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Hybrid Electric Vehicles: An Art Review

[1] Saima Yaqub, [2] Farhad Ilahi Bakhsh
Department of Electrical & Renewable Energy Engineering, Baba Ghulam Shah Badshah University, J & K, India

***Abstract*: -- This paper gives the overview of work done by various scientists on the hybrid vehicle. Here the illustration is given as which methodology they used while working on it. Various new practices were introduced to get the better results. Most of the scientists which worked on this project were keen to overcome the drawbacks of previous ones. In this paper, the nutshell of 25 research papers is given. For every paper, a brief review is given which highlight the main strategies used in that particular work. The main focus of almost every scientist was to reduce the dependency on fossil fuels which are likely to get extinct thereby increasing fuel economy. In critical situations, we need storage so HEV also provides storage in terms of battery. As we all are aware of fact that pollution is caused by fossil fuel based vehicles like diesel vehicles, petroleum vehicles etc. so HEV is one of the best solutions to overcome this effect. The scientist has taken every effort to improve the quality of HEVs to serve the people with better advancement and also to make it eco-friendly without disturbing the quality of atmosphere. There are different types of HEVs present and work is done upon them to improvise their quality so that they could serve better. Various types of HEVs and the methods and strategies applied to them is given in this paper.**

***Index Terms* — SOC (State of charge), PMSM (Permanent Magnet Synchronous Motor), VSC (Vehicle System Controller), SCS (supervisory control system), FT (fixed transmission), ECMS (equivalent fuel consumption minimization strategy).**

I. INTRODUCTION

A hybrid electric vehicle is a type of hybrid vehicle and electric vehicle i.e. it combines any two power energy sources. Possible combinations include diesel/electric, gasoline/flywheel and fuel cell/battery. Typically one energy source is storage and the other is conversion of fuel to energy. HEV combines a conventional ICE system with an electric propulsion system (hybrid vehicle drivetrain). The combination of two power sources may support two separate propulsion systems. The presence of electric powertrain is intended to achieve either better fuel economy than a conventional vehicle or better performance. There are a variety of HEV types and the degree to which each functions as an electric vehicle also varies. The most common form of HEV is hybrid electric car although hybrid electric trucks and buses also exist. Modern HEVs make use of efficiency improving technologies such as regenerative brakes which convert the vehicle's kinetic energy to electric energy to charge the battery. Some varieties of HEV use their internal combustion engine to generate electricity by spinning an electrical generator to either recharge their batteries or to directly power the electric drive motors. This combination is known as motor-generator. Many HEVs reduce idle emissions by shutting down the ICE at idle and restarting it when needed, this is known as start-stop system. HEV produces less emission from its ICE than a comparably sized gasoline-car, since an HEV's gasoline engine is usually smaller than a comparably sized pure gasoline burning vehicle and if not used to directly drive the car, can be geared to run at maximum efficiency thereby improving fuel economy. HEVs did not become widely available until the release of Toyota Prius in Japan in 1997 followed by the Honda Insight in 1999. While initially perceived as unnecessary due to the low cost of gasoline, worldwide increases in the price of petroleum caused many automakers to release hybrids in late 2000s they are now perceived as a core segment of the automotive market of the future. As of January 2017, over 12 million hybrid electric vehicles have been sold worldwide. As of April 2016 Japan ranked as the market leader with more than 5 million hybrids sold followed by United States with cumulative sales of over 4 million units since 1999 and Europe with about 1.5 million hybrids delivered since 2000. Japan also has the world's highest hybrid market penetration. In 2016 the hybrid market share accounted for 38% of new standard passenger car sales and 25.7% of new passenger vehicle sales including key cars. Norway ranks second with a hybrid market share of 6.9% of new car sales in 2014 followed by the Netherland with 3.7% France and Sweden both with 2.3%. Global sales are led by the Toyota Motor Company with more than 10 million Lexus and Toyota hybrids sold as of January 2017 followed by Honda Motor with cumulative global sales of more than 1.35 million hybrids as of June 2014 Ford Motor Corporation with over 424000 hybrids sold in the United States through June 2015, and the Hyundai Group with cumulative global sales of 200,000 hybrids as of March 2014 including both Hyundai Motor Company and Kia motors hybrid models. As of January 2017, worldwide hybrid sales are led by the Toyota Prius lift back with cumulative sales of almost 4 million units. Objectives of HEV are to maximize fuel economy, minimize fuel emissions, minimize propulsion system cost to keep affordable, maintain acceptable performance with reasonable cost and reduce conventional car weight. HEV has several advantages over conventional engines like regenerative braking, reduction in engine and vehicle weight, increase in fuel efficiency, decrease in emission etc. HEV is lighter and roomier than a purely electric vehicle, there is less need to carry heavy batteries. The internal combustion engine in HEV is smaller, lighter and more efficient than the engine in a conventional vehicle. In fact most automobile manufacturers have announced plans to manufacture their own hybrid versions. The most commonly used hybrid is gasoline-electric hybrid car which is just a cross between gasoline-powered car and an electric car. A gasoline-electric hybrid vehicle is a vehicle which relies not only on batteries but also on an ICE which drives a generator to provide electricity and may also drive a wheel. In hybrid electric vehicle the engine is the final source of the energy used to power the car. All electric cars use batteries charged by an external source leading to the problem of range which is being solved in hybrid electric vehicle.

We can combine the two power sources found in a hybrid car in different ways. One way known as parallel hybrid has a fuel tank which supplies gasoline to engine. But it also has a set of batteries that supplies power to an electric motor. Both the engine and the electric motor can turn the transmission at the same time and the transmission then turns the wheels. Another way of combining the power sources found in a hybrid car is by series hybrid. Here the gasoline engine turns a generator and the generator can either charge the batteries or power an electric motor that drives the transmission. Thus the gasoline engine never directly powers the vehicle.

II. LITERATURE REVIEW

Zhong [1] et. al showed their keen interest towards cascaded H-bridges multilevel motor drive control. Their work showed that each phase of a three phase cascaded multilevel converter can be implemented using only a single DC source and capacitors for the other DC sources. Here a scheme is proposed that allows the use of a single DC source as the first DC source with remaining n-1 DC sources being capacitors. By the use of switching control harmonics are eliminated and DC voltage level of capacitors is maintained by virtue of which sinusoidal three phase output voltage is produced. So this scheme provides the capability to produce higher voltages at higher speeds with a low switching frequency method for motor drive application. It has low switching losses and high conversion efficiency. From their work we conclude that with the development of new hybrid cascaded H-bridges multilevel motor drive control scheme only one power source is required for each phase.

Kaijang Yu [2] et.al; worked on a battery management system which uses a predictive control strategy. They add two contributions to this field. First is the apparent relationship between battery power and future road load is addressed in the cost function of the fuel economy optimal control problem with a simplified hybrid electric vehicle energy management system model. In the second contribution engine efficiency is taken into consideration by the use of hybrid electric vehicle energy management electronic control unit simulator. Their work has focused on to reduce the use of fossil fuels and improve economy. The basic key technology of hybrid electric vehicle is its energy management. For the energy management of power split hybrid vehicle both dynamic programming and equivalent consumption minimization strategy is used. Also the battery power to the vehicle future power requirements is formalized in the cost function of the hybrid electric vehicle fuel economy optimization problem. The engine operating points are apparently optimized using a continuously variable transmission. From their work we conclude that this method has the potential to be realized in the commercially available hybrid electric vehicle energy management ECU production. Their future work will be focused on the unknown future road loads which may also cover road slopes and traffic information. They want to apply the proposed nonlinear MPC approach to plug-in hybrid electric vehicles in near future.

Bingli Zhang [3] et. al, worked on Overrunning-clutch Speed Coupling Control Strategy in a Parallel Plug-in Hybrid Electric Vehicle. Here the speed coupling control strategy of a PHEV is put forward. Models are established by using MATLAB/SIMULINK according to the structure of overrunning clutch. The output speed of powertrain components is controlled by discrete PID controllers. The real-time simulation is performed on d SPACE platform. Compared to traditional HEV Plug-in Hybrid vehicle has a large capacity of energy storage. The charging of battery pack is done by electric grid. Cost can be reduced by charging batteries from public electric grid. For the combination of powertrain components of PHEV overrunning-clutch coupling is preferred over other ways of dynamic coupling as it is much easier and has advantage of simple structure, low design cost and small shock. Here the problems were faced on switching the powertrain components, distributing power, collecting data, coupling shock and transient overload for electric motor in process of coupling.

R.C Baraszu [4] et. al; work is based on model of a Pre-transmission parallel HEV where mathematical modeling, analysis, simulation in an iterative process, system performance measures, control software and complete PHEV powertrain system synthesis is described. Synthesis of PHEV is done by conventional spark ignited internal combustion engine(ICE) ,a dry clutch between the internal combustion engine and an alternating current induction traction motor, a converter less automatic transmission and a differential and half shafts to drive front wheels. For delivering tractive power to the wheels by one or both devices electric motor is combined with conventional powertrain system. With the help of ICE and regenerative braking the battery is kept sufficiently charged so there is always energy to start the ICE and no external charging is required. Fuel economy and vehicle performance can be improved by combining an ICE with conventional powertrain.

Reza Razi [5] et. al; present their work using back to back converter in a utility connected micro-grid. Their work focused to overcome major drawbacks of battery chargers which are their high volume, low power, long charging time, harmonics and low flexibility and reliability. They used an AC micro-grid connected to grid through B2B converter and for battery charging DC link is used. On the basis of power requirement of vehicle this proposed structure can run in four different modes :battery charging mode from the grid(G2V),battery charging mode from micro-grid(M2V),vehicle to grid mode(V2G) and vehicle to micro-grid mode(V2H).This new innovation is inspired by the prior works of Majumder et.al. Frequency isolation is also provided by B2B converters between utility and micro-grid. The best controllers have been utilized to achieve better performances in V2M, V2G, G2V and M2V modes. For sensitive loads the proposed scheme is flexible and reliable. Extensive simulations on MATLAB/SIMULINK are done for excellent performance of proposed structure.

Jiawen Kang [6] et. al; proposed a Peer-to-Peer(P2P) model in smart grids for locally buying and selling electricity among Plug-in Hybrid vehicles in smart grids. This model achieves demand response by providing incentives to discharging PHEVs to balance local electricity demand out of their own interests. They explored a promising consortium block chain technology to improve transaction security without relying on a trusted third party. A localized P2P electricity trading system with consortium block chain method is proposed to illustrate detailed operations of localized P2P electricity trading. The electricity pricing and the amount of traded electricity among PHEVs are solved by an iterative double action mechanism to maximize social welfare in this electricity trading. In smart grid system PHEVs play key roles in distributed renewable energy transportation and management. PHEVs not only charge electricity from home grid with renewable energy sources but can also get electricity from other PHEVs to shift peak load through vehicle to vehicle trading. In social hotspots like parking lots or charging stations, PHEVs with bidirectional chargers can trade electricity in a localized P2P manner. The P2P electric trading consist of elements like PHEVs, LAGs, smart meters. PHEVs play different roles in localized P2P electricity trading at hotspots, charging PHEVs, discharging PHEVs. LAGs work as energy brokers to provide access points of electricity and wireless communication services for PHEVs. Each charging pole with a built in smart meter calculates and records the amount of traded electricity in real time.

Fabrizio Marignetti [7] et.al; present their work using a test rig for half a bus which is able to produce operating conditions of driving during a driving cycle. Their work focused to overcome the ill effects of the present day operating vehicle which have negative effect on environment and economic issue is also one big factor. The use of electric and hybrid vehicles is best solution to these problems. They used motion equations which regulate the interactions between the wheels and the rolling surface. Their system of observation consists two main sections: the drivetrain and the road/wheel emulator. The road wheel emulator implements the vehicle dynamics and the interaction between the wheel and the road. A system of rollers connected to a load generator/motor is driven to copy the reaction of the road over the wheel surface. The software of the road/wheel emulator integrates in real-time the vehicle dynamical equations in order to reproduce on the traction wheel the same mechanical stress the environment exerts over the wheel surface. The test rig is useful to test electric drives without the need of prototyping the whole vehicle.

Mineeshma G.R[8] et.al; present their work by sizing and configuring the components of the powertrain. Their work is a solution to energy and environment issue. Component sizing is done as to meet the performance requirements with optimum resources and also component sizing prevents wastage of energy and other losses. The optimum design of EV/HEV configurations is achieved by backward simulation which is based on vehicle dynamics and the required drive cycle. Backward simulation gives the quantities of resources required to meet the design specifications. In the backward simulation the input vehicle speed goes from the vehicle dynamic model back to engine to determine how much each component should perform during the drive cycle operation. Power required at wheels of the vehicle is calculated. The required power is then translated into torque and speed that go upstream to find the power required at the power source. The power flow is calculated component by component considering losses in backward move through drive train and at the end use of fuel or electric energy is computed for the given drive cycle. The power requirement is met by different sources like battery, fuel cell, IC engine, ultra capacitor etc. The backward vehicle modelling is implemented using MATLAB/SIMULINK.

Clara Marina Martinez[9] et.al; worked on hybrid electric vehicle to provide solution for emission, reduction and fuel displacement. Their work presents a comprehensive analysis of energy management strategies evolution towards blended mode and optimal control providing a thorough survey of the latest progress in optimization based algorithms. Hybrid electric vehicles have been found as the most suitable and immediate choice by manufacturers to replace the vehicles which cause toxic emissions. HEVs are those vehicles which are powered by at least two power sources usually concerning an internal combustion engine and an electric motor. The ultimate case is the plug-in hybrid vehicle which can be recharged directly from the grid. PHEVs have more degree of freedom to supply power due to multiple power source. Energy management manager power sources and each power source provide energy to satisfy driver demand. Energy management usually targets to maximize the overall powertrain efficiency and minimize fuel consumption. Raghavan et.al measured PHEV impacts with an energy based analysis obtaining valuable insights into fuel consumption reduction through the electrification potential factor (EPF).This paper provides a comprehensive collection and survey on the recent PHEV EMS literature, with the goal to systematically summarize the state-of-the-art of PHEV EMSs and explore research trends in the context of synergies of intelligent transport system (ITS), smart grid and smart city. This review on PHEVs EMSs algorithms highlights strengths and weakness of virtually all the existing approaches.

Xiaoxia Sun[10] et.al; focused their work for the efficient use of energy, energy recycling and brake security for series-parallel hybrid electric vehicle. The whole model is studied under an UDDS driving cycle. According to model result the integrated brake system and control strategy are effective for the series-parallel hybrid electric vehicle. The electrical brake system ensure the security of the vehicle driving and battery energy storage and also can enhance the energy utilization and prolong the life of mechanical brake device in the brake process. Based on the operating conditions and work process 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 electricity is generated from brake process which is used to charge battery. The electric consuming brake is applied in the high intensity brake process or continuous brake process. There are four kinds of energy which are used to study the energy flow of series-parallel hybrid electric vehicle in the UDDS driving cycle, vehicle braking energy, vehicle brake recycle energy and vehicle effective brake recycle energy. According to the model results under UDDS driving cycle, the analysis method based on the coupled simulation model can be applied on the dynamic brake traits and energy distribution research for series-parallel hybrid electric vehicle feasibly and effectively.

Francesco Mocera [11] et.al; worked on the architecture and design of hybrid electric vehicles. Work on ground vehicles electrification process is creating new design methods that allow testing and optimization of innovative architectures based on real working cycles. Hardware-in-the-loop is considered as a practical solution to integrate hybrid simulations within the design chain. The development of the new efficient ground vehicles have become important due to environmental issue in today's life. A lot of attention is being dedicated to develop hybrid technologies to obtain better performance of the vehicle. The combination of the two power sources viz ICE and electric generator can be in new architectures to achieve better efficiencies. Electric vehicles, hybrid electric vehicles and plug-in hybrid electric vehicles have been proposed in field of both heavy duty vehicles as well as light vehicles. Performance and efficiency of electric vehicle or hybrid electric vehicle depends on the architectural design with respect to the specific working cycle that has to be accomplished. A pure electric configuration can be considered best choice for a machine which has not to work continuously all the day. The vehicle's ESS can be designed to fulfill several cycles and in the remaining time the Machine can be left in its charging station. The design reduces ESS reduces size and cost and operate at zero emission. In longer working cycles the size increases and cost also increase. In this case hybrid series configuration can be considered suitable.

Hadi Kazemi[12] et.al; worked to improve the performance of one of the most promising real-time powertrain control strategies namely Adaptive Equivalent Consumption Minimization Strategy(AECMS) by using predicted driving conditions. They proposed three real-time powertrain control strategies for HEVs each of which introduces an adjustment factor for the cost of using electrical energy in AECMS. The benefits of ITS for conventional vehicle in terms of the fuel consumption is limited due to the strict constraints enforced by the driver's power demand and the internal combustion engine(ICE) as the role source of motive power. HEVs have an extra degree of freedom which provides them more flexibility to fully exploit situational awareness for the improvement of their fuel economy. This additional power comes from electric motor. Power distribution strategies can be categorized based on the level of prior knowledge of the drive cycle. XU et.al authors designed three different strategies which improved the efficiency by adding the new degree of freedom to the optimization problem. Zhang et.al found a sub-optimal solution of the optimization problem by using method called Power Weighted Efficiency Analysis for Rapid Sizing (PEARS) in order to reduce the computational complexity of the group of strategies. Sun et.al developed a neural network based predictor to forecast the future velocity of the vehicle based on the driving history. The prediction was used for equivalent factor adaptation for AECMS controller and more than three percent reduction in fuel consumption was reported. This paper proposed a framework which utilizes the predicted driving conditions and energy requirements of the vehicle to find the most optimal combination of EM and

ICE power outputs which minimizes the fuel consumption while sustaining the state of charge of the battery ESS.

Teng Liu[13] et.al; worked on HEVs to develop a system of efficient energy management. Their work presents a predictive energy management strategy for a parallel hybrid electric vehicle based on velocity prediction and reinforcement learning. The procedure starts with modeling the parallel HEV and defining a cost function. Reinforcement learning (RL) based energy management strategy is introduced to determine the optimal control behaviors and power distributions between two energy sources. RL optimized control is able to significantly reduce fuel consumption and computational time. Energy management strategies of HEVs are mainly classified into two types via rule based and optimization based. Gao et.al proposed a novel rule-based energy management strategy that focuses on all charge depletion range and electric range operations. Jalil et.al have devised a rule based energy management strategy to set thresholds for determining power split between the engine and battery for a series HEV. Li et.al proposed a novel correctional DP-based controller to realize power split in a plug in HEV considering drivability and varying road slopes and loads. Recently two emerging methods namely Game Theory (GT) and Reinforcement Learning (RL) have been presented to implement real time optimization feasible for HEVs. Chen et.al reported a game-theoretic approach based on a two-level single leader multi follower game. RL based system is used to address trade-off between real time performance and optimality. RL system enabled predictive control strategy for a parallel HEV in which a detailed control-oriented model for the parallel HEV is built first and then two novel velocity predictor are presented to predict the future velocity profile in RL control framework.

Soodeh Nagarestani[14] et.al; proposed an approach to determine the optimal size of storage system for a fast charging station. The size depends on PHEV charging demand, PHEV characteristics and driving patterns of PHEV owners. The optimal size of electrical storage system in the charging station is then determined such that station energy cost and storage cost are minimized. Society of automotive engineers in the United States has proposed three standard EV charging levels out of which the short charging time i.e. the fast charging level is being worked upon. A coordinated charging strategy is proposed to minimize the power losses and to maximize the main grid load factor to approach to an optimal charging profile for PHEVs. Different models and theories have been proposed by the authors on the basis of surveys and investigations made in the suggested areas and on this basis charging system is designed to meet the expected demand. ESS provides a main charging demand if the charging demand increase the network peak load in a fast charging station. The aim of this paper is to determine the optimal size of storage system which in turn depends on charging demand. For calculating charging demand of station, the charging demand of PHEV during a definite period is modeled and then the station demand is derived by aggregating the demand associated with all PHEVs with different characteristics. An optimization based algorithm is proposed to specify the optimal size of storage system in the charging station. The aim is to minimize the cost of the storage system and the energy cost of charging station.

Yangang Wang[15] et.al; investigated thermal design of a Dual Sided Cooled (DSC) power module for HEV/EV. It is said that DSC structure has substantial advantages in performance and volume/weight but comprehensive design is essential to develop qualified product. The concept of optimization of the DSC module is investigated and the thermal measurement on the module prototype is reported. The aim is to design a high quality automotive power module in terms of performance, temperature, reliability, weight, volume and cost. The power devices employed in automotive power electronics system are dominated by Silicon based Insulated Gate Bipolar Transistor (IGBT) and Free Wheeling Diode (FWD) at present. In the challenging phase of automotive module packaging, the Direct Liquid Cooled (DLC) and Dual Sided Cooled (DSC) module are regarded as the most promising candidate for automotive application due to their advantages in electrical, thermal, mechanical performance and reliability. DSC has superior electrical and thermal performance and advantages in volume, weight, and cost. In this paper the detailed thermal design of a DSC and automotive IGBT module are put forward and the prototype is built and tested by realizing the proposed design. In the design the Active Metal Brazed (AMB) AIN substrate and Molybdenum spacer are used which give high thermal performance and high thermal reliability. The material combinations and dimensions are optimized for thermal, electrical performance and cost. Different solder alloys are used for die attach, moly attach, and substrate attach.

Liu Yonggang [16] et.al; draw their keen interest on the combination of intelligent transportation technology and hybrid electric vehicle management strategy and control strategy which is based on Global Positioning System (GPS) and Geographic Information System (GIS). The knowledge of road events like distance, road grade, altitude, velocities are used to predict the electric energy consumption. To solve the problem of battery over discharge when PHEV drives at mountain area or continuous slope, the energy management strategy using road grade preview has been proposed. Before entering the slope the PHEV can reach target state of charging (SOC) by pre-charge mode to avoid battery electricity shortage and over discharge during uphill. The information of slope such as length, size and average velocity on slope is obtained from Intelligent Transportation System (ITS). The driving cycle with similar average velocity to the slope is selected to estimate the electricity consumption. The energy management strategy with road grade preview is proposed. The SOC trajectory is planned in CS mode. Charge timing is calculated and SOC is charged to the target value before uphill to avoid battery electricity shortage and over-discharge during uphill. The simulation model of PHEVs powertrain is established based on the platform of MATLAB/SIMULINK. According to the simulation results, the control strategy proposed is verified to effectively avoid the battery over discharge during uphill. The performance of battery interms of lifetime is improved.

KEB [17] et.al; described the Low Storage Requirement (LSR) Hybrid Electric Vehicle configuration and discussed the advantages of their type of hybrid vehicle. Powell et.al; sujjested that the combination of a conventional drivetrain and the electric traction motor system to form HEV is a promising alternative achieving lower emissions than a conventional vehicle and increased range over an EV. Bailey and Powell proposed series and parallel as two major HEV configurations. The LSR hybrid vehicle is a parallel hybrid equipped with an electric motor that is underpowered for providing the sole tractive power for the vehicle. The LSR hybrid drivetrain includes a conventional ICE and an electric machine attached directly to the engine flywheel that acts as a starter/alternator (S/A) to discharge and charge a high-powered energy storage device as well as provide additional power. S/A and high power battery has an advantage of shut-off/ restart strategy. In addition to quick engine restart it also offers an advantage of supplementing engine torque for high power modes for better performance, collecting limited regenerative braking energy for improved fuel economy, improve shift quality and damp drive line oscillations. The vehicle system controller (VSC) translates driver demands, energy management conditions and fault detect conditions into torque commands to the S/A during the start/stop of the engine, boost mode charging, regenerative braking and battery bleed. The start/stop behavior of the LSR is an integral part of the strategy to improve fuel economy. The purpose of the bleed mode is to reduce the SOC of the battery to allow room for a regenerative brake energy to be captured to recharge the battery. Boost mode, in contrast to the bleed mode is a driver initiated behavior which refers to the additional torque deliver to the wheels from S/A operating in motoring mode. The charge mode is entered when the SOC is low and in this case the S/A is operated as a generator to increase the SOC. The purpose of regenerative braking is to capture kinetic energy dissipated in braking and store it in the battery.

Wassif Shabir [18] et.al; work is based on to analyze the performance of a continuously variable transmission by using an intuitive control in a HEV of a series architecture under varying driving conditions. As we know that fixed transmission (FT) uses a fixed final drive ratio between the motor and wheels but here detailed dynamic vehicle simulation model is employed to enable in depth evaluation of CVT. They aim to reduce motor energy consumption up to 9.38% by using three distinct driving cycles. Also by analyzing energy flows from permanent magnet synchronous motor (PMSM) give us the impacts of transmission system. In this era the main disturbing things prevailing are climatic changes, scarcity of fossil fuels, pollution etc. So it becomes responsibility of manufacturers and regulators that how they tackle this situation. So they put forward a trend towards electrification of vehicles. Use of mechatronic systems for transmission system also there. Use of electromechanical continuously variable transmission is more promising than hydraulic or mechanical system. Not only Wassif Shabir et.al; the existing scientists have also studied the use of CVTs for parallel hybrid vehicles viz Bowles et.al, Won et.al, Lee and Kim. It also acts as a power split device between the engine and motor. But in this paper it only investigates the effectiveness of CVT in a series HEV where only motor drives the wheels. For a series powertrain the motor to which the CVT is connected provides all the propulsion in the vehicle, so the performance of CVT is independent from the choice of supervisory control system (SCS) for powertrain energy management. In contrary parallel HEV wheels are mechanically connected to both engine and the motor and thus performance of a CVT would be strongly dependent on choice of SCS. So this study isolates the performance of CVT from SCS. This study has also the relevance for the performance of a CVT for a battery electric vehicle (BEV) where the motor is also the only means of driving the wheels. FT leads to very high PMSM friction losses during low sped driving and very high PMSM resistance losses during high speed driving but CVT keeps both losses at low level for any type of driving. This is attained by operating the PMSM close to its optimal point in terms of rotor speed and torque. Reduction in motor losses (48.39%) are almost eliminated by increase in transmission losses. Organisation of this paper is as follows: First it introduces vehicle model implementation of a CVT and its control, simulations of multiple driving cycles are conducted and results are presented and finally conclusions are drawn.

LV Ming [19] et.al; worked on the energy management strategy which has direct influence on the performance of the whole vehicle. Energy saving and emission reduction can be obtained from PHEV. In this paper the research object is PHEV. The strategy of this paper is firstly a rule based algorithm established then energy management using fuzzy control is presented to improve the rule based algorithm. Finally the proposed control strategies are simulated and verified under three typical driving cycles. More smooth control effect is achieved by fuzzy control strategy to alleviate the decline rate of battery SOC. Compared with rule based algorithm, significant fuel consumption reduction could be achieved. Fuzzy control strategy can achieve an extension of charge depleting (CD) phase by upto 4.45% and reduction in energy loss can be upto 5.99%. This can be achieved under certain driving conditions. The problems which mainly restrict the development of automotive industry are environmental pollution and energy shortage. So the introduction of PHEV not only ensures the pure electric but also improve fuel economy. Because of its features it has gained lot of attention from organizations and companies. Most important parts in research of PHEV is control strategy which effect the fuel economy and exhaust emissions. The three major categories of energy management strategy are: Rule based algorithm, intelligent control method and optimization algorithm. These control methods have their advantages and disadvantages too. Rule based and fuzzy control approaches can be easily implemented in real time control due to their simple structure and strong robustness. The basic purpose of this paper is to compare the rule based with fuzzy control method in using the same energy management strategy for PHEV. Rule based and fuzzy control strategy are simulated by building models in MATLAB/SIMULINK software. Results show that with rule based algorithm the proposed fuzzy control strategy not only improve fuel economy but also can achieve more smooth control to alleviate the decline rate of SOC effectively.

Jen-Chiun Guan, Bo-Chiuan Chen[20] et.al; proposed an adaptive power management strategy (PMS) based on equivalent fuel consumption minimization strategy (ECMS) for a four-mode HEV. The four-mode HEV which consists of an ICE and two motors provides four modes of operation, including EV mode, range extended mode, hybrid mode and engine mode. The adaptive PMS is designed for charge sustaining such that the SOC can be maintained at a certain value. A self-organizing fuzzy controller (SOFC) is employed to adaptively adjust the equivalence factor of electric energy consumption based on the SOC deviation and the change of SOC deviation. Simulation results show that adaptive PMS can effectively improve the fuel economy for different driving cycles. The PMS of HEV can be classified into three types. The first one is rule-based control, second type is equivalent fuel consumption minimization strategy (ECMS) and the third one is global minimization over a time horizon based on dynamic programming. Sun et.al; proposed an adaptive-ECMS combined with a velocity predictor to provide temporary driving information for real time adaptation for equivalent factor (EF). Model predictive control (MPC) can be employed to design PMS. Borhan et.al; formulated a non-linear and constrained optimal control problem for the PMS design. Simulation results show that the adaptive PMS has superior fuel economy improvement than ECMS for different driving cycles.

Wei Liu[21] et.al; demonstrated a comparison study of two energy management methods for a plug-in serial hybrid electric vehicle. The two methods are the optimal single point start-stop (SPSS) control and the optimal Operation Line Power track (OLPT) control respectively. The control logics of the two methods are designed in this paper and the performances are verified and compared under simulation condition, which reveals that power track control strategy performs better energy economy both theoretically and practically. The plug-in series hybrid electric vehicle can act as range-extending hybrid electric vehicle (RHEV), taking advantage of both EVs and HEVs. The RHEV is equipped with a range extender which is also called as auxiliary power unit for longer mileage. RHEV and PHEV are similar in a way that both are HEVs having two driving sources and both RHEV and PHEV can be charged from the external power grid. The difference between two is that RHEV has a fixed serial hybrid powertrain but PHEV has a variety of powertrains including the serial, parallel and the mixed hybrid type. RHEV have stronger power performance within the whole SOC working range. The APU is mainly used for extending the mileage rather than supplement the driving power. The rule based APU control strategies, including the optimal single point start-stop (SPSS) control and the optimal operation line power track control (OLPT) etc. are most widely used energy management methods of HEVs. The control methods SPSS and OLPT are designed to obtain a longer mileage and prevent battery over-charging and over-discharging at the same time.

Christopher H.T[22] et.al; work is based on three partitioned stator(PS) machines, namely the PS flux-switching permanent magnet(PS-FSPM) machine, PS-FS hybrid-excitation(PS-FSHE) machine and the flux adjuster PS-FSPM (FA-PS-FSPM) machine which are all proposed for the hybrid electric vehicles. The electric machines provide high efficiency, high power and torque densities, high controllability, wide speed range and maintenance free operation. PS-FSPM machine can improve power and torque densities as compared with the conventional design. It is due to better utilization of inner space. The concept of hybrid-excitation (HE) machines have been developed to improve the flux-regulation capability. The mechanical flux adjusters (FAs) have been proposed to regulate the PM flux levels by short circuiting PM fluxes in order to reduce the undesirable copper losses. The purpose of this paper is to incorporate the concept of FA topology into the

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PS-FSPM machine, hence forming the proposed FA-PS-FSPM machine, purposely for the HEV applications. Unlike the existing FSPM machines that insert the FAs on to the outer shell of the outer-stator, the proposed machine instead places the FAs inside the inner shell of inner-stator. Therefore, the inner space of the proposed machine can be further utilized, such that the FAs will not enlarge the machine dimensions as the existing counter parts too. All the proposed machines namely the PS-FSPM machine, the PS-FSHE machine and the FA-PS-FSPM machine are designed based on the specifications of the typical HEV applications. The FA-PS-FSPM machine has shown great potentials for HEV applications.

Lu Xiong[23] et.al; proposed a method that make use of the rear motor to achieve vehicle longitudinal impact control. For a 4 WD-Hybrid electric vehicle with front wheels driven by engine and rear wheels driven by in-wheel motor, the engines intervention in driving and the engagement of the transmission during the shifting will cause the longitudinal impact and influence the drive comfort. A disturbance rejection H robust controller has been designed to control the impact. A ground-coupled four-wheel drive hybrid structure with rear wheels driven by in-wheel-motor has an advantage over gear box coupled parallel hybrid electric vehicle in mixed degrees. Ground coupled four-wheel drive hybrid vehicle is able to reduce the longitudinal impact caused by hybrid vehicle during the transmission shifting or the transition condition that from the engine drive to the electric drive throughout rear-wheel drive force control. This paper design H robust control controller based on a four- wheel drive hybrid electric vehicle platform, treat front drive system shift impact as disturbance to the vehicle system, and use the rear wheels in-wheel-motor to achieve vehicle longitudinal impact control in the transition conditions. The model used for the experiment is a self-developed four wheel drive hybrid vehicle. The vehicle front wheel drives by the engine through automatic transmission (AT) and the rear wheel is driven by in-wheel motor. Another belt drive start generating integral motor of 5 KW installed on front wheels driven system in order to achieve quick start and stop of the engine.

Aishwarya Pandey[24] et.al; focused on the effect of temperature on various battery parameters. Usage of battery in HEV reduces the demand of petroleum but increases the complexity in terms of SOC estimation. Due to temperature conditions, battery charging/discharging efficiency changes which effects vehicle performance. To overcome this SOC estimation formula is introduced. Genetic algorithm based control strategy is exercised to find the optimal fuel economy for the hybrid electric vehicle at various temperatures using proposed SOC estimation method. Fuel economy is found better at higher temperatures as compared to lower temperatures but life of battery reduces at higher temperatures and diminishes vehicle performance. Battery plays an important role in HEVs and its performance gets analyzed by the different parameters like OCV, resistance, capacity and SOC. These parameters get influenced by the temperature, aging and charging/discharging cycles. This paper concentrates on the effect of temperatures on battery functioning and thus on the vehicle performance. There are various methods for SOC estimation but the voltage based SOC and current based SOC are found to be most promising methods. Here a novel method of SOC estimation is introduced along with the consideration of temperature variation. Pang et.al used OCV method to calculate the SOC of the battery. Tang et.al, Verbrugge and Tate identified the contribution of both SOCv and SOCi together to estimate accurate SOC. Temperature variation effects the current, voltage and SOC of the battery which effects the engine transition. Effect of temperature is analyzed to restrict the operating range of vehicle to achieve the fuel efficient performance along with the longer battery life.

Yangang Wang[25] et.al; focused on the thermal design of a dual sided cooled(DSC) power module for HEV/EV. Power semiconductor module is one of the critical components affecting the overall performance of HEVs and EVs. Thermal design addresses the issue of high quality automotive power by optimizing the thermal resistance (Rth), material combination and cooling solution. It is proposed that DSC structure has advantages in performance and volume/weight but comprehensive design is essential to develop a qualified product. The concept of thermal resistance optimization of the DSC module is investigated and the thermal measurement of the module prototype is reported. The main DC/AC inverter is the critical system of HEV/EV powertrain system, which controls power conversion from battery to motor by power semiconductor devices. The power devices employed in automotive power electronics system are dominated by Silicon based IGBT and FWD at the moment. For increasing power reliability and prolonging lifetime, IGBT and FWD chips are packaged to power module with multiple devices, isolation gear and protection parts. Direct liquid cooled (DLC) and dual sided cooled (DSC) are considered promising candidates for automotive application due to electrical, thermal, mechanical performance and reliability. In this work thermal design of a new DSC automotive IGBT module is investigated and the prototype achieving the design is assembled. The detailed thermal designs in concept and Rth optimization are reported and the Zth measurement has been done.

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III. CONCLUSION

So hereby it is concluded that countries usually the developed countries are more keen towards the manufacturing, development and advancement of hybrid electric vehicles. The invention of new technology is obviously of the fact from needs and necessity of present world. That is why HEV comes into play. Not only its invention but scientists also focused on to use different strategies to improvise HEV. HEV has gained much attention in various organizations also by virtue of its qualities. So HEV is a better choice from other vehicles.

REFERENCES

[1] Zhong Du, Leon M Tolbert, John N Chiasson, Burak Ozpineei, Hui Li, Alex Q Huang, "Hybrid Cascaded H-bridges Multilevel Motor Drive Control for Electric Vehicles"

[2] Kaijiang Yu, Masakazu Mukai, Taketoshi Kawabe, " A Battery Management System using Non-linear Model Predictive Control for a Hybrid Electric Vehicle" proceeded by 7th IFAC Symposium on Advances in Automotive control the International Federation of Automatic Control Sep 4-7 Tokyo Japan.

[3] Bingli Zhang, Qingliang Hou, Xin Li, Guosheng Xu, Yi Zhu, "Research on Overrunning-clutch Speed Coupling Control Strategy in a Parallel Plug-in Hybrid Electric Vehicle" published by Elsevier Ltd Selection or peer-review under responsibility of Hainan University 2012.

[4] R.C Baraszu, S.R Cikanek, K.E Bailey, B.K Powell, "Dynamic Model of a Pre-Transmission Parallel Hybrid Electric Vehicle" by IFAC Mechatronic Systems Darmstadt Germany 2000.

[5] Reza Razi, Behzad Asaei, Mohammad Reza Nikzad Department of Electrical and Computer Engineering Faculty of Engineering University of Tehran, Tehran Iran, "A New Battery Charger in Plug-in Hybrid Electric Vehicle Application using Back to Back Converter in a Utility Connected Micro-grid" 8th Power Electronics Drive Systems and Technologies Confrence(PEDSTC 2017) 14-16 Feb 2017, Ferdowsi University of Mashhad, Mashhad Iran.

[6] Jiawen King, Rong Yu, Member, IEEE, Xumin Huang, Sabita Maharjan, Member,IEEE, Yan Zhang, Senior Member, IEEE, Ekram Hossain, Fellow, IEEE, "Enabling Localized Peer-to-Peer Electricity Trading Among Plug-in Hybrid Electric Vehicles Using Consortium Blockchains" IEEE 2016.

[7] Fabrizio Margnetti, Damiano D'Aguanno, Giuseppe Volpe, Department of Electrical and Information Engineering University of Cassino and Southern Lazio via Gaetano di Biasio, 43, 03043 Cassino Italy, "Design and Experiments of a Test Equipment for Hybrid and Electric Vehicle Drivetrains" Twelfth International Confrence on Ecological Vehicles and Renewable Energies(EVER) 2017.

[8] Mineeshma G.R, Renji V Chacko, Amal S, Srideevi M.L, Vishnu V, Power Electronics Group, Centre for Development of Advanced Computing, Thiruvananthapuram, "Component Sizing of Electric Vehicle/Hybrid Electric Vehicle Subsystems using Backward Modelling Approach" 978-1-4673-8888-7/16/s31.00 IEEE 2016.

[9] Clara Marina Martinez, Xiosong Hu, Dongpu Cao, Efstathios Velenis, Bo Gao, Matthas Wellers, "Energy Management in Plug-in Hybrid Electric Vehicles:Recent Progress and a Connected Vehicles Perspective" proceeded by IEEE.

[10] Xioxia Sun, Lining Yang, Chunming Shao, Xin Li, Guozhu Wang, Yusong Yue, "Research on Electrical Brake of a Series-Prallel Hybrid Electric Vehicle" World Congress on Sustainable Technologies(WCST-2016) IEEE 2016.

[11] Francesco Mocera, Aurelio Soma Department of Mechanical and Aerospace Engineering Politecnico di Torino, Torino Italy, "Study of a Hardware-in –the-loop Bench for Hybrid Electric Working Vehicles Simulation" Twelfth International Confrence on Ecological Vehicles and Renewable Energies(EVER) Europian Union 2017.

[12] Hadi Kazemi, Yaser P. Fallah, Andrew Nix, Scott Wayne, "Predictive AECMS by Utilization of Intelligent Transportation Systems for Hybrid Electric Vehicle Powertrain Control" IEEE Transactions on Intelligent Vehicles 2379-8858© 2016.

[13] Teng Liu, Xiaosong Hu, Senior Member, IEEE, Shengbo Eben Li, Dongpu Cao, "Reinforcement Learning Optimized Look-Ahead Energy Management of a Parallel Hybrid Electric Vehicle" IEEE/ASME Transactions on Mechatronics 2016.

[14] Soodeh Negarestani, Mahmud Fotuhi-Firuzabad, Fellow,IEEE, Mohammad Rastegar, Student Member, IEEE, Abbas Rajabi-Ghahnavieh, Member, IEEE, "Optimal Sizing of Storage System in a Fast Charging Station for Plug-in-Hybrid Electric Vehicles" IEEE Transactions on Transportation Electrification 2332-7782© 2016.

[15] Yangang Wang, Yun Li, Xiaopping Dai, Shiwu Zhu, Steve Jones, Guoyou Liu, “Thermal Design of a Dual Sided Cooled Power Semiconductor Module for Hybrid and Electric Vehicles” 978-1-5090-5366-7/17/$31.00© 2017 IEEE.

[16] Liu Yonggang, Li Jie,Qin Datong, Lei Zhenzhen School of Automative Engineering and Chongqing Automotive Collaborative Innovation Center Chongqing University China, “Energy Management of Plug-in Hybrid Electric Vehicles Using Road Grade Preview” National Natural Science Foundation(No. 51305468).

[17] K.E Bailey, M.Jankovie, A.Phillips and B.K Powell, “Dynamic Model and Control of a Hybrid Electric Vehicle” IFAC Mechatronic Systems Darmstadt Germany 2000.

[18] Wassif Shabir, Simos A. Evangelou, Imperial College London, “Efficiency Analysis of a Continuosly Variable Transmission with Linear Control for a Series Hybrid Electric Vehicle” Proceedings of the 19th World Congress the International Federation of Automatic Control Cape Town South Africa August 24-29 2014.

[19] LV Ming, Yang Ying, Lijie Liang, Lu Yao, Wenyu Zhou, “Energy Management Strategy of a Plug-in Parallel Hybrid Electric Vehicle Using Fuzzy Control” by Elsevier Ltd. 2017.

[20] Jen Chuin Guan, Bo-Chiuan Chen, “Adaptive Power Management Strategy for a Four-Mode Hybrid Electric Vehicle” Energy Procedia 105(2017) 2403-2408 Elsevier Ltd.

[21] Wei Liu, Hongwen He, Zexing Wang National Engineering Laboratory for Electric Vehicles Beijing Institute of Technology China, “A Comparison Study of Energy Management for a Plug-in Serial Hybrid Electric Vehicle” Energy Procedia 88 (2016) 854-859 by Elsevier Ltd.

[22] Christopher H.T Lee, Member, IEEE, James L Kirtley, Jr, Life Fellow, IEEE, M Angle, Member, IEEE, Research Laboratory of Electronics, Massachusetts Institute of Technology Cambridge MA 02139 USA, “A Partioned-Stator Flux-Switching Permanent-Magnet Machine with Mechanical Flux Adjusters for Hybrid Electric Vehicles” IEEE Transactions on Magnetics 2017.

[23] Lu Xiong, Zhuoping yu, Automotive College Tangji University 4800 CaoAN Roag 201804 Shanghai, “Research on Robust Control for Longitudinal Impact of 4 Wheel-Drive Hybrid Electric Vehicle” Procedia Engineering 15 (2011) 293-297 by Elsevier Ltd.

[24] Aishwarya Panday, Hari Om Bansal , Department of Electrical and Electronics Engineering BITS Pilani Jhunjhunu Rajasthan India, “Hybrid Electric Vehicle Performance Analysis Under Various Temperature Conditions” Energy Procedia 75 (2015) 1962-1967 by Elsevier Ltd.

[25] Yangang Wang, Yun Li, Xiaoping Dai, Shiwu Zhu, Steve Jones, Guoyou Liu, “Thermal Design of a Dual Sided Cooled Power Semiconductor Module for Hybrid and Electric Vehicles” IEEE.

