Hybrid Electric Vehicle using PI PD Controller

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Abstract— This paper deals with the increasing oil price and mounting environment concerns, cleaner and sustainable energy solutions have been demanded. At present transportation constitutes a large portion of the energy consumed and pollution created. One of the efficient solutions is the existence of vehicle that works on both fuel energy and electrical energy with optimized performance. HEV with different structures such as series, parallel, series parallel has been studied so far. HEV is consists of mainly two design elements mechanical and electrical. Mechanical design part includes ICE Car Dynamics while Electrical part includes Controller Design and Electrical Subsystem. This dissertation work especially focuses on the controller design of HEV. HEV control section includes four different rudiments to be controlled. These are engine speed controller generator controller motor controller and battery controller. This paper considered design of proportional integral (PI), proportional derivative (PD), proportional integral derivative (PID)for analysis of engine, motor and generator performance This leads to the development of component models of the physical system such as the power distribution system and mechanical driveline. In this paper work design of electrical part i.e. control design and ESS design has been carried out. The designed SPHEV has been analysed with the step change accelerator profile for the PI, PD, PID using performance measures such as rise time settling time peak time and peak overshoot.

Key words: Electric Vehicle, Hybrid Electric Vehicle, MATLAB Modeling, Control Vehicle

I. INTRODUCTION

In recent years a major interest in HEV has arisen globally because of pressing environmental concerns and skyrocketing price of oil. Representing a revolutionary modification in vehicle style philosophy hybrid vehicles surfaced in many various ways. However they share the hybrid power train that combines multiple power sources of different nature including conventional ICE, batteries, ultra-capacitors, or hydrogen FC. These vehicles with on board energy storage devices and electric drives allows braking power to be recovered and ensures the ICE to operate only in the most efficient mode thus improving fuel economy and reducing pollutants.

The United Nations estimated that over 600 million individuals in populated area worldwide were exposed to traffic generated air pollution. So traffic connected air pollution is drawing increasing concerns worldwide. Hybrid electric vehicles hold the potential to significantly scale back GHG emission and different gas pollution. A fuel cell HEV which only produce water and heat as emissions during operation makes pollution more controllable by centralizing GHG emission and air pollution to the hydrogen production method at giant scale producing facilities. ICE based hybrids on the opposite hand, will improve the fuel economy and reduce tailpipe emission by additional economic engine operation. The improvements come from regenerative braking motion down the ICE whereas stationary and permitting a smaller more efficient engine that isn't needed to follow the power at the wheel as closely as the engine in a conventional vehicle must. In an emission result comparison of the Toyota (HEV) and Toyota Corolla it was reported that the only produced 71% of CO2, 4% of CO and 0.5% of compared with the Toyota Corolla. The Corolla is one of most effective typical vehicles on the market.[1]

II. HEV CLASSIFICATIONS

One of the most common ways to classify HEV is predicated on configuration of the vehicle drive train. During this section three major hybrid vehicle architectures introduced are series, parallel and series parallel. Until recently several HEV in production are either series or parallel. In terms of mechanical structure these two are primitive and comparatively simple. A series parallel power train brings in more degrees of freedom to vehicle engine operation with added system complexity.

A. Series Hybrid Configuration

One of the basic types of HEV is series hybrid. In this configuration the ICE is used to generate electricity in a generator. Electric power produced by the generator goes to either the motor or ESS. The hybrid power is summed at an electrical node the motor. Early on in the latest development of the hybrid vehicle many automotive OEMs explored the likelihood series hybrid vehicle. Some of the most notables are the Volvo ECC and BMW 3 Series. Despite the early research and prototypes the possibility for series hybrids to be ordinarily employed in transport applications looks to be remote. The series hybrid configuration tends to have a high efficiency at its engine operation. However the summed electrical mode has tied up the size of every component. The weight and cost of the vehicle is increased due to the large size of the engine and the two electric machines needed. The dimensions of the power electronic unit is additionally excessive. The configuration of fuel cell HEV is also technically in series.

B. Parallel Hybrid Configuration

The parallel hybrid is another HEV type that has been closely studied. In parallel configurations each the engine and also the motor provide traction power to the wheels which suggests that the hybrid power is summed at a mechanical node to power the vehicle. As a result, each of the engine and also the motors can be down sized creating the parallel architecture more viable with lower prices and better efficiency.

The parallel hybrid vehicles usually use the constant gearboxes of the counterpart standard vehicles either in automatic or manual transmissions. Based on where the gearbox is introduced in the power train there are two typical parallel HEV architectures named pre transmission parallel and post transmission parallel respectively.

In a pre-transmission parallel HEV the gearbox is located on the most drive shaft after the torque coupler. Thence gear speed ratios apply on each the engine and also the electric motor. The power flow is summed at the gearbox. On the other hand in a post transmission parallel hybrid the gearbox is located on the engine shaft prior to the torque coupler. The gearbox speed ratios only apply on the engine.

C. Series Parallel Configuration

In the series parallel configurations the vehicle can operate as a series hybrid a parallel hybrid or a combination of both. This design depends on the presence of two motor generators and the connections between them which may be each electrical and mechanical. The mechanical connections between the engine and electrical machines are sometimes accomplished by planetary gears called as PSDs.

One advantage of a series parallel configuration is that the engine speed can be decoupled from the vehicle speed. This advantage is partially offset by the additional losses within the conversion between mechanical power from engine and electrical energy. There are a unit variety of variations of series parallel configurations. A most renowned one is the Toyota THS design that was first used on a Toyota. Today, most hybrid vehicles at the production stage have been either of parallel or series configuration, as the series parallel design is a smaller amount mature in its development. But review of the literatures from both academic and commercial sources reveals that the present state of the art of hybrid technology employs the series parallel configuration [2],[3]

III. Hybrid electric vehicle design

A diagram of one possible HEV architecture is shown in Figure1 the arrows represent possible power flows. Designs can also include a generator that is placed between the power splitter and the battery allowing excess energy to flow back into the battery conceptually the hybrid electric vehicle has characteristics of both the electric vehicle and the ICE vehicle. At low speeds it operates as an electric vehicle with the battery supplying the drive power. At higher speeds the engine and the battery work together to meet the drive power demand the sharing and the distribution of power between these two sources are key determinants of fuel efficiency.

Note that there are many other possible designs given the many ways that power sources can work together to meet total demand.

IV. Design steps

The key problems in HEV design are typical of classical engineering issues that involve multilayer, multi domain compleness with tradeoffs. Here we have a tendency briefly the key aspects of the part design.[4]

A. Engine Design

The key parts of engine design are very similar to those of a traditional ICE. Engines used in an HEV are typically smaller than that of a traditional vehicle of the similar size and the size selected will depend on the total power needs of the vehicle.

B. Battery Design

The main concerns in battery design are capacity, discharge characteristics and safety. Traditionally a higher capacity is associated with increased in size and weight. Discharge characteristics determine the dynamic response of electrical components to extract or supply energy to the battery.

C. Motor

Motors generally used in HEV systems are DC motors, AC induction motors, or PMSM. In this list the PMSM has the highest power density and the DC motor has the lowest.[5]

D. Power Splitter

A planetary gear is an effective power splitter that allows power flows from the two power sources to the driveshaft. The engine is typically connected to the sun gear while the motor is connected to the ring gear.

V. Vehicle dynamics

The focus is on friction and aerodynamic drag interactions with weight and grade ability factors accounted in the equations. Following parameters has been considered so far has the design of the HEV has been concerned. The parameters are for motor, generator, controller and vehicle dynamics etc.

VI. Summary

In this paper described simplified model of SPHEV during which we have focused on different parts such as vehicle dynamics electrical subsystem and energy management system. In this chapter we have also enlightened controllers such as PI, PD and PID in brief used for speed control of SPHEV. It can be noted that modelling and simulation will play important roles in the success of HEV design and development.

In this paper PI, PD, PID control for engine has been investigated. The main aspect is maximizing the vehicle's energy capture during the braking process. Finally sustaining the SOC of the battery is adopted by a robust controller of the ICE. The controllers have been designed by considering speed of vehicle as main constraint. The vehicle's performances have been analyzed for given accelerator profile.

The simulation results show that world control system is effective to regulate the engine operating points within the highest efficiency region, exploiting of machines for capturing most braking energy as well as to sustain the SOC of the battery while satisfy the drive ability. The proposed management strategy for the studied HEVs sounds interesting than the conventional strategies PI, PD and PID controller and is possible as supported by a large amount of simulation results.

VII. Conclusions

Following conclusions can be drawn from this paper.

1) In this paper how the complications arise from the complex interaction between various mechanical and electrical components i.e. engine battery electric machines controllers and vehicle mechanics and complications get removed by using HEV.

2) In this paper conclude that the efficiency, fuel consumption and pollution is reduced by using HEV.

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