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A Review on Matlab Simulink Modeling of Solar Based EV System with Control of its Utility Parameters

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Abstract- Emerging topics such as environmental protection and energy utilization have pushed research and development of electric vehicles. In the last few decades, numerous technologies have been developed for EV importance. In this article, key research topics in the area of EVs, namely electric machines, electrochemical energy sources, wireless charging infrastructure, and latest EV/HEV models are covered. This Review paper aims to consolidate the key emerging technologies in this field and provide the readers a blueprint to begin their own journeys.

Index Terms- Electric machine, induction machine, wound field synchronous machine, reluctance machine, stator permanent-magnet machine, field modulation machine, high-speed machine

I. INTRODUCTION

Greenhouse gases have a great effect on our planet and one of the ways to reduce it is by replacing the conventional internal combustion engine vehicles with electrical vehicles, nowadays all countries and companies around the globe are moving toward changing to electrical vehicles, governments are offering huge financial support, and companies are setting a deadline for the full transfer from conventional vehicles to electrical vehicles. Electrical vehicles have zero emissions and almost no sound which makes them environment friendly. [1] To change from conventional vehicles to electrical vehicles means an increase in the electricity demand, and to overcome this problem we need to utilize renewable energy sources because they can be installed anywhere. By utilization of renewable energy sources like solar and wind…etc. we also get less usage of fossil fuel which means less greenhouse gas emissions. It can be installed at home or in the parking of a company where the cars are parked for a long period. [2]

II. RESEARCH MOTIVATION

The MATLAB/Simulink software, which is capable of modeling complete EV powertrains at various levels of fidelity and detail, has proven to be an invaluable modeling platform. This software features a variety of shipped sample models for simulation of pure battery electric as well as hybrid electric vehicles of different configurations and types. The MATLAB/Simulink platform supports many add-ons which have been used in vehicle modeling, such as Super systems and SimDriveline, Advisor Sims cape, Powertrain Block set, etc. For vehicle modeling, Simulink supports an equation-based, data-driven, and physical modeling approach. Simulink also supports hardware testing and deployment code generation, testing and analysis frameworks for test case management, and report generation. The literature contains numerous studies of MATLAB/Simulink models. However, methodologies for validating these models in a research set within a real-world environment have not been adequately addressed in the existing literature [2-5].

III. RESEARCH PURPOSE

In this vehicle design, the designed vehicle's turning radius is obtained by steering geometry analysis (Afkar et al., 2012) and is judged by whether the design could pass every curve in the racing field smoothly (Pourasad et al., 2016). The loads on the front and rear axles of the vehicle in constant speed motion, acceleration, braking, and cornering are calculated by front and rear axle load analysis. The stress on the axle parts is analyzed by finite element analysis, according to the calculation result, to ensure that the part would not suffer from plastic deformation under the loading condition. The rigidity of the frame before and after being equipped with stiffeners is analyzed to check whether the reinforcement design could enhance the rigidity effectively. Finally, modal analysis is performed for the frame, and the modal frequency and vibration mode shape are verified mutually by experimental modal analysis to guarantee the model verification.

IV. ELECTRIC VEHICLE (EV)

An **electric vehicle (EV)** is a type of vehicle that is powered primarily by electricity, using an electric motor instead of an internal combustion engine. EVs are equipped with a rechargeable battery pack, which stores electricity and supplies energy to the motor for propulsion.

Key Characteristics

- **Energy Source:** EVs rely on electricity, typically stored in lithium-ion batteries.
- **Zero Emissions:** They produce no tailpipe emissions, making them environmentally friendly compared to gasoline or diesel-powered vehicles.
- **Charging:** EVs are recharged by plugging into electric power sources, such as home chargers or public charging stations.

Types

- **Battery Electric Vehicles (BEVs):** Fully electric with no internal combustion engine.
- **Plug-in Hybrid Electric Vehicles (PHEVs):** Combine an electric motor with a gasoline engine for extended range.
- **Hybrid Electric Vehicles (HEVs):** Use an electric motor to supplement the internal combustion engine but cannot be plugged in to recharge.
- **Components:** Key components include an electric motor, battery pack, inverter, and controller.

Benefits

- Reduced greenhouse gas emissions.
- Lower operating and maintenance costs.
- Energy efficiency compared to traditional vehicles.

V. LITERATURE REVIEW

Zhiqiang Zhai et al. [1] The development of battery electric vehicles (BEVs) raises a demand to develop a tool to estimate and predict their energy consumption accurately and efficiently. This study proposes a model to estimate the energy consumption of BEVs based on the trajectories of in-use vehicles, including both BEVs and internal combustion engine vehicles (ICEVs). This model consists of three modules: vehicle specific power (VSP) distributions, energy consumption rates, travel time and mileages. The estimation results are validated and compared with those derived from driving cycles and instantaneous speeds. It is found that the VSP distributions can capture the variation of the energy consumption relating to average speeds, and the results are unbiased with average errors less than 1.9%, comparing with instantaneous speeds. It is practicable to employ the trajectories of ICEVs to model the activity of BEVs for energy consumption estimates, and the average errors are less than 2.7%. Jingeun Song et al. [2] This paper is a study on 5-cycle fuel economy prediction model of electric vehicles using numerical simulation. It aims to develop a prediction model for the energy efficiency of electric vehicles and compare it with the results of chassis dynamometer tests. Driving tests were conducted on a chassis dynamometer, which included various test cycles of the 5-cycle test. Using MATLAB Simulink, a vehicle dynamics analysis model for electric vehicles was constructed, and analytical research was conducted focusing on light-duty electric vehicles. By comparing and analyzing the experimental data obtained from the chassis dynamometer with the data calculated through simulation, it is possible to verify the accuracy of the electric vehicle energy efficiency prediction model. And the reliability of the simulation model was secured by comparing the experimental data obtained through chassis dynamometer test with the simulation results of the developed electric vehicle energy efficiency prediction model. There is good agreement between the experimental and simulation results. In most areas, the error rate remains below 3 %, indicating that the simulation model closely follows the experimental results from the chassis dynamometer. Based on these results, it is expected that the developed simulation model can be utilized for measuring the energy efficiency of electric vehicles.

N.I. Shchurov et al. [3] The article is devoted to the development of simulation model in the MATLAB Simulink software environment of an electric vehicle hybrid traction drive based on fuel cells and lithium battery. The applied topologies of battery and hybrid traction drives are considered. A traction drive model has been synthesized, in which the main energy source is a fuel cell (FC) with a proton exchange membrane (PEM), and the unevenness of the transport load is smoothed out by a high-power buffer storage unit (BSU) based on a lithium-titanium-oxide (LTO) battery.
The dependence of the required BSU capacity on the power of the primary source, reduced to a ton of vehicle weight, was obtained. Based on this, the optimal range of hybrid power plant parameters was determined (FC power from 5 to 11 kW/t, LTO battery capacity from 6 to 10 Ah/t) when driving according to the WLTC load cycle. The calculated fuel consumption in this case was 0.56 kg/(km-t), and the time of included state of FC was 94.53%.

Nand Lal Shah et al. [4] Electric vehicles have been introduced to address environmental concerns related to excessive burning of fuels in the automobile industry. The key component solely responsible for its preferences over other modes is the battery. The Charging and discharging states under different running model of vehicle is directly related to the health of battery and thereby the degree of hybridization of the series-parallel hybrid electric vehicle (SP-HEV) considered in this research. In this study, the state of charge of a series parallel hybrid electric vehicle was continuously modeled under different driving conditions, and two models were used to predict the charging states of the battery. A swarm-based prediction model resulted in a prediction error of 0.9114, while a modified differential evolutionary method reduced the error to 0.6672, indicating its effectiveness in estimating battery charge conditions. The prediction of battery SOC will enhance the power efficiency of the vehicle along with its SOH. Liguo Zhang et al. [5] In the vector control of permanent magnet synchronous motor (PMSM), the speed overshoot and torque pulsation phenomena need to be solved. There are two prerequisites for the drive control of PMSM in electric vehicle (EV). The first is that the vehicle control has to be ensured as a whole. The second is, to ensure the economy of the vehicle control while ensuring the stable control of the motor. Therefore, this paper first proposes the fuzzy exponential convergence law fractional-order sliding mode control (F-CFSMC), it is constructed with the purpose of online correction of the exponential convergence law of the fractional-order sliding mode surface. It is expressing the arrival time and convergence speed of the fractional-order sliding mode surface explicitly with parameters. The stability of the F-CFSMC is proved to be derived using the Lyapunov equation. The F-CFSMC is applicable to PMSMs with different parameters. Next, the fuzzy controller that considers the battery parameter factor in EV is introduced to combine the lithium battery and PMSM to enhance energy utilization. At this point, the double-hierarchical fuzzy exponential convergence law fractional-order sliding mode control (DF-CFSMC) build is complete. Moreover, comparative simulations and experiments using the DF-CFSMC and the conventional PMSM control are conducted, and the results are performed in PMSM hierarchical. Simulations are also performed in the EV hierarchical application to show the universality, repeatability and advantages of DF-CFSMC.

Adolphe junior Loga Paglan et al. [6] Research focused on electric vehicles is increasingly numerous, regularly relying on design methods on the traction chain, ergonomics and autonomy, thus undermining the passage necessary for the realization of a prototype that is simulation. This paper propose a methodology for co-simulating electric vehicles in a 3D environment impacting on a traction chain developed in Matlab. According to ISO 4138:2004(E), using open-loop test methods refers to an approach for analyzing vehicle dynamics and performance when maintaining a constant circular trajectory at a steady speed. This work use the constant-speed and varied steering-wheel angle test method, mesure yaw rate, lateral velocity and calculate side slip angle. The simulation results show that the combination of Webots and MATLAB, while adhering to the dynamic modeling of an electric vehicle, is an excellent option for simulation testing. This integration allows for realistic simulations, leveraging Webots' advanced 3D robotics environment and MATLAB's robust computational capabilities, to model vehicle dynamics, control strategies, and performance in diverse scenarios. This co-simulation approach provides a powerful platform for validating and optimizing electric vehicle designs.

Shangyi Zhao et al. [7] Soft computing technology has attracted extensive attention in computer engineering and automatic control domains because it can deal with uncertainties, fuzziness, and complex practical problems. This study adopts a Genetic Algorithm (GA) in soft computing technology to realize the cooperative optimization of electric vehicle's dynamic and economic performance. The advantage of soft computing technology lies in its adaptability to uncertainty, fuzziness, and complex practical problems, making GA an effective tool for solving complex optimization problems. Firstly, the electric vehicles' power system structure and energy management strategy are investigated and analyzed. Secondly, the improved non-dominated sorting genetic algorithm II (NSGA-II) is selected to optimize the parameters of electric vehicles because of its simple operation and high optimization accuracy. Thirdly, NSGA-II is used to construct the electric vehicles' power and energy configuration, with power and economic performance as the main optimization objectives. Meanwhile, a fuzzy logic controller is designed to adjust the parameters of GA online, so that the optimization process is closer to the actual operating conditions. Finally, the relevant variables are selected to achieve the optimization goal, the optimization objective function and constraint conditions are established, and the model is simulated and evaluated. The results show that the optimized electric vehicle's acceleration time is remarkably reduced, the dynamic performance is improved by more than 7 %, and the power loss is reduced by 5 %. In addition, compared with the current multi-objective optimization model, this model enables electric vehicles to travel longer distances under the same power. This study provides a new idea and method for the performance optimization of electric vehicles. Moreover, it offers a valuable reference for the innovation and development of electric vehicle technology in the intelligent manufacturing field. This study indicates that electric vehicles could be more efficient, energy-saving, and environmentally friendly to serve people's travel needs in the future. Johan Wellten et al. [8] Greater use and reuse of electric vehicle batteries is needed for the ongoing electrification of the transport sector towards a net-zero and carbon-low economy. Such battery second-life uses and later recycling requires an ecosystem with actors having reliable battery tracking and equitably sharing usage information. However, existing studies do not prescribe viable solutions to such circular ecosystems. Therefore, this study explores the electric vehicle battery ecosystem's structures, actors, and processes that may enable battery circularity. The study was conducted on one global electric vehicle battery supply chain in the heavy-duty and commercial vehicle sector. It covers all phases of the battery journey. Primary data was collected through interviews and observations, and supported by secondary documentary data. For contribution, while the existing literature on battery circularity largely focuses on technology choices for information transparency, sharing and tracking, our study develops a value model that identifies key considerations for creating a viable electric vehicle battery ecosystem and the challenges that participating actors need to resolve. Practically, the findings demonstrate the importance of actors being adaptive in all parts of EVB circularity development, and it highlights the critical role the OEM has to ensure that equitable value sharing occurs among the various partners. Marziyeh Razeghi et al. [9] Climate change and the rise in carbon dioxide levels due to gasoline vehicles are global challenges that require innovative and sustainable solutions; this study presents an innovative strategy to promote electric vehicles (EVs) adoption through the establishment of solar-powered charging stations. Utilizing ArcGIS10.8.2 software, a comprehensive analysis was conducted to identify optimal locations for these stations, considering technical, economic, environmental, and geological data. This research, unlike other past research, leverages public spaces such as gas stations, shopping centers, and parking lots for station construction, minimizing operational costs and fostering a sustainable infrastructure. This approach applies not only to the study area of this research, which is Khuzestan province, but can also be extended to other regions and serves as a model for reducing CO_2 emissions in the transportation sector worldwide. This research evaluates the location for establishing electric vehicle charging stations using solar energy innovatively, from both technical and operational perspectives. By using the systematic and new method presented in this research, it is possible to identify the highest potential for the construction of electric car charging stations that simultaneously use solar energy all over the world, and the results of applying this new method in the studied area showed that 90 % of the cities within this province have the potential to establish charging stations for electric vehicles utilizing sunlight. Specifically, Mahshahr County in this province can supply 90.55 % of the required energy for charging stations through solar energy. Operationally, 70 % of the cities in the region possess such potential. The study demonstrated that this area has the capacity to convert 11 % of vehicles to electric cars by 2040 and can reduce CO_2 emissions by more than 30 tons.

Yuerong Zhang et al. [10] In light of the UK's commitment to achieving Net Zero emissions by 2050, coupled with the impending 2035 ban on new diesel and petrol vehicles, the promotion of Electric Vehicle (EV) adoption has become increasingly critical. High accessibility of EV charging infrastructure has been shown critically important to promote the public's intentions to purchase EV (Canepa et al., 2019; Coffman et al., 2017). Recent study also found that the enhanced accessibility to EV chargers improves traffic flow and lower particulate matters (PM2.5) emission levels by 1.3–2.2% (Liang et al., 2023), underscoring the environmental benefits of expanded EV infrastructure. Despite these advantages, the rollout of EV charging facilities, especially public on-street chargers, is progressing at an insufficient pace for certain types of charging points. This slow deployment is rendered even more critical by the fact that over two-fifths (44%) of UK homes, as reported by Lloyds Bank (2022), lack off-road parking, making them unsuitable for home EV charging solutions. This situation is projected to affect approximately 10 million electric cars and vans by 2050, which are regularly parked overnight on the street (HM Government (2022)). To ensure that the UK's transition to electric vehicles is both inclusive and effective, it is imperative to address these challenges.

VI. CONCLUSION

Due to the increasing concerns on energy crisis and energy utilization, development of EVs has become a one-way train. There are plenty exciting technologies invented in the last few decades while an overview of emerging technologies can benefit many stakeholders. This paper aims to serve as a starting point for engineers, researchers and scholars who are keen to develop their interests in this area. In this paper, several key topics, namely electric machines, electrochemical energy sources, wireless charging infrastructures and latest EV models, are discussed in detail. This paper targets to provide the readers a blueprint for them to begin their own journey in the field.

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