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The Use of C.N.G. Engine and Electric Motor as the Power Source in a Hybrid Engine

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Abstract: **Hybrid vehicles are gaining popularity now-a-days due to their environment friendliness and better mileage. Hybrid cars are now even available in market for public use and provide better performance than fossil fuel based cars. This paper presents a hybrid vehicle that can be used in competitions like go-kart racing where mileage is a major concern. Firstly, the components of the hybrid system are discussed followed by the working approach of the vehicle.**

Keywords: **Hybrid, Vehicle, Electric, CNG, Transmission.**

I. INTRODUCTION

As most of the vehicles used today runs on fossil fuel and availability of fossil fuels is limited, so there is a need to find some alternate source of energy. Electricity seems to provide an answer to limited fossil fuel resources but again availability of electricity on vehicle itself is a question. As a vehicle is mobile in nature and its path is random so it cannot be provided with a continuous power supply as in case of trains. So the electrical power source in a vehicle is limited to batteries only and since batteries discharge with use and need to be recharged before they can be used again, traveling long distances in a vehicle completely running on electricity is not possible. This gave rise to development of hybrid vehicles.

A hybrid vehicle is one which can run on more than one power sources. Battery driven motor when combined with conventional internal combustion engine in a vehicle forms a hybrid vehicle. A hybrid vehicle run using motor until battery lasts and then switches to IC engine. It is also possible to switch between motor and engine depending on the requirements. A hybrid vehicle gives better mileage than a conventional vehicle and hence proves to be eco-friendly.

Hybrid vehicles have been in development since start of 20th century (Berman, 2011). Major development took place in 1990s after Audi unveiled the first generation of the Audi Duo experimental vehicle, based on the Audi 100 Avant Quattro which had a 12.6 horsepower electric engine that drove the rear wheels instead of a propeller shaft. The front-wheel drive was powered by a 2.3-litre five-cylinder engine with an output of 136 horsepower. (Berman, 2011) Two years later, Audi unveiled the second generation Duo, also based on the Audi 100 Avant Quattro. From 1997 onwards, manufacturers like Toyota and Audi started volume production of hybrid cars for commercial use.

This paper focuses on use of hybrid system for the racing cars that are used in various competitions. One popular competition is kart racing. Kart racing or karting is a variant of open-wheel motorsport with small, open, four-wheeled vehicles called karts, go-karts, or gearbox/shifter karts depending on the design. (Kart racing, n.d.). Since in go-kart, speed and performance are important so only components and their layout are discussed along with the transmission capable of switching between engine and motor.

The next section describes the different components of a go-kart that have been used. The rationale for selecting the particular component and its working has been described. In the next section, the working of the complete system has been discussed. It includes the sequence of operations and processes that will be carried out. A design for power transmission from engine/motor to the wheels is also provided in this section.

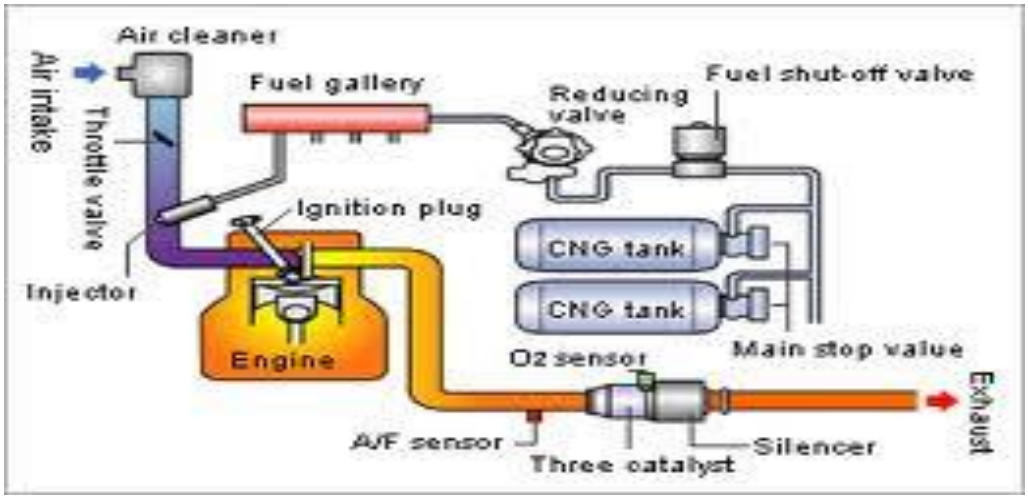
II. EXPERIMENTAL APPARATUS AND ITS DESCRIPTION

Experimental apparatus includes three major systems i.e. a CNG engine, an old Maruti 800 alternator, brushless DC electric motor and a lithium ion rechargeable battery. The engine system used in this experiment, whose technical data are shown in Table 1 is a commercial engine. Properties of alternator, battery, Brushless DC electric motor are described in table 2,3,4 respectively.

A. The CNG engine

The CNG engine uses a fuel tank which has to be attached with it. This tank isusually has to store the compressed gas. The amount of pressure may vary from engine to engine, but it is compressed to around 3,600 pounds per square inch. This Natural-gas engine uses the same basic principles as gasoline-powered vehicles. In other words, the fuel (natural gas in this case) is mixed with air and in the cylinder ignited by a spark plug to move a piston up and down. Although there are some differences between natural gas and gasoline in terms of flammability and ignition temperatures (see chart below), CNG engines themselves operate on the same fundamental concepts as gasoline-powered vehicles.

When the engine starts, natural gas flows from the storage cylinders into a fuel line. Near the engine, the natural gas enters a regulator to reduce the pressure. Then the gas feeds through a multipoint gaseous fuel-injection system, which introduces the fuel into the cylinders. Sensors and computers adjust the fuel-air mixture so that when a spark plug ignites the gas it burns efficiently. A natural-gas engine also includes forged aluminium, high-compression pistons, hardened nickel-tungsten exhaust valve seats and a methane-specific catalytic converter.



Layout of used CNG engine

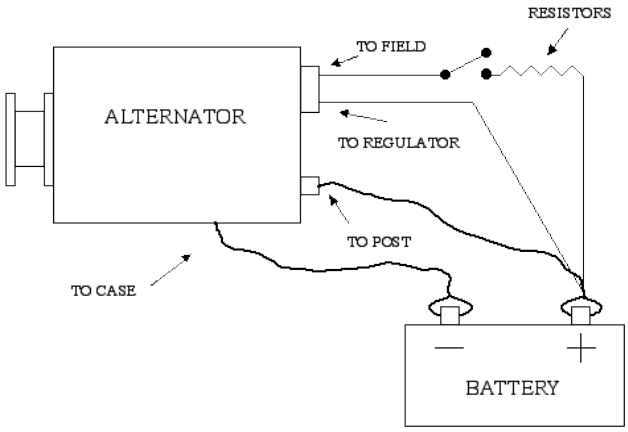
B. Battery

The battery used in this experiment is a Portable 12V 9800mAh Li-ion Rechargeable Battery.

C. Alternator

The alternator used is an old Maruti 800 alternator. This alternator differs from a dc motor in that it contains no permanent magnet. Instead, there are two concentric wound coils of wire within the alternator- a stator coil and a rotor coil.

An electromagnet is created when current flows through the field coil. The strength of the magnet is directly proportional to the amount of current flowing through the field. As the rotor moves clockwise, the resultant magnetic field sweeps clockwise through the outer coil of wire, and electricity is generated in the stator coil. Since the magnetic field sweeps back and forth through the stator coil, an alternating current is produced. Since the purpose of the alternator is specifically to charge batteries, the alternating current it produces is rectified through a diode bridge. The resulting current is direct current, which can be used to charge the attached battery. The voltage coming out of the alternator depends on two variables- the amount of current flowing through the field coil (i.e. the strength of the magnetic field) and the speed at which the alternator's field is rotating. The alternator has a regulator that tries to keep the voltage across the battery at a steady 14.4V.



D. Motor

The motor used in the experiment is a brushless DC electric motor. Brushless DC electric motor also known as electronically commutated motors are synchronous motors that are powered by a DC electric source via an integrated inverter/switching power supply, which produces an AC electric signal to drive the motor. In this context alternating current (AC), does not imply a sinusoidal waveform, but rather a bi-directional current with no restriction on waveform. Additional sensors and electronics control the inverter output amplitude and waveform (and therefore percent of DC bus usage/efficiency) and frequency (i.e. rotor speed).

The rotor part of a brushless motor is often a permanent magnet synchronous motor, but can also be a switched reluctance motor, or induction motor.

The working can be understood of this motor by given animation.

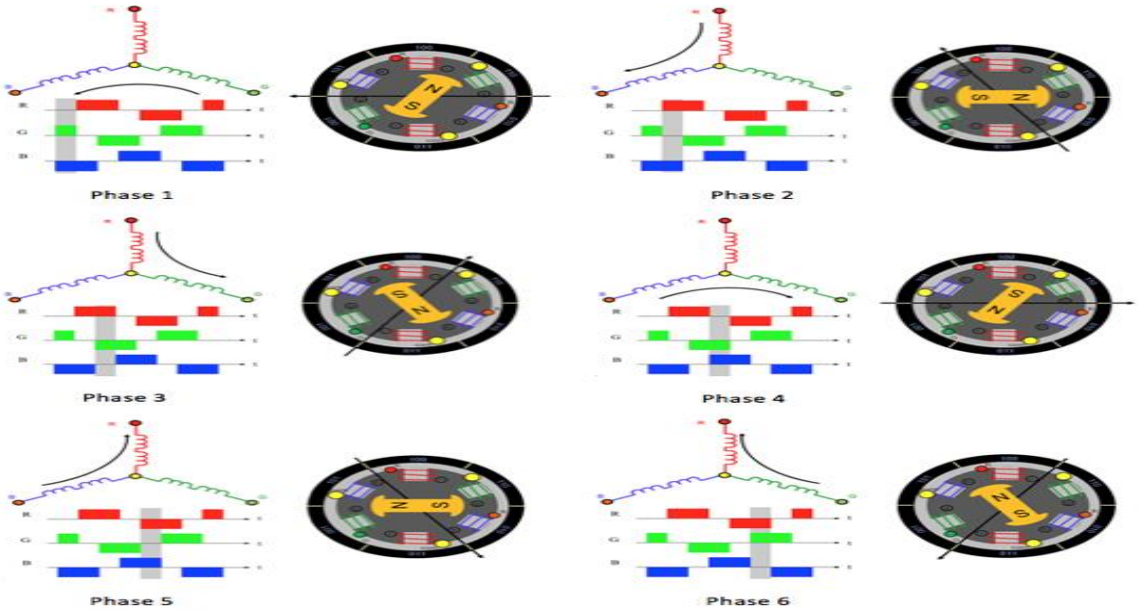


Table 1:-

General properties of the test engine

Engine type: - 4-stroke, water cooled, multipoint injection system, Number of cylinders 2
Firing order 1-3-4-2
Capacity: - 624 cc
Maximum power (5500 rev/min) 33PS
Maximum torque (3500 rev/min) 45 Nm

Table 2:-

General properties of the alternator
Voltage generation: - 14.4 V
Taken from: - Maruti 800

Table 3:-

General properties of the Battery
Capacity: - 9800 mAh
Electrolyte Volume: - 23.8 litre

Table 4:-

General properties of the Motor
Motor type: - Brushless DC motor

III. CONCEPT OF VEHICLE (RESEARCH)

The concept of research is given in following steps:-

1. The engine will start with CNG and vehicle run with it up till the running condition of vehicle get smooth. The reasonbeing most of the power loss of an electric vehicle occurs while starting a vehicle and moving it from parking to main road. Here we use CNG engine to save Battery power.
2. After reaching a relatively smoother ride, it switches to electric motor. And it runs on electric motor until it gets completely discharged. If it is found heavy traffic the driver can then decide which of the fuels they wish to use by simply pressing a switch on the dashboard. The motor stops and CNG starts working again.
3. Batteries: -

   There should be two batteries in the vehicle. One common automotive battery which is used in general gasoline/diesel vehicle for general purpose like lighting, ignition, to start CNG engine etc. The second battery is a li-ion battery as described in table-4. It is for generation of power for driving the motor hence the vehicle.
4. Alternator would be joined to the transmission shaft of CNG engine.
5. Charging of batteries:-

   Both batteries would be charged when the vehicle run on the CNG engine.That means as described earlier, the vehicle start on CNG engine and runs on it till reaches an ideal condition, during this period both batteries will start charging. And if the battery used for motor gets discharged, vehicle will run on CNG (batteries start charging).

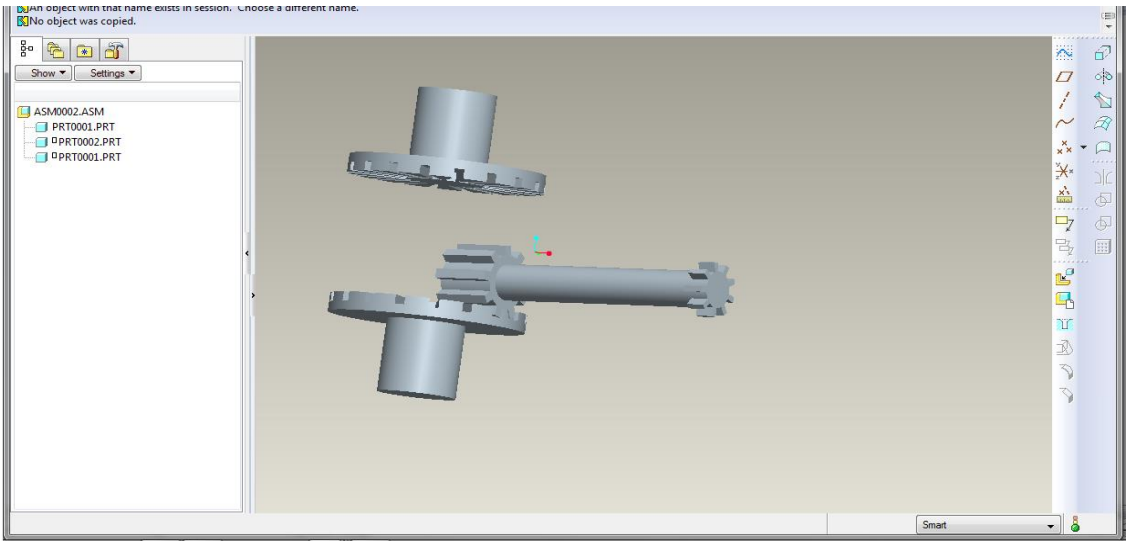
IV. POWER TRANSMISSION

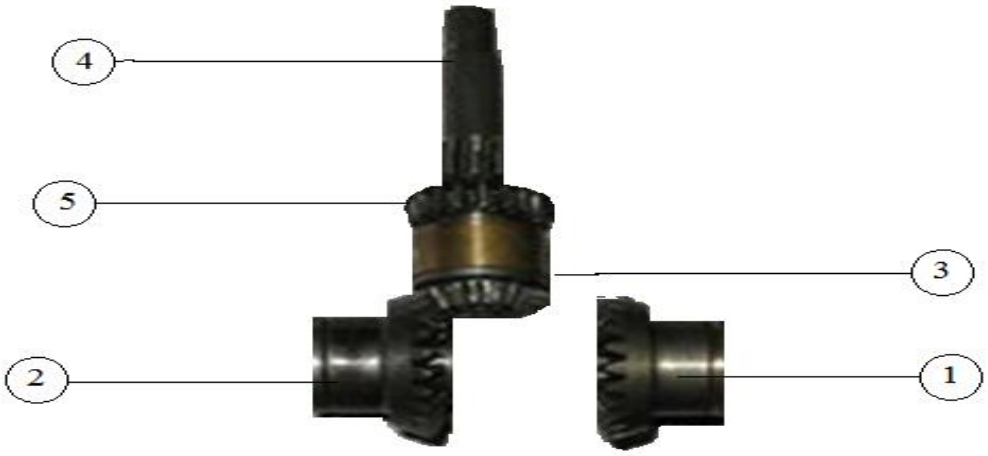
Here we can see that the sources for rotational output are two. So we need a smart gear system before clutch and gear box which can switch the clutch shaft to CNG engine and electric motor output.

The Working of Engine-motor transmission system and description of above diagram is described in following steps.

1. Two crown Bevel gears represent the output of motor and CNG engine.
2. One crown wheel would have idler gear if needed.(In case of wrong direction rotation)
3. One follower with shifting enabled carries the motion further.
4. Another end of follower kept in constant mesh with gear connected to clutch shaft.
5. This follower connected with handle on dashboard via mechanical constraint.
6. The driver can change the input method by just pushing the lever left or right.
7. The follower shift accordingly and power transmitted is on the will of driver.

The required power switching system is designed on PRO-E andmanufactured in our university mechanical workshop and given below:-





1. Power source from electric motor
2. Power source from C.N.G. Engine
3. Follower gear
4. Shaft connected to Clutch via universal joint
5. Gear which is connected to mechanical constraints forshifting purpose.

V. RESULT AND DISCUSSION

The above described CNG-electric Hybrid engine arrangement is tested in a go-kart. Hence the following result came out.

A. General Properties

The CNG is chosen instead of gasoline and diesel because compressed natural gas is marginally cheaper than ordinary gasoline or diesel. In addition, the CNG engine is considered to be more environmental friendly. There are considerably less pollutants associated with compressed natural gas being ignited, and study shows that it emits 40 percent lesser greenhouse gases. On the downside, a CNG engine will usually get fewer miles with the full tank than a regular gas engine.

This Engine design contains CNG powered engine to make low running cost for consumer and thus will be eco-friendly.

The different properties where the CNG are found to be rich over the conventional fuel gasoline and diesel are given below:-

Property	Natural Gas	Gasoline	Diesel
Flammability Limits (Volume % in air)	5-15	1.4-7.6	0.6-5.5
Auto-Ignition Temperature (F)	842	572	446
Peak Flame Temperature (F)	3423	3591	3729

B. Mileage

The mileage of a normal car is 11.76 kmpl i.e. it covers 100 km in 8.55 liters of gasoline on average.

The hybrid car covers 100 km in 3.92 liters i.e. has a mileage of 25.52 kmpl.

This experimental hybrid when tested in a go-kart, it has covered 65 km in 1 liter of CNG fuel with initially full charged batteries i.e. has a mileage of 65 kmpl.

C. Advantages

1. Lower fuel consumption than an existing hybrid car.

   It is found practically that the fuel consumption of this engine is quite lower than existing hybrid go-kart because of smart switching between the CNG engine and electric motor.

2. Less emission than other hybrid engines and quite lesser than conventional gasoline engine and diesel engine.

   The vehicle runs on CNG engine for a very less time and then switches to battery. The CNG engine gives less emission and after switching to motor it gives zero emission.

D. Dis-advantages

1. High initial cost due to extra gear system for switch between the electric motor and CNG engine.
2. High manufacturing cost because of two engines.
3. Engine size increases due to many numbers of additional components.

VI. CONCLUSION

Hybrid vehicles are going to become the medium of transportation in coming world as they have the potential to reduce the consumption of fossil fuels. From the experimental results, it is clear that requirement of fuel is reduced to less than 50%. Apart from saving fuel, carbon emissions will also decrease reducing harmful impact on surroundings. The major issue that has to be improved is the energy density of storage batteries and harmful effect material of batteries.

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