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# Numerical Analysis of Speed Optimization of a Hybrid Vehicle (Toyota Prius) By Using an Alternative Low-Torque DC Motor

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## ABSTRACT

*Hybrid Vehicles has been considered the most fuel efficient vehicle available nowadays[i]. However, it is not used excessively due to its high cost. If by any means the usage of such vehicle can be encouragedin developing countries like Pakistan, the benefits will be remarkable and contribution towards fuel saving will initiate. So this study has been aimed to design, model, simulate & optimize a hybrid vehicle and modification of the vehicle's speed with the comparison of a common hybrid vehicle obtained mathematically. Numerical method& software have been used to simulate all the vehicle's cross-sections and results have been obtained in graphical form so that it can be used for research and development in the future. It seems essential in near future that hybrid system should be usedin automobiles as a lot of fuel is wasted on traffic signals and in traffic blockages which waste a lot of fossil fuel and pollute environment[ii]. If the hybrid system is implemented in vehicles, we can save fossil fuels and also it will be economic to consumers as they don't have to pay more for the fuels. It will be user friendly and environmental friendly as well[iii]. The system will automatically shift itself on batteries whenever the speed of the automobile is below a threshold speed hence decreasing the fuel usage. It will benefit our economy as well as it will help in saving fossil fuel for the natives.*

**Keywords:** *Hybrid Vehicle, Aerodynamic Design, IC Engine, Drag Force.*

## 1. INTRODUCTION

**Hybrid Vehicle** usually consists of two types of power sources i.e. internal combustion engine andd.cmotor[iv]. The mechanism is that there is a speed limit upon which the batteries are consumed as an energy source and whenever the speed is increased by that limit (say 60 km/h) the ICE will ignite. Then the engine starts charging the batteries, which are then used when the speed is decreased again[v]. It is really helpful when people are driving within cities where they have to apply brakes repeatedly or where the engine is idle. So fuel consumption is reduced and it will be environment and user friendly. As people have grown habitual to faster speeds that can be achieved by modern gasoline powered cars, it has been noted that hybrid cars are usually slower than regular automobiles[vi,vii]. It can be observed that modifications within the hybrid systems can meet a wide range of speed and power requirements[viii] and hence the EMS (Engine Management System) can be made more efficient and adaptable[ix]. Basic model of hybrid system has been shown in Figure 1.

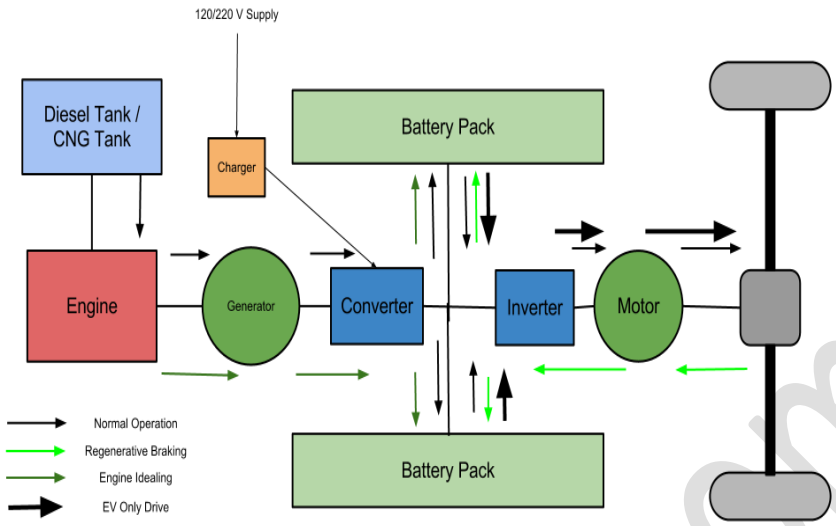


**Figure 1: Basic Model of Hybrid System.**

## 2. METHODOLOGY

### 2.1Modelling

All the dimensions have been calculated manually according to design and drag force and stresses have been calculated and then 3-D model is made on the SOLIDWORKS 2016. Diagram from three viewpoint were made depending upon calculations and then they were assembled on SOLIDWORKS.

### 2.2 Drag ForceAnd StressAnalysis

As a car moves Drag force acts parallel and in the same direction as the airflow. Drag force depends upon the area of the body and speed of the body. The cross sectional area of the car in direction of motion experiences drag force which depends on the area of car and speed of car.When a body moves through a fluid then some forces are exerted on them due to their motion. Due to this stress the body of object undergoes a temporary and sometimes permanent deformation. So stress is calculated in order to minimize its effect on body. All the simulations were designed in SOLIDWORKS and results were obtained via analysis and calculations.

### 2.4 Modification

With the help of information obtained from Toyota Prius Full Hybrid info sheet the values of Power, Speed and torque of Prius Full Hybrid motor are:

Power = 67.051 HP.
Speed = 1370 rpm.
Torque = 295 lb-ft.

In order to improve the speed of the car, a motor of 57.33 kW power of Rexroth Bosch Group model number MAF180C-0150 can be used. Figure 2 shows the drawing of proposed motor.

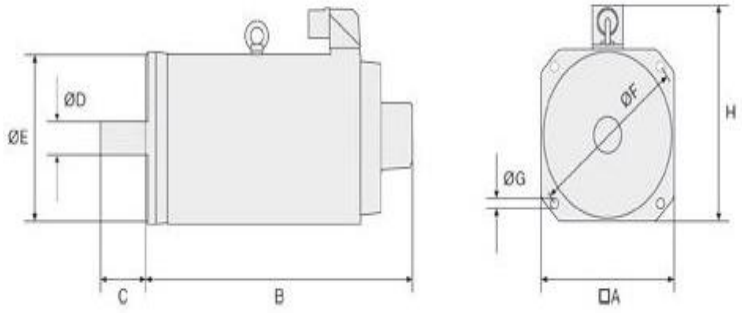


**Figure 2: Drawing of Proposed Motor.**

Power = 76.881 HP.

Torque = 268.38 lb-ft.

$$HP = \frac{Torque \times Speed}{5252}$$

The comparison of original and modified values has been calculated and shown in Table 1.

| Toyota Prius Full Hybrid | | Modifications |
|---|---|---|
| Power (kW) | 50 | 57.33 |
| Power (HP) | 67.051 | 76.881 |
| Torque (Lb-ft) | 295 | 268.38 |
| Speed (rpm) | 1370 | 1504.5 |

Table 1: Comparison of modified values.

It is obvious from the above comparison that by using a motor of 57.33 HP having 7.33 kW more power that the speed of the car is increased to a value of 1504.5 rpm a total increase of 9.8 %.

## 3. RESULTS

The Hybrid Vehicle has been designed on solidworks for simulation and analysis as shown in Figure 3

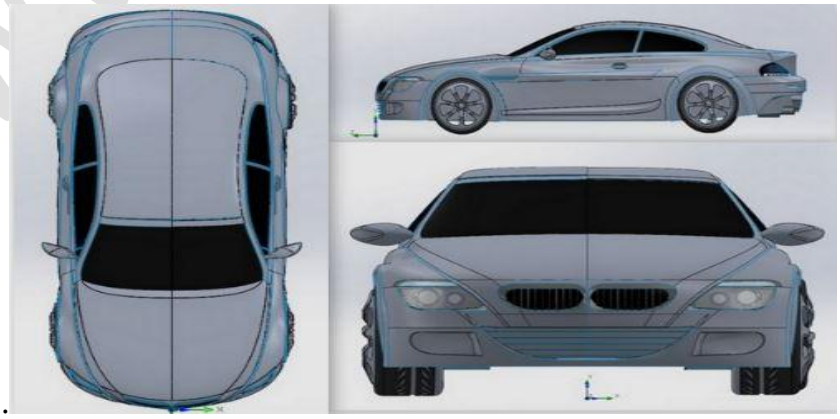

Figure 3: 3D view of the vehicle.

As discussed earlier the focus of the study was to calculate overall drag forced that the hybrid vehicle encounters while undergoing linear motion. Calculations have been made by using basic mathematical relations shown as follows:

Drag Force: $$F_d = \frac{Cd \times \rho \times V^2 \times Af}{2}$$

Fig.4 shows the curve obtained showing the relationship of drag force and velocity.

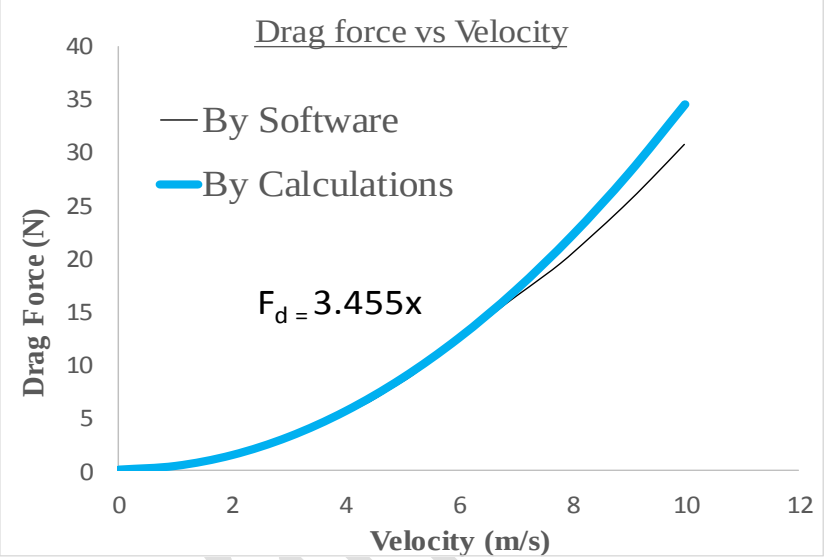


**Figure 4: Drag Force of the vehicle.**

## 4. CONCLUSION

As people have grown habitual to faster speeds that can be achieved by modern gasoline powered cars, it has noted that hybrid cars are usually slower than regular automobiles. The aim of this study was to have a look at the specifications of hybrid electric vehicle used for heavy and light traffic vehicles and it demonstrates reductions in exhaust emissions and fuel consumptions. Further the speed has been further modified by simulation and analysis so that the apparent drawback i.e. lower transmission speed as compared to conventional automobiles can be improved. When these applications are compared to other available low emission and fuel efficient technologies, they are the mostly effective in urban level, significantly lowering pollutant emissions and providing cost efficient. This marks the dawn of new efficient energy means that will take over global industry in the near future. Today, most of the countries don't have any policies regarding fuel economy. So in order to approach global $CO_2$ reductions which are required to stabilize greenhouse gas emissions that effects climate change so encouragement of its use should be promoted in this age of crisis. This will help when all the sectors of the government will show involvement to manufacturers, importers and consumers. A hybrid car is environment friendly but the speed of a hybrid car on electricity is less so its speed is increased to make it more competent and it can be increased up to 9.8%.

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