Review of Design and Development of Hybrid Two Wheeler

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Abstract— In, Asia two wheeler are popular mode of transportation to a large group of people because of there relative affordability and ability to maneuver in heavy city traffic. However the rate of fuel consumption and emission contribution by them, especially in urban areas need more attention to improve sustainability of energy and air quality. Recently plug-in hybrid technology has been emerged as one of the most promising alternative in reducing petroleum consumption and emission.

Key words: Hybrid Two Wheeler, BLDC Hub Motor, Battery drive, Drive Controller, IC Engine

I. INTRODUCTION

Around 93% of today's automobiles run on petroleum based product, which are estimated to be depleted by 2050[1]. Moreover, current automobiles utilize only 25% of the energy released from petroleum and rest is wasted into the atmosphere[2]. Despite recent efforts to improve fuel efficiency and reduce toxic emissions in cars, emissions have continued to increase steadily in the past two decades. For preservation of gasoline for future and increasing the efficiency of vehicle an electric vehicle can be a major breakthrough. An electric vehicle is pollution free and is efficient at low speed conditions mainly in high traffic areas. But battery charging is time consuming. Moreover, it cannot provide high power required by drives during high speed conditions or in slopes of hilly areas. Gasoline engine proves its efficiency at higher speeds in high ways and waste a lot of energy in urban areas. A hybrid vehicle solves these problems by combining the advantages of both the systems and uses both the power sources at their efficient conditions. The objective of this project aims at better utilization of fuel energy and reduces dependence on non-renewable resources using latest technology. The implementation involves development of HEV that uses battery as well as gasoline power for propulsion of vehicle[1].

The project discloses a hybrid system consisting of an Electric and Internal Combustion(IC) based power drives. The front wheel is being propelled by battery and the rear wheel is powered by gasoline, i.e, it includes a single cylinder, air cooled internal combustion engine and a BLDC motor based electric power drive used for hybrid powering of the vehicle[2]. The controller is designed to implement the switching between IC Engine and Electric motor depending on the power requirement and load conditions. Many a literature are used to carry out the project which includes notes on HEVs, electric drives, energy management, batteries, internal combustion engine, etc[1].

A hybrid electric vehicle (HEV) is a type of hybrid vehicle and electric vehicle that combines a conventional internal combustion engine (ICE) system with an electric propulsion system (hybrid vehicle drive-train). The presence of the electric power-train is intended to achieve either better fuel economy than a conventional vehicle or better performance. There is a variety of HEV types, and the degree to which each functions as an electric vehicle (EV) also varies. The most common form of HEV is the hybrid electric car, although hybrid electric trucks (pickups and tractors) and buses also exist[1].

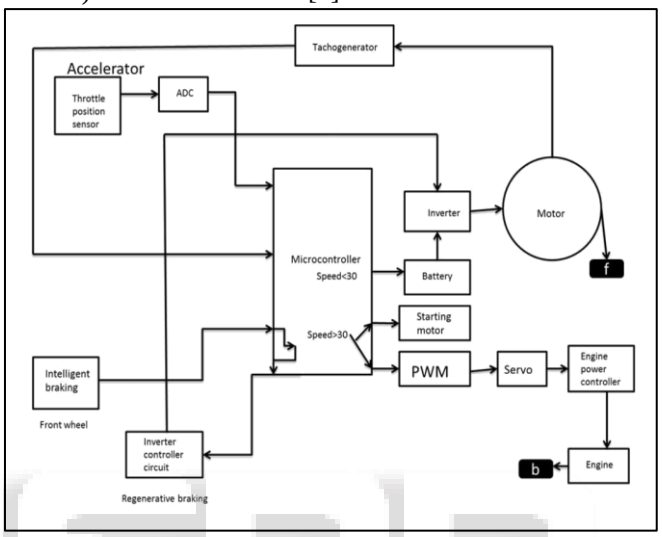

Fig. 1: Schematic diagram of hybrid-vehicle[1]

II. LITERATURE REVIEW

A. Design Of Hybrid Electric Vehicle by Toshali Mohanty[1]

The vehicle at lower speed act as front wheel drive and at high speed gets switched to rear wheel drive automatically. There is no need for any gear reduction since the torque produced is sufficient enough to drive the vehicle. The axle of the motor is connected to the suspension. Suspension is connected to the handle which is connected to the main chassis. A microcontroller powered up from battery, performs the switching from electric to internal combustion or vice versa as per the requirement. It senses throttle position and controls the hub motor speed via controller circuit and the IC Engine via servo motor to control speed of rear wheel. CVT is connected to the crank shaft of the engine to avoid any shocks while switching and it makes the controlling simpler and easier[1].

B. Battery

There are six major rechargeable batteries available today. They are as follows: lead-acid (Pbacid), nickel-cadmium (NiCd), nickel-metal hydride (NiMH), lithium-ion (Li-ion), lithium polymer (Li-poly), zinc-air [1].

1) Vehicle Design

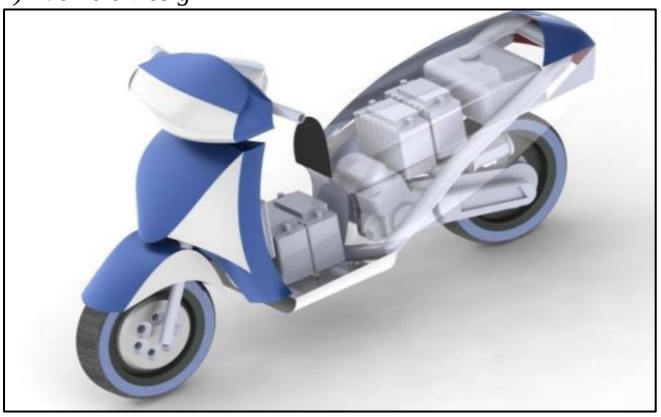

Fig. 2: Transparent body frame isometric view[1]

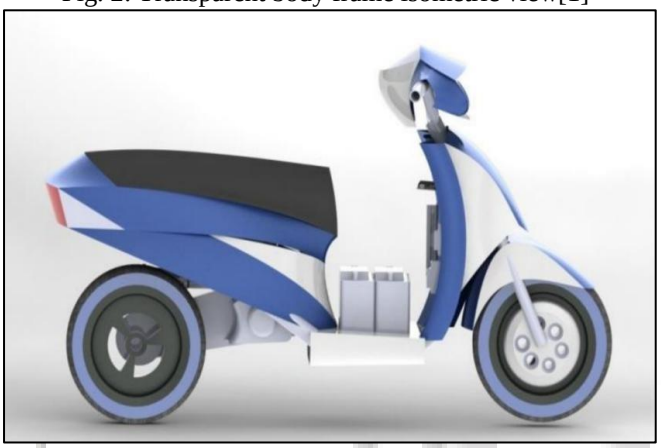

Fig. 3: Side Rendered View[1]

Evaluation of energy requirements for all-electric range of plug-in hybrid electric two- wheeler by Shaik Amjad, R.Rudramoorthy, P.Sadagopan, S.Neelkrishnan[2]

The electric range of plug-in hybrid electric vehicle technology has the potential to displace a significant portion of petroleum consumption. An analytic vehicle model and MATLAB simulation model has been discussed for plug-in hybrid electric two-wheeler, for sizing of electric power-train components and evaluation of battery energy and power requirements. The impact of driving cycle and all-electric range on energy capacity, additional mass and initial cost of batteries has been analyzed. The driving cycle (Indian driving cycle) has marginal influence on the peak power demand, but the estimated energy capacity increases 5-6.5% times at IDC compared to ECE R40. For ECE R40, the battery pack weighs around 23-25% low, and hence, the initial cost also 24-25% low compared to IDC. For the desired AER, the initial cost of Ni-MH batteries seen to be on the higher side, however, if the battery cycle life is considered into account, the annual cost is 62% lower than lead-acid and 33% lower than Li-ion batteries. As the two-wheeler contribute two-third of the total vehicle population in India, the implementation of plug-in hybrid concept in these vehicles will lead to dramatic reduction of petroleum consumption and helps to achieve national energy security in the near future[2].

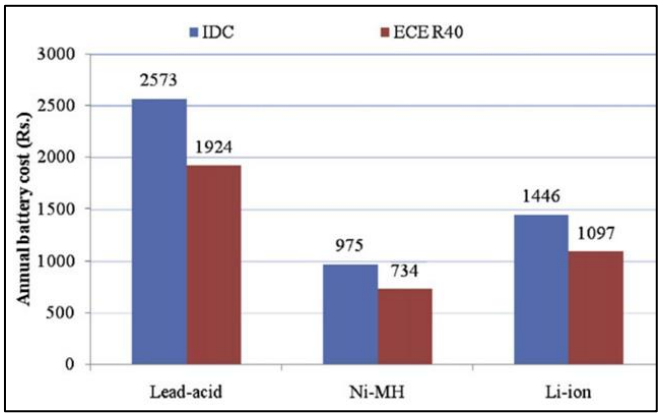

Fig. 4: Annual battery cost (Rs.) for AER-25[2]

Energy consumption and cost analysis of hybrid electric powertrain configurations for two wheeler by Paul D. Walker, Holger M. Roser[3]

For a compact HEV powertrain, where efficiency, capital costs and ongoing maintenance costs are all considered as important factors in selection of a particular configuration, it is considered that the series configuration not requiring a power-splitting transmission but needing a larger traction motor outweighs other benefits of other HEV configurations. This can be realized, where series–parallel powertrains are developed for hybrid scooters. One may consider the complexity introduced in these parallel type powertrains, and how this will impact on upfront and maintenance costs. Alternatively, a series type configuration, whilst requiring a larger motor, and potentially generator, benefits from greatly reduced mechanical complexity, overcoming some issues raised in . Thus, making it suitable to compact and cost effective powertrains[3].

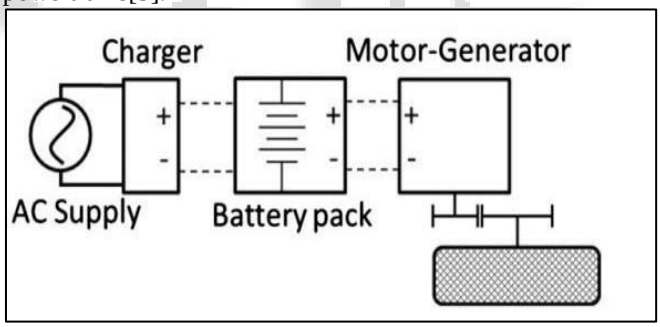

Fig. 5: Pure electric vehicle [3]

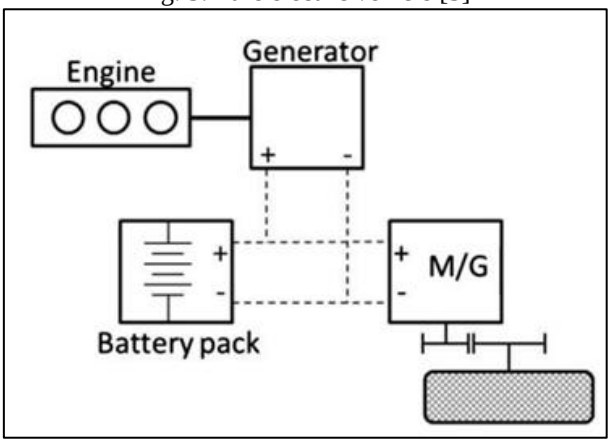

Fig. 6: Series hybrid electric vehicle [3]

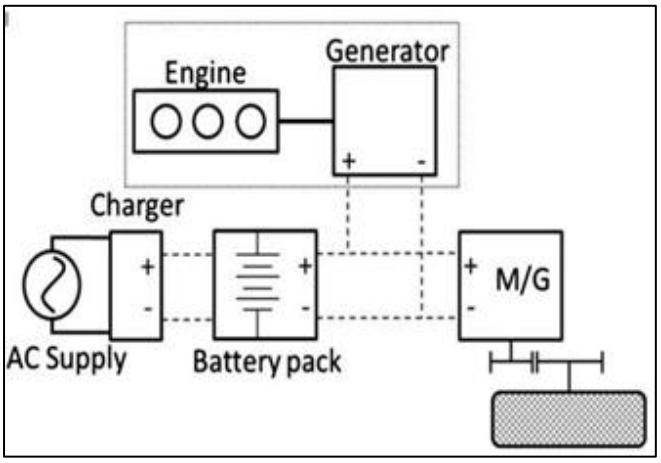

Fig. 7: Series plug-in hybrid electric vehicle [3]

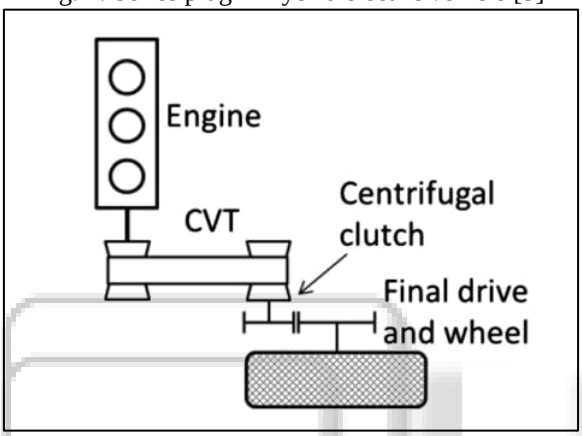

Fig. 8: Conventional vehicle.[3]

C. Comparative analysis of two hybrid energy storage systems used in a two front wheel driven electric vehicle during extreme start-up and regenerative braking operations by Khaled Itani , Alexandre De Bernardinis , Zoubir Khatir , Ahmad Jammal[4]

The Li-Ion battery is becoming the most installed storage element in electric vehicles. This is due, in first place, to its high energy density (allowing a great distance drive) and, in second place, to the promising technology not yet fully mature. Nevertheless, for automotive applications, specifically in hard braking and traction maneuvers, this battery presents several weaknesses related to the chemical reactions taking place while charging/discharging. These reactions could lead to capacity fade, lifespan reduction of the battery and in extreme cases to fire hazard. The lifespan reduction will allow a premature replacement of the battery, the most expensive component in the vehicle. Another interesting point is that the battery is not able to respond to the power requirements recommended by the traction control or the braking control systems during these severe operations[4].

D. Development of 48 V Starting Systems for a Two Wheeler Parallel Hybrid by Dipanjan Mazumdar, Surajit Das, N Pramila Rao, A.Sivakumar, S.Jabez Dhinaga[5]

Typically, in most of the hybrid systems, the traction battery is at a higher voltage than 12 V. As lithium-ion battery is becoming the obvious choice for most hybrid vehicles, the decision which needs to be taken for every two wheeler hybrid system is the configuration of the starting system. One of the possible options is to have two batteries i.e. a 48 V battery for the traction motor and a 12 V battery for operating the traditional starter motor. On the other hand, highlighting the possibilities of single battery system, it is being proposed to use an integrated 48 V starter-generator in hybrid vehicles which could also include torque assist and kinetic energy recovery. Four wheeler hybrid automobiles are already using integrated starter generator for cranking the hybrid engine. Due to cost constrains in two wheeler segment specially designed for Indian market, a separate integrated starter generator controller development might not be financially feasible[5].

III. FUTURE SCOPE

The future work deals with finding ways to charge battery automatically without using electricity. The idea is to use that energy which is lost in the exhaust and cooling of the engines. According to Sankey Diagram for gasoline engines only 25% of fuel energy is converted to useful work and rest is rejected into the atmosphere[1]. Nearly 40% energy is wasted in exhaust and 30% as coolant. To convert this unused energy a stirling engine and an array of thermocouple can be used which converts heat into mechanical energy. To implement the stirling engine concept an exhaust pipe can be connected to one of the hot cylinders of stirling engine, the cold cylinder is exposed to the atmosphere. The heat difference created drives the stirling engine. The stirling engine is connected to dynamo. As the stirling engine rotates through dynamo electric power is produced used to charge the battery[1].

IV. SUMMARY

HEV is a vehicle that uses two sources of power- gasoline and battery. For low power application battery drive is used whereas for high power application where power requirement is very high gasoline engine is used. Gasoline drive is most efficient at high speed drive. Thus HEV's both mode of operation occurs at their maximum efficiency. But in gasoline engine low speed operation is not efficient. Its high speed mode is only efficient[1]. Therefore, it gives twice the mileage given by a normal vehicle. As this hybrid vehicle emits 50% less emission than normal vehicle it plays an important role for reducing pollution to certain extent without compromising with efficiency. Thus it is most efficient in urban areas mainly in high traffic where gasoline engines are least efficient as the energy from gasoline is being wasted away and creates pollution.

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