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Performance Analysis of Various 4-Wheelers with IC Engines for Hybridization

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Abstract: ***A major portion of the vehicles used for transportation run on fossil fuels which is a non-renewable source of energy. It is estimated that we will run out of resources of fossil fuels in the next 25 years if the consumption continues at the same rate. Due to the rising demands for petroleum and the depleting resources, the cost of fuel has also increased. Another drawback of using these energy sources is the pollution that they cause which affects the environment and the health of the people. To reduce the dependency on fossil fuels and make use of the abundantly available natural resources there is a need to develop a vehicle which can make a transition between these two and hence reduce the pollution, cost of fuel thereby increasing efficiency. On an average, every square meter of the earth's surface receives 164 W of solar energy. This can be utilized through solar cells to generate electricity which can be converted to motive energy to run an automotive. This can be done using hub motors which decrease the maintenance required as compared to the petroleum only cars. Since they derive the motive energy from solar powered batteries the need for refueling is eased.***

Keywords: ***Hybridization, Hub Motor, Clutch, Drive Train, IC Engine.***

I. INTRODUCTION

People have traversed the earth for many years using various methods. These methods have been constantly changing from things like animals to complicated systems. These systems are now polluting our environment. Industrialization along with automation has induced the evolution of fast and dependable means of transport, allowing us to move rapidly and comfortably to different destinations. These transportation systems have become essential in our daily routine. Most of these systems are driven by internal combustion engines.

Fossil fuels are non-renewable and they emit harmful gases called the greenhouse gas into the atmosphere. The primary source of fuel is petroleum, which is a fossil fuel. The price of such crude oil has increased significantly in the past few year and there seems to be no turning back. The dependence on such source has to be reduced by choosing an alternative source.

It is estimated that if the consumption continues at the same rate then the fossil fuel resources will be completely depleted in 25 years.[1] The concerns about the petrol reserves and prices, as well as pollution and global warming issues, have increased the interest in electric vehicles. The governments have started to provide more incentives and, private companies have concentrated on electric vehicle development projects. By looking at past ten years studies, it is seen that main attention was focused on series and parallel hybrid drives. Recently, however, plug-in hybrids (PHEV) and all-electric vehicles (EV) seem to receive more attention. In all front wheel driven types, mechanical differentials are used for a rear wheel similar to conventional Internal Combustion Engine (ICE) driven vehicles. In spite of this trend, the driving each wheel separately by direct drive electric motors without any differential has not been widely adopted. Mainly because of the difficulties of designing an electric machine inside the rim and angular speed limitations governed by vehicle wheels [2, 3, 4]

II. METHODOLOGY

In our paper, we have incorporated the hub motor in the rim of rear wheels of the test vehicle. This motor is energized when supplied by electricity. The motor is connected to the battery. When the motors are energized caused the rotation of the wheel. The battery is charged via solar panels, which are designed based on the power requirements of the test vehicle. Solar panels are incorporated on the rooftop of the car. The panels are designed individually for each car as the power ratings vary for each car as in fig 1.

The car use fossil fuelled IC engine during ignition. After the vehicle's speed reaches a predefined speed we make use of a manual switch to switch over another mode of operation. Our main concern is the working of the clutch. In the first mode, the car runs on IC engine irrespective of the clutch position. In the second mode, the vehicle will run on IC engine above the half clutch point and below that it will be a hybrid vehicle which runs on hub motors. After the battery is completely discharged, the car will be made to run on IC engine by using the manual switch. Here a module is designed so as to monitor the charge in the solar powered battery.

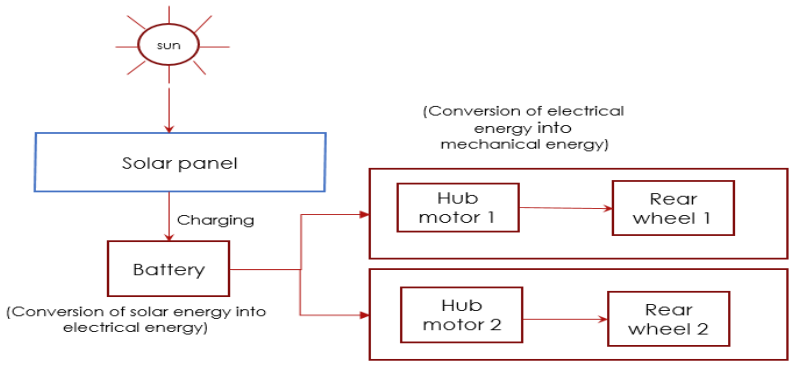

Fig1: Block diagram

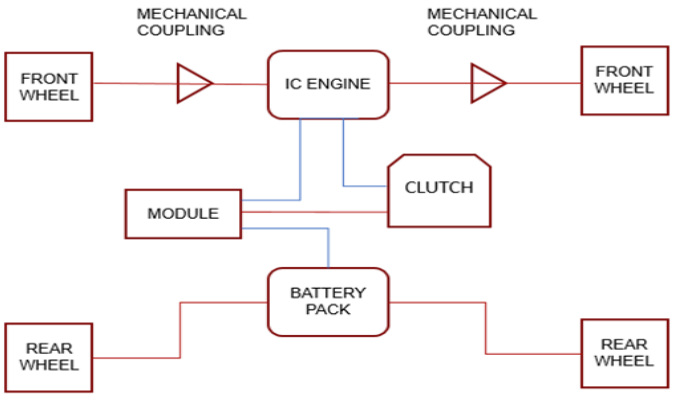

Fig 2: Working Principle

I. *Components*

1) *Motor*: Choosing a motor is the first step in creating an appropriate system for the hybrid car. When comparing a typical DC motor to an AC motor, the fundamental advantage is the ease with which the motor can be controlled to give varying speeds, direction, and even regenerative braking. The main drawback to the DC motor is that the carbon brushes of a conventional DC motor wear down and create a great amount of dust. This, in turn, requires a great amount of maintenance and lead to the overall replacement of motor itself. Another major problem that conventional DC motor have is their high level of radio-frequency interference (RFI). The RFI generated by the brush gears can be of major concern to communications between certain aspects of a DC motor applications and may cause failure. Thus, the brushless DC motor (BLDC motor) was developed to have the same advantages of a conventional DC motor, without the problems and disadvantages caused by the brushes.[7] The main advantages and characteristics of a BLDC motor compared to conventional dc motor includes: Longer life and high reliability, Higher efficiency, Ability to operate at various speeds, including high-speed applications, can reach peak torque from standstill, Construction of motor is rigid, eliminates radio frequency interference due to brush commutation and heat generated inside the stator, easier to remove and maintain, Rotor has permanent magnets vs coils. Thus, it is lighter and has less inertia and hence is easier to start and stop, Linear torque/current relationship, smooth acceleration or constant torque, Higher torque ripple due to lack of inflammation between sectors', Low cost of manufacture, Simple, loss cost design for fixed speed applications, Clean, fast, and efficient, Speed proportionate to line frequency (50 or 60 Hz), Complex control for variable speed and torque[8]All of this contributed to the decision to use a BLDC hub motor as the driving source of our hybrid car. The benefits of the BLDC motor give the hybrid car the reliability and features it needs to make a practical and reliable alternative source of transportation. In a hub motor, the electromagnetic fields are supplied to the stationary windings of the motor. An alternative for having a single motor giving power to all the wheels using gears or chains, there can be separate motors mounted directly on the hub of each wheel so the motors and wheels are one and the same thing [5]. Electromagnetic fields are supplied to the stationary with windings of the motor. The outer part of the motor follows, or tries to follow, those fields, therefore turning the attached wheel.

In a brushed motor, energy is transferred by brushes contacting the rotating shaft of the motor. Since energy is transferred in a brushless motor electronically, it eliminates physical contact between stationary and moving parts

2) *Valve regulated lead acid (VRLA) battery:* In a valve regulated lead acid battery (VRLA) the hydrogen and oxygen which are produced in the cells mostly recombine to form water. The leakage in the battery is minimal, although some electrolyte still escapes if the recombination cannot keep up with the rate of evolution of gas. Since they do not require regular checking of the electrolyte level, they are called maintenance free batteries. However, the cells of the battery do require maintenance. As the electrolyte is lost, VRLA cells tend to "dry-out" and lose capacity. This can be detected by taking regular measurements of internal resistance, impedance or conductance. VRLA types became popular on motorcycles around 1983, because the acid electrolyte is absorbed into the separator, so it cannot spill. The separator also helps them better withstand vibrations.

3) *Solar panel:* The solar panels are the basic concepts of the generation and storage of photovoltaic solar energy. Solar panels are devices that convert light into electricity. They are also called photovoltaic which means “light-electricity”. Solar cells in the solar panel rely on photovoltaic effect to absorb the energy of the sun and cause current to flow between two oppositely charged layers in each solar cell. Photovoltaic modules use light energy (photons) from the Sun to generate electricity through the photovoltaic effect. The majority of these modules use wafer-based crystalline silicon cells or thin-film cells. The structural (load carrying) member of a module can either be the upper layer or the back layer. The photovoltaic cells should also be protected from mechanical damage and moisture. Although most modules are rigid, semi-flexible ones are available, based on thin-film cells. The cells must be connected electrically in series, one to another. The electrical connections in the modules are made in series to attain the desired output voltage and/or in parallel to attain a desired current capability. The conducting wires that take the current off of the modules may contain silver, copper or other non-magnetic conductive transition metals. Some special solar PV modules also include concentrators in which light can be focused by lenses or mirrors onto the smaller cells. This enables the use of cells with a high cost per unit area (such as gallium arsenide) in a cost-effective way. Solar cells are most commonly made from silicon, which is the same material that is used to make computer chips. Silicon is one of the Earth’s most common elements and is a major component of sand and many kinds of rocks. A solar cell is built like a sandwich, with two layers of silicon separated by a thin layer of insulating material. All three layers work together to convert sunlight into electricity. As sunlight falls onto the solar cell, it produces a small electric charge. Like a battery, the charge is positive on one side and negative on the other. A wire connects the two sides of the cell, allowing electricity to flow. This flow, or current, of electricity can be used to power a small light bulb, turn an electric motor, or recharge a battery. To capture and convert more energy from the sun, photovoltaic cells are linked to from photovoltaic arrays. An array is simply a large number of single cells connected by wires. Linked together in an array, solar cells can produce enough electricity to do some serious work. Many buildings generate most of their electrical needs from solar photovoltaic arrays.

4) *Clutch:* A clutch is a mechanical device which connects and disconnects power transmission especially from the driving shaft to driven shaft. A drive shaft is a mechanical element for transmitting torque and rotation, mostly used to connect other elements of a drive train that cannot be connected directly because of distance or the need to allow for relative movement between them. In the simplest application, clutches engage and disengage two rotating shafts (drive shafts or line shafts). In these devices, one shaft is attached to an engine or another power unit (the driving member) while the other shaft (the driven member) provides output power for work. While typically the motions involved are rotary, linear clutches are also possible. Clutches transmit power from the engine to the gearbox and allows the interruption of power transmission while a gear is selected to move off from a stationary position, or when gears are changed while the car is moving. To allow the car to both change speed and to come to a complete stop without turning off the engine, the connection between the wheels and the engine needs to be temporarily broken. There are two main parts to your clutch: the clutch plate and the flywheel. If the clutch pedal is not pressed down, there are a set of springs which keep a pressure plate pushed up against the clutch plate. The pressure from the springs also pushes the clutch plate up against the flywheel. This connects the engine to the shaft which transfers motion to the wheels and makes the two turn at the same time. When the clutch is 0 pushed down on the clutch pedal, it presses down on a release fork, which, through a series of springs and pins, pulls the pressure plate away from the clutch plate. This breaks the connection between the rotating engine and the wheels, which means that the wheels continue to spin but under their own momentum, not through the power of the engine. The default state of the clutch is engaged - that is the connection between engine and gearbox is always "on" unless the driver presses the pedal and disengages it. If the engine is running with the clutch engaged, the engine spins the input shaft of the transmission but power is not transmitted to the wheels.

II. *Modes of Operation*

In this application, the half clutch point acts as the demarcation between the vehicle propulsion methods as seen in Fig.3
In switch 1, the vehicle runs with propulsion from the IC engine at all points of the clutch. This allows the car to run on the conventional fossil fuel powered internal combustion propulsion mechanism.

In switch 2, the car runs on the IC engine above the half clutch point. when the clutch is disengaged to below the half clutch point, the vehicle is propelled by the conventional IC engine and the solar battery powered in-wheel hub motors, the clutch then acts as an accelerator and hence is called parallel hybridization. The switch provided is mechanical in nature which allows the user to shift the drivetrain being powered by the IC engine to being powered by both the engine and the motor.

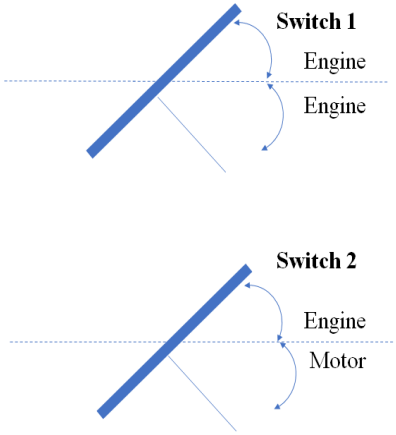

Fig 3- Modes of Operation

III. PERFORMANCE ANALYSIS

The chart 1-6 are the speed-time curve those have been obtained for two different cars (santro and innova) in 3 different road conditions. The heavier vehicle with more torque i.e. the innova in our case has better performance compared to santro, which has comparatively less torque, in all road conditions.

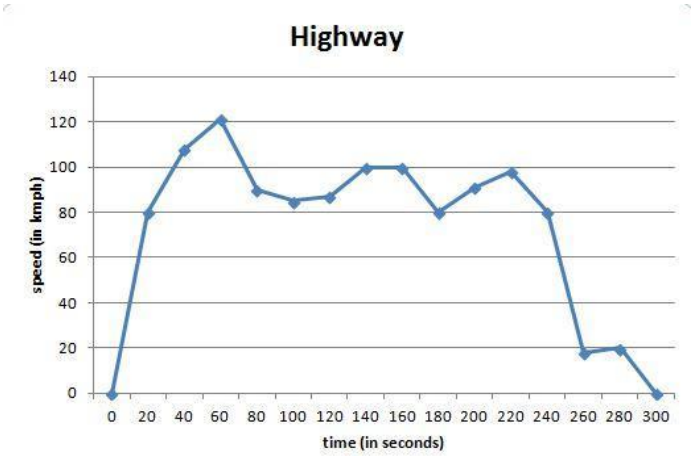

Chart-1: speed-time curve (innova)

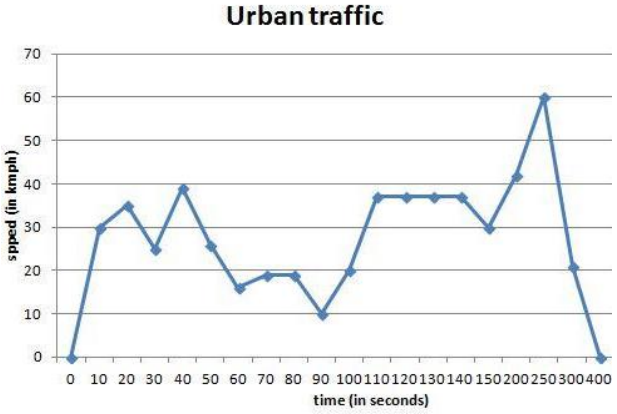

Chart-2: speed-time curve (innova)

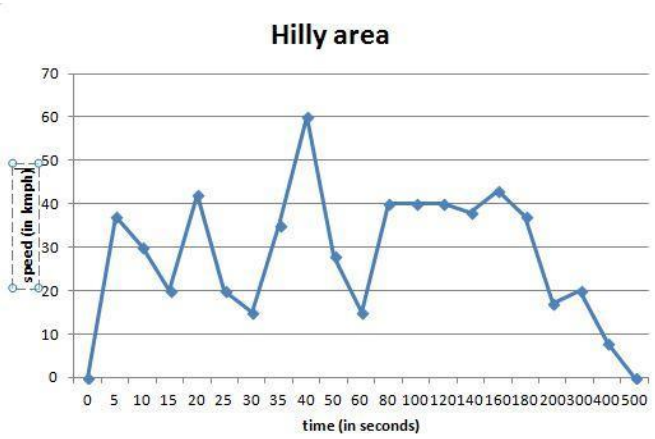

Chart-3: speed-time curve (innova)

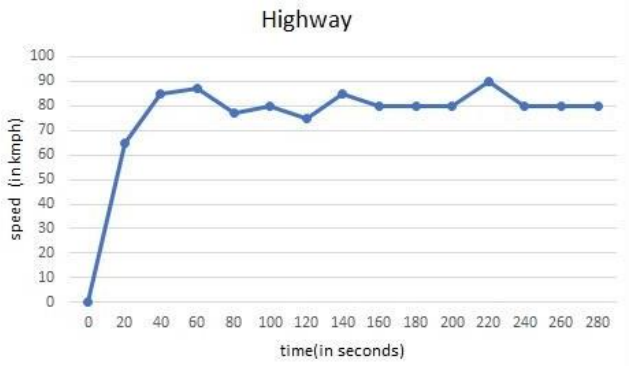

Chart-4: speed-time curve (santro)

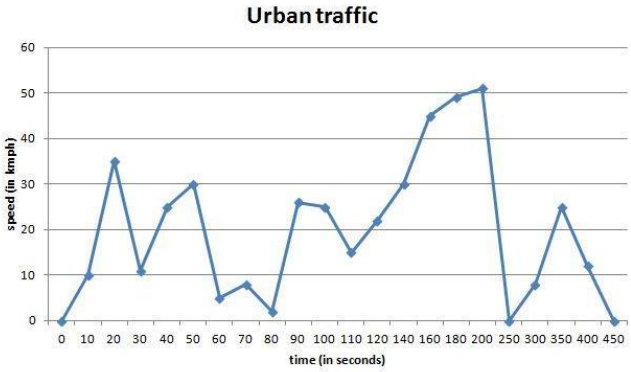

Chart-5: speed-time curve (santro)

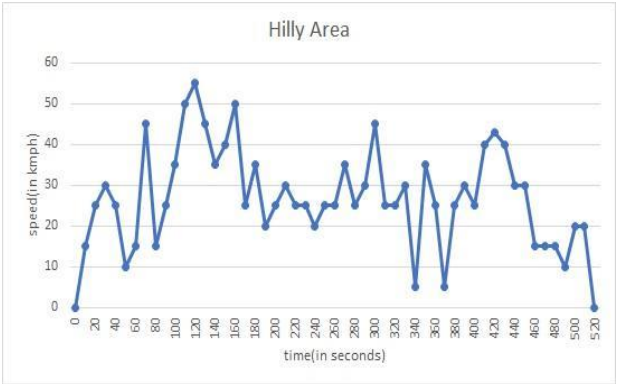

Chart-6: speed-time curve (santro)

CONCLUSION

In this paper, we have studied about the various existing technologies which make use of various techniques to utilise a cleaner, eco-friendly alternative. We have come up with a more feasible idea of retrofitting the working components in the vehicle. This eliminates the need to exclusively manufacture cars for this purpose and also, can be incorporated in the vehicles by making minor modifications. Another advantage is that even if the alternate source i.e. solar power in our case, runs out we can still drive the vehicle using the IC engine.

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