JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Design optimization of electric vehicle for energy efficiency

[1]Rajat Srivastava, [1] Nitin Jangra, [1] Abhishek Arora , [1] Dr. J.P. Khesari
[1]Department of Mechanical Engineering, Delhi Technological University, New Delhi, India,

Abstract :In the context of climate change, most governments have agreed to take measures to slow the process of global warming. Governments all over the world have implemented notable programmes based on their individual circumstances; nonetheless, increasing the penetration ratio of sustainable energy and electric vehicles (EVs) is widely regarded as a critical way to reduce CO_2 emissions. On the market, EV sales have expanded significantly in recent years, despite the COVID-19 epidemic; in Europe, EV sales grew 57 percent in the first half of 2020, compared to a 37 percent fall in overall automobile sales. BES (Battery Energy Storage) and distributed renewable energy integration particularly photovoltaic (PV) in an EV charging station would lessen the burden on the electric grid even further and is seen as a potential business concept with the PV parity (in certain sunlight-abundant areas) and Renewable energy prices are constantly falling. The widespread use of EVs will increase the load on the electrical system. This study suggests using an optimum charging approach for EVs with extra BES to increase charging capabilities in a residential neighborhood. The needed charging capacity is estimated using the Monte Carlo approach by simulating the EV charging behavior, and the BES size is derived as the difference between the required capacity and the distribution capacity. The ideal charging approach is then provided to lower charging costs while ensuring the distribution network's safety.

***IndexTerms* -Electric Vehicle, Modeling, Optimization, Design Optimization.**

I Introduction

1.1 World EV Scenario

Worldwide selling of electric vehicles exceeds 2.1 million units in the year 2019, surpassing 2018 , and the total number of vehicles reached 7.2 million units. In recent years, ambitious political statements have been essential to drive the adoption of electric vehicles in major automotive markets. In 2019, there is a shift from direct subsidies to policy approaches that rely heavily on regulations and other structural measures, such as those that promise to make the transition economically sustainable. There are signs. The general consensus is that government support for the purchase of electric vehicles is only temporary until sales improve. In 2019, the government reduced spending on EV purchasing incentives for the first time, but personal consumption and overall EV spending increased. At the national level, both China and the United States saw significant or partial abolition of purchase subsidies in 2019, but in some cases these reductions were offset by increased government support.

1.2 Indian EV Scenario

India's EV industry is projected to grow at the compound annual growth rate (CAGR) of 90% over the last decade, reaching US $ 150 billion by 2030. India's EV industry is currently in its infancy and is expected to grow at a CAGR of 90.2 in 2021 and 2030. The industry is growing rapidly and is expected to be even more valuable in the future. The transition to shared, electrified and connected transportation modes in India will help avoid carbon emissions of about gigaton by 2030. According to the analysis, India will need about 400,000 charging stations to meet the needs of 2 million electric vehicles that could drive on the road by 2026. To meet this massive demand, an integrated work approach including both the business and governmental sectors is essential. In this context, power supply units (PSUs) have been active in providing much needed charging infrastructure.

1.3 Optimization framework of EV

The layout and optimization of EV batteries is state-of-the-art and multi leveled. The relative problems of lithium ion batteries are loosely cut up into 3 degrees from the perspective of gadget engineering: marketplace degree, battery gadget degree, and battery reaction unit degree. This examination supplied an optimization model to expedite the ecodesign optimization modeling methods for EV batteries. On the marketplace, the point of interest of lithium ion batteries is totally on the cost, safety, and toughness of the very last EV battery parts. At the battery gadget degree, EV battery layout optimization is ordinarily represented within the scope of the maximum suitable battery generation and shape with accordance to the unique utilization necessities of EVs with a purpose to gain the high-quality average overall reports of battery products. At the lowest degree of battery response units, a great deal interest has been paid to the examine and evaluation of battery response mechanisms with the goal of the usage of the idea of battery electrochemical response to enhance the overall performance of modern-day batteries. Many troubles arise on the battery gadget degree, which includes low capability and occasional output power. This may be solved with the aid of using an intensive examine and expertise of the ideas of battery electrochemical response

on the battery response degree.

II ELECTRIC VEHICLE DESIGN

2.1 Review of Literature

With the rapid expansion of the machinery industry, the number of moving types is increasing. The car is still the most used means of transport. There can be two main types of vehicles namely standard cars and motorbikes. Type with internal combustion engine and type without electric motor. Electric vehicles have yet to completely replace gasoline-powered cars. Electric vehicles have several disadvantages, especially in areas where cost, autonomy, refueling and speed are taken into consideration [1]. In fact,there is a significant increase in production of the autoparts . As the process becomes more difficult, costs inevitably add up and the battery drains within hours. It is recommended to recharge the battery regularly after 100 km. These shortcomings are incomplete. Rising fuel prices and tougher emissions regulations require new regulatory technologies to be created to fulfill these needs. At the exact time, the automobile industry must continuously innovate to fulfufill the needs of customers while maintaining high performance standards. Manufacturers are trying to develop solutions for this process with the aim of helping electric vehicles win the hearts of customers in the near future. The preliminary design of the tram [2–4] can be done using various tools such as Multidomain Modelica, Matlab/Simulink and VHDL AMS. Several studies have been done to develop and optimize electric vehicle models to create more reliable and efficient vehicles. For instance, the author of [3] focuses on the modeling and design of battery packs. This has to include enough power in a particular range and enough performance to accelerate and decelerate. The author of [4] suggested a simple model for the pre-design of electric vehicles. This model can be used to describe the behaviors of the motor and the box of gears of the drive system. For the performance prerequisites that are similar to different test cases like test of acceleration, top speed and flat speed etc.

2.2 Research Gap

When designing a battery for an electric vehicle, the design team needs to consider many factors, including: EV battery system cost and other factors. The Battery Ecodesign of EV Optimization Framework helps designers perform ecodesign tasks and ensures the reliability of ecodesign decision-taking behavior by eliminating probable optimization design risks. Provided for. This framework combines a conceptual product model, a performance analysis module, and an optimized design model. With respect to the conceptual model of the product, the general architecture of battery packs majorly contains the basic structure of cell packs, packs having module and battery packs, battery charge / discharge control systems, and heat management mechanisms. After creating the proper design scheme, you can create a series of analytical modules, including product having structural models, mechanics analysis models, LCS models, and electrochemical models of lithium-ion batteries, according to the basic design requirements of electric vehicles. Analyze battery performance. The product structure model is the most basic model of all the models described in the Performance Analysis module and can provide the input needed for subsequent analysis modules. The LCS model is a module that analyzes the environmental impact of EV battery packs, which are the basis of eco-design. Finally, the design variables, constraints, and objectives defined by the power analysis module are three important aspects of the optimized design model. Given the complexity and variety of EV battery design and development, the optimization framework uses an open architecture to increase the efficiency of EV battery optimization design. The scope of design analysis and the goals of performance analysis can be continuously adapted to the needs of current development. Designers can add modules to their optimized designs if more thorough investigation is required.

2.3 Importance and Objectives

The purpose of this paper is to explain the model-based design of small electric vehicles and the optimization of elastic design to obtain a higher vehicle range for specific power, maximum speed, and load criteria. .. At the beginning of the electric vehicle design process, a small diesel hatchback of Indian origin was used as a reference vehicle. Detailed batteries, motors, and basic vertical vehicle models were created by using a language platform that is well known as Modelica, and component sizing beforehand was based on the characteristics of the reference vehicle and the desired EV target. We used a hybrid optimization approach to identify the optimal EV component size parameters that provide vehicle range and minimum mass while satisfying all constraints.

Many automakers are trying to change their vehicle technology with the primary purpose of reducing emissions and integrating power into future vehicles. New technologies such as, for example, high-capacity lithium batteries are the primary energy source for the driving force of electric vehicles. With the new technology, various manufacturers that are completely electric vehicles, such as Tesla, Chevrolet Bolt EV, and Nissan Leaf, are launching products. Energy saving is one of the most urgent problems facing the world's environment. Electric vehicles not only consume energy, but also generate, store and transmit energy. As a result, they are excellent alternative fuels for fuel vehicles.

III RESEARCH METHODOLOGY

3.1 Modeling of an EV

Electric vehicles are categorized on criteria that depend on the type of motor (DC/AC), the inverter type , and the battery behavior that is generally in voltage fluctuations. The electric vehicle model for this study was created using the MATLAB programming language. The mathematical formulation of electric vehicles was motivated by the models established in the references. This model consists of a DC power supply battery, a DCAC inverter rectifier, a synchronous electric motor, a transmission model, resistance, and a control system. It uses sensors that monitor current, power sensors, speed sensors, and SoC components to detect the battery current generated, the power needed for the motor, the speed of the vehicle, and the amount of charge present in the battery. Use MATLAB Simulink to model the components of the battery and include the entire device. In addition, MATLAB Simulink is used to simulate the equivalent equation for EV battery and EV verification. MATLAB is a programming/simukation language that combines programming, computation, and visualization into a single package. It has been extended and applied in many areas to address engineering and scientific challenges. MATLAB includes a large and powerful graphical toolbox that allows users to work in a comfortable and easy environment. In addition, the BEV components were designed using MATLAB Simulink and the entire structure was integrated. This is different from typical diesel vehicles, which are efficient, environmentally friendly and have a storage unit. The BEV model and its equations were also simulated. In this study, we investigated the modeling of BEVs and their electrical system components. In addition, investigate all the effects related to the simulation. In [5], the author presented effective battery modeling using several evolutionary algorithms. The engine, electric motor, battery charge controller, driving cycle, driver model, and vertical vehicle are all components of the dynamic model.

3.2 Electrical Components

3.2.1 Battery

Batteries store electrical energy that are similar to the oil tanks of internal combustion engines. The highest mileage of an electric vehicle is usually given by the capacity of the battery. The larger the capacity, the longer the mileage. With that in mind, increasing capacity seems like a natural choice. Long mileage eliminates the need to stop at the charging station frequently. However, the choice is not very clear, as the size and weight of the battery also have a significant impact on vehicle performance. Large and heavy batteries occupy cabin / storage space, reducing fuel efficiency and fuel consumption. Therefore, the best way to optimize performance is to maximize the energy density of the battery.

Prepare a small and lightweight battery that stores as much electrical energy as possible. Battery management system Manages many cells of the battery so that they function as one unit. Electric vehicle batteries consist of only 10-thousand minicels, and each cell should be in the same condition as all other cells to optimize battery life and performance. In most cases, the BMS is built into the battery case, but it can also be built into the power control unit (EPCU). BMS mainly monitors the charge / discharge state of the cell, but when it detects a failed cell, the power state (on / off) of the cell is automatically set via the relay mechanism (conditional mechanism that opens and closes other circuits).

3.2.2 Inverter

An inverter is a component that converts direct current used in electric vehicle motors into alternating current. The inverter has the ability to avert the speed at which the motor revolves by altering the frequency of the AC power supply. You can also increase or decrease engine output or torque by adjusting the signal amplitude. Electric vehicles (EVs) and hybrid electric vehicles (HEVs) use traction inverters to convert DC power to three phase AC power. It is used to power the traction motor from a high voltage battery or DC bus. I need it. The traction inverter typically transfers power in the range of 20100 kW, the switching voltage range is 200V to 800V, and the current range is hundreds of amperes. The entire system can be monitored and controlled via an automated bus such as CAN ("Comm" in the image below). The CAN bus is separated by a digital isolator, such as the Si86xx, and a digital isolator with a built-in DCDC power converter, such as the Si88xx.

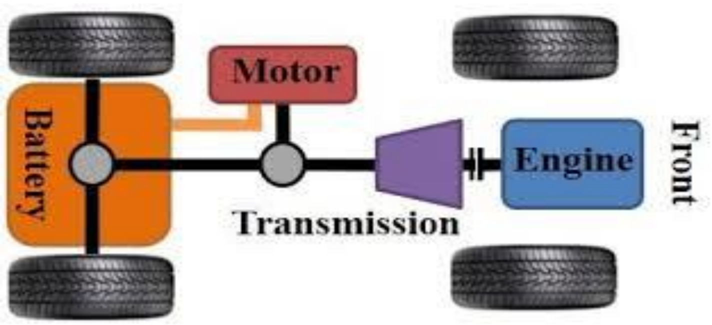
3.2.2 Motor

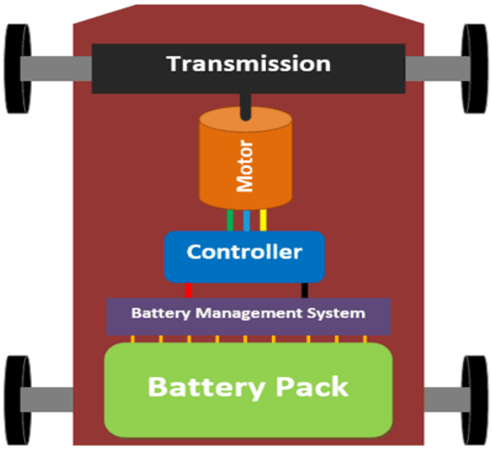
Electrical power is provided to the stator through the car battery. The winding that is in the stator (consisting of a conductor) is on the opposite side of the stator core and acts like a magnet. Therefore, when supplying power from a car battery to the engine, the coil will create a magnetic field that pulls the guide bar outside the rotor to reverse. The rotating rotor generates the mechanical energy needed to turn the car's gears, turning the tires. I'm in a regular car. H. There are non-electric types, both motor and alternator. The battery powers the motor, which turns the gears and wheels. Then, the rotation of the wheels will lead to the car's alternator, which will charge the battery. That's why you are asked to drive for a while after jumping. The battery must be charged for it to function properly. Electric vehicles do not have generators. The motor model specifies the conversion between electrical and mechanical levels. The model includes two ports and two output connections. Ports are connected to the inverter and grounded respectively. The flange of the mechanical connector is responsible for connecting to the reducer, providing two values: torque flange and motor shaft angle flange a. non-Variable is the third output of the model and includes the electric angular frequency that the motor seeks to meet the drive cycle requirements. Note that the output connection is associated with the parameter of the inverter defined and described.

3.3 Transmission and Control

3.3.1 Transmission System

The transmission system can be scaled down early in the design phase, represented by three mechanical components in the Modelica library, placed in the global model , and coupled to the engine output. These components are the mass of the transmission, wheels, and vehicle. Each vehicle type has different values for the parameters associated with these components. Therefore, before running the simulation, the designer must provide all the characteristics of the transmission system. In such cases, the three main characteristics required for the design of the transmission system are a gear ratio of R_g, a wheel radius r_w, and a vehicle mass M_v.





3.3.2 Resistive Forces

This section consists of two blocks. The first block is a formula that calculates drag based on the super quick vehicle speed, the secondary block accepts the results obtained and then it converts them into reaction forces that are applied to the very end of the transmission.

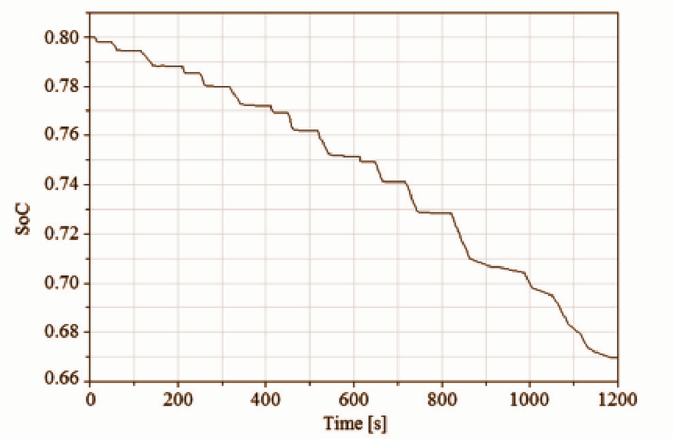
3.3.3 Control System

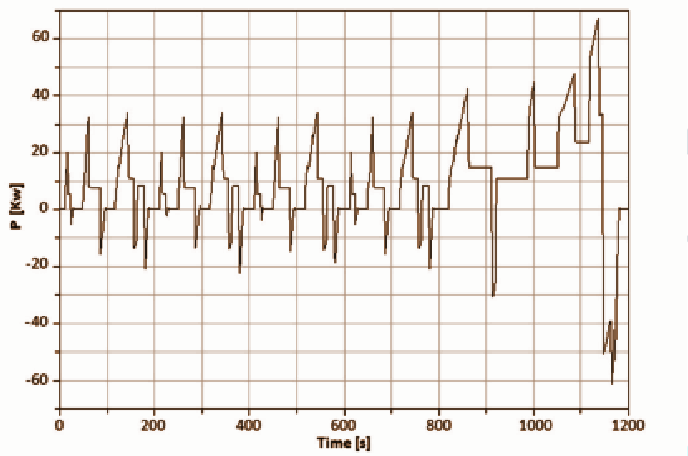
The control system has dual input parameters that are speed of reference and calculated speed and only a single control parameter that is the control factor of inverter voltage. The PID voltage has the responsibility for calculating the difference between the input reference speed and the calculated speed providing the best value for the output parameter. Evaluation of the analytical model used later in the optimization process is done by comparing the exit speed of the electric vehicle to the standard driving cycle provided as an input.

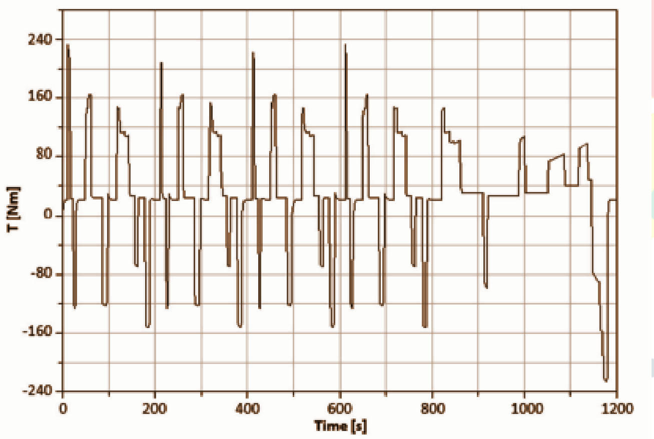
IV. CASE STUDY

The case study can be described as four objective functions of Electric Vehicle

Consideration is given to the optimization of electric vehicles with four objective functions and three design constraints. Objective 1 is to minimize the mass of the energy storage system in order to select the best battery. Goal 2 is to maximize the charge of the battery at the end of the drive cycle. Goal 3 is to minimize the power required for the drivetrain and transmission system to select the best electric motor. Goal 4 is to minimize the gear ratio to reduce the volume of the gearbox.







For the design variables, we will focus on the number of series linked cells N_s, the number of parallel strings N_p, and the electromotive force constant Emf. the gear ratio and the electric motor R_g.

This project combined the Modelica modeling language with Model Center to optimize electric vehicles. Optimization is performed using the algorithms provided by the ModelCenter library, especially the NSGA II non-dominant gene sorting algorithm. The NSGA II method was developed to solve the multipurpose nonlinear optimization problem. NSGA seeks to identify the best design collection (such as the Pareto set), not the best design. If another design outperforms the design in all goals, then that design is said to be dominant.

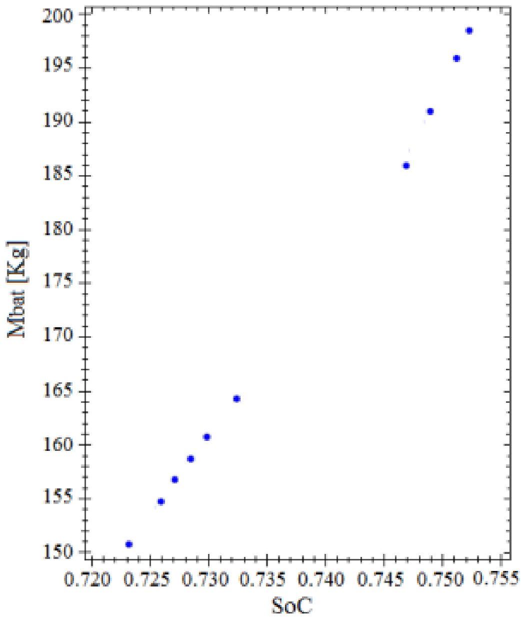
The input design vector consisting of X for ModelCenter is defined as: X = [N_s, N_p, Emf, R_g]. The output variables are defined by Y = [M_{bat}, SoC P, R_g, V_{10}, V_{max}] which is determined by the Modelica simulations at every input design point. Because optimization is versatile, there is a set of solutions (parate front) for these problems, as shown in the figure. Each point of the pallet front is defined by an input vector X (design variable to optimize) and an output vector Y (objective function to achieve and constraints to follow). Table 2 summarizes the best design alternatives after the Pareto front was generated. For example, Figure above shows that the maximum output P required for an engine is 151.1kW to 178.4kW and the deviation of P is about 15.3 percent. The Rg of the gear varies between 4.92 and 7.36, with a change in Rg of approximately 33.15 percent. As a result, the two criteria fluctuate significantly along the ideal front, suggesting a trade-off between them. If one of the criteria is found to deviate significantly from the other, for example, B. Insignificant P to Rg, which is the gear ratio Rg. This means that the maximum output standard required for engine P can be improved without significantly affecting the standard.

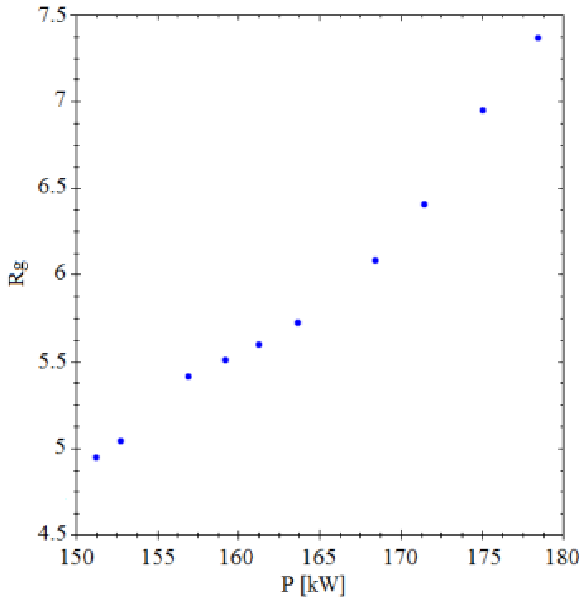
V. RESULTS

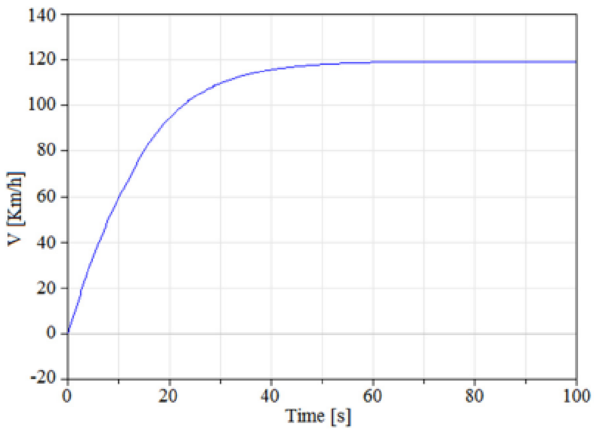
In this circumstance, a compromise is most likely. It is tough to choose a solution on all fronts. As a result, it is critical to design rules that allow for decision-making in such circumstances of dispute. For example, if reducing battery mass is a goal, there is only one solution with the following characteristics: (N_s = 76, N_p = 4, Emf = 0.264, and R_g = 6.91).

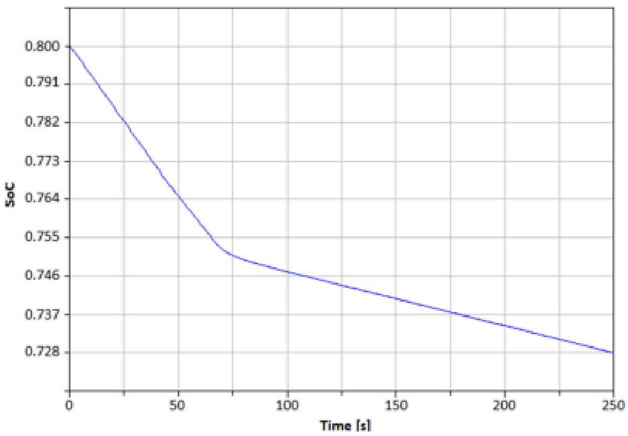
However, if decreasing the volume of the gear-box is a goal, the optimal option in this situation is: (N_s = 79, N_p = 5, Emf = 0.309, and R_g = 4.92).

In this case study, the optimized design is selected for N_s = 80, Np = 4, Emf = 0.251, R_g = 6.1, with V_{max} = 119.6 km.h-1 and V_{10} = 60.04 km.h^{-1}). Figures below show changes in power and charge status in an optimal configuration over 250 seconds. The maximum power available is 49 kW, the battery mass is 158.72 kg, and the maximum charge is 0.728. Comparing these results with the pre-optimized results, we can conclude that the gear ratio and charge state are about the same, but the battery mass is significantly reduced by 20% and the power consumption is significantly reduced by 23.43%.









VI. CONCLUSION

Both developed and developing countries are becoming more active in EVs Introduction and dissemination. In developed countries, the government has ordered promotion . Next-generation eco-friendly car. Not just in industry Not only traditional automobile manufacturers but also large and small companies are participating in EVs. Business as a new business opportunity. According to many implementations there are pilot projects and events related to electric vehicles, and general expectations for electric vehicles are high. However, there are no clear signs of full-scale adoption. This is limited due to the high price of electric vehicles , lack of model, lack of charging infrastructure, and lack of market confidence in lifespan . The safety of electric vehicles. On the other hand, when it comes to electric cars, major automakers are bold. Development aimed at addressing the above issues and speeding up EVs diffusion.

VII. REFERENCES

[1] C. Chan, K. Chau, Modern electric vehicle tech. , Oxford University Press, 2001, p. 47
[2]Sabri M. F. M. Danapala Singam K. A., Rahmat M. F. "A review on hybrid electric vehicles architecture and energy management strategies Renew Sustain Energy" Rev, 53 (2016), pp. 1433-144.
[3] E. Schaltz, Electrical vehicle design and modeling, INTECH Open Access Publisher, 2011
[4] Cheng Zhang, Yun Liu, Yongming Qian, Hong Bao, An optimization framework of electric vehicle (EV) batteries for product eco-design, Procedia CIRP, Volume 90, 2020, Pages 366-371, ISSN 2212-8271
[5] Shaosen Su, Wei Li, Yongsheng Li, Akhil Garg, Liang Gao, Quan Zhou, Multi-objective design optimization of battery thermal management system for electric vehicles, Applied Thermal Engineering,
Volume 196, 2021, 117235, ISSN 1359-4311,