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Methods to Reduce Dependency on Conventional Battery in Electric Vehicles

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***Abstract* - The proposed research work is with the aim of analyzing the sources of energy for EV with the intention to reduce dependency on battery pack. EV needs no introduction for the automobile world. Almost all vehicle manufacturers in the car segment are looking for alternate ways to propel the vehicle ever since fossil fuel operated vehicles have become a cause of concern by the spiraling cost of fuel and pollutants. The paper through descriptive research methodology intends to identify opportunities to reduce the dependency on battery pack. Consideration of utilizing the kinetic energy of the car, wind energy by using vested funnels and solar energy using flexible solar array is made. These findings may serve as input in improving efficiency, ensuring clean energy for EV and further research on the subject.**
***Keywords:* Electrical Energy, Dynamo and Magneto, Vested Funnel, Wind Energy, Solar Energy**

I. INTRODUCTION

An electric car which uses clean energy as compared to conventional vehicles can be; battery electric vehicle, plug in hybrids, fuel cell vehicles. In a battery electric vehicle electricity is stored in a battery pack, fossil fuels with electric motor and battery is used in hybrid cars, and split electrons from hydrogen molecules produce electricity to rum motor in fuel cell vehicles. These are automobiles which are given thrust by electric motors utilizing energy stored in the batteries. It is clear that there is heavy dependency of Lithium in electric cars. Chile is the largest producer of Lithium, apart from Argentina and China. Bolivia has the largest deposits of Lithium. One of the identified alternatives of Lithium-ion battery is Sodium-ion battery. Because of abundance of sodium in comparison to lithium even though they are next to each other in periodic table, Sodium-ion batteries are preferred being cheaper. Another advantage or cost reduction is from the point that sodium-ion batteries do not require cobalt. Cobalt is expensive and 25% of the cost of the battery is from use of cobalt. Sodium which is found in the sea water can provide clean drinking water by processing sodium from sea water. The drawback of sodium-ion battery is less energy dense. However, they are lighter than Lithium-ion batteries.

Hence one of the major challenges for powering the motor is availability of power for running the motor. As batteries have limited storage capacity it reflects on the radius of action of the electric vehicle in comparison to fossil fuel vehicles. At an average an electric car can run 300 km in one charge which is reasonable. But when compared to a fossil fuel car it is less. Electric cars at present are not designed to charge while driving. Hence the limitation is faced by the capacity of the battery which stores electric power. There are peculiarities because of which the size of the battery is a constraint. Solar cars have a limitation as far as weight is concerned.

The principle on which electric cars work is that on application of throttle, the power pack provides energy to the stator making the rotor to move which in turn provides mechanical energy to the gears of the electric vehicle. Turing of gears induce rotation of gears which makes the wheels rotate. In an electric car, the electric motor is just one part of a larger unit called the power train. Here we also find the Power Electronic Controller (PEC), in charge of the electronics that control the motor’s power supply and battery charging, and the gear motor which adjusts the torque (turning force) and speed of rotation.

II. OBJECTIVES OF THE STUDY

1. This paper aims at working out a conceptual power pack for driving a motor to propel a car.
2. The power train in an EV is generally run by a battery. Battery is one of the costliest components of an EV. This paper aims at reducing the dependency of the battery to a great extent. The aim would be bringing out alternative sources of generation of electric power in an EV.

III. LITERATURE REVIEW

Enge Per, Enge Nick, (2020), Electrical Vehicle Engineering, Amazon. This hands-on resource thoroughly explains the technologies and techniques involved in the design and operation of today’s electric vehicles. Originally written for use in a course co-taught by the authors at Stanford University [2].

Johnson Chris, (2020), The Arrival of Electric Car, International Kindle Paper white. There are over 25 battery EVs from which to choose including pickup trucks, SUVs and sedans. This book is a comprehensive, easy-to-understand overview of the passenger EV.

Chandler Matter, (2020), The Tech behind Electric Cars, International Kindle Paper white. Electric cars have come a long way since the first petrol-electric hybrid vehicles hit the market in the late 1990s. Some modern electric cars boast a range of around 480 kilometers (300 miles) on one charge. This book takes young readers on a journey through the technology that makes electric cars so amazing [1].

Larminie James, Lowrie johns, (2012), Electric vehicle Technology explained, Wiley. This book is a complete guide to the principles, design and applications of electric vehicle technology. Including all the latest advances, it presents clear and comprehensive coverage of the major aspects of electric vehicle development and offers an engineering-based evaluation of electric motor scooters, cars, buses and trains [5].

Ekhlas Hussien& others, (2017), A Comprehensive Study of Key Electric Vehicle (EV) Components, Technologies, Challenges, Impacts, and Future Direction of Development, MDPI. The impacts EVs cause in different sectors have been discussed as well, along with the huge possibilities they hold to promote a better and greener energy system by collaborating with smart grid and facilitating the integration of renewable sources. Limitations of current EVs have been listed along with probable solutions to overcome these shortcomings [3].

Xiaoli Sun & others, (2020), Technology Development of Electric Vehicles, Research gate. This paper provides a comprehensive review of the technical development of EVs and emerging technologies for their future application. Key technologies regarding batteries, charging technology, electric motors and control, and charging infrastructure of EVs are summarized. It also highlights the technical challenges and emerging technologies for the improvement of efficiency, reliability, and safety of EVs in the coming stages as another contribution [7].

Nanaki A Evanthia, (2021), Electric Vehicles for Small Cars, Science Direct. This chapter includes an overview of electric vehicle technologies as well as associated energy storage systems and charging mechanisms. Different types of electric-drive vehicles are presented. These include battery electric vehicles, plug-in hybrid electric vehicles, hybrid electric vehicles and fuel cell electric vehicles. The topologies for each category and the enabling technologies are discussed [6].

IV. INCLUSION/EXCLUSION

Electric motor powered vehicles have been in the technology sector since long. The first crude electric vehicle was built by an inventor in 1884. As electric vehicles came onto the market, so did a new type of vehicle - the gasoline-powered car - thanks to improvements to the internal combustion engine in the 1800s. Electric cars didn't have any of the issues associated with steam or gasoline. They were quiet, easy to drive and didn't emit a smelly pollutant like the other cars of the time. Electric cars quickly became popular.

In this paper the discussion is on the power pack system for electric car. Hence design of an electric car has not been holistically considered. Similarly, the concept of a hybrid car which is popular in certain areas is also not considered. Fuel cell cars which use split electrons from hydrogen to produce electricity is not considered. The aim is to find combination of sources of energy to power the motor for running an automobile using electrical energy.

V. METHODOLOGY

A. Descriptive Research Analysis

Most of the car users travel around 50 kilometers on any normal day. This when translated to energy requirement would be 10 kWh with an average consumption of 5 to 6 km for a kWH. The energy requirement can be ideally split based on the accessories powered by DC motor and the main engine powered by AC motor. Synchronous motor produces high torque at low speeds and is compact and light hence in a way suitable for city driving. In an asynchronous motor the rotor is pulled to spin, trying to catch up developing high power output. For traction in an EV, AC motors are used and DC motors for windshield wipers, electric windows. Electric motor is one part of the power train.

The power requirement of the EVs is now met from a Lithium-ion battery. As per the data available the maximum range works to 600 km. In an EV the battery is the costliest item, and a 60 kWh battery may allow the car to drive about 3 hours. Alternate sources of powering the EV can be from a combination of resources. The potential ones observed are mechanical energy, wind energy, solar energy and regenerative braking system. The cars have four wheels which rotate around propelled by mechanical force. As the control of the car is a steering which is connected to the front wheel utilizing the kinetic energy created by rotation of these two wheels may be a problem.

However, the mechanical energy created by rotation of the two rear wheels can be utilized. By connecting one dynamo each to the rear wheels the mechanical energy generated by these two wheels can be tapped to produce electrical energy that can be used to provide the energy for propelling the car. Let us now work out the energy requirement and energy produced by such an arrangement. The power requirement of an EV is in two groups, and these are power requirement for a range of speeds and power requirement for acceleration. The power required to propel a car is derived from the equation;

$$Power\ required = Total\ resistance\ force\ X\ maximum\ velocity$$

Using an ICE, a 1200 kg car consumes 66 kW power. The peak power is used during acceleration and not coasting. Out of the two types a hub or a bottle type dynamo, the consideration can be a hub dynamo which is built on the hub of the car wheel. It is not that dynamos are not without problems. A hub dynamo generally increases the weight of the hub three times, but this can be reduced. As regards drag, a hub dynamo creates a drag which increases as the speed of the vehicle increases. There are hub dynamos in operations currently which have been constantly pursuing the technology and reducing the weight of the hub dynamo. Diagram of a hub diagram [8].

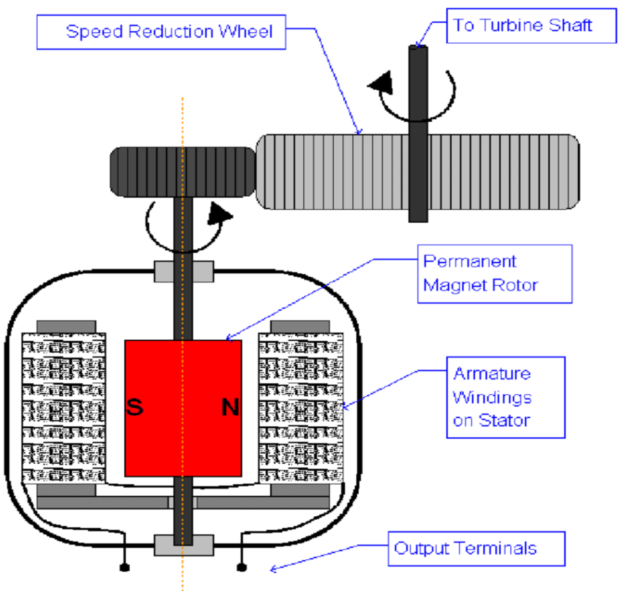

Fig. 1 Hub dynamo

Fig. 2 Picture of a hub dynamo [8]

For traction in EV, AC motors are used and DC motors for other accessories. As we know magneto is an electric generator which uses permanent magnets to produce alternating current. Magnetos are used in IC engines to provide power to spark plugs by producing pulses of high voltage. Both dynamo and alternators require a source of power to drive the coils, hence some process of bootstrapping is required. The field in magneto is excited by magnets whereas in the case of alternator it must be excited by a battery.

There is a possibility of combining the utilization of magneto and dynamo in power generation of an EV. This is primarily to increase the circuit of action. The magneto would be used for generating high voltage current in system where it is required and as it generates alternating current it can be considered for the power train.

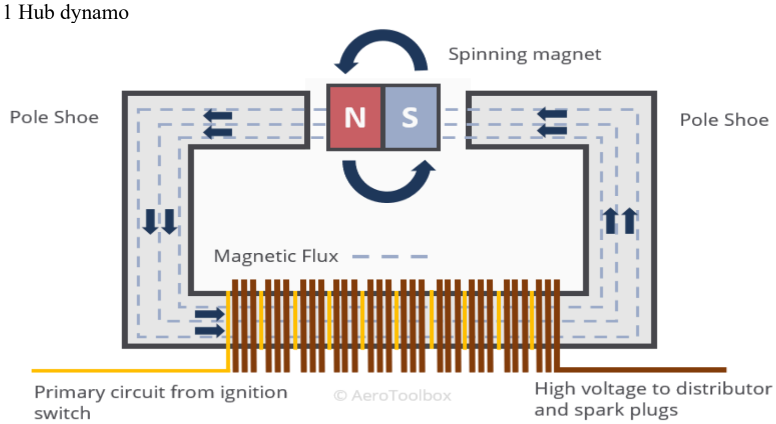

Fig. 3 Magneto [9]

How does an EV function? On activating the car pedal, electrical energy from the battery and inverter is taken by the controller and energy based on the depth or pressure of the pedal is send to the motor which converts electrical energy into mechanical energy. Rotation of the motor turns the transmission, with which the wheel turn and car moves. The auxiliary battery provides power to operate the car accessories. Here electric traction motor is the major component of the EV. Hence the traction battery pack provides power for the vehicle and auxiliary battery provides power to the accessories. If suppose through the use of hub dynamo fitted to the rear wheels of the car is able to generate enough power for traction, then the requirement of stored electric power would be limited to a portion of the 66 kWH. Which implies that the traction battery bank can almost be eliminated to great extent with the requirement to provide stored energy till the vehicle moves to operate the dynamo to the potential level for generating the electric power. This can be supplemented once the vehicle moves by making use of the power generated from regenerative braking system.

For tapping wind energy, the cut in speed is 10-15 kmph when the blades start rotating and generating power till rated speed and reaches the limit. The sides of the EV can be articulated to be made into a funnel based energy harvesting system. Here the flow of the air is made into a nested funnel. We are aware that the velocity of turbine is increased in the case of wind energy by venture speed ratio of 1.80 to 3.22 than the inlet velocities of vested funnel. Vested funnels are made on the sides of the vehicle which channelizes the airflow to operate mini turbines of small sizes at the end of the funnel. In such an arrangement the electric power generated from the wind energy by funneling the exterior side walls of the car would complement the traction power provided by the hub dynamos. The wind turbine gets in factors such as cut-in speed, rated speed and cut- out speed for uniform power generation and prevention of damage to the turbine. In this case of utilization of wind energy as an auxiliary source for EV, efficiency of the motor and its size are important.

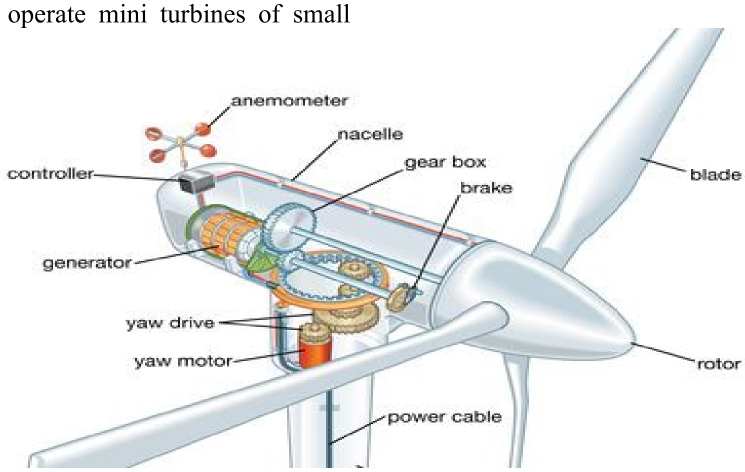

Fig. 4 Wind Turbine [10]

These vested funnels can be channelized to a wind turbine located to the rear portion of the vehicle for generation of power.

A schematic diagram is given below.

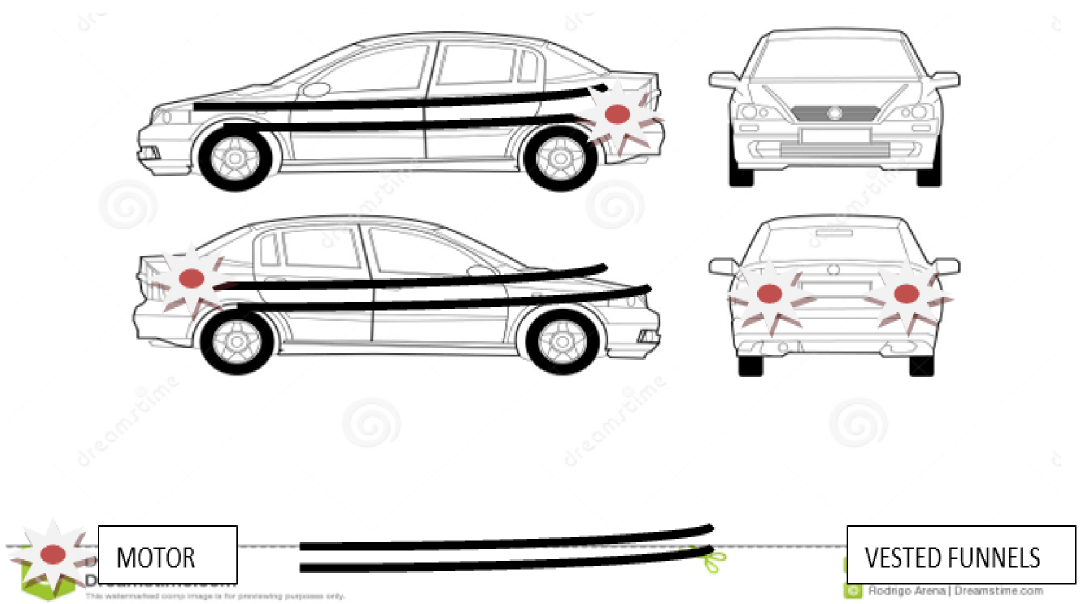

Fig. 5 Vested funnels [10]

A typical solar powered car uses solar cells to get energy to power the EV. Requirement as in the case of other EV is energy efficient power train. PV or photovoltaic cells which are made of semiconductors such as silicon, alloys of indium, gallium and nitrogen convert the sunlight to electric current. A thin flexible array would ideally suit the EV is as an auxiliary source of power. A motor which operates with solar power can generate up to 3 horsepower. Top surface of the car can be fitted with flexible array of photo voltaic cells. Surface area of a normal car is 60 square feet which can generate up to 2 hp that can partially charge the system which can be used to power the accessories relieving the alternator from consuming engine power.

Fig. 6 Roof of a car with solar panels[11] [12]

VI. FINDINGS OF THE STUDY

EVs are presently powered by a power train based on a battery pack which is based on Lithium-ion cells. There are two aspects which causes concern for a customer, which are the limited range and then the high cost of Lithium-ion cells. Sodium-ion batteries can be used but they require three times the size being less energy efficient. Even though the cost can be reduced using Sodium ion cells, it does not take care of the limited range. The thought process went on to identifying a power train which is less dependent on battery pack for the power train.

Utilization of dynamo and magneto has been considered for converting the kinetic energy produced by the car on its motion to electrical energy using the dynamo or magneto as the case may be. Magneto can provide electrical energy with high voltage. On the other hand, dynamo can provide regular electric current to run the motor to drive power train and traction of the car.

In addition to the electric current produced by the dynamo and magneto, the high voltage electric current can be complemented by using regenerative braking system. What are the other sources available for generating electrical energy? These have been analyzed and we found that the structure of the car provides utilization of technology to generate power from wind energy and solar energy. Wind energy as a source of auxiliary power can be cultivated through vested funnels.

The cut-in, rated and cut-off speed should be identified to generate maximum electrical energy and prevent damage to the rotor. The vested funnels can be aerodynamically designed on the side walls to gain maximum electrical energy. Another source of auxiliary power is solar energy. An average car has a roof area of 60 square feet. By fitting flexible solar array, it can generate a constant 2-3 hp power.

VII. CONCLUSION

EV has become a necessity due to various reasons. Spiraling of oil price may be a temporary phenomenon but more importantly is the depletion of fossil fuel which gives a hint that sooner or later it would finish. Technologically EV has taken shape in various forms and most of the automobile companies have moved on to the transition of manufacturing EV engines from IC engines. One of the common technologies adopted is relying heavily on battery pack. With the dependency on Lithium-ion battery being heavy despite being the alternative of Sodium-ion available cost factor is a cause of concern. Hence dynamos and magnetos can provide a solution by providing electrical energy from the kinetic energy produced by the wheels of the car. In addition, there is scope for utilizing wind energy adopting vested funnels in the side panels of the EV. As has been tried out in the past, flexible solar arrays can be incorporated on the roof of the EV for harvesting electrical energy.

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