Energy Management in Hybrid Electric Vehicle (HEV)

Abstract

The excessive use of vehicles these days has led to the depletion in fossil fuels and increase in the level of pollution which has led to the climate crisis. The impact of pollution cause by the vehicles on the environment is making choose more eco-friendly ways of transportation which is the use of hybrid vehicles. Hybrid vehicles involves the use of both electricity and fossil fuel to power the vehicle. In the last couple of years, the introduction of electric motors to make the vehicles hybrid has seen a positive impact on the performance and the reduction in the emission. This paper highlights the introduction of new braking system found in Electronic Stability Program (ESP) that help us to improve fuel consumption in hybrid vehicles and the ways to improve the efficiency of existing vehicles just by replacing some mechanical parts. Earlier electric motor for energy conservation in regenerative braking was only used in front wheel which has shown positive outcomes, but no one used electric motor on rear axle which is also discussed below and its impact it made on energy conservation for HEVs.

Introduction

The increase in the demand and the depletion in the level of fossil fuels has seen a rapid increase in the fuel prices across the globe. The awareness about the pollution and the effects of burning fossil fuels among the younger generations has seen an exponential raise in the demand for more hybrid electric vehicles. This in return has the pressure on modern day engineers and the manufacturers to come up with better solutions. A hybrid electric vehicle (HEV) is combination of two sources of energy: an electric motor which runs by battery and internal combustion engine (ICE). As the vehicle has two sources of energy flow it has always interested researcher. In HEVs the battery inside vehicle is charged through the engine (which runs on fuel) and regenerative braking during de-acceleration of the vehicle [1].

A regenerative breaking is a mechanism for energy recovery which converts the kinetic energy into electric energy and this energy can be stored and used whenever needed. One of advantage of regenerative braking over conventional braking system is when kinetic energy is converted to thermal energy by friction the energy can be converted and stored and used to run the electric motors or any electrical and electronic devices in the vehicle [2].

The HEV is based on either electrical variable transmission (EVT) or continuous variable transmission. The reasons for using electrical variable transmission in hybrid vehicle is its capability to deliver higher efficiency and has much lower maintenance [3]. The research on energy management system (EMS) is divided into 2 categories that are, rule - based energy management strategy and optimal energy management strategy. This paper majorly focuses rule – based energy management strategy [4].

Literature Review

The researchers introduced the control strategy of regenerative braking system (RBS) in electric variable transmission (EVT) in HEV to reduce energy consumption. Figure 1 below shows a structure of EVT – HEV. Reduction of energy consumption is done by using rule - based strategy in two modes engine-motor coordinating braking mode (EMCB) and dual motor braking mode (DMB). First in EMCB mode the engine keeps on operating in the optimal state and energy can be transmitted into the battery during regenerative braking process. In EMCB one of the electric motors (EM1) is not

used because to keep engine in idle state and another electric motor (EM2) is used by which it reduced the fuel efficiency of vehicle by 46. 1% compare to existed control strategy in which the engine use to disengaged and all the energy got wasted. In DMB mode both the motors are fully utilized by which motors quickly respond to torque change. By these quick responses system improved system operating coordination and increased the energy recovery efficiency by 11.9% compared with the existed control strategy in which only EM2 is utilized [5].

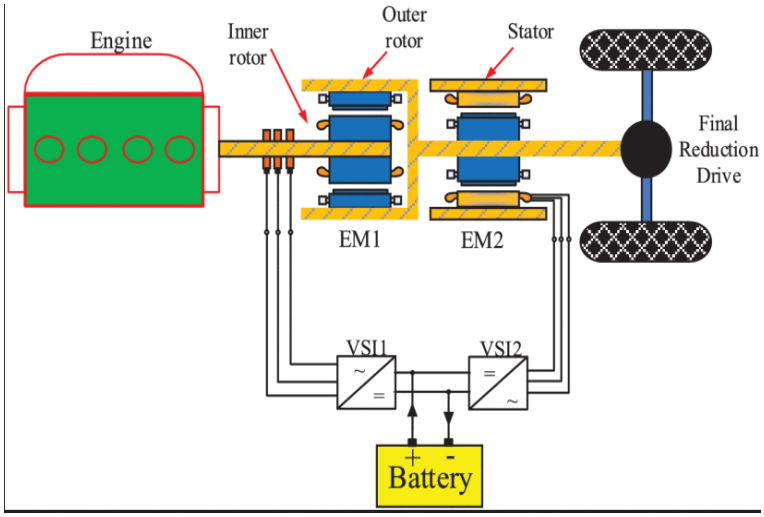

Figure 1: Structure of EVT – HEV

The researchers proposed a method to recover more energy in the process by introducing motor control on the on the rear axle and using a control strategy of distributing of braking force to the front and rear wheels. Distribution of force was possible by electronic control unit (ECU) and fuzzy inference system. By this control strategy simulation result showed that regenerative braking was able to achieve y up to 28.29% energy recovery [6].

The introduction of modern control techniques and microcontrollers has paved the way to make vehicles more efficient and much easier to drive by eliminating the clutches. This breakthrough as seen majority shifting from conventional manual transmission system to automated manual transmission (AMT). Some researchers proposed that by the appropriate downshifting of gear in automated manual transmission (AMT) in regenerative braking process the energy conservation increased by 10.5% - 32.4%. It is also observed that lower gear position usually recovers more energy, and this happens in three steps. First, the electric motor reduces its torque to zero and simultaneously hydraulic brake system compensate the braking torque. After the torque reduction AMT downshift, the gear. Finally, electric motor recovers its torque. By this smooth downshifting no mechanical losses takes place [7].

The researchers stated that using the regenerative braking system is the key technology which can not only improve fuel efficiency by 20% – 50% but also improves the vehicle safety and performance. The performance of the vehicle is improved by the introduction of Electro - Mechanical Brake (EMB) system technology. In this system we replace the conventional hydraulic braking systems with electrical components like electric calliper and electro – mechanical discs. This system delivers a large breaking force with an application of minimal brake pedal force which makes it braking effortless, remarkably durable and deliver impressive efficiency. Figure 2 below shows a schematic diagram of an electro-mechanical braking system.

Today's technology allows us to work on the simulation environment, with the help of such a software called MATLAB and Simulink the simulations have been carried out and the results have been promising to deliver higher charging state of the batter even while decelerating. The other advantage of this system is it helps to simplify production of right as well as left hand drive vehicle variants by which complexity for designing product for another variant is reduced [8].

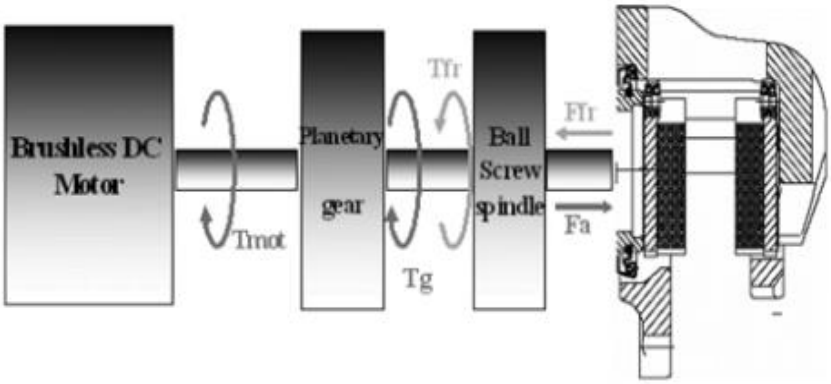

Figure 2: Schematic Diagram of EMB System

Reasearch Gaps

As all the researches on this braking technology was carried on simultation environment the actual results in the real world might vary depending the conditions like:

- Different road conditions, like hilly regions which requires a lot more energy to generate the force required to create the motion. How much energy will be recovered at that point?
- The driving styles varies for person to person, the learners tend to use the breaks more often when compared to teh experts which has a greater impact on the volume of fuel consumed.
- Continuous use of brakes in the traffic results in heating up the brake pads but there is nothing much done about harnessing that thermal energy for regenerative use.
- The physical and the chemical state of the battery in the vehicle also plays a important role in the efficiency.
- The current researches on this braking system have failed to conider the most popular braking system used today which is anti-lock braking system (ABS). The safety of vehicle is questionable as none shown impact on ABS (Anti – lock braking sytem) so there a possibility while braking the wheel get lock and driver will not able to the steer wheels to saferty refer to Figure 3 [9].

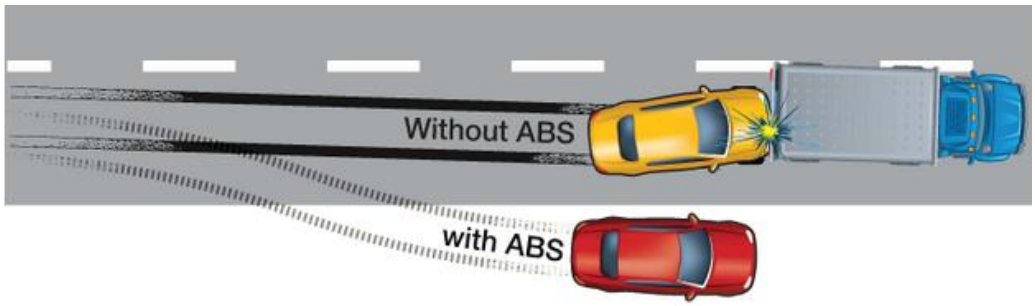

Figure 3. Comparison of vehicle with ABS and Without ABS

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