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Hybrid Energy System in Hibrid Vehicle – State of Art

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Abstract: **This paper proposes the energy availability and cost for human utilization and explores the disadvantage associated with the large spread use of automobiles relates to Green House Gas (GHG) emissions, global warming and pollution, The present state of development of automobile technology is explained. The need for curtailing use of fossil fuel in transportation and surveying other energy is to be adapted to transportation for reducing fuel use is also examined. How to increase efficiency of transport vehicle using present technological development is explored. It is concluded that it is ripe time to go for hybridization using other nonpolluting energies, energy storing devices like batteries, fuel cells and super capacitors to save the earth for life sustainability. Research study on the investigation of regenerative braking force in highbred electrical discussed. Then control strategies are discussed for recovery of regenerative brake energy and successful operation of HEVs**

1. INTRODUCTION

Today, the number of Internal combustion engine vehicles ICEV models and applications is astonishing, ranging from small personal transport cars to a hundred passenger buses, to heavy load and goods transportation trucks and heavy work caterpillars. Modern ICE vehicles encompass top comfort, excellent performance and advanced security, for relatively low prices and, needless to say, have become most attractive consumer products However, despite approximately a century-long auto industry and academia struggle to improve ICE efficiency, in vain and still continue to be, incredibly low.

The transportation sector is especially affected by this fuel situation and needs to develop new energy vectors and systems to reduce the oil dependency whilst attending to environmental issues. The development of innovative technologies is increasingly oriented towards electrification of vehicle propulsion systems expected to lead to: a reduction of harmful emissions, an increased efficiency of vehicles, improved performances, a reduction of fuel consumption, a reduction of noise, and potentially lower maintenance costs. The intermediate step for fuel cries with available technology is a hybrid electric vehicle (HBV). Hybrid electric drive configurations consist of a fuel-burning prime power source – generally an ICE–coupled With an electrochemical or electrostatic energy storage device, driven electric motor. These two power sources work in conjunction to provide energy for propulsion

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ENERGY AVAILABILITY

With an electrochemical or electrostatic energy storage device, driven electric motor. These two power sources work in conjunction to provide energy for propulsion Energy availability and cost is at the heart of today's political and scientific agenda involving many economic, ecologic and geopolitical aspects, because the world primary demand for energy will increase by 30 % in two decades. The Total Final Consumption of energy, TFC, in the modern world is also mainly in the form of fossil fuels and oil will remain the single largest fuel in the fuel shares of total final consumption (43.4 % in 2005, 41.3 % in 2009) with transport and power generation sectors absorbing a growing part of global energy. Indeed, the transports sector alone was responsible for 60.3% of the World Oil Consumption. Yet this challenging situation had to be dealt with urgently since only finite amount of fossil fuel available for an ever-increasing world fleet. Motor vehicles are the largest net contributor to Green House Gas (GHG) emissions and global warming pollution, followed by the burning of household biofuels (i.e. wood and animal dung) and raising livestock. The world Total Primary Energy Supply, TPES (with nearly 87 % coming from fossil fuels in 2009) has to fulfill this Demand.

Due to the prior mentioned issues, there is now a general public awareness for the need for more economic, ecological and efficient transportation, namely electric vehicles (EVs) and hybrid electric vehicles (HEVs). Indeed, electric traction is the key to advanced and sustainable transports as the electric motor (EM) is much more efficient (typically with 70-90 % efficiency) than the ICE (10-30 %). This allows a much smaller *in vehicle* (or *Tank-To-Wheel*) energy consumption in vehicles driven by EMs comparatively to ICE vehicles,

For instance, the European Council has established the objectives of reducing greenhouse gas emissions by 20%, of increasing the share of renewable energy to 20% and of improving energy efficiency by 20% by 2020, high lights the urgency of energy scenario.

1. HYBRID ELECTRIC VEHICLES

Hybrid Electric Vehicles (HEVs), i.e., those that combine ICE with electrical machines fed by batteries or fuel cells (hydrogen derived electricity), are offered by world's greatest carmakers. The performance of HEVs, from the driver's standpoint, rivals or outdoes that of modern ICEVs. Their energy consumption ranges from circa 10% to 70% lower than that of an equivalent ICE car, depending on their power, battery size, control strategy, etc. The dramatic gain in energy efficiency, besides much lower

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or zero gas emission and noise-free operation, is due to the much higher efficiency of electric motors and control strategies such as regenerative braking and storage of excess energy from the ICE during coasting.A hybrid electric vehicle is distinguishes from a standard ICE driven by four different parts: a) a device to store a large amount of electrical energy, b) an electrical machine to convert electrical power into mechanical torque on the wheels, c) a modified ICE adapted to hybrid electric use, d) a transmission system between the two different propulsion techniques.

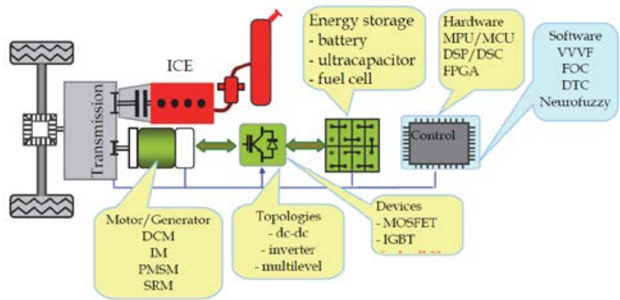

Fig. Main components of a hybrid electric vehicle

2. THE ENERGY STORAGE ISSUE IN ELECTRIC VEHICLES

To allow H EVs to become the effective sustainable transportation solution, a great effort has to be done in R&D to overcome the major technical issue in EVs: the energy storage. The bulky, heavy and expensive battery with low specific energy, it is very difficult to make a general purpose EV, that to effectively competes with ICE cars. For massive deployment of EV, its driving range problem must be solved. At present and in the foreseeable future, the viable EVs energy sources are batteries, fuel cells, SuperCapacitors (SCs) and ultrahigh-speed flywheels. For the "full electric" EV the solutions pass by significant progresses in battery technology and by using different energy sources with optimized management of the energy flow as none of the available energy sources can easily fulfill alone all the demand of EVs to enable them to compete with gasoline powered vehicles.

Their main advantage gas engines is the very high energy density of liquid fuel (12500Wh/kg) that allows long driving ranges with small (and light-weight) storage tanks and safe and fast refueling processes. Moreover, gasoline and diesel fuels have an established infrastructure of distribution that is difficult and very expensive to replicate for other energy sources .In essence, these energy sources have a common problem: they have either high specific energy (HSE)or high specific power (HSP), but not both. A HSE energy source is favorable for long driving range, whereas a HSP energy source is desirable for high acceleration rate and high hill climbing capability. The concept of using and coordinating multiple energy sources to power the EV is typically denominated *hybridization*. Hence, the specific advantages of the various EV energy sources can be fully utilized, leading to optimized energy economy while satisfying the expected driving range and maintaining other EV performances.

There are several configurations of electric and hybrid vehicles: 1. electric vehicles equipped with electric batteries and/or supercapacitors called BEV (Battery Electric Vehicles), 2. hybrid electric vehicles which combine conventional propulsion based on ICE engine with petroleum fuel and electric propulsion with motor powered by batteries or supercapacitors called HEV (Hybrid Electric Vehicles), 3. Electric vehicles equipped with fuel cells, called FCEV (Fuel Cell Electric Vehicles). Concept of hybrid electric vehicle with ICE-electric motor aims to overcome the disadvantages of the pure electric vehicles, whose engines are powered by electric batteries or supercapacitors for limited duration of use (low autonomy) and time recharging for batteries.

3. CLASSIFICATION OF HYBRID VEHICLES

Hybrid Electric Vehicles can be classified according to their architecture, the discharge/recharge mode of batteries and the level of hybridization. As for architecture, HEV are called "parallel" when they use a gasoline or diesel engine mechanically coupled with an electric motor at the same shaft to satisfy the power request at the wheels.

A series HEVs the wheels are only driven by the electric motor that also operates as generator during break and coasting, augmenting thus the overall energy efficiency. This topology simplifies power train design, since clutch and reduction gear are not necessary. Speed and torque control is carried out by controlling the electric motor only, which is a very efficient with power electronics converter .The ICE's role is charging (or recharging) the battery and supplying energy to the electric motor, always being operated at maximum efficiency. This is another strategy that helps increasing the overall energy efficiency.

A parallel HEVs, propulsion can be the result of torque generated simultaneously by ICE and the electric motor. This technology provides for independent use of the ICE and electric motor, thanks to the use of two clutches. One of the key features of parallel HEVs is that, for a given vehicle performance, the electric motor and ICE too, can be significantly smaller than that achieved with series architecture, what allows for a relatively less expensive vehicle. On the other hand, wheel propulsion by the ICE leads to superior dynamic performance of this topology.

A series-parallel HEV, at the expense of one more electric generator and a planetary gear, a quite interesting architecture for the power train is obtained which blends features of both series and hybrid topologies, and is conveniently named series-parallel architecture. Though more expensive than any of the parent architectures, series-parallel is one of the preferred topologies for HEVs, specially when automakers target excellence in dynamic performance and high cruising speeds for their models.

A complex HEV consist of two bidirectional power converters are utilized, one for the main electric motor, and another one for the auxiliary electric motor. Unlike in series-parallel HEVs, both these motors can propel the wheels concomitantly. In other words, three different torque sources add up to drive the wheels, thus leading to a better foreseeable dynamic performance vehicle and clearly higher cruising speed car.

5. ENERGY SOURCES

At present and in the foreseeable future, the viable EVs energy sources are batteries, fuel cells and Super Capacitors (SCs).

Batteries:

Typically, EVs store energy in batteries (usually Lead-Acid, NiMH and, more recently, Li-Ion) that are bulky, heavy and expensive. The specific energy of gasoline is about 12500Wh/kg (of which only 2000-3000 can be considered useful energy, due to the very low efficiency of ICE) against typically 40-50 Wh/kg in good lead-acid batteries or 70 Wh/kg in NiMH, which gives an idea of the volume and weight necessary to store the energy needed to do the same work. Li-ion batteries have higher specific energy, around 150 Wh/kg but they are still expensive and some particular Li-ion technologies have safety issues that have to be carefully addressed. Due to these problems, with current battery technologies it is very difficult to make a general purpose EV that effectively competes with ICE cars.

Fuel Cell

The developments leading to an operational FC can be traced back to the early 1800's with Sir William Grove recognized as the discoverer in 1839.A FC is an energy conversion device that converts the chemical energy of a fuel directly into electricity. Energy is released whenever a fuel (hydrogen) reacts chemically with the oxygen of air. The reaction occurs electrochemically and the energy is released as a combination flow-voltage DC electrical energy and heat. Types of FCs differ principally by the type of electrolyte they utilize. The type of electrolyte, which is a substance that conducts ions, determines the operating temperature, which varies widely between types. Proton Exchange Membrane (or "solid polymer") Fuel Cells (PEMFCs) are presently the most promising type of FCs for automotive use and have been used in the majority of prototypes built to date.

Super capacitors

The basic principle of electric double-layer capacitors lies in capacitive properties of the interface between a solid electronic conductor and a liquid ionic conductor. This effect is called electric double-layer, and its thickness is limited to some nanometers In SCs, the dielectric function is performed by the electric double-layer, which are constituted of solvent molecules. They are different from the classical electrolytic capacitors mainly because they have a high surface capacitance (10-30 μF.cm-2) and a low rated voltage limited by solvent decomposition (2.5 V for organic solvent). Therefore, to take advantage of electric double-layer potentialities, it is necessary to increase the contact surface area between electrode and electrolyte, without increasing the total volume of the whole. The most widespread technology is based on activated carbons to obtain porous electrodes with high specific surface areas (1000-3000 m2.g-1). This allows obtaining several hundred of farads by using an elementary cell.

4. INVESTIGATION OF THE REGENERATIVE BRAKING FORCE IN ELECTRIC VEHICLES

It is known that during a work cycle of a motor vehicle, which consists of a period of acceleration, another one of running at constant speed and a period of deceleration, the power required during acceleration is much greater than that required while running at constant speed and, in principle, it is this power what determines the size of engine installed on the motor vehicle. Upon vehicle braking, kinetic energy acquired by acceleration of the motor vehicle is converted into heat energy, which is located in the braking system and gets lost, irreversibly, into space, with negative effects on *global warming*. So, rightfully, there has been formulated the technical problem that, during the motor vehicle braking stage, the kinetic energy gained by it to be recovered and stored in power batteries / supercapacitors and then used during start-up and acceleration stages. Therefore, vehicle manufacturers consider that one of radical solutions in order to achieve the above mentioned goals is a deep change of motor vehicle propulsion method, promoting *hybrid propulsion systems*, which are considered to be solutions for the near future for a substantial decrease of fuel consumption and polluting emissions. Propulsion systems that are composed of besides a conventional propulsion system with an internal combustion engine and at least another one based on another type of energy, capable of providing torque/traction moment at the motor vehicle wheels, form a hybrid propulsion system. If they, along with propulsion, can recover, during braking stage, part of the kinetic energy accumulated in the acceleration stages, then they are called hybrid regenerative systems.

7. CONTROL STRATEGIES

Control is a fundamental part of a successful HEV design. Control engineering has matured for decades and now-a-days counts on sophisticated microcontrollers and digital signal processors hardware and advanced integrated development environments. Despite all the available powerful tools and techniques, "efficient" control of HEVs continues to challenge engineers and researchers, for the EVs embrace nonlinear processes (like battery behavior), devices that are difficult to model (such as the ICE), and some conflicting goals, as for instance control for energy efficiency and control for better dynamic performance. It is not a coincidence that this area is one of the most prolific in the technical literature. Advanced digital control technique, such as optimal control and fuzzy control, are used by researchers and carmakers as they strive to improve HEVs behavior.

SOME OF TESTED RESULTS WITH HBVs RESEARCH

1. This work is to implemented and ultracapacitor system installed in a Chevrolet LUV truck, similar in shape and size to a Chevrolet S-10, which was already converted to an electric car.

It is interesting to mention that, if ultracapacitor reaches in the future, a specific energy of at least 20Wh/kg (at this moment some laboratory samples reach 10 Wh/kg), it will be possible to implement EVs with ultracapacitors only. They could give a range of 100 kms with a 500 kgs capacitor bank, with very short charging time and excellent life expectancy. The EV will be able to be fully charged in few minutes. Besides, the ultracapacitor could last all the vehicle useful life.

2. A mild ultracapacitor hybrid powertrain concept considered in this research shows a potential to improve the fuel economy of passenger vehicles in city driving. Results also indicate that the energy provided by regenerative braking may be sufficient to sustain the motor's assistance to propulsion for city driving conditions similar to those encountered in the drive cycle. This paper has not explored additional fuel economy improvements due to an optimized shifting strategy, nor the improvements possible by implementing a real-time optimization-based control strategy. More detailed analysis is also needed to determine if fuel consumption can be further reduced for a downsized engine or by elimination of the torque convertor. These topics are relegated to future work.

3. Ultracapacitors can generally cover peak power demands and store energy released during regenerative braking. In EVs, ultracapacitor application can increase battery cycle life as well as battery cycle efficiency, prolonging vehicle's operating range. Ultracapacitors can even replace battery and become the only onboard power source. In HEVs they allow to apply unusual combustion engines as power source, for example micro-turbine. This can improve the vehicle's efficiency and its emissions.

4. The research presents the benefits of hybridization of energy storage for an urban electric vehicle. Simulation results show how combination of lithium batteries and ultra capacitors improves the efficiency and reliability of the source. The hybridized source can provide desired maximal power independently to battery ageing process, in various temperature conditions. Energy recovered during regenerative braking is stored firstly in ultracapacitors, which makes this process more efficient than in case of storing it in an electrochemical battery. At the same time hybridization reduces the maximum battery current and number of executed cycles, slowing down battery ageing process and extending time periods between maintenance(costly battery replacement operations)

8. CONCLUSIONS

Hybridization along with batteries, fuel cells and super capacitors has resulted in reduced fossil fuel consumption automotive emissions. Some of the results like adoption in Chevrolet S-10 LVU truck gave a range of 100 KMs with 500 Kg super capacitor bank, with very short charging time, excellent life expectancy, fuel economy and peak power demands. Kinetic Engineering Limited is going to lanch Hybrid Electric Three Wheeler shortly. This is the outcome of research by KEL in collaboration with CRTR India.

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8, SulajjaFirodiaMotwani press briefing on KVL research on the launch of Kinetic Engineering Limited Hybrid Electric three wheeler shortly.