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Regenerative Applications in Electromechanical Drives

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Abstract: This paper presents a work which replaces the current generation of automobiles with innovative generation and environmentally friendly technologies. The present generation automobile cars which one can see in their daily life are purely mechanical drives i.e. vehicles running on engines. Many efforts are being made to introduce electromechanical rather electrical drives. A Hybrid Electric Vehicle (HEV) has two types of energy storage units, electricity and fossil fuel. Batteries, ultra capacitors serve as electrical sources, and an electromotor from now on called motor will be used as traction motor. Fuel tank, and an Internal Combustion Engine ICE, from now on called engine is used to generate mechanical power, or a fuel cell will be used to convert fuel to electrical energy. In the first case, the vehicle will run on both engine and motor, while in the latter case, traction will be performed by the electric motor. Our concentration in this paper would be the generation and regeneration of electrical power.

Key words: Hybrid car, Battery, Regenerative braking, electrical drives

INTRODUCTION

Global Warming is one of the currently faced prominent issues in the world. This is majorly because of high usage of fossil fuels for power generation and transportation due to which there is a sudden decline in fossil fuel reserves all around the world. Hence Research has to be conducted in the field of power generation and transportation such that the usage of fossil fuels is minimized where ever possible which will in turn have a great impact on environment.

Electrical energy serves as a solution for majority of our problems. Electrical drives, battery driven vehicles have thus become popular now days. Our project is further concentrated in harnessing energy from electromechanical drives [1]

Non-Conventional mechanism:

Leading to the effort of reducing the need for fossil fuels, it is now time to harness and use electrical resources for steering the global energy supplies towards sustainable path. Fuel/Gasoline powered cars are perhaps the most inefficient devices that we use in our day to day life. Electrical energy can be reduced, reused and recycled and thus much advancement has been made in the global market of electricity. Size of batteries gradually reduced taking very considerable amount of time to charge and discharge. Battery details are specified in annexure 1. In light of such betterments, electrical drives rather electromechanical drives have become prominent.

Types of Electromechanical Drives:

1. Series Hybrid

In a series hybrid system, the combustion engine drives an electric generator which is usually a three-phase alternator plus rectifier, instead of directly driving the wheels. The electric motor is the only means of providing power to the wheels. The generator both charges a battery and powers an electric motor that moves the vehicle. When large amounts of power are required, the motor draws electricity from both the batteries and the generator.

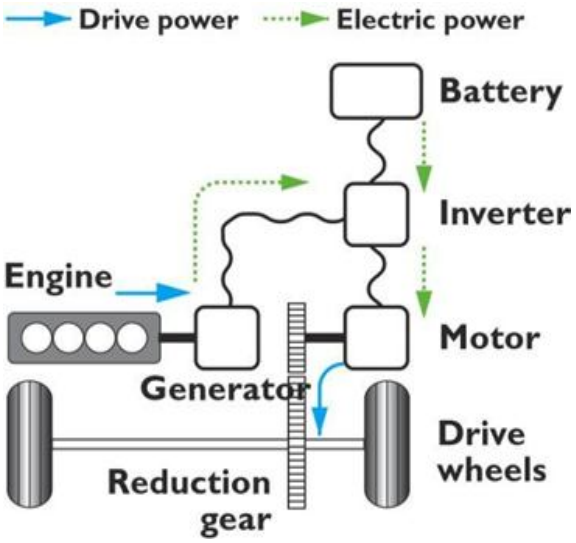

Figure 1. Series Hybrid

2. Parallel Hybrid:

Parallel hybrid systems have both an internal combustion engine (ICE) and an electric motor in parallel connected to a mechanical transmission.

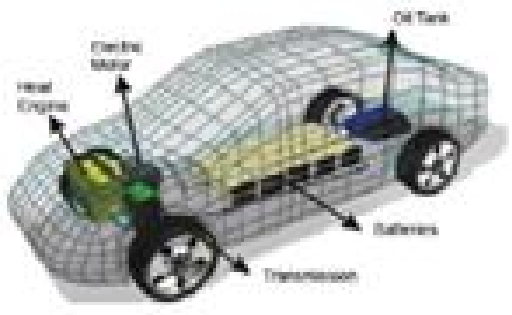

Figure 2. Parallel Hybrid

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3. Combined Hybrid:

Combined hybrid systems have features of both series and parallel hybrids. There is a double connection between the engine and the drive axle: mechanical and electrical. This split power path allows interconnecting mechanical and electrical power, at some cost in complexity [2]

Experimental Setup:

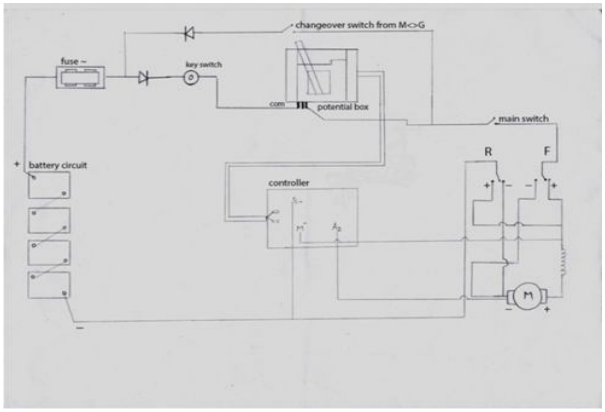

Fig 3. Block Diagram of Experimental Rig

The motor is connected to the shaft by the chain drive mechanism with a gear. Supply is given from the batteries to the motor through fuse, diode and potential box. The potential box is a variable resistance device used for the speed control of the motor and it regulates the current flow through the series field winding thus, decreasing the flux and speed of the motor. The reversing of motor is done through a two way switch such that it provides forward and reverse actions of the motor. The reversing action is performed by a simple mechanism in which the polarities of rotor are reversed. Specifications of the motor and wires used are mentioned in annexure 2, 3 respectively. Set of batteries A, B, C, D is connected. In an electromechanical vehicle, while the power is being extracted from the batteries, AB, CD are connected in series and in turn these pair of batteries is connected in parallel, where as if the engine is running above rated speed, energy can be regenerated i.e. supplied back to the batteries. During regeneration all the batteries are connected in parallel and thus are charged.

Working model

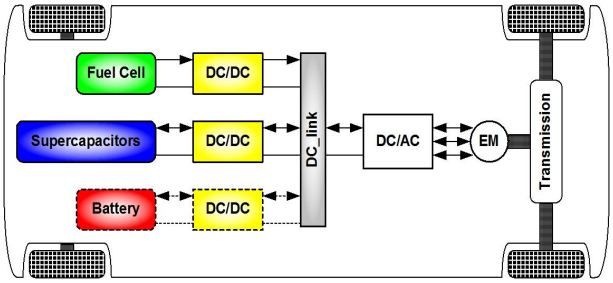

Fig4. Graphical Representation of working model

The above shown figure is a hybrid vehicle with electrical and mechanical supply sources. Fuel cells, super capacitors or batteries can be used as electrical input sources whereas internal combustion engine is used as mechanical input source. When the speed of the shaft is below the rated speed, electrical motor will assist the engine by providing excess torque to the drive shaft. During this process power is consumed from the battery bank and thus discharging batteries. Likely if the speed of the shaft is above the rated speed, the electrical motor will act as the generator and recharge the batteries that were discharged. Under appropriate conditions the vehicle can solely be run on pure electrical energy there by increasing the range of the vehicle.

Regeneration Braking Mechanism

The process by which energy is extracted from running energy source and supplied to auxiliary energy source is regeneration. The most common form of regenerative brake involves an electric motor as an electric generator. In electric railways the electricity so generated is fed back into the supply system. In battery electric and hybrid electric vehicles, the energy is stored chemically in a battery, electrically in a bank of capacitors [3].

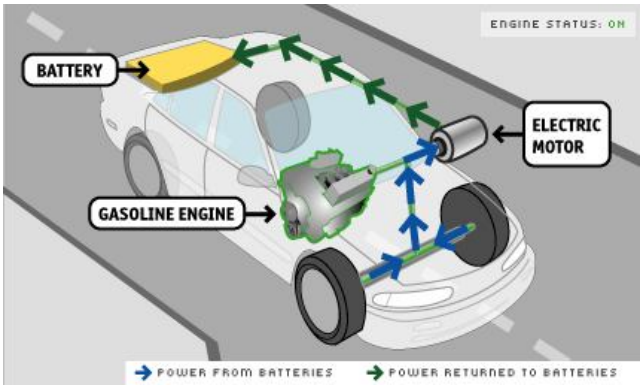

Figure 5. Regeneration

Results and Discussions

The generation is done when the cart is running on Engine. The main drive circuit is converted to a generating circuit just by closing a switch which bypasses potential box. The prime mover to the generating machine is the shaft itself which is run by engine. Speeds and EMF generated are thus specified.

Table 1. Output results of the kart

S.no	Speed of the kart (kmph)	Speed of the shaft (rpm)	Speed of the generator (rpm)	EMF generated (volts)
1	20	278.70	557.42	7.128
2	40	557.42	1114.84	14.264
3	60	836.12	1672.24	21.40
4	80	1114.84	2229.68	28.536

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Average speed of the kart: 50 kmph
Average speed of the shaft: 696.77 rpm
Average speed of the generator: 1393.54 rpm
Average EMF generated: 17.832V

Advantages:

1. Each time you apply brake while driving a hybrid vehicle helps you to recharge your battery a little. An internal mechanism kicks in that captures the energy released and uses it to charge the battery which in turn eliminates the amount of time and need for stopping to recharge the battery periodically.
2. Hybrid vehicles are made up of lighter materials which mean less energy is required to run. The engine is also smaller and lighter which also saves much energy.

Future Scope:

Hybrids, plug-in hybrids, and electrics typically recapture as much of the car's energy as they can. When the driver applies the brakes or when the engine runs above the rated speed, a portion of that energy is sent back into the battery for later use. Recharging an electric or plug-in hybrid is different than the typical routine of filling up a traditional vehicle. There's not just one pump, like for gas. There are multiple types of charging, ranging from the trickle of a normal household outlet, which takes hours to fill a battery, to fast charging stations such as Tesla's supercharger that add about half a charge to a battery in 30 minutes. It's as if some gas pumps drip into the tank, and some are fire hoses. For electrics or plug-in hybrids, the additional time required to charge the car encourages businesses to offer expanded services at highway rest stops, in order to make it more engaging for people who would have to linger to charge a car's battery One of the biggest advantages of hybrid car over gasoline powered car is that it runs cleaner and has better gas mileage which makes it environmentally friendly.

Acknowledgements

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Annexures:

Annexure 1:
Type: Lead Acid
Voltage rating: 12 V dc
Current rating: 12 AH

Annexure 2:
Type: DC series motor
Power: 0.5 hp.
Voltage rating: 24 V dc
Speed: 1500 rpm.
Insulation: Class-F

Annexure 3:
Gauge: 2.5 sq.mm, Length: 8m
Gauge: 0.75 sq.mm, Length: 3 m