and electric power representation.

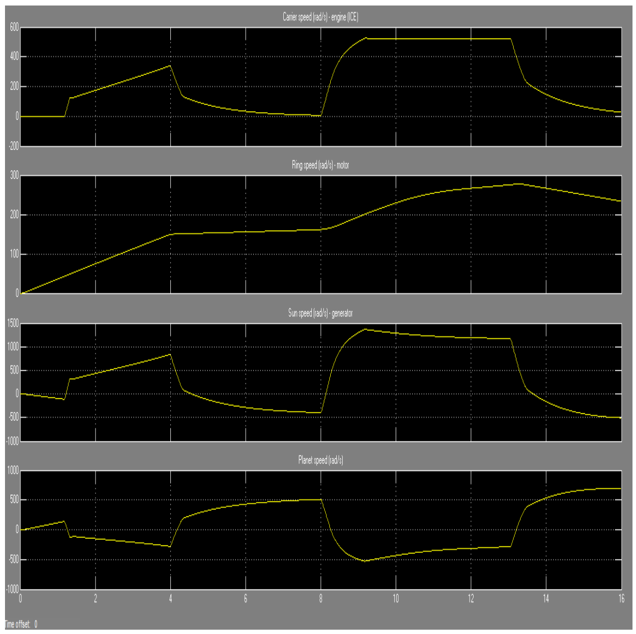

Fig. 6. Sub module of Planetary Gear system with representation of Speed of different module.

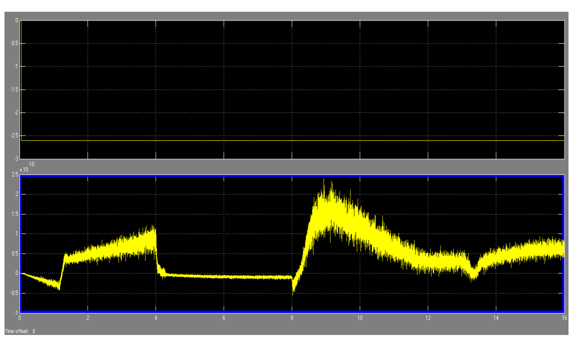

Fig. 7. Planetary gear final results.

Figure 7 shows the final output result of Planetary gear system which is shown in two parts upper part shows the will relation output and lower half shows combination of ICE engine power generator power and motor power. Figure 8 shows the power output of Planetary gear system which is subdivided into three form ICE power, Generator Power and Motor power, all power should be measured in watts. Figure 9 shows the torque generated in the planetary gear system, which is subdivided into four forms ICE torque, Motor Torque, Generator torque and torque of planet.

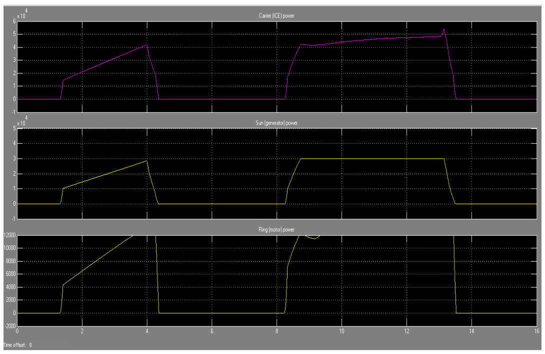

Fig. 8. Power of Planetary gear system.

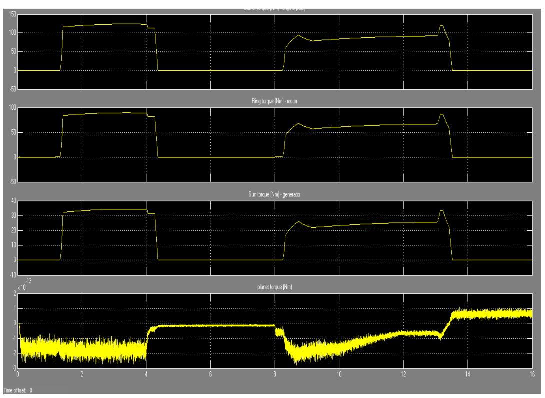

Fig. 9. Torque of Planetary gear system.

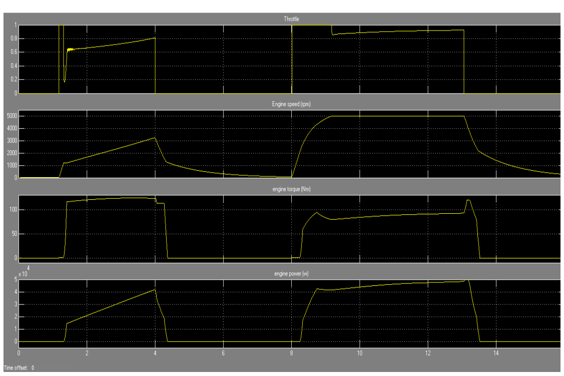

Fig. 10. ICE Throttle and engine end parameters output.

In above figure Internal combustion engine terms like throttle and engine parameter are shown, it is shown throttle power, engine power, engine speed and engine torque.

V. CONCLUSION

The lower operating and surroundings prices of a vehicle with regenerative braking system ought to create it a lot of attractive than a standard one. The standard value of the system may be recovered within the few years only. The exhaust emission of auto using the regenerative braking conception would be a lot of but equivalent standard vehicles as less fuel are used for consumption. These systems are significantly appropriate in developing countries like India wherever buses are the preferred means that of transportation within the cities. Regenerative braking could be a little, however important, step toward our eventual independence from fossil fuels.

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