Hybrid Electric Vehicles Technology and Performance Analysis Using Matlab/Simulink

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Abstract— The hybrid electric vehicles incorporate an integrated approach for designing and evaluating results. This method takes into account a set of parameters which affect performance of the system. this research provides an approach to electric vehicle modeling taking into account the dynamics of the engine, the drive train, the rotational wheel and the load dynamics. hybrid electric vehicle performance is unsatisfactory due to the difficulties of optimal choices for benefit. to overcome this problem, setting the rules for better performance requires a new type of fuzzy logic controllers. Therefore, a gain adjustment approach based on fuzzy logic for the PID controller is proposed and compared to some earlier control techniques for better efficiency. In MATLAB/Simulink, this model was created & simulations were completed along with the results

Keyword **—Electric Vehicle, Hybrid Electric Vehicle, Fuzzy System, Power System, MATLAB/Simulink**

I. INTRODUCTION

The global problem of oil depletion and air pollution has led to many studies on how the combustion engine can be replaced [1]. It is important to note that hybrid and electric vehicles are the cars of tomorrow, largely because they do not emit emissions, are calm and have improved fuel efficiency at about the same time, there are still some problems that need to be solved, like limited driving range and long payload time. [2]. This is growing steadily and software is expected to power more than 90% of automotive systems in the next few years. From this perspective, the software impact on electric vehicles will be very strong. [3].

The research community needs to be very practical to ensure that the testing process is successful. In recent years, the automotive industry has moved toward more complex electronic control systems. By that time, mathematical modeling and simulation methods had become more sophisticated and the idea of simulation has become a real design methodology. Simulation is now the principal method used before real words can be searched. [4]. The wellbeing practices and guidelines are getting more directed as industry embraces a normalized set of item plan and test rehearses. Every producer should offer verification in recognition of the new enactment. as the electric vehicles are fueled by a put away wellspring of electrical energy, the scope of drive is regularly restricted relying upon the gadget effectiveness and the fuel source power. One approach to build framework execution is by improving electric vehicle control framework. for powerful and energy proficient activity of the electric vehicle, hence, a compelling control framework is required. to this end, in this examination, a versatile fluffy procedure is proposed to adequately control machine activity. utilize fluffy rationale assists with bettering determination the vulnerabilities or obscure varieties in plant boundaries the framework power [3, 4].

This control strategy is more strong, and takes into account different plan goals. in contrast to PI regulators, fluffy regulators needn't bother with the cycle's exact numerical model, rather they need the experience and information on the oversaw interaction to build the standard base [5, 6].

Control strategies truly utilized incorporate regulators like PID, Fluffy rationale, Neuro Fluffy. many examination strategies have been carried out lately, centered around cutting edge control frameworks in electric vehicles. in [7, 8], creators utilized astute fluffy control to build the proficiency of the framework while managing the mind boggling activity modes. in [9, 10] distinctive control methodologies dependent on PI techniques are utilized to control the electric vehicle framework by performing numerical displaying of electric engine and electric vehicle elements. these regulators are straightforward and don't perform well for control frameworks with changing boundaries and require continuous on-tuning. Tuning is finished by manual or hit and preliminary techniques to pick appropriate additions. the underlying increase choice is a significant factor in the presentation of any regulator, cautious decision of these additions can lead towards better framework reaction.

Beforehand this underlying addition choice is made upon the data about the control framework conduct however in the event of a control framework with changing boundaries these increases ought to be changed by the changing framework boundaries. presently a few days, fluffy rationale is utilized to control these control frameworks, in light of the blunder sign and its time subsidiary, by figuring the regulator acquires on

the web. these fluffy rationale regulators can be considered as nonlinear regulators for PIDs. the fluffy rationale functions admirably under changing gadget boundaries however to make the regulator the underlying static increase significantly more exact should be appropriately chosen to forestall imperfect reaction. to do as such, another fluffy rationale is utilized to painstakingly change the underlying static additions working in corresponding with the sketchy tuned PID regulator.

This extra fluffy rationale regulator gives the pay the capacity to adjust under changing framework boundaries and make up the framework in the addition tuning.

II. ELECTRIC VEHICLE

The electric vehicle (Kaushik Rajashekara 1993) is Reconciliation of the vehicle's body, electric drive, and capacity tank and energy protection. it isn't just a moving vehicle yet a cutting edge type of electrical hardware also. the electric vehicle Is a street vehicle dependent on present day electric impetus, comprising of an electric engine, a force converter and a force source, and having its own particular component properties. Figure 1 shows the electric-vehicle arrangement.

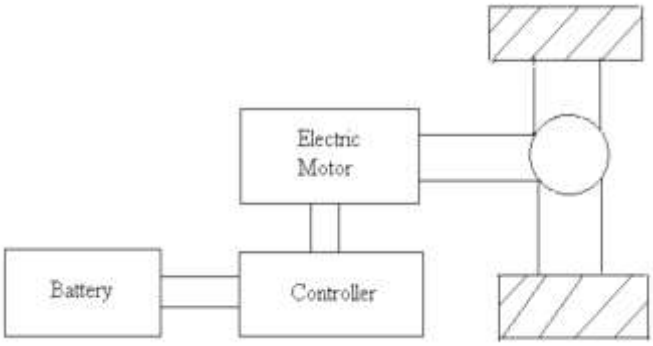

Figure 1 Electric vehicle configuration.

A. Electric Motors in Electric Vehicle

Electric vehicle impetus framework (Iqbal Husain et al 1999) the vehicle is liable for changing electrical energy into mechanical energy over to defeat streamlined grating, moving opposition rubbing and active obstruction. the electronic control can accomplish high force, low speed and consistent force fast districts in an advanced engine drive. furthermore, the arrangement of the electric vehicle drive might be more adaptable, including single or various motors, with or without decrease gear, with or without differential stuff, and engine pivot or plate. the electrical impetus framework comprises of an engine drive, a transmitter and a discretionary wheel transmission unit.

One more of the mixture engines is an alternate sort of less mechanized perpetual magnet brush. The assistant dc field winding is incorporated in this engine in such a With the goal that the air hole motion is a part of the perpetual magnet engine transition and winding field motion. the transition of air holes will differ to any degree by changing the field winding excitation current, in this manner giving most extreme productivity over an expansive speed range. Exchanged hesitance because of its straightforwardness and unwavering quality in the arrangement of both engine and force converters, the motors offer promising highlights for electric vehicle applications, enormous scope of rates, positive warm administration, productive recovery slowing down. they do experience the ill effects of waves of force and acoustic clamor issues however.

When all is said in done, for electric vehicle gradually subbed dc engine drives by engines, acceptance engine engines, perpetual magnet engine drives with various arrangements, and adjusted hesitance engine drives.

These high level engine drives are explicitly intended to satisfy the specific needs of electric vehicles.

B. Hybrid Electric Vehicle (HEV)

HEV includes blend/consolidating of mixture vehicles by customary vehicles of inner ignition motor. the vehicle hence has two wellsprings of force: inward ignition motor and electric engine. this utilizes the two sources to supply the vehicle with the most extreme drive required. contingent upon arrangement or equal connection, the connection courses of action about those two sources concentrate the force stream to the wheels. while associating the Successive electric engine and ICE the vehicle is a progression of crossovers and the electric engine gives the mechanical force expected to the wheels. at the point when the electric engine and ICE are connected couple, the vehicle is pair cross breed, and both the ICE and the electric engine give the mechanical force expected to the wheels. ICE utilizes fluid fuel as fuel source in HEV and electric engine utilizes battery as fuel source. the fuel utilization in the motor can be limited by utilizing the ICE consistent electric engine, by expanding the force and rpm. due to the presence of two fuel sources, it offers a decision for more prominent driving reach while beating the downsides of unadulterated electric vehicles.

The arrangement equal model is appeared in Figure 2. this consolidates all arrangement advances just as Crossover Equal Vehicles. so this should be possible both as arrangement and as equal cross breed electric vehicles. A mechanical coupling between the motor and driving wheels of the vehicle is available here. in arrangement equal mixture electric engines, contrasted with equal crossover, act less like a siphon, and less like an engine.

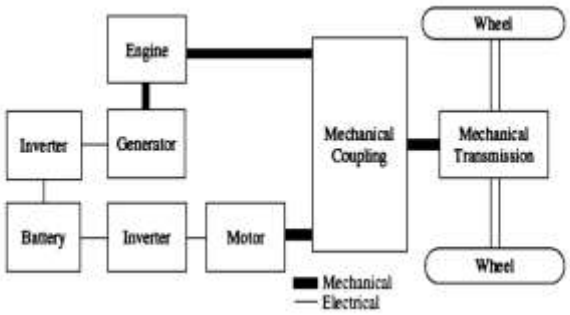

Figure 2: Series-Parallel Hybrid Configuration.

Since this kind of cross breed works as an arrangement just as equal sorts of half and halves, it is feasible to change the fuel yield contingent upon working conditions. when contrasted with other half breed types, this sort of crossover is more

unpredictable and expensive to plan and construct.

C. HEV Fundamentals

HEVs are vehicles which incorporate both ICEF or an electric footing framework for inferring the impetus of the vehicle. this normally comprises of at least two force stockpiling units, or at least two force sources in the motor. The ICE is for the most part utilized for consistent state administration in HEVs when the electrical framework is utilized Powertrain is utilized or depended on for dynamic help. A portion of the benefits that HEVs offer are:

- Regenerative slowing down is a bleeding edge innovation not utilized in ordinary vehicles.
- Since ICE will work with less idlers, this will prompt better efficiency.
- Simple drivability by means of electric footing powertrain.
- Condensed emanations.

III. LITERATURE REVIEW

The writing review was led in the accompanying explicit classes, with the point of perceiving the highlights and arrangements of electric vehicles.

a) Hybrid Electric Vehicle
b) Electric Vehicle
c) Fluffy Rationale Regulator
d) Electric DC motor
e) Electric AC motor
f) Batteries
g) Field Programmable Door Cluster

Niles et al (2002) built up an equal setup fluffy rationale based force regulator for mixture vehicles. this regulator has been intended to advance the progression of energy between the fundamental segments of the equal cross breed vehicle (PHV) and to improve the age and change of energy in the individual parts. the regulator was built utilizing proficiency guides of the vehicle segments. the force regulator design guarantees reliable fulfillment of the driver contributions from the brake and speed increase pedals, consistently satisfactory charging of the battery, and augmenting the PHV mileage. the consequences of the reproduction show conceivably change utilizing fluffy rationale over different procedures which enhance just the productivity of inside ignition motors.

Chan (1993) investigations the Status and future improvements in electric vehicle innovation, focusing on the effects of the quick development of electric engines, batteries, microelectronics and new materials. examination has been done on the most recent innovations of electric vehicle and it was It was tracked down that engine drives with cutting edge power converters and regulators and progressed batteries are by and large progressively embraced. the interest for electric vehicles is filled by enactment. the creator likewise underlines the requirement for normalization and framework to help the electric vehicle.

Paresh C. Sen (1990) Presents definite examination of condition of - the-workmanship electric engine drives and force procedures. it was likewise revealed that new high velocity, high-productivity exchanging frameworks, new motor models, new converter plans, new control strategies and new high velocity microcontrollers will additionally improve elite engine drives.

Farrall et al (1993) examined the altogether different pith of car control issues, bringing about two Fluffy rationale executions with to some degree distinctive core interest. the primary utilization of the Fluffy framework was semi-ride systemactive suspension frameworks. the reenactment results recommended that, along with ideal damper exchanging activity, the fluffy rationale regulator with next to no exhibition tuning, accomplished better vehicle reaction to both street and drive inputs. the second utilization of fluffy rationale in a crossover power train was in energy stockpiling. fluffy rationale's control objective was to support the vehicle's response while changing the manner in which energy was utilized to decrease the utilization of the put away energy. It was thusly recommended that fluffy strategies offer ascent to amazingly valuable outcomes in the designing of autos.

Singh et al (1995) the fluffy rationale technique was utilized in the auto area to evaluate the distance that an electric vehicle would have the option to cross over, in view of certain standard battery conditions. The creators built up a ' DIANE ' programming bundle which decides the scope of the battery's charging conditions from the given state. two determined boundaries were traffic thickness and wind speed, influencing the scope of the electric vehicle. it was additionally suggested that this method could be stretched out to numerous other huge components that influence the electric vehicle range. this strategy is a productive method of handling an overwhelming issue in electric vehicle plan.

Chuen Chien Lee (1990) a review of the fluffy rationale regulator, an overall strategy for making a fluffy rationale regulator was introduced. the creator gave specifically a discussion on fuzzification and defuzzification techniques, the deduction of the data set and fluffy control laws, the idea of fluffy results and the investigation of fluffy thinking systems.

Salah G. Foda (2000) fabricated a fluffy rationale regulator for a functioning suspension framework with a quarter vehicle. the planned fluffy rationale regulator significantly improved ride execution. they likewise gave solid damping abilities to different street inputs, utilizing both body ride and work space reactions to the suspension.

Rizzotto et al (1994) differentiated the proficiency of fluffy rationale with that of ordinary numerical techniques for assessing street fuel utilization model by utilizing just four determined factors of a vehicle driven in thick regions of traffic.

Funabiki et al (1991) the current order for profoundly proficient DC shunt engine force control was characterized considering the attractive immersion and armature response. thought was given to Impact of attractive immersion and armature response by characterizing the electromotive power and force coefficients as an element of field pressure, armature pressure, and turning speed. in the proposed technique the deficiency of the engine driver framework decreases than the misfortune in the steady field flow control, particularly in the scope of the little force order. the creator likewise tended with the impact of attractive immersion and response of the armature on force control and the decrease of loss of the engine drive framework.

Philip D. Olivier (1991) talked about the idea of arrangement criticism regulators and shunt-associated engines dependent on the linearization input procedure. it was likewise expressed that these regulators can be constructed and are exact at all working focuses aside from when interesting connections exist between the flows.

Kouroshsedghisigarchi et al (2001) considered three separate nonlinear control techniques designing shunt DC engine speeds. the three methodologies were linearization of criticism, linearization of information yield and guideline of the fluffy rationale. the initial two methodologies utilized DC shunt engine numerical model toward lessen the non-linearity and attempt to build up direct conditions. comparative procedures were utilized in these two techniques to develop the regulator. the consequences of the reenactment demonstrate that the linearization strategy for input yield had a solid reaction contrasted with the other one.

The upside of the information yield linearization approach was to control the heading and speed of the DC shunt engine while the input linearization approach was utilized to control speed alone. the creators assembled the fluffy rationale based regulator to exhibit how a keen nonlinear regulator can react to capacities and characterize reasonable principles and fozzy sets. at long last the creators close by proposing that savvy For those frameworks which might not approach their numerical models or have complex non-straight models, control techniques, for example, fluffy control can be an answer.

Ajay Yelne et al (1996) tests showing numerous benefits of adding SR (Exchanged Hesitance) motors to electric vehicle drives like, Superior and extraordinary force highlights over an enormous scope of paces, solid engineering and adaptation to non-critical failure and financial large scale manufacturing limit. SRD's (exchanged Hesitance Drive) the plan and development of rotors/stators, the selection of materials, the determination of electronic parts and the expense of creation were dissected. the presentation highlights, for example, drive power, force wave and commotion, adaptation to internal failure, effectiveness, speed and recovery force qualities were additionally examined. a portion of these styles, and creation concerns are frequently brought up conversely with related issues for electric vehicle drive frameworks at present in activity.

At last, it was recommended that the proficiency of SRDs is similar with other condition of - the-workmanship EV drive advancements Luca Salero (2001) portrayed the arrangements embraced for the immediate wheel drive of an underlying, three-wheel electric vehicle (EV) model committed to metropolitan versatility. a lasting hub transition magnet engine is utilized to deliver a consistent force of 4.5 KW at 500 fire up/min with a complete mass of 15Kg at an effectiveness of roughly 90%. the large scale manufacturing expenses of the EV drive framework plan are assessed to be practically identical well with those of ordinary nuclear power withthe same positioning that opens up opportunities for new lightweight, financially savvy EV items planned for business use.

IV. Result & Simulation

The electric vehicle utilized in this examination is a type of little vehicle improvement fit to metropolitan regions in Indonesia. figure 3 shows electric vehicles with parts, for example, the enlistment machine as the essential mover, the inverter as a media connect between dc source and acceptance machines and the battery as a fuel source. the idea is created utilizing the Simulink/Matlab programming.

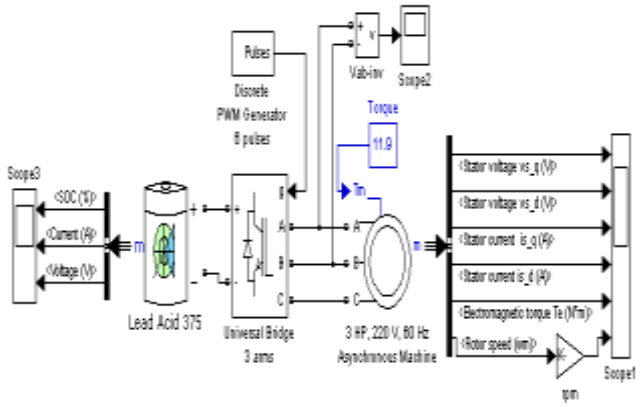

Figure 3: The model of electric vehicle in this study.

Enlistment engine is utilized as the driver has numerous benefits of proficient, less expensive, and generally utilized for electric driving at consistent speed, high idleness, no every day upkeep required. Acceptance engine in facilitates as the drive was planned of qdn. Every format is more flexible than customary ones. As the model can be worked with a non-sinusoidal voltage, the model can in any case be examined much under states of non-balanced source.

The battery utilized as a wellspring of energy is the type of lead corrosive batteries, for the most part seen available and the genuinely modest cost. that is one significant motivation behind why this sort of battery ought to be picked. Further more, this type of battery can be utilized to turn over the motor cycle which needs a generally high current. the battery's yield is a dc voltage/flow, while the engine of an electric vehicle with an enlistment engine utilizes the force converter as the force supply to the acceptance engine. the force converter innovation utilized in this model is the PWM Converter.

Unit proficiency is dictated by model exactness. the continuous model is typically accumulated and stacked onto a test system in Matlab/Simulink. the reenactment model sudden spikes in demand for equipment (single-processor or multiprocessor frameworks) for the computer chip. the Moderate size Test system produces I/O signals and tests them through the coordinated d Space I/O sheets. the arrangement of capacities is supplemented by a reproduction of burden and failure[11]. UI programming can screen a test system running the recreation model. this gadget gives direct admittance to all information sources and yields of an EEC being assessed. In this test climate, an EEC's data sources and yields can be viewed as a component if an article situated scripting language is utilized to control them consequently. the model that can be effortlessly executed into a HIL program is utilized to assess the proficiency of plan of the half breed vehicles. figure 4 presents a recreation model of the HEV block graph for one crossover vehicle design.

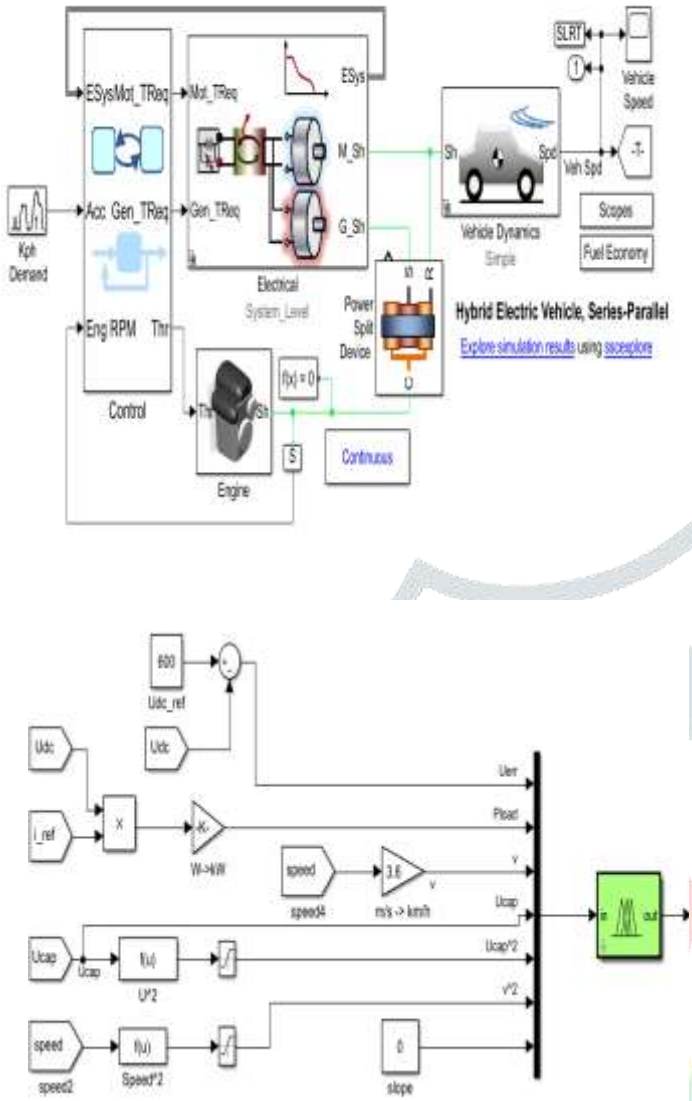

Figure 4: Complete Architecture of Hybrid Electric Vehicle, Series-Parallel with Simple Vehicle Dynamics and below model is Fuzzy control Model.

The Electronic Control Unit interacts with all major components: The Battery, the DC / DC Converter, the Electric Motor / Generator and the ICE. One can model the structure shown in Figure 2 and the architecture of the HEV system.

- Models of physical components at different fidelity levels are required for HEV growth.
- Modeling the plant and controller in a single setting allows optimization of the device stage.
- Integration with MATLAB and Simulink makes growth, post-processing and production more effective.

OVERVIEW HYBRID ELECTRIC VEHICLE MODEL

1. Modeling
   - Electrical System
   - Mechanical, thermal, other domains
   - Mode logic and control system
2. Simulation and Post Processing
   - Optimization and series-parallel computing
   - Result Generation
   - Power analysis
3. Deployment /Integration
   - Local Solver
   - Code generation

HYBRID ELECTRICAL VEHICLE MODEL

1. Electrical System
   - System Level: Test integration, optimize system
2. Battery System

There are three type of battery are used.

- Predefined Battery
- Generic Battery
- Cells Battery

3. Vehicles System
   - Inertial & Aero Effects (Simple Model)
   - Tire Models (Full Model)

SIMULATION REQUIREMENTS

- Overall System Requirements

The following requirements apply to the HEV

Dimensions

1. Curb Weight: 1325 kg
2. Length 4450 mm
3. Width 1725 mm
4. Height 1490 mm

Performance

1.Total Range: 870 km

2. Electric Range: 18 km

- Engine System Requirements

The following requirements apply to the functionality of this module.

ICE		
1.	Power	57 kW @5000 RPM
2.	Min Speed	1000 rpm
3.	Max Speed	4500 rpm
4.	Torque	115 Nm @ 4200 RPM

- Fuel Consumption

The following requirements apply to the fuel consumption:

Regular Gas

1. City: 51 MPG
2. Highway: 49 MPG
3. Combined: 50 MPG

Electrical + Gas

1. Combined 95 MPG - e
   - Speed controller module requirements For the Speed Controller module the following requirements apply.

• The controller module must enforce proportional and integral control at a minimum.

• The method must be within 5 per cent of the final value within 0.1 seconds of a change of angle (Settling Time).

• The method will hit 10 percent of the final value within 0.7 seconds after a shift of 10 percent.

V. SIMULATION RESULT

Here the hybrid electric vehicle used three different types of acceleration data and battery system. The vehicle dynamics are also used in two separate versions, which are seen in the section above.

- Result Simulation for Duty Cycle 1, Electrical System Level, Predefined Battery, Simple Vehicle Dynamics Model

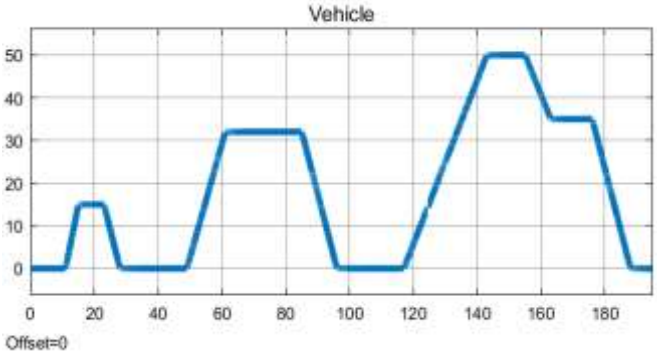

Figure 5: Simulation Analysis for Acceleration of Hybrid Electric Vehicle Model on Duty Cycle1.

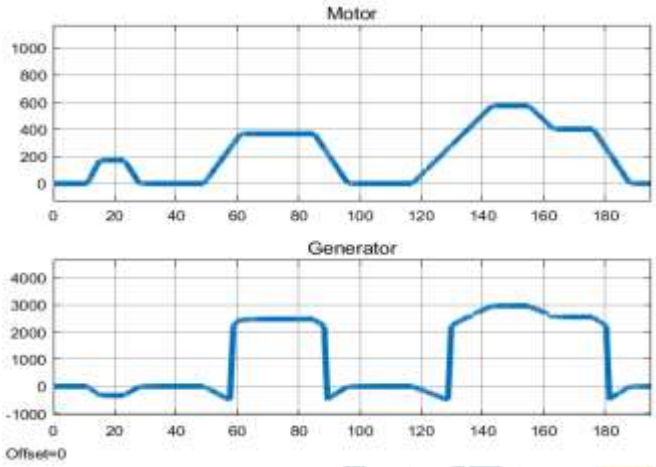

Figure 6: Motor and Generator Speed versus time of Hybrid Electric Vehicle on Duty Cycle1.

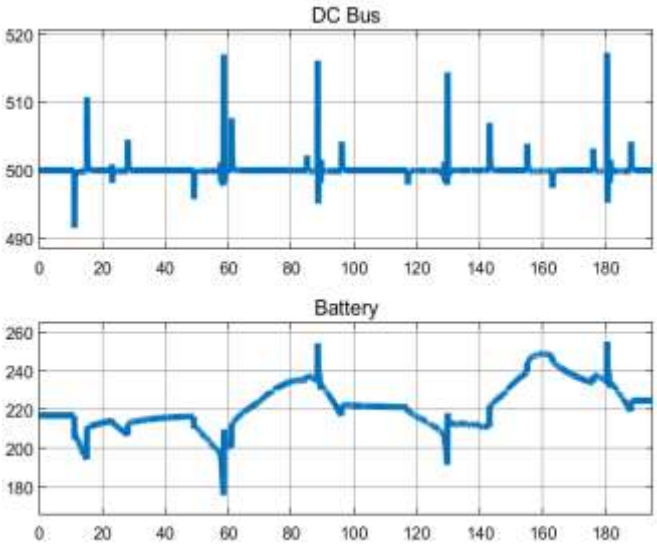

Figure 7: DC Bus and Battery Voltages versus time of Hybrid Electric Vehicle on Duty Cycle1.

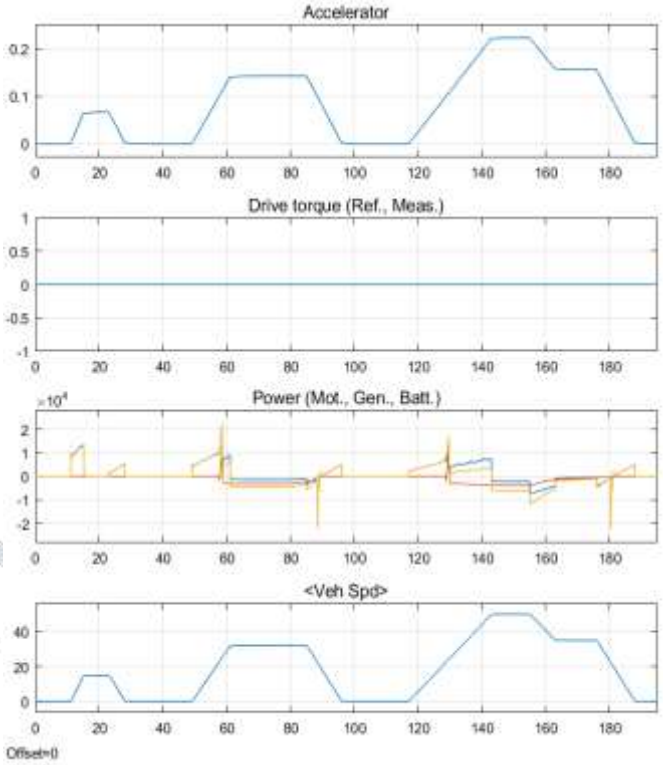

Figure 8: Result Analysis of Vehicle model of the Hybrid Electric Vehicle on Duty Cycle1.

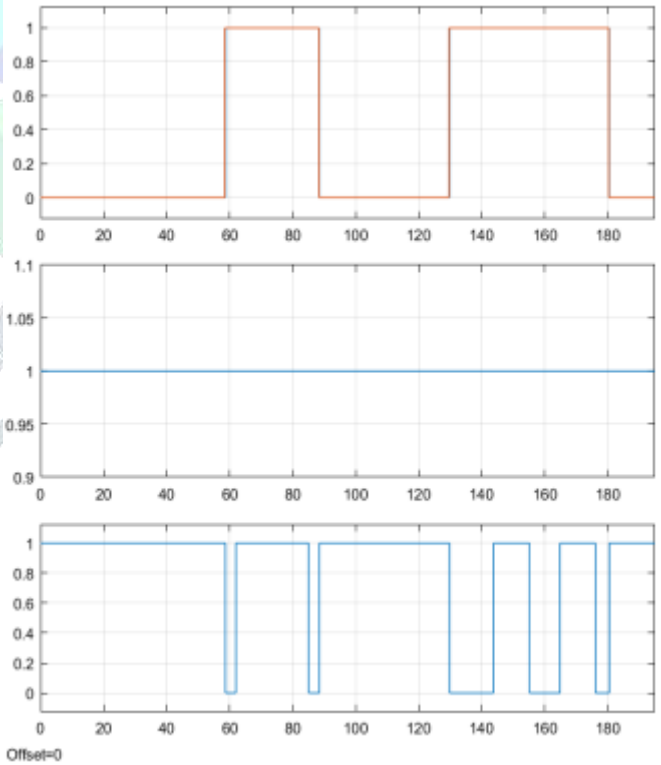

Figure 9: Model Control logic for Hybrid Electric Vehicle on Duty Cycle1.

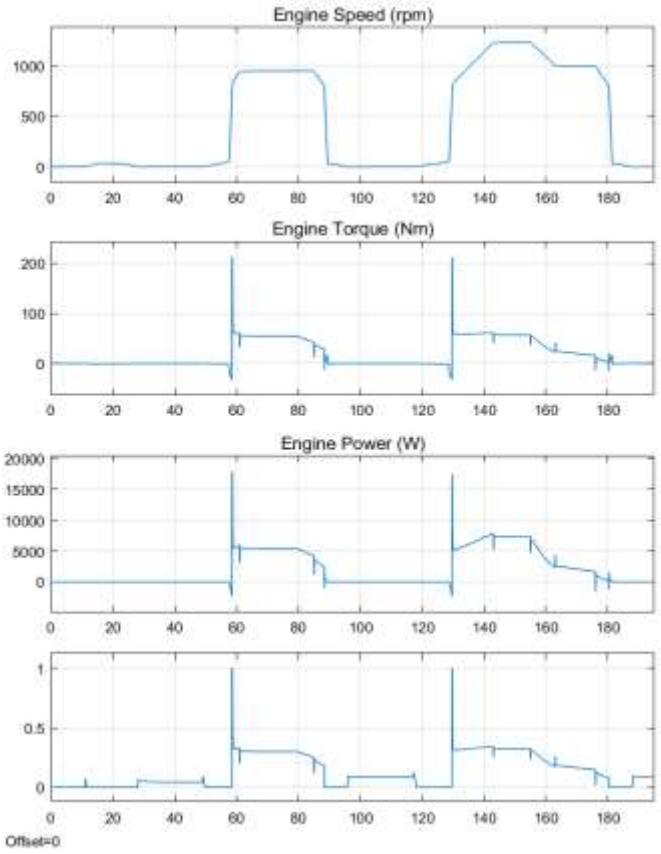

Figure 10: Internal Combustion Engine (ICE) performance for Hybrid Electric Vehicle on Duty Cycle1.

VI. DESIGN OF FUZZY LOGIC

Here a sugeno fluffy regulator is picked due to some fruitful benefits like the utilization of versatile philosophy, high operational proficiency and synchronization with direct control hypothesis. The FLC technique basically comprises of fluffy participation input work, fluffy enrollment yield work and fluffy principles.

In which we showed the example of participation work dependent on the three diverse information variable in figure 12.

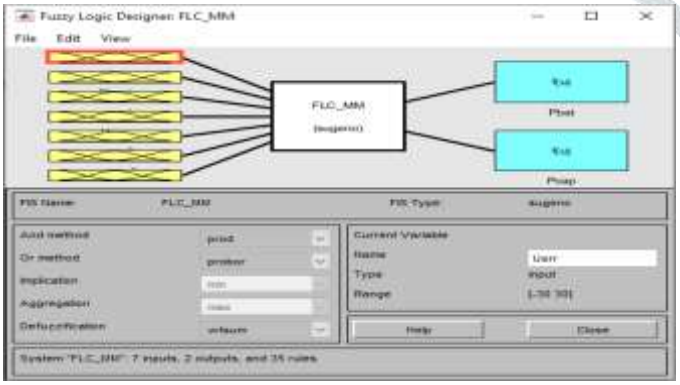

Figure 11: Fuzzy Logic Rule for HEV.

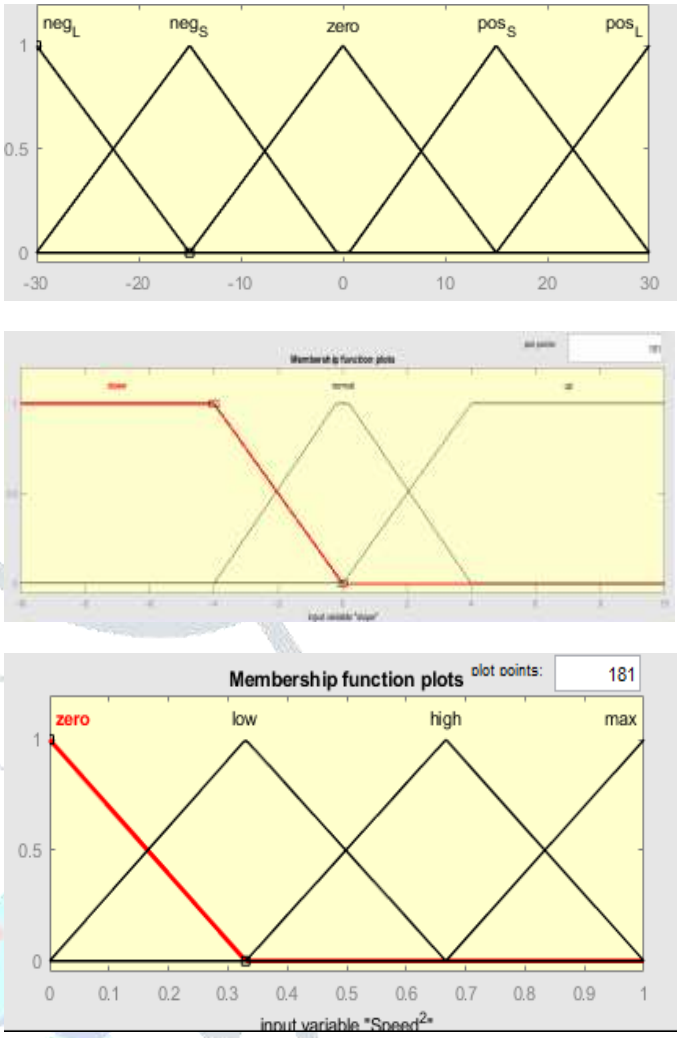

FIGURE 12: FUZZY LOGIC MEMBERSHIP RULE FOR HEV.

The outcome surfaces according fuzzy logic rules are shown in Fig. 13 and 14. According to compare of proposed fuzzy logic control with HEV PI controller. If we compare figure 5 and 13, it's clearly seen that fuzzy logic (figure 13) having the 100 Km/h speed but existing HEV having 50 km/h.

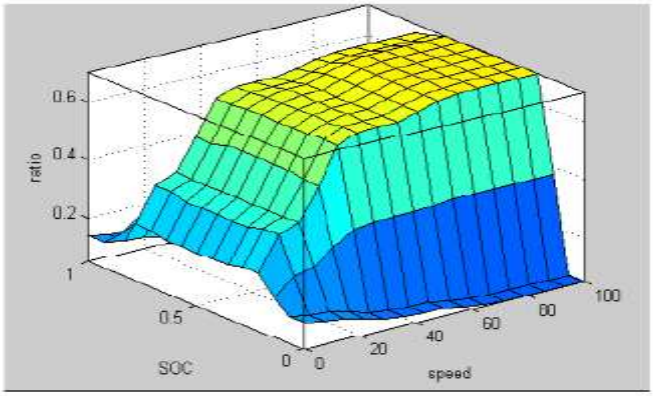

Fig.13: The relation among the vehicle' speed, battery's SOC and output ratio.

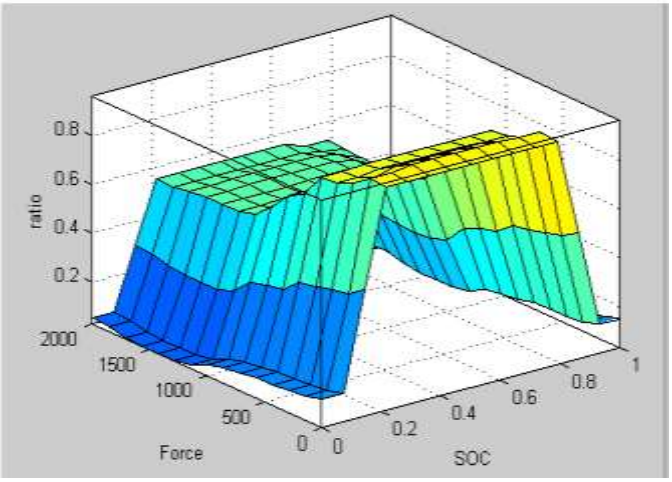

Fig. 14: The relation between braking force, battery's SOC and output ratio.

The Fuzzy logic controller based HEV have the higher and fast execution performance.

Table II: Performance Comparison

Parameters	EV	HEV	FLC-HEV
Convergence Speed	Varies	Medium	Fast
Implementation Complexity	Low	Medium	High
Periodic Tuning	No	yes	Yes
Sensed Parameters	Voltage-Current	Voltage-Current	Voltage-Current
Rotor Speed	1299 rpm	6000 rpm	8000 rpm
Running time	2.5- 5 sec	5-10 sec	2-3 sec

VII. Conclusion

Displaying the electric vehicle framework makes it simple to realize how much battery power an electric vehicle likewise needs to work with specific determinations over a specific distance. This model can be utilized to assess the battery life of electric vehicles. The model can likewise be utilized to decide the exhibition of electric vehicles, like beginning or running at a steady speed.

Here we originally recognized a normal HEV framework and introduced an outline of the key difficulties. We examined how the intricacies of multidomain emerge from the powerful idea of the motor, battery, electrical hardware, controls and vehicle elements with various mechanical and electrical parts. This intricacy joined with the enormous number of subsystem boundaries, makes HEV design an imposing designing issue.

We picked Model-Based Plan as a plausible way to deal with tackling the issue in light of its various advantages, including the utilization of a solitary framework for overseeing multi domain intricacy, permitting iterative displaying and idea elaboration. Ceaseless testing and investigation of the prerequisites diminished mix-ups in the plan cycle and creation period.

Our initial phase in the improvement cycle was the acknowledgment of an entire thought at the level of the HEV technique. The subsystem parts were normal adaptations, which went through programming improvement with equal refinement and configuration changes. We showed how you can address the working methods of the vehicle utilizing state outlines. We put it on board into the framework The level model analyzed the recreation consequences of the normal and itemized models after every part model was created, and noticed the effect of model elaboration on the yields.

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