Proficiency Study of an Integrated Plug-In Hybrid Electric Vehicle with Cost Optimization

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Abstract: The present research paper acquaints with a cohesive method for a performance analysis of the hybrid electric vehicles. The inspiration of this research is given by the fact that the evolution happens in automotive sector, in recent times Hybrid Electric Vehicles are trending. As EV become hopeful alternatives for sustainable and cleaner energy emissions in transportation, the modelling and simulation of Hybrid Electric Vehicles has involved the researchers. This research is based on Mat lab modelling, both Modelling and simulation have become inseparable actions in any applied branch in engineering research and development. Nowadays, the nature of inseparability is even more obvious in the case of automotive industry. A set of 3 different research studies are projected and efficiency of designed Hybrid Electric Vehicle is tested through a series of simulation results. The power train machineries consist of a motor, a battery, a generator and a controller; modelled according to their mathematical concepts. Simulated electrical and mechanical results are plotted and discussed. The torque and speed circumstances during motoring and regeneration were used to determine the flow of energy, and performance of the drive. The credit is given by the accuracy of the model and simulation with the presented performance analysis methods. The improvement of this method is that the system performance can be validated to a large extent from an initial stage. The results can contribute to the real-world of developing Hybrid Electric vehicles at higher quality standards, quicker and with a better cost.

1. Introduction

After the past engineering time, interest for energy rate is expanding a result of developing the utilization of electrical and mechanical machines particularly in transport sector. After the development of IC and EC engines, fuel-controlled vehicles have become a crucial aspect of our critical life. As of late, the majority of the total populace practice's fuel controlled vehicles for transportation reason. In everyday life, utilization of engine based vehicles produce CO_2 to an enormous degree makes a genuine danger in climate causes air contamination. Besides air contamination, it also causes running out of fossil based assets. Researchers are endeavouring to concoct novel greener energy advances in the field of transportation. With crossover advancements, the principle system is to enhance the utilization of oil and at the same time upgrade's the utilization of efficient power energy advances in fuelling the vehicle. A middle ground approach has been decided, where engines scale back with high force yield's utilizing current control procedures and powertrains become progressively zapped. By and large, the idea of the Hybrid Vehicles proposes presence of numerous wellsprings of energy to drive the vehicle. Most generally in Hybrid Vehicles, an interior ignition engines is utilized in relationship with batteries. It has been found by simulation and experimentally that batteries and IC engines have exclusively higher efficiencies when the force request is lower and higher respectively. Along these lines, this integral nature of effective features of the force sources, fits the hybridization of the powertrain (for e.g., with IC engine and battery). At the point when the vehicle is running at low speeds in city, the battery can give the necessary force, and when the vehicle is running at high speeds on turnpikes, the IC engine can supply the necessary force. Regenerative breaking down is similarly an extremely valuable component, which can give extra energy reserve savings.

2. Design Of Hybrid Electric Vehicle Fundamentals

Aerodynamic Drag

The streamlined/aerodynamic drag that any vehicle unnecessarily is unprotected during driving,springs from the evolution of air around and through the vehicle which are referred to as outside and interior streams. Because of the intricate shape of automobiles, and to the significantly more mind overwhelming nature of fluid elements, precise and dependable insightful models of aero dynamical drag are hard to develop. A compromise that is frequently used to prototypical the aero dynamical drag Force (Fa), is incompletely experimented, and partly depend on the outflow of dynamical weight, which is indicates a solid reliance on the square of the vehicle speed as $\mathbf{F_a = \frac{1}{2} \rho_a C_d A_f (V_{vehicle} - V_{wind})^2}$

where,

ρ_a (kg/m^3) is the air density,

C_d the aerodynamic drag coefficient,
A_f (m^2) is the effective cross sectional area of the vehicle,
$v_{vehicle}$ (m/s) is the vehicle speed
v_{wind} (m/s) wind speed moving in the path of the vehicle.

The aero dynamical drag accordingly increments with head wind speeds. A head wind speed of 20 m/s gives an additional drag equivalent to a vehicle driving 50 km/h in no wind, and one of 40 m/s gives a drag equivalent to a vehicle speed of 90 km/h. All things considered, the course of the wind breeze that strike the vehicle is fairly irregular, and non-head winds increment's the vehicle's powerful cross sectional area, yet additionally the streamlined drag coefficient by around 5 to 10 % for traveller vehicles in basic wind breeze conditions (marginally more for family sedan type cars and somewhat less in sports vehicles),density of air shifts relying upon temperature, humidity and pressure of wind stream, where the later shows dependent in altitude. For near investigations, frequently the air density estimates of 1.225 (kg/m^3) is utilized, which means settled conditions, for example, dry air at 15 ◦C at standard air pressure (1013.25 Pa) at sea level . For temperatures between - 30 to 50 ◦C the density of dry air might be 80 to 110 % of the standard density of air, while an expansion in elevation of around 300 m above sea level prompts a decline in the dry air density of around 3 % comparative with the standard air density.

3. Factors That Affects Torque While Selecting Drive For The Electric Vehicle

Different elements should be considered to test the maximum required torque.

The factors are:

1. Rolling Resistance (RR)
2. Grade Resistance (GR)
3. Acceleration Force (F_a)

3.1 Rolling Resistance

A wind turbine exerts the active kinetic energy from a stream of moving air, decreasing the air down in the process. A moving vehicle does the specific inverse of a wind turbine – it chances upon fixed air and gives it kinetic energy, speeding the air up as it is pushed in front of the vehicle. Since energy is saved, the vehicle needs to surrender a portion of energy to the air to get the air moving. Those energy losses in terms of air, RR (or) Aerodynamic drag

3.2 Calculation For Rolling Resistance

Rolling Resistance is the unique force that the vehicle needs to defeat because of the moving gesture between the wheels surface of the vehicle. The rolling obstruction depends upon the coefficient of moving resistance which shifts relying on the material of tires and the unevenness of the outside of movement.

The Rolling Resistance can be determined as:

$$\mathbf{RR = GVW x C_{rr}}$$

Where,

RR = Rolling Resistance
GVW = Gross Vehicle Weight
C_n = Co-efficient of Rolling Resistance

3.3 Calculation of Grade Resistance

Evaluation resistance is the arrangement of gravitational power. The power tends to pull the vehicle back when it is mountaineering a slanted surface. The evaluation resistance performing on the vehicle can be determined as:

$$\mathbf{GR = GVW x sin\theta}$$

Where, (1)GR=GradeResistance
(2) θ = Grade or inclination angle

3.4 Calculation of (F_A) Acceleration Force

Acceleration force is the power that causes the vehicle to attain a predefined speed with respect to a particular timeframe. The engine force stands an immediate alliance with the speeding up power. Force gets improved, lesser the time needed by the vehicle to accomplish a given evaluated speed. The Acceleration power is a drive the mass of the vehicle.

Acceleration force is calculated as:

$$\mathbf{F_A = m \times A} \text{ [or] } \mathbf{m = GVW/g}$$

Where, F_A = Acceleration force
m = mass of the vehicle
g = acceleration due to gravity(9.81m/s)
a = required acceleration

3.5 Finding The Total Tractive Effort(Tte)

The Total Tractive Effort is the absolute force required to move the vehicle with the predefined qualities and the arithmetical amount of the force is determined in over three segments. Subsequently, the Total Tractive Effort can be planned as:

TTE=RR +GR +FA

Where, TTE = Total Tractive Effort

3.6 Torque Required On The Drive Wheel

The force that is essential on the drive wheel will be the one that the motor drive needs to yield in order to get the ideal of drive train qualities. The force is:

$$\tau = R_f \times TTE \times r_{wheel}$$

Where,

τ = Torque

R_f = Friction factor (i.e)frictional losses between bearings and axles

r_{wheel} = radius of drive wheel

3.7 Gross Vehicle Mass (Gvm)

Gross Vehicle Mass (GVM) is the most extreme usable weight/mass of a vehicle as seen by the observer including the vehicle's base chasis, whole body,Electric motor, Electric motor liquids for example, motor oil and brake oil, extras, driver, travellers, pilions and vehicle barring that of any trailers. The Total load of a vehicle is depends by travellers, vehicle, so various terms are utilized to communicate the heaviness of a vehicle in an assigned state. Gross Combined weight rating (GCWR) signifies the absolute mass of a vehicle, with all trailers. GVWR and GCWR both assign a vehicle that the cycle is utilized to require weight, cutoff points and limitations. Dry weight further overlooks the heaviness of all consumables, for example, fuel and oils. Net trailer weight rating needs the greatest load of a trailer and the gross hub weight appraisal indicates the most extreme load on a specific pivot.

4. Regenerative Braking Control Algorithm

In normal conventional vehicles, the energy need to reduce the speed would typically be scatter and lost as heat during slowing down. Then again, HEVs have a regenerative stopping mechanism that can expand mileage. In a HEV, the decelerating force is put away in a battery and recovered through the electric engine/generator. At the point when this happens, the BCU should control the degree of regenerative slowing down force from the regenerative electric intensity of engine/generator to keep a brake detecting like that of an predictable vehicle. The control methodology for amplifying regenerative braking force is finished to build the amount of battery charge.

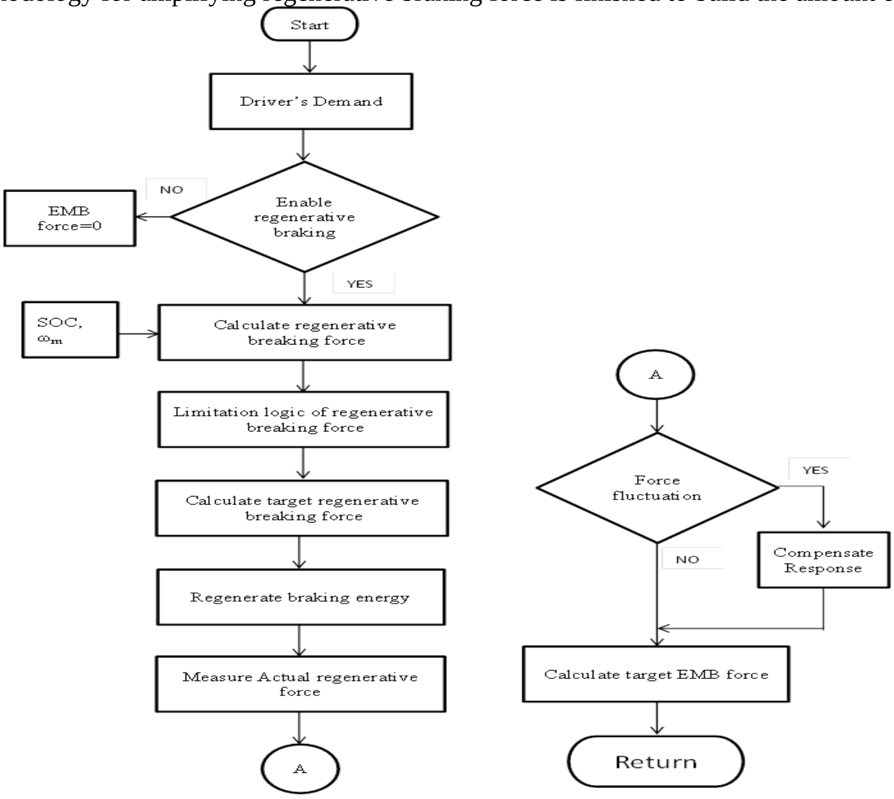

Fig 1: flow chart of Decision logic of regenerative braking torque

To start with, sense the driver's interest for braking, at that point it computes the necessary brake power to the front and back tires by utilizing the brake power curve dispersion. Then the logic selects whether the slowing mechanism ought to perform regenerative braking, relies upon the conditions of the accelerator, the brake, the clutch, and the speed of both motor and vehicle, and on the fail signal. On the off chance that regenerative braking is accessible, the ideal power of regenerative braking will be resolved by the battery's State Of Charge (SOC) and the speed of the engine. Taking everything into account, the calculation will decide the objective regenerative braking force. In a condition where the variety of the regenerative braking causes a distinction of torque, the reaction time postpone compensation control of the front wheel could be utilized to variety of brake force. After it arrives at target, braking force is inspected, the contrast between target slowing down force and the regenerative braking force will be communicated through the EMB framework.

5. Results

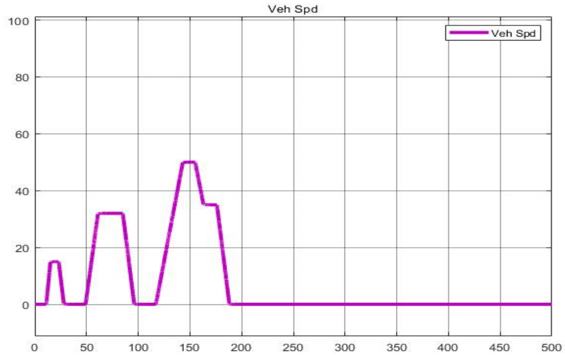

Fig 2: Characteristics of Vehicle Speed vs time

Vehicle speed is given as input data which includes variation of speed and constant speed. Here the input is given as vehicle speed gradually increases form 0 to 60km/hr then speed decreases by applying break after 5ms it attains the steady speed of 60km/hr with increase and decrease of speed lasts upto 300ms.then again sudden break is applied to reduce the speed at 350ms.At 420 ms the vehicle comes to rest position

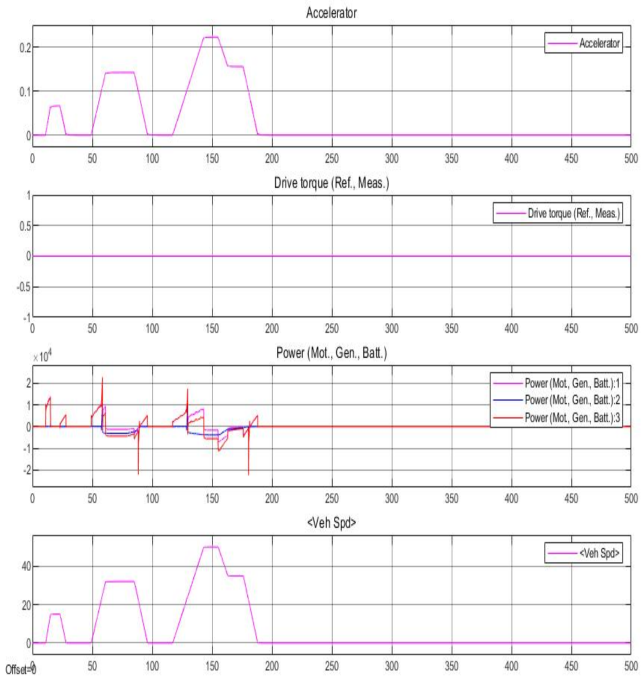

Fig 3: Characteristics of various vehicle parameters (Motor power, drive torque, Accelerator, speed) with respect to time

Accelerator graph determines the amount of pressure in accelerator pedal. The amount of pressure in accelerator pedal is directly proportional to vehicle speed the reference drive train torque is at zero position throughout the testing of vehicle. The power produced by motor, generator and IC Engine. the power variation occurs only when the vehicle starts and rest of the time it attains the steady condition.

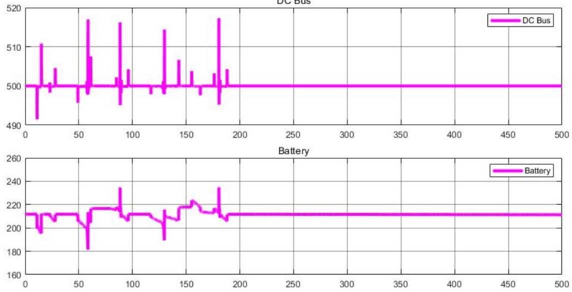

Fig 4: Variation of DC bus Voltage and battery voltage with respect to time

DC Bus voltage depends on the state of voltage present in the Bus which connects the motor generator and the battery. Battery voltage changes with respect to charging and discharging by either through ac main supply or regenerative mechanism by generator

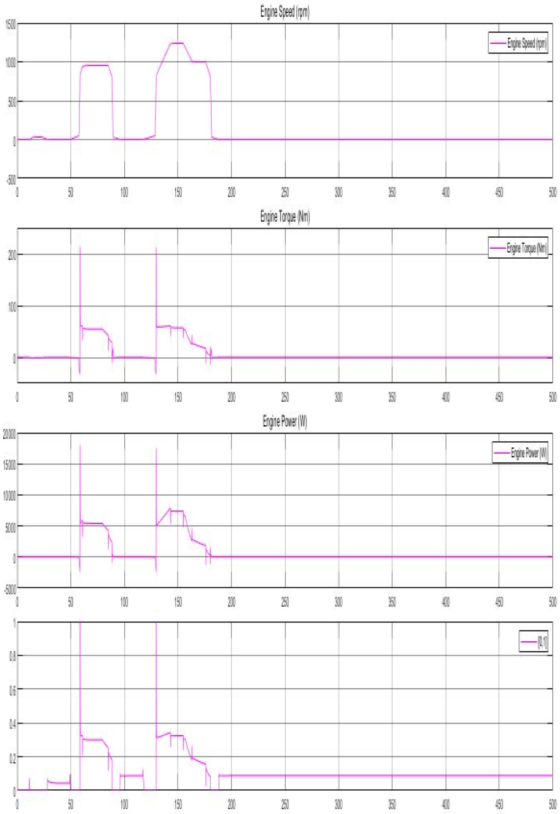

Fig 5: Characteristics of various IC engine parameters (speed, torque, power, IC engine enable logic) with respect to time

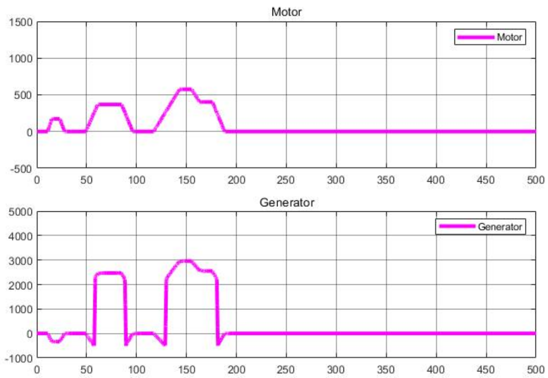

Fig 6: Speed characteristics of Motor and Generator (in rpm) with respect to time.

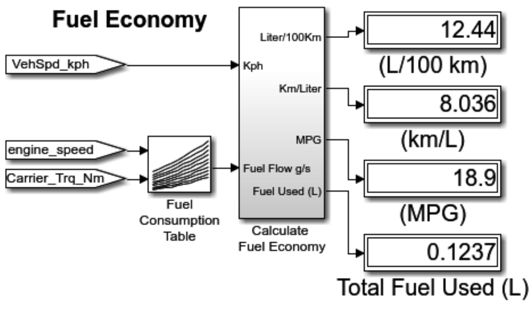

Fig 7: Display of Fuel Gauge

Measuring the fuel gauge readings such as mileage (km / litre), fuel consumption for reaching 100 km, total fuel used while running the vehicle, Miles per Gallon

6. Conclusion

The consequences of beginning plan enhancement considers normally the preliminary thought for further examinations that may bear the cost of more knowledge on the intricate relationship present in genuine designing frameworks. In this study relationship between vehicle subsystems were resolved and comparative studies were went with offering a superior comprehension of various parameters of Hybrid E Vehicle. These incorporate advancement which decides the subsystem for neighbourhood plan factors. For example, mathematical measurements, geometric dimensions and further for adding control methodology plan. Since the controller is eventually work under transient conditions.

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