

# Mechanical Engineering Design: A Multidisciplinary Approach

Dr. Vikash Pandey<sup>1\*</sup> and Dr. Nidhi Gupta<sup>2</sup>

<sup>1</sup>Department of Mechanical Engineering, United College of Engineering and Research, Allahabad, India.

<sup>2</sup>Department of Mechanical Engineering, United College of Engineering and Research, Allahabad, India.

---

**Abstract**---Electric Vehicles (EVs) are considered more efficient and eco-friendly vehicles in the road transportation sector. EVs can possibly alleviate the fossil fuel byproducts brought about by customary fuel-controlled vehicles. Half breed Electric Vehicles (HEVs) have somewhere around one electric drive train to give foothold power either somewhat or totally. A productive energy stockpiling media like batteries, supercapacitors, ultra-flywheels are utilized in HEVs to store and supply electrical power. Series, equal and series equal drivetrains are the various setups of HEVs. Drive framework works like a heart in HEVs, it gives the fundamental footing ability to move the vehicle. Photovoltaic (PV) Innovation is considered as the most encouraging energy change innovation of the 21st hundred years because of the limited accessibility of traditional assets. PV innovation, for example, independent and network associated framework is standing out overall to produce electrical energy. By and by, energy interest for street transportation area is 45% of complete transportation energy interest in India. Consequently, the HEVs using inexhaustible assets of energy, for example, PV innovation would be a manageable move toward decarbonize the street transportation area in India.

**Keywords**--- Energy, Electric Vehicles, Solar PV.

---

**Received: 04 - 09 - 2024; Revised: 12 - 10 - 2024; Accepted: 21 - 11 - 2024; Published: 26 - 12 - 2024**

---

## I. Introduction

Energy is an essential part of our daily lives and the functionality of the advanced industries such as transportation, manufacturing, global communication and computer aided-organization is totally based on the energy supply. The potential energy known as stored energy, kinetic energy known as movement energy, capacitor energy also known as electro energy and energy of the resistor also known as electrical work, are the different forms of energy (Chen et al., 2019). According to the conservation law of energy, "energy of the universe remains constant". Therefore, energy can be transformed from one form into another but cannot be destroyed nor be created. Electrical energy is produced by the conversion of stored energy in natural sources such as water, fuels and radioactive elements. Nonconventional and conventional methods are employed to generate electricity with the help of prime movers such as turbines, pumps and engines. The discovery of automotive vehicle is one of the greatest inventions of modern time, it enables easy, comfort and personal speedy transport of peoples and goods (Song et al., 2020). At present, there are more than 1.2 billion vehicles on this planet and the future expected figure is about 2 billion till 2035. The vehicles that use IC engine drive technology, proved to be a revolution in the automobile industry. The first ICE was built by Nikolaus Otto in 1876. The IC engine vehicles rely on fossil fuels such as petroleum, diesel, CNG etc. Combustion of fossil fuels, take place inside the engine cylinder, generates the necessary power to drive the vehicle, simultaneously release several burning products and heat into the atmosphere. In current times, the essential focal point of the vehicle business is to foster more effective, more secure and eco-accommodating transportation framework. Elective vehicles like crossover electric vehicles (HEVs), module half and half electric vehicles (PHEVs) and Electric Vehicles (EVs) have been presented by current auto businesses. In future, elective electric vehicles would be a supportable move toward decarbonize the transportation framework to supplant the traditional vehicles. The idea of an electric vehicle is given by Gustave Trouvé in 1881. In 1900, absolute 4200 vehicles were sold around the world, out of which 38% were electric fueled autos. In the year the 1990s, General Motors sent off EV1, a practical electric vehicle in the serious market of the customary motor vehicle (Ren et al., 2018). An electric drive framework is used either to some extent or totally to give the essential footing force in EVs. Battery, ultracapacitors, power module and cross breed framework are utilized in EVs as an energy stockpiling medium instead of the gas tank of ordinary vehicles. Albeit, the vehicles using inexhaustible assets, for example,

sun powered PV innovation is considered as a manageable move toward decarbonize the street transportation area. The availability of area to directly integrate PV panel with an electric vehicle is the most crucial factor. To integrate PV technology with the vehicle, the three-wheeled electric vehicle is the appropriate solution. Lightweight, low cost and large available area are the additional advantages of the three-wheeled electric vehicle (Deng et al., 2017). The verification of traction torque and power needed to overcome all the resistive force is performed for the three-wheeled e-electric vehicle. Analysis of PV output power for different irradiation levels is carried out for the three-wheeled electric vehicle. Selection, designing, controlling, and analysis of electric propulsion system is carried out for the three-wheeled electric vehicle. Design and analysis of chassis are presented for a three wheeled electric vehicle.

## **II. Background of the Study**

Globally, Pollution is the major concerns associated with Internal Combustion Engine vehicles. Global warming, greenhouse gas emissions, depletion of the ozone layer are directly linked with the air, water and land pollutions exhausted by ICE vehicles. ICE vehicles use conventional resources of energy i.e. fossil fuel that is 'finite' and 'noninvertible' in nature. The low conversion efficiency of ICE vehicle demands more nonrenewable resources of energy and ejects more combustion products into the environment. The traditional assets of energy are the essential point of support for the endurance of people in the ongoing time. Coal, oil and gaseous petrol are the fundamental wellsprings of regular energy and all around the world 74% of the absolute populace's fuel utilization relies upon these sources (Hu et al., 2019). The ordinary energy sources are draining step by step at the same time the pace of multiplying is likewise high which has brought about a lopsidedness between the organic market for worldwide energy. Consequently, there is a shortage of ordinary assets to satisfy the current energy need and extra energy is expected to keep the current humanity improvement. Among the accessible sustainable assets of energy, sun oriented energy is thought of as one of the promising assets to meet the present and future energy interest. Sunlight based energy has the elite potential to create power through Photovoltaic (PV) boards innovation. The ability of power age from sun oriented PV innovation is flexible from milliwatt to gigawatt. Also, sun powered PV innovation has exemplary qualities like clean-climate and non-contaminating nature. Thus, an electric vehicle that uses electric drive framework would be a feasible move toward decarbonize the transportation area (Ren et al., 2018). Further, sun based PV innovation can likewise be utilized with electric vehicles either straightforwardly incorporating PV board with these vehicles or by implication through PV power station to re-energize these vehicles.

## **III. Proposed Method**

The edge of the three-wheeled "electric" vehicle is an essential component as it upholds inside as well as outside load. Chassis is the leading base of solar powered three-wheeler electric vehicle that supports the steering system, suspension system, drives system, braking system, battery system and loads of passengers. Performance of the chassis depends on the rigidity resistance during bending and torsion, load absorbing effectiveness and overall weight of chassis (Martins et al., 2020). In India, delta type suspension is normally utilized in the three-wheeled vehicles including both "auto-cart" and "electric cart" because of the upsides of less turning bend and back tires drive engineering as contrast with fledgling kind arrangement (Li et al., 2018). Delta type design has one front haggles back tires while fledgling kind setup having two front haggles back tire. Skeleton of the three-wheeler sunlight based controlled "electric" vehicle is an unconstrained design. Thus, the static investigation can't have any significant bearing straightforwardly to examinations the inside burdens and strain because of vertical and longitudinal stacking of three-wheeler vehicle structure since solidness lattice becomes particular because of the resolute body development of design (Ševo & Avramović, 2016). The design phase is consisting of the need for design, detailed specifications and collection of other relevant information followed by a feasibility study of the conceptual design. The second phase which is analysis phase includes stress calculation based on predefined boundary & loading conditions and if required based on all calculations the optimized model can be produced. These two phases come under the umbrella of CAD i.e. computer aided design. In the field of Computer Aided Design (CAD) modelling are the foundation of any project and most time-consuming process. It has been considered as the backbone of any of the CAE projects by the designing professionals and researchers. It is the process of elaborating computerizes models of the component before they will physically produce. The user can visualize their design and deal with problems before the resources invested to convert them into physical form. Double type monocoque chassis are extensively used in the existing three-wheeled "battery" vehicles (Zhang et al., 2019). Single type monocoque chassis is the modified version of double type chassis. Double and single type chassis is constructed in the Weldments module of

SolidWorks tool. Rectangular hollow cross-section profiles having dimensions 56x38x2 mm, 56x28x2 mm, and 30x30 mm are employed for modelling the frame structure. The selection criteria of the rectangular profile are based on higher torsional strength and bending moments over other profiles (Yi et al., 2021).

The response of an unsupported or unrestricted structure that is subjected to a constant or gradually fluctuating external force is analyzed through inertia relief analysis. Static analysis cannot be applied to the unconstrained structure such as automotive, air and naval vehicle body parts as the stiffness matrix becomes singular due to the inflexible body movement of the chassis (Pang et al., 2019). In the present work, Basic Approximation of Finite Element Inertia Relief Analysis technique is employed to solve the structure of three-wheeler electric vehicle shows in figure 1.

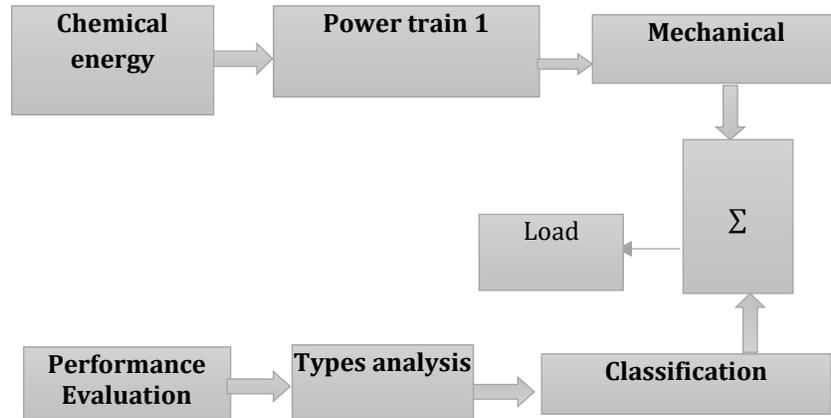


Figure 1: Proposed Framework

#### IV. Results and Discussion

The chart that shows the reasonable ecological method of the determined vehicle for different street circumstances concerning time is known driving cycle. Driving cycle is broadly utilized for displaying and reproduction to anticipate drive train execution prior to fostering the genuine model of vehicles. The Car Exploration Relationship of India, (ARAI), Pune gathered information in various urban communities to foster Indian Driving Cycle (IDC) and Changed Indian Driving Cycle (MIDC). As per Worldwide Place for Auto Innovation (ICAT), Manesar and Indian Driving Cycle (IDC) is utilized for a three-haggled wheeled electric vehicle having speed up to 70 km/h. Figure 2 and 3 shows the variety in speed and speed increase according to existing IDC as for time for various street circumstances.

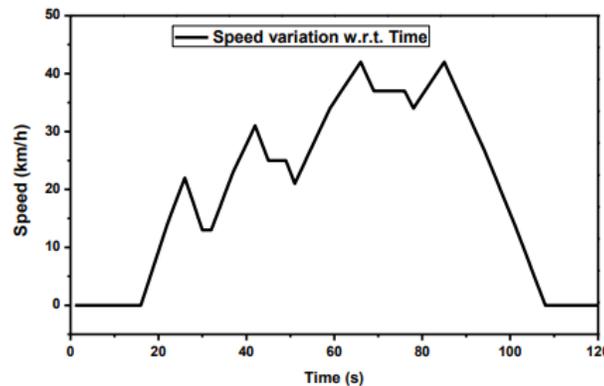


Figure 2: Speed Variation for Different Road Conditions as per IDC

Force and power necessity for three-wheeled e-vehicle in light of Pb-corrosive and Li-ion are processed utilizing MATLAB® apparatus according to existing IDC. To register these prerequisites, numerical conditions of LVD model is coded in the MATLAB programming climate. Demonstrating boundaries values are doled out to the coded conditions for Pb-corrosive and Li-Particle battery framework. From there on, reproductions are performed as per IDC.

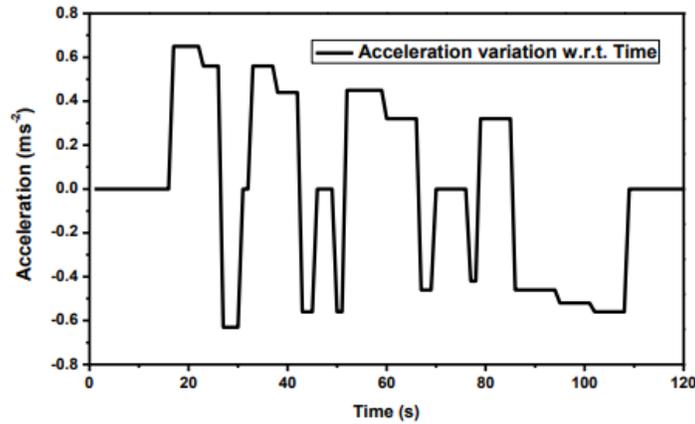


Figure 3: Acceleration Variation for Different Road Conditions as per IDC

Figure 4 shows the wheel torque required based on Pb-acid and Li-ion based three-wheeled e-vehicle for selected IDC. Rating of BLDC motor is done on the basis of RMS value of torque and power as winding losses in BLDC motor are directly linked with RMS value of torque and power. Therefore, the RMS value of torque and power are computed for the rating of the BLDC motor of three-wheeled e-vehicle.

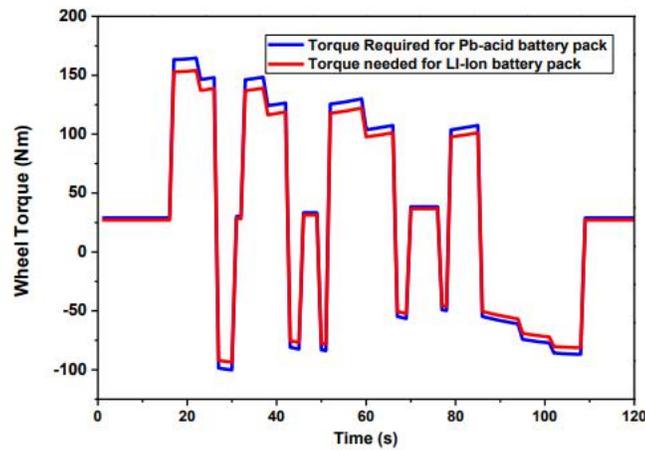


Figure 4: Torque Requirement for Three-Wheeler e-vehicle as per Existing IDC

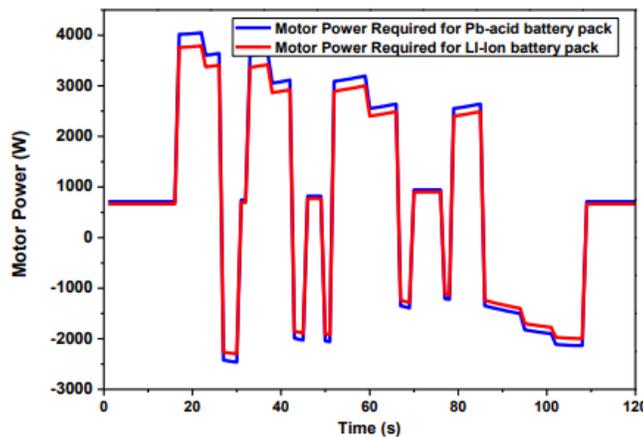


Figure 5: Motor Power Requirement for e-vehicle as per Existing IDC

Figure 5 shows the greatest or top force and power prerequisite from the e-drive framework for Pbacid battery-based framework are 90 Nm and 4.05 kW separately. While for Li-Particle battery-based framework, these necessities are 84 Nm and 3.912 kW. Extra force and power for the Pb-corrosive battery-based framework when contrasted with the Li-Particle battery pack is because of the extra weight of Pb-corrosive batteries. Above estimations are made for the immediate drive transmission framework. Rating of BLDC engine is finished based on Root Mean Square (RMS) worth of force and power as twisting misfortunes in brushless DC engine are straightforwardly connected with RMS worth of force and influence. Thusly, the RMS worth of force and power are processed for the rating of the brushless DC engine of three-wheeled e-vehicle.

## V. Conclusions

CAD models of the existing and modified chassis are prepared in the SolidWorks® software for three-wheeled "electric" vehicle. Further, inertial relief approach-based FEM examination is acted in ANSYS® apparatus to figure force response, second response, identical burdens, inertial alleviation translational and rotational speed increases for existing and adjusted case. The outcome shows that the strength of the adjusted case is more when contrasted with existing body in view of von mises' burdens created under a similar applied stacking. The processed outcome means that the wellbeing factor for the altered frame is 1.84 when contrasted with the security element of 1.66 for existing suspension. The outcomes confirm that the upsides of the power response for the current and changed case are roughly zero under the vertical and longitudinal loadings. Inertial alleviation translational and rotational speed increase adjusted the remotely applied load in the relating heading. At last, the outcome shows that the computer aided design model of altered case for three-wheeled "electric" vehicle has more strength, lightweight and simple to create contrasted with existing frame plan.

## References

- [1] Chen, X., Zhang, Q., Han, J., Han, X., Liu, Y., & Fang, Y. (2019, December). Object detection of optical remote sensing image based on improved faster RCNN. In *2019 IEEE 5th international conference on computer and communications (ICCC)* (pp. 1787-1791). IEEE. <https://doi.org/10.1109/ICCC47050.2019.9064409>
- [2] Song, G., Wang, Z., Bai, L., Zhang, J., & Chen, L. (2020, September). Detection of oil wells based on faster R-CNN in optical satellite remote sensing images. In *Image and Signal Processing for Remote Sensing XXVI* (Vol. 11533, pp. 114-121). SPIE. <https://doi.org/10.1117/12.2572996>
- [3] Ren, Y., Zhu, C., & Xiao, S. (2018). Deformable faster r-cnn with aggregating multi-layer features for partially occluded object detection in optical remote sensing images. *Remote Sensing*, *10*(9), 1470. <https://doi.org/10.3390/rs10091470>
- [4] Deng, Z., Sun, H., Zhou, S., Zhao, J., Lei, L., & Zou, H. (2017, July). Fast multiclass object detection in optical remote sensing images using region based convolutional neural networks. In *2017 IEEE International Geoscience and Remote Sensing Symposium (IGARSS)* (pp. 858-861). IEEE. <https://doi.org/10.1109/IGARSS.2017.8127088>
- [5] Hu, Y., Li, X., Zhou, N., Yang, L., Peng, L., & Xiao, S. (2019). A sample update-based convolutional neural network framework for object detection in large-area remote sensing images. *IEEE Geoscience and Remote Sensing Letters*, *16*(6), 947-951. <https://doi.org/10.1109/LGRS.2018.2889247>
- [6] Martins, V. S., Kaleita, A. L., Gelder, B. K., da Silveira, H. L., & Abe, C. A. (2020). Exploring multiscale object-based convolutional neural network (multi-OCNN) for remote sensing image classification at high spatial resolution. *ISPRS Journal of Photogrammetry and Remote Sensing*, *168*, 56-73. <https://doi.org/10.1016/j.isprsjprs.2020.08.004>
- [7] Li, Q., Mou, L., Jiang, K., Liu, Q., Wang, Y., & Zhu, X. X. (2018, July). Hierarchical region based convolution neural network for multiscale object detection in remote sensing images. In *IGARSS 2018-2018 IEEE International Geoscience and Remote Sensing Symposium* (pp. 4355-4358). IEEE. <https://doi.org/10.1109/IGARSS.2018.8518345>
- [8] Ševo, I., & Avramović, A. (2016). Convolutional neural network based automatic object detection on aerial images. *IEEE geoscience and remote sensing letters*, *13*(5), 740-744. <https://doi.org/10.1109/LGRS.2016.2542358>
- [9] Yi, D., Su, J., & Chen, W. H. (2021). Probabilistic faster R-CNN with stochastic region proposing: Towards object detection and recognition in remote sensing imagery. *Neurocomputing*, *459*, 290-301. <https://doi.org/10.1016/j.neucom.2021.06.072>

- [10] Pang, J., Li, C., Shi, J., Xu, Z., & Feng, H. (2019).  $\mathcal{R}^2$ -CNN: fast Tiny object detection in large-scale remote sensing images. *IEEE Transactions on Geoscience and Remote Sensing*, 57(8), 5512-5524. <https://doi.org/10.1109/TGRS.2019.2899955>
- [11] Zhang, C., Wei, S., Ji, S., & Lu, M. (2019). Detecting large-scale urban land cover changes from very high resolution remote sensing images using CNN-based classification. *ISPRS International Journal of Geo-Information*, 8(4), 189. <https://doi.org/10.3390/ijgi8040189>
- [12] Ren, Y., Zhu, C., & Xiao, S. (2018). Small object detection in optical remote sensing images via modified faster R-CNN. *Applied Sciences*, 8(5), 813. <https://doi.org/10.3390/app8050813>