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A COMPREHENSIVE REVIEW ON RANGE EXTENDED ELECTRICAL VEHICLE

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ABSTRACT

Present paper includes comprehensive review with conclusions and further suggestions of nearly thirty three research articles in the field of hybrid vehicles. The objective of the work includes comprehensive understanding of technicalities of hybrid vehicles, identify gaps in the literature, find a lack of consistency in reported results across the studies, flaw in previous research based on its design, data collection instruments, sampling, or interpretation.The paper focuseson solving the issues of pollution and efficiency regarding the transportation technology used in current scenario. The environment suffers a lot due to such activities. The review is targeted towards developing a new arrangement of drivetrain to reduce the emissions and increase fuel efficiency while keeping up with the power figures. Anewer technology for the above parameters are suggested at the end of the paper.

I. INTRODUCTION

Extended-range electric vehicles (EREV) or range-extended electric vehicles (REEV) were designed to be run mostly by the battery, but have a petrol or diesel generator to recharge the battery when charge becomes low. However, range extension can be accomplished with either series or parallel hybrid layouts. In a series-hybrid system, the combustion engine drives an electric generator instead of directly driving the wheels. The generator provides power for the driving electric motors by charging batteries. In short, a series-hybrid is a simple vehicle, which is driven only by electric motor traction with a generator set providing the electric power. The EREV is unique vehicle, where battery and propulsion system are sized such that the engine is never required for operation of the vehicle when energy is available from the battery. As a full-performance electric vehicle, battery, motor and power electronics must be sized for the full capability of the vehicle. An E-REV does not need to start the engine for speed or power demands and therefore does not need to be on when battery energy is available. The engine is used only when the battery charge is low and to charge the battery in such cases. Unlike an internal combustion engine, electric motors are highly efficient with exceptionally high power-to-weight ratios providing adequate torque when running over a wide speed range. Internal combustion engines run most efficiently when turning at a constant speed. An engine turning a generator can be designed to run at maximum efficiency at constant speed. Conventional mechanical transmissions add weight, bulk and sap power from the engine with automatic shifting being complex. Unlike conventional transmission mechanism, electric motors are matched to the vehicle with a simple constant-ratio gearbox hence multiple-speed transmission can be eliminated.

Along the years, automobile industry has used the same technology as means of propulsion for the vehicle, but developing new improvements. It was in 1885 when Karl Benz patented the first vehicle with an Internal

Combustion Engine (ICE) (Danielson, 2008).The main fuel source for the ICE is petrol, a derivate from oil. It was the best choice thanks to its high heat of combustion, portability and easy storage (The classic times, 2008). The purpose of fuel is to let free calorific energy that can be transformed into another kind of energy. The users employ it to generate heat that is transformed into kinetic energy (Brame, 1920). Due to the problems that started appearing from the consumption of fuel for the internal combustion engines, it was necessary to look for a new more sustainable fuel. The main problems derived from the consumption of petrol are the massive consumption of oil and the problems derived from it.

A graph of the oil consumption until 2005 can be seen in Figure 1.

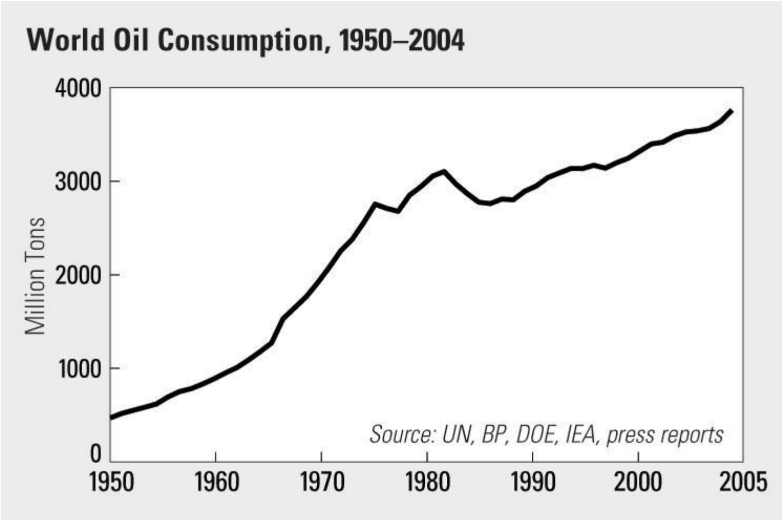

Figure 1. Graph of oil consumption. (World watch Institute, 2005)

During the last years, new alternative fuels have appeared. The research has obtained other alternatives to gasoline as biofuel, alcohol fuels or hydrogen. Nevertheless, all these alternatives still have several problems as the unsustainable biofuel production or the difficulty to store the hydrogen.

The electricity is one of the alternatives that are becoming more useful in the recent years as source of energy for the propulsion of an automobile.

Nowadays, electric cars are a reality and are taken as a possible alternative to cars with fuel engines. Although these cars have many advantages, they have a problem for their improvement: their batteries. Electric car batteries are not still developed enough to equalize the capacity to store energy of gasoline. Due to the problems derived from the use of batteries in cars plus the price difference between them, a combination of both resources (electric and fuel engine) is the best solution for now, the hybrid cars. Nevertheless, this system implies to carry one fuel engine that is switched off most of the time. This fact produces the need to look for a solution that allows the user of an electric car to mount the fuel engine only when needed. In the recent years, some solutions of electric vehicles with detachable systems to extend the range of autonomy have appeared in the market. However, these solutions usually consist on a trailer to be mounted in the back of the car, which causes a bad aesthetic impression. It would be interesting to develop a device to be mounted in the back of the car in a manner that it did not use an extra pair of wheels.

II. LITERATURE REVIEW

Mehrdad et. al. [1] (1997) presented a design methodology for Electrical Vehicle (EV) and Hybrid Electrical Vehicle (HEV) propulsion systems based on the vehicle dynamics. The methodology is aimed at finding the optimal torque-speed profile for the electric powertrain. The study reveals that the extended constant power operation is important for both the initial acceleration and cruising intervals of operation. The more the motor can operate in constant power, the less the acceleration power requirement will be. Several types of motors are studied in this context. It was concluded that the induction motor has clear advantages for the EV and HEV at the present. A brushless dc motor must be capable of high speeds to be competitive with the induction motor. However, more design and evaluation data is needed to verify this possibility. The design methodology was applied to an actual EV and HEV to demonstrate its benefits. Karen et. al. [2] (1999) presented a simulation and modeling package developed at Texas A&M University, V-Elph 2.01. V-Elph was written in the Matlab/Simulink graphical simulation language and was portable to most computer platforms. It was also discussed the methodology for designing vehicle drivetrains using the V-Elph package. An EV, a series HEV, a parallel HEV and a conventional internal combustion engine driven drivetrain have been designed using the simulation package. Simulation results such as fuel consumption, vehicle emissions, and comple. Ma Xianmin [3] (2002) developed a novel propulsion system design scheme for EVs requiring high power density. The theory analysis 20 mathematical models of EV are first set up based on the vehicle dynamic characteristics, then the whole system was divided into seven function blocks according to power flow, the simulation models are formed in the MATLAB language. The simulation results were verified in a PDM AC-AC converter, which shows that the suggested method was suitable for EV. Bartlomiej et.al. [4] (2003) provided the evaluation of driving power and energy requirements for automotive vehicle. A survey of most promising applications of electric and hybrid vehicles in cities with commercial line solutions was given. Evaluation of vehicle’s energy, when it was referred to urban driving cycles, reflects an important diversification of the average and maximal power requirements. Simulation results of a small car equipped with advanced fuel cell converter and supercapacitor storage bank have indicated the power flow between these sources at normalized urban driving conditions. Su-Hau et.al. [5] (2004) focused on the highly efficient energy usage of the battery energy and proposed an integrated management system for electric motor. This integrated management system includes the power-saving controller, energy management subsystem and some hardware protection strategies. The energy management system acts as a supervisor to manage all the events about the battery energy, including the residual capacity estimation and regenerative braking operation. David and Chung [6] (2004) proposed new parallel-type hybrid-electric-power system comprises an engine’s energy distribution and a torque-integrated mechanism (specifically including an engine, a motor/alternator, a CVT device, and PCM as well as a 3-helical gear set). To let the engine achieve maximum thermo-efficiency with minimum emissions, the servomotors adjust the diameter size of the pulley to control the engine output for the final power-output axle and the alternator. The system is applied with a stable engine-load to maximize operating performance. The vehicle was driven by the motor alone in the light-duty mode. Meanwhile, in the medium-duty mode, power comes from the engine, with extra energy being used for battery charging. Finally, in the heavy duty mode, both the engine and motor together power the vehicle. The engine output is fixed, but the motor output power can be controlled. Wenguang et. al. [7] (2005) presented an approach to control powertrain of series hybrid electric vehicles. A formulation of the system equations and controller design procedure were proposed by them. It was also proposed a new switching algorithm for the power converter for motor torque and motor flux control. The sliding mode method was applied to excitation winding control in synchronous generator to achieve the desired current distribution in powertrain. Yimin and Mehrdad [8] (2006) introduced a speed and torque coupling hybrid drivetrain. In this drivetrain, a planetary gear unit and a generator/motor decouple the engine speed from the vehicle wheel speed. Also, another shaft-fixed gear unit and traction motor decouple the engine torque from the vehicle wheel torque. Thus, the engine can operate within its optimal speed and torque region, and at the same time, can directly deliver its torque to the driven wheels. It was also discussed the fundamentals architecture, design, control, and simulation of the drivetrain. Simulations show that the fuel economy in urban and highway driving cycles can be greatly improved .Andrea et. al. [9] (2005) described the energy budgeting for the EV and the HEV, which shows that the HEV was today competitive alternative to the ICE vehicles. A series hybrid technology is built and tested on a prototype. The range extender and power-assist mode of operation were tested and the 27 results reported. The solution was designed to meet very low production costs without compromising too much on the efficiency. The cost of the additionally needed DC-DC converter between the battery and the DC link is more than compensated as it allows to keep the battery at a smaller size without having to reduce the capacity to very small and hardly controllable capacities. Rajeswari et. al. [10] (2006) studied the capacity of the energy storage system i.e. the battery in a hybrid vehicle. Various tests on the discharge characteristics, including study of Ohmic resistances under various cases was carried out for a separate battery as well as a battery used in a hybrid vehicle and the former was found to have greater impedance while cycling. The relevance would be the battery selection and analysis, charging modes and technologies. . Bao and Hua [11] (2006) incorporated a mechanical type rubber V-belt, continuously-variable transmission (CVT) and chain drives to combine power of the two power sources, a gasoline engine and an electric motor in hybrid power system. The system uses four different modes in order to maximize the performance and reduce emissions: electric-motor mode; engine mode; engine/charging mode; and power mode. The main advantages of this new transmission include the use of only one electric motor/generator and the shift of the operating mode accomplished by the mechanical-type clutches for easy control and low cost. Kinematic analyses and design are achieved to obtain the size of each component of this system. A design example is fabricated and tested. Markel and Simpson [12] (2006) proposed that, plug-in hybrid electric vehicle technology holds much promise for reducing the demand for petroleum in the transportation sector. Its potential impact was highly dependent on the system design and the energy storage system. They discussed on the design options including power, energy and operating strategy as they relate to the energy storage system. They studied the design options including power, energy, and operating strategy as they relate to the energy storage system. Expansion of the usable state-of-charge window was dramatically reduce cost but it was also limited by battery life requirements. Increasing the battery power capability was provides the ability to run all-electrically more often but it was increase the cost. Increasing the energy capacity from 20-40 miles of electric range capability provides an extra 15% reduction in fuel consumption but also nearly doubles the incremental cost. Wong et. al.[13] (2006) studied the advanced batteries for HEV and PHEV applications and investigated the lifecycle costs of different types of 28 vehicles quantitatively. General equations were developed to describe the performance requirements and cost of all subsystems in vehicles. Their conclusions suggest that lead-acid batteries can be manufactured to meet the vehicle life cycle requirements of HEVs and PHEVs. The life cycle cost of HEVs was the lowest among CVs, PHEVs, HEVs. The batteries of PHEVs should be sized according to the driving habits of the drivers. Markel and Simpson [14] (2007) discussed the battery power and energy requirements for grid-charged parallel hybrid electric vehicles with different operating strategies. First, they considered the traditional all-electric range based operating concept and shown that this strategy can require a larger, more expensive battery due to the simultaneous requirement for high energy and power. They then proposed an alternative electric-assist operating concept for grid-charged HEVs to enable the use of a smaller, less costly battery. 24 However, this strategy was expected to reduce the vehicle efficiency during both charge-depleting and charge-sustaining operation. cheng et.al. [15] (2007) presented a novel approach to the problem of power control strategy of series hybrid electric vehicle. It was defined the three modes of operation and a cost function. To determine which operation mode was to be chosen during driving cycles they generated a classifier using support vector machine (SVM). It was claimed that their approach does not need any models of devices and needed less computational time. The control strategy was based on inputs from road situation data, battery state-of-charge data and vehicle speed data. Their simulation studies showed the feasibility of the approach. Daniel [16] (2007) designed, developed and implemented a series hybrid electric vehicle. Though he proposed the architecture as hybrid electric vehicle architecture, he showed that the vehicle runs well in the electric mode and left the hybrid conversion as future expansion. Before developing the hardware part, he did a simulation using PSCAD/EMTDC and validated the simulated results using the hardware he developed. Gonder and Markel [17] (2007) analysed the energy management strategy for the operation of hybrid electric vehicles. They summarised three potential energy management strategies and compares the implications of selecting one strategy over another in the context of the aggressiveness and distance of the duty cycle over which the vehicle was likely operate. The particular operating strategy employed during the charge-depleting mode was significantly influence the component attributes and the value of the PHEV technology. EV. Brian [18] (2007) created a model in MATLAB and ADAMS to demonstrate its fuel economy over the conventional vehicle. He used the Honda IMA (Integrated Motor Assistant) architecture, where the electric motor acts as a supplement to the engine torque. He showed that the motor unit acts as generator during the regenerative braking. He used a simple power management algorithm in the power management controller he designed for the vehicle. Cuddy and Keith [19] (2007) performed a parallel and series configured hybrid vehicles likely feasible in next decade are defined and evaluated using a flexible Advanced Vehicle Simulator (ADVISOR). Fuel economies of two diesel powered hybrid vehicles are compared to a comparable technology diesel powered internal combustion engine vehicle. The fuel economy of the parallel hybrid defined is 24% better than the internal combustion engine vehicle and 4% better than the series hybrid. O'Keefe and Markel [20] (2007) have presented a comparison of the costs (vehicle purchase costs and energy costs) and benefits (reduced petroleum consumption) of PHEVs relative to hybrid electric and conventional vehicles. A detailed simulation model is used to predict petroleum reductions and costs of PHEV designs compared to a baseline midsize sedan. A simple economic analysis was used to show that high petroleum prices and low battery costs are needed to make a compelling business case for PHEVs in the absence of other incentives. Markel [21] (2007) incorporated platform engineering steps including, reduced mass, improved engine efficiency, relaxed performance, improved aerodynamics and rolling resistance can impact both vehicle efficiency and design. Simulations have

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been completed to quantify the relative impacts of platform engineering on conventional, hybrid and PHEV powertrain design, cost and consumption. The application of platform engineering to PHEVs reduced energy storage system requirements by more than 12%, offering potential for more widespread use of PHEV technology in an energy battery supply-limited market. Results also suggest that platform engineering may be a more cost-effective way to reduce petroleum consumption than increasing the energy storage capacity of a PHEV. Eckhard et. al. [22] (2007) characterises the associated vehicle attributes and in particular, the various levels of hybrids. New requirements for the electrical storage system are derived, including: shallow-cycle life, high 29 dynamic charge acceptance particularly for regenerative braking and robust service life in sustained partial-state-of-charge usage. Advanced batteries may be considered for mild or even medium hybrids once they have proven robustness under real-world conditions, particularly with respect to cycle life at partial-states-of-charge and dynamic charge acceptance. For the foreseeable future, Ni-MH and Li-ion are the dominating current and potential battery technologies for higher-functionality HEVs. Li-ion, currently at development and demonstration stages, offers attractive opportunities for improvements in performance and cost. Opportunities and challenges for potential battery pack system suppliers are discussed. Yimin and Mehrdad [23] (2008) discussed the design and control methodology of plug in hybrid electric vehicle. Their design methodology 25 focused on battery energy and power capacity design. They tried with Ni-MH and Li-ion batteries. Also their control strategy focused on all-electric range and charge-depletion range operations. A constrained engine on and off control strategy was discussed for charge-sustained operation. The simulation results they performed for passenger car indicated that significant amount of fuel can be displaced by electric energy. Emadi et. al. [24] (2008) focused more on power electronics as an enabling technology for the development of plug-in hybrid electric vehicles\ and implementing the advanced electrical architectures to meet the demands for increased electric loads. A brief review of the current trends and future vehicle strategies and the function of power electronic subsystems were described. The requirements of power electronic components and electric motor drives for the successful development of these vehicles was also presented. Bauml and Simic [25] (2008) discussed the importance of vehicle simulations in designing the hybrid electric vehicles. A series hybrid electric vehicle simulation with the simulation language Modelica was developed. They explained the simulation approach. They concluded with some of the simulation results emphasizing the simulation importance. Zhou and Chang [26] (2008) established powertrain dynamic simulation model of an integrated starter/generator (ISG) hybrid electric vehicle (HEV) using Simulink. The parallel electric assist control strategy (PEACS) was 21 researched and designed. The analysis of dynamics performance and fuel economy of the model was carried out under the FTP drive cycle, which can provide a design reference for the setup of the powertrain test bench. The results show that the fuel consumption can be effectively reduced by using the designed PEACS with the state-of-charge of the battery maintaining in a certain scope. Kuen-Bao [27] (2008) described the mathematical modelling, analysis and simulation of a novel hybrid powertrain used in a scooter. The primary feature of the proposed hybrid powertrain is the use of a split power-system that consists of a one-degree-of-freedom (dof) planetary gear-train (PGT) and a two-dof PGT to combine the power of two sources, a gasoline engine and an electric motor. Detailed component level models for the hybrid electric scooter was established using the Matlab/Simulink environment. The performance of the proposed hybrid powertrain is studied using the developed model under four driving cycles. The simulation results verify the operational capabilities of the proposed hybrid system. Bhoopal et al [28] (2009) discussed the delectronics and real time control technology for hybrid electric vehicle. These include AC drives with real time torque control, compact and rugged induction motors, auxiliary electric circuits etc. He developed a set of DSP based circuits for AC induction motor drives for EVs. It provides torque control for propulsion and power control for generation and battery charging. The propulsion motor was controlled by a fixed point DSP based controller, which provides torque control based on driver commands. The IC engine was coupled to a generator, whose output was rectified to get the DC voltage. A dashboard, with microcontroller based circuits, provides the driver interface. The various controllers were interlinked through a serial network. Bhim Singh and Sanjeev Singh [29] (2009) presented state-of-the-art permanent magnet brushless DC (PMBLDC) motor drives with an emphasis on sensor less control of these motors. The PMBLDCM drives are suitable for many applications; however, the choice of the motor (i.e. rotor configuration), control scheme (i.e. sensorless or with sensors) and controller topology depends on the accuracy, cost, complexity and reliability of the system. ASICs are one step in the direction of low cost controllers and many more 30 such ICs with cost effective solutions was to be developed in the near future. A customer can select a PMBLDCM drive with their desired features, however, there was a trade-off between the number of parameters (e.g. sensorless or with sensors, accuracy, complexity, reliability and cost of controller). It was hoped that this investigation on PMBLDCM drives was to be a useful reference for users and manufacturers. Divya and Jacob [30] (2009) discussed the present status of battery energy storage technology and methods of assessing their economic viability and impact on power system operation. Further, a discussion on the role of battery storage systems of electric hybrid vehicles in power system storage technologies had been made. As far as the battery technology was concerned, in future the significant development in reducing the battery cost and improving their reliability. The future of large scale batteries extensively designed for using in electricity grid is also quiet promising. Finally, they suggest a likely future outlook for the battery technologies and the electric hybrid vehicles in the context of power system applications. John et.al. [31] (2010) explored two aspects of market for plug-in hybrid electric vehicles: (1) PHEV performance goals and (2) the abilities of present and near-term battery chemistries to meet the resulting technological requirements. They summarized evidence stating that battery technologies do not meet the requirements that flow from three sets of influential PHEV goals due to inherent trade-offs among power, energy, longevity, cost, and safety. However, it was also shown that part of this battery problem was that, those influential goals were overly ambitious compared to goals derived from consumers' PHEV designs. They elicited PHEV designs from potential early buyers among U.S. new car buyers; most of those who were interested in a PHEV are interested in less technologically advanced PHEVs than assumed by experts. Using respondents' PHEV designs, they derived the peak power 31 density and energy density requirements and shown that current battery chemistries can meet them. Ismail et.al.[32] (2010) presented a design procedure for an internal combustion engine hybrid electric propulsion system. The choice of suitable components was the key issue in the design procedure of a hybrid electric vehicle. Different selections and different sizing choices highly influence the overall performance expected from the vehicle. Maximum cruise speed, acceleration performance, gradability and energy recovery are defined as the key parameters of the design procedure. Finally, a case study was also presented to demonstrate the propulsion system design procedure of a parallel hybrid electric vehicle. Jeremy and Ahmad [33] (2011) took a first step toward an assessment by estimating the impact of battery second use on the initial cost of PHEV/EV batteries to automotive consumers and exploring the potential for grid-based energy storage applications to serve as a market for used PHEV/EV batteries. It was found that although battery second use is not expected to significantly affect today's PHEV/EV prices, it has the potential to become a common component of future automotive battery life cycles and potentially to transform markets in need of cost-effective energy storage. Based on these findings, the authors advise further investigation focused on forecasting long-term battery degradation and analysing second-use applications in more detail.

III. CONCLUSION

This drivetrain uses a power unit planted up at beginning which produces power for the functioning. This power is in the form of electrical energy which is then stored in the batteries. Electrical motors provided at the wheelswill utilize the power when required from the batteries for the movement of the vehicle. The auxiliary units provided in the vehicle will draw power from the batteries. The batteries are charged up from the power unit and provide this charge to all the components that require it. Various features like brake power recuperation, weight reduction, structural ability, aerodynamic ability make this technology better than the currently used technology.

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