Dynamic Modeling and Simulation on a Hybrid Power System for Electric Vehicle Applications: A Review

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Abstract - Hybrid electric vehicles, sometimes abbreviated as HEVs, are a product of the automotive industry's reaction to the growing environmental challenges it faces. These cars combine the advantages of gas and electric power trains. The benefits that electric cars and conventional vehicles powered by internal combustion engines provide are brought together in hybrid electric vehicles, or HEVs. They accomplish this by combining a traditional internal combustion engine with an electrical system that consists of a battery and an electric motor. This allows them to achieve higher fuel efficiency and reduced emissions while still retaining an appropriate driving range. Plug-in hybrid electric vehicles, also known as PHEVs, have larger battery storage systems than conventional hybrid electric vehicles (HEVs). Because of this, plug-in hybrid electric vehicles are able to receive a full charge by connecting to an external electric power source, such as the electrical grid. One of the three fundamental ideas for PHEVs is called the power-split architecture. It has a tendency to provide higher efficiency than the parallel architecture and the series architecture, but it also has more sophisticated dynamics than those two types of architecture. In light of this, the objective of this research project was to examine the problem of optimizing the component sizes of a power-split PHEV in an attempt to make the most of the edibility of this power train system and further increase the vehicle's fuel efficiency. For the purpose of this experiment, a Toyota Prius with a plug-in hybrid system was employed as the baseline car. In order to develop a model of the vehicle, the Autonomies software was used. This model was then used as the basis for the formulation of an optimization problem. The major objective of this matter is to lessen the quantity of gasoline that is used up during the typical driving routines. Several factors of the design were taken into account, including the maximum power of the engine, the number of battery cells, and the maximum power of the electric motor. The issue of optimization for the various driving cycles was resolved by making use of the genetic algorithm technique, and an adequate reduction in fuel consumption was achieved by making use of the sizing procedure. Both of these accomplishments were possible thanks to the application of the genetic algorithm technique. In order to ensure that the model was accurate, a Maple Sim model was used.

Key Words: Dynamic modeling, Hybrid Power, Electrical, vehicle, Hybrid electric vehicle.

1. INTRODUCTION

Electric cars, also known as EVs, are a practical alternative to conventional automobiles powered by internal combustion engines (ICE), which are notorious for the excessive amount of noise they produce and the amount of gasoline they use. Electric cars, also known as EVs, are a viable alternative to conventional automobiles powered by internal combustion engines (ICE). Because the only source of power that electric cars need is the electrical energy that is stored in their battery systems, there is no longer any need to directly consume fossil fuels while operating electric vehicles because this requirement is eliminated entirely. In addition, the exhaust that exits their tailpipes does not generate any noise or particles that contribute to air pollution. Nevertheless, despite these benefits, electric cars have not had a substantial effect on the global vehicle markets, which are still dominated by traditional internal combustion engine (ICE) vehicles. This is because electric automobiles are more expensive than conventional ICE vehicles. This is due to the fact that electric cars have a higher purchase price compared to other kinds of vehicles. The key reasons for this tendency are the expensive price tag of electric cars as well as the restricted driving range that can be achieved due to the limitations of their battery packs. As a result of these challenges, manufacturers have been compelled to design platforms that are capable of successfully bridging the gap between cars powered by internal combustion engines (ICE) and vehicles that produce no emissions as part of their efforts to overcome these deficiencies. These efforts are being made as part of the manufacturers' efforts to overcome these shortcomings. These platforms will fill the role of transitional technologies until electric cars are able to more fully penetrate the consumer market. As a direct and immediate consequence of these efforts, hybrid electric cars and, more recently, plug-in hybrid electric vehicles are now available to purchase on the market (HEVs and PHEVs, respectively).

1.1. Hybrid Electric Vehicles

Previously, it was mentioned that the hybrid electric vehicle (HEV) was presented as a short-term solution that makes use of technologies from both the electric vehicle (EV) and the internal combustion engine (ICE) platforms. This was done so because the HEV is able to take advantage of both sets of platforms' respective strengths. This approach makes use of the technology that is specific to both electric vehicle and internal combustion engine platforms. Combining the internal combustion engines that are found in traditional automobiles with the electric motors that are found in electric vehicles is one way that this may be accomplished (EVs). This makes it possible to have access to a different source of energy, which opens up the possibility of incorporating it into the functioning of propulsion systems for vehicles. Hybrid electric automobiles are clearly more fuel efficient than their conventionally powered equivalents. This is due to the fact that the electric system supports the engine in maintaining within its most economical operating range. As a result of this, the engine is able to either totally shut off while it is idling or charge the batteries with the extra power that it generates while it is running. Conventional motor vehicles are not equipped to provide propulsion through electric propulsion. Because of this, it is especially beneficial to operate a vehicle in an urban environment using the electric propulsion system, as it is possible to do so almost entirely. As a direct consequence of this, this is particularly useful in urban settings. This results in a decrease in fuel consumption and makes it feasible for the vehicle to have a smaller engine, both of which are desirable features to have in areas with a high population density since they make it possible to utilise vehicles with smaller engines. In addition, the kinetic energy that is generally lost as heat as the vehicle is decelerating may be reclaimed and put to use to charge the batteries, which is something that is not normally feasible for a vehicle of this kind. Each of these benefits contributes to the overall reduction in the amount of gasoline that may be saved, making the total amount of fuel savings a more reasonable quantity. Nevertheless, hybrid electric vehicles (HEVs), despite the fact that they cannot run on the electric system alone and, as a result, must consume at least a small amount of fuel, can be regarded as a workable solution for the intermediate term until fully functional electric vehicles that have zero fuel consumption and zero emissions are produced. This is because HEVs are able to run on both the electric system and the fuel system simultaneously, which allows them to run on the electric system alone when the fuel system is not in use. This is as a result of the fact that HEVs are able to operate on the electric system in combination with the electric system. The figure of the hybrid electric vehicle is given below:

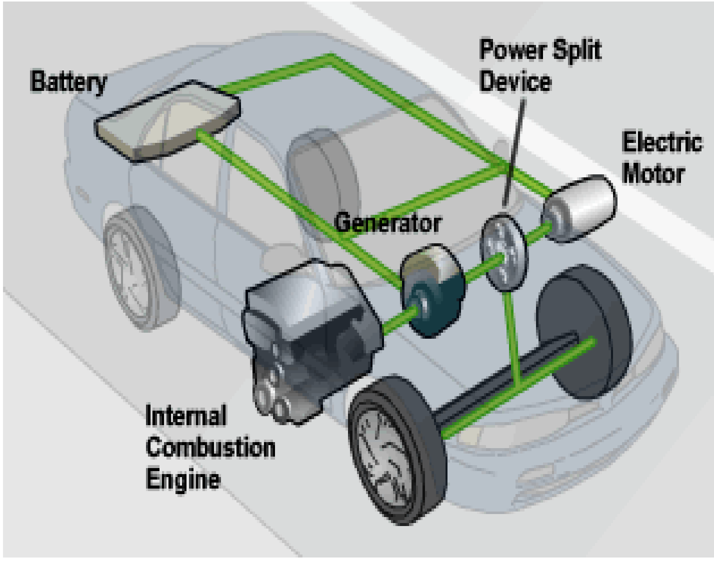

Figure-1: HEV

2. LITERATURE SURVEY

After studied research paper related to the hybrid electric vehicle, the summary of all paper is given below with the author name:

[1] David: modelling and simulation of high-energy vehicles, with the major focus being on modelling that is particularly focused on physics. In this essay, we will take a brief look at a few alternative tactics that may be employed in dynamic digital simulations in order to suppress numerical oscillations. These strategies have the potential to be applied in a variety of different ways. When modelling and simulating HEVs, it is possible to attain a greater degree of freedom by making use of additional simulation approaches, such as bond graph modelling. This may be done by modelling and simulating HEVs. Because powerful computing, the development of computational methods, and advancements in software-in-the-loop (SIL) and hardware-in-the-loop (HIL) modelling and simulations are now available, it is now possible to study numerous iterations of different designs with the combinations of different components and different topology configurations. This was not possible in the past. In times past, doing so would have been impossible. My first attempt was a complete and utter failure. For the goals of quick prototyping and the development of control systems for new vehicles such as X-by-Wire [46], HIL is becoming an increasingly crucial component. HEV will attract growing attention from both the automotive industry and the consumer as constraints imposed on energy supplies become ever more rigorous and as environmental concerns become more widespread. This is because HEVs provide a number of advantages that conventional vehicles do not. This is due to the fact that it is anticipated that the limitations placed on available energy supplies would get more restrictive as time goes on.

Even though their current market share is still relatively modest, it is reasonable to anticipate that HEVs will gradually acquire appeal in the market as a result of their improved fuel efficiency and increased vehicle performance. This can be attributed to the fact that HEVs have improved fuel efficiency and increased vehicle performance. This is due to the fact that HEVs have superior vehicle performance when compared to conventional automobiles. When it comes to the design and development of HEVs, the use of modelling and simulation will be an extremely important factor in deciding the amount of success that will be achieved.

[2] Grunditz, Jansson: After the vehicle was constructed and modelled racing circumstances were simulated, the performance of an electric go-kart was simulated as it competed in a modelled race. However, to this day, a go-kart of this kind has not been built in the real world, nor have any tests or measurements been carried out on the go-kart or any of its parts in order to validate the correctness of the model. This is despite the fact that the model has been in existence for quite some time. This is by far the most serious problem with the work that has been done up to this point. In addition, some mechanical and electrical losses, including those that occur in electrical motors, gears, and wheels, in addition to the electrical losses that occur in cables, are not taken into consideration. It has been made to seem as if this is the case, despite the fact that the values of the electrical parameters of the induction machine are not, in fact, predetermined in any way. For example, an increase in temperature and an increase in the frequency of the current both lead to an increase in the rotor's resistance. Additionally, the magnetization of the motor iron may approach its limit, which will have an impact not only on the capacitances but also on the inductances. This will have an effect not only on the capacitances but also on the inductances. When it is desired to analyse a real go-kart by using this simulation tool, there are a few essential parameters, in addition to the parameters for the driveline, that need to be validated and possibly altered in order to obtain a valid result. These parameters include: the wheelbase, the tyre diameter, the tyre pressure, and the tyre width. These criteria include things like: These elements make up the total mass of the go-kart, which takes into account the weight of the driver in addition to the go-cross-sectional kart's area, the vehicle's rolling coefficient, and the amount of air resistance. In light of the specific circumstances, these figures should at best be considered mere estimates.

[3] Chehresaz: kind of hybrid electric vehicle (HEV) that utilises the framework established by the Toyota Prius. The computer simulation application Autonomies was used at various stages during the process of fabricating the model of the vehicle in order to give help. Before beginning the process of optimization, the model of the car was analysed in order to determine the effect that size would have on the amount of gasoline that would be consumed as well as the overall performance of the vehicle. This was done in order to determine whether or not the vehicle could be optimised. As a direct consequence of doing this study, we were in a position to validate the precision of the optimization outcomes even before putting them into practise. Because we wanted to be successful in accomplishing our main target of reducing the amount of fuel that we used, we came up with an optimization problem utilising this model. This was done because we wanted to reduce the amount of gasoline that we used. We were successful in determining the optimal dimensions for the automobile's most important parts, such as the internal combustion engine, the electric motor, and the batteries. Our efforts in this direction were met with great success. As a direct consequence of this, the highest possible combined output of the engine and motor, in addition to the total number of battery cells, was one of our key concerns during the whole design process. Through the use of the Genetic Tool (GA) approach as an optimization algorithm, the issue was resolved across a wide range of different trip cycles. This was carried out. These driving cycles comprised commuting on city streets, highways, and a mix of the two types of roads, in addition to both types of roads individually.

When compared with rates calculated from the baseline model and in other driving cycles, such as urban (FTP) or highway (HWFET) or a mix of urban and highway cycles, this effort to size the components led to a significant reduction in fuel consumption. This was the case both in the urban (FTP) and highway (HWFET) driving cycles as well. This decrease was accomplished when compared with rates derived from the baseline model as well as in other driving cycles (EPA). While some of our optimization findings that were identified without taking limits into account showed dramatically lower fuel usage, the vehicle platform that was produced as a consequence was unable to fulfil needed performance parameters and was, as a result, unattractive. Some of our optimization findings were identified without taking limits into account. This happened because we failed to take into consideration any restrictions that could be present.

[4] Abdelrahman: The parameters of the car model were adjusted so that it would be consistent with a prototype of an electric vehicle that is now being manufactured by the industrial partners that are a part of the Motive organization. The United States of America are the ones responsible for this new breakthrough. This included the transmission system of the automobile, which was capable of operating at two different speeds. Both single-speed and two-speed gearboxes were put through their paces in a series of performance tests and simulated driving cycles so that researchers could compare and contrast the advantages offered by both types of transmissions. The purpose of these studies was to investigate and contrast the various benefits offered by the various gearboxes. According to the findings of the study, the two-speed gives substantial benefits over the single-speed in terms of both performance and the amount of energy it consumes. A cyclist riding a bicycle with a single speed has just one gear ratio to select from. Both the effects of using a single transmission and those of using a transmission that can switch between two speeds have been analyzed and compared, respectively. According to the findings of the study, the research shows that the performance of the vehicle that has a gearbox that only has two speeds is superior in terms of both its economic and dynamic performance. A gearbox that has two speeds, as opposed to a transmission that only has one speed, not only makes the motor more efficient, but it also extends the distance that it is capable of travelling in comparison to a transmission that only has one speed. According to the findings, switching to a transmission that can operate at two speeds results in an improvement of 2.2 percentage points with regard to the total transmission efficiency.

[5] Hong et.al: the dynamic model of a passive hybrid power system that is based on the idea of an ultra capacitor in conjunction with a venin battery. According to the results of the simulation, optimising the performance of the power system by combining high-energy-density batteries and high-power-density ultra capacitors for use in electric vehicles can take advantage of the benefits offered by both of these components and improve the system's overall functionality. This combination is intended to be used in order to maximise the performance of the power system. When employing a hybrid power system, it is feasible to avoid the impact that a high current would have on the battery pack. This is made possible because of the hybrid nature of the power system. Because its charging current is significantly lower than that of the power system that relies solely on the battery, it will be of great assistance in increasing the cycle life of the battery in order to provide smoother working conditions. This is because its charging current is significantly lower than that of the power system that relies only on the battery. The energy consumption of the battery pack in a hybrid power system is lowered by 2 percent when compared to that of a power system that depends only on batteries, while the system as a whole is able to accomplish a 7.78 percent decrease in the quantity of electricity that is utilised. It is essential to establish a suitable matching of the features of the passive hybrid power system in order to get a higher level of performance. This may be accomplished by: It has been determined that the maximum voltage of the ultra capacitor pack should be identical to the open-circuit voltage of the battery pack when the state of charge is equal to ninety percent.

[6] Rahul et.al: This decision was based on the benefits and convenience of integrating signal-based solutions into the design control process rather than Matlab/toolbox Simulink's (SimPower System and SimDriveline). SimPower System and SimDriveline were developed using a signal-based method owing to their dependency on physical model modelling. With Matlab/toolboxes, SimDriveline and the SimPower System, we were able to simulate the behaviour of electric automobiles. A signal-based strategy was discovered to be compatible with Matlab/Simulink and its toolbox. To test a broad range of controller simulation models on the same computer, the EV model is very flexible. Because of the design, this is a viable alternative. This is now possible because to the framework's scalability. Electrical systems operate dynamically, and you must understand this in order to evaluate alternative vehicle controller designs. As a result, you may put your trust in the designs you get. In this research, Matlab and Simulink are used to assess and analyse many aspects of electric vehicle design, such as efficiency and emissions. Software users may rapidly see the effects of architectural and parameter changes made using visual programming methodologies. A lot of features of the software are implemented using visual programming techniques. Data is completely within the control of the user. In addition to the larger electric motors and battery packs, there are smaller versions of both. Various standards may be defined by using data. The finished product may be compared to the original specs after it has been completed. Future electric vehicles will benefit from improved vehicle and driving system design. The development of electric cars that are more efficient is ongoing. We want to improve the quality of electric cars via the implementation of this programme. An electric vehicle that can fulfil future demand must first be demographically studied. They can meet their performance standards in the actual world, according to substantial evidence. According to computer simulations, using this strategy has a significant impact on battery and controller design. Without simulations, this job would have taken significantly longer and been far more difficult. These claims need to be supported by a computer simulation. Virtual battery architectures have been constructed as part of our study. This approach will be used to assess battery packs in electric vehicles. A closer examination of this issue is forthcoming. This method resulted in a simple and modular description of the components of an electric automobile (EV). To provide a more complete picture of the vehicle's performance, these models may be merged. It's possible to examine this option after the prototypes have been completed. You may easily examine the design and control systems of the car with this realistic model. A more efficient and cost-effective creative process will result. If this strategy works, it might benefit any other electric vehicle design. According to [Insert reference], is this accurate? " It's very possible that the simulation may reveal new domains in the model. Data collection on the charging process may be enhanced by applying regenerative braking to improve battery dynamics. The model's meticulous attention to detail and careful analysis may be to fault for the issue. A wide range of parameters were examined in order to fine-tune the model.

[7] Kyung: The modelling, analysis, and controller design for a fuel cell power system that combines a fuel cell system, a DC/DC converter, and a battery in a number of different electric combinations in order to provide a variety of various electric outputs. We create controllers by making use of linear quadratic optimization methodologies, and the range of fuel cell operations that we cover includes load following as well as load levelling. Because of this, we are able to compute the required size of the fuel cell-battery combination (the degree of hybridization), as well as the subsequent trends in the system's efficiency. The controller that was developed is capable of handling the flow of air and electrons in the fuel cell stack in an ideal manner. As a result, the controller was able to achieve a balance in the sluggish power response of the stack without either overestimating or underestimating the stack's capacity to respond to transient events. Our optimal control method consumes the absolute minimum amount of battery power feasible, hence establishing the absolute minimum amount of hybridization that is required in FC autonomous power systems. This work is being done with the end goal of making a significant contribution to the field of fuel cell technology, notably in the fields of control and coordination, and in particular for hybrid power applications that make use of a variety of power sources. A lot of attention is now being paid to the idea of increasing the number of FCs that are already present in the power system. The control strategy as well as the dynamic load capacities are both susceptible to change based on the connection (whether it be parallel, series, or something else). This work will also make a contribution to the research that is currently being done in the field of power management of fuel cells. This research is being done in order to maximise fuel economy in applications that are relevant to the transportation industry. The results of this research will contribute to the core system technology that will be used for the design assessment of other potential future energy systems. Because of the emphasis placed on coordination issues and the incorporation of multidisciplinary elements, it is anticipated that this effort will have a substantial influence. Long term, the work that we have been doing on multivariable dynamic energy systems will be able to be expanded to address reliable distributed energy by defining requirements on the minimum communication among the embedded controllers in distributed power sources and the requirement for energy storage. This will allow the work that we have been doing on multivariable dynamic energy systems to address reliable distributed energy. Because of this, we will be able to solve the problem of consistent energy distribution.

[8] Yuliang: ADVISOR and Dymola are both examples of software programmes that may be used in the process of modelling cars. In order to better assist in the design and development of future generations of HEV, these programmes were utilised to conduct research and simulate three distinct vehicular systems. The first prototype is of a hybrid power backup system that is based on fuel cells. It is intended to be used in an elevator that is positioned in a high-rise building. It was initially based on a model of an electric automobile that was created in ADVISOR before being changed. The results of the simulation indicated that it would be possible, both technically and monetarily, to employ a fuel cell power system in order to supply continuous energy to the elevator system. The building of the second model, which was a Class 7 commercial truck, made advantage of an existing two-mode vehicle model that had been built on ADVISOR. The findings of the simulation showed that the two-mode hybrid power train has adequate power and a considerable improvement in its efficiency in terms of the amount of fuel it uses. The final vehicle model of a parallel hybrid electric automobile has been finished using the Dymola platform. It was agreed that computer models of important components of a vehicle's power train, such as the engine, transmission, and chassis, would be constructed. Utilizing the test data provided by the automobile manufacturer is one method that may be used to validate the reliability of the results acquired from the simulation. It has not yet been determined whether or not the integrated system model or the vehicle simulation will be successful.

[9] Ramachandra: One option for improving the air quality in urban areas is to replace conventional internal combustion engine (IC) cars with hybrid electric vehicles (HEVs), which are powered by rechargeable batteries rather than traditional gasoline-powered automobiles. Batteries are a crucial component of the hybrid electric cars that are now in the design stage. In this regard, simulation tools are very important since they make it feasible to construct and improve battery technology. Vehicle simulators have the capacity to deal with a broad range of charge and discharge routines, which is one of the features of these simulators. PSAT is an excellent simulation tool that may be used in the testing and assessment of vehicles. The results of the model's simulation and the PSAT for a high voltage NiMH battery pack were compared and contrasted with one another. The two models were able to reach a mutually agreeable consensus with one another in terms of the shape that the profile should take. The size, on the other hand, was not consistent from one instance to the next because of the existence of a number of other aspects, all of which were taken into consideration in the model that was developed for this thesis. In order to study the potential outcomes of the oxygen reactions that were taking on inside the batteries, simulations were carried out. However, the important characteristics like charge efficiency and pressure have not been tested with any of the other models. This is a problem. This is due to the fact that many of the traditional modelling tools ignore these concerns, and as this is a relatively new area of difficulty and study in the design of batteries, it is also a very new area of focus for researchers. As a direct consequence of this, none of the alternative models has been successful in validating these parameters.

3. CONCLUSION

After studied above research paper in the literature survey section, there is conclusion found that given that, The total efficiency of the vehicle is improved when it is equipped with a hybrid-electric power train. This is accomplished by ensuring that the engine functions in the most efficient way possible and by making the most effective use of the power that is available. Research on the many different hybrid-electric drive-trains that are now available on the market was the first thing that needed to be done in order to get started on this project. The terms "series," "parallel," and "power-split gear based" drive trains are used to refer to the three basic kinds of hybrid drive trains that are now in use. Every possible choice for the drive train comes with its own specific set of advantages as well as disadvantages. After considering the advantages and disadvantages of each of the prospective drive trains, the researchers came to the conclusion that the power-split gear based drivetrain would be the best candidate for further investigation. This was due to the great performance of this drive-train as well as the fact that this drive-train is used in a significant number of hybrid electric vehicles that are now for sale on the market. Both of these factors contributed to this result.

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