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

Electric Vehicle Powered by Solar Energy

[1]Prof.Shivanand Konade, [2]Mr.Sarvadnya Satish Nimbalkar
[1]Assistant Professor, Electrical Engineering Department, Smt. Indira Gandhi College of Engineering. [2]Research Scholar student, University 0f Mumbai.

Abstract
The project's main goal is to design and build an electric car that runs on solar power. So far, the project's goal has been to create a comprehensive first iteration design including planning documents. The car must follow the engineering specifications specified for the Shell Eco Urban Division Marathon competition. Although it is not necessary to employ a solar panel for the competition, this idea will use solar energy to charge the vehicle's battery. Since efficiency is the foundation of this competition, energy efficiency will be given top importance. The project's schedule and financial restrictions were also significant. Subsystems including the structure, drivetrain, power, suspension, and steering were individually designed and combined into a master system in order to achieve this goal.

Keywords: Vehicle Subsystem, Shell Eco-Marathon, CAD, Design, Engineering, Electric Vehicle, FEA, Solar, Solar Energy

I. INTRODUCTION

The need for renewable energy sources is currently one of the biggest engineering problems. For the production of power, a large portion of the world is heavily dependent on coal and natural gas. Despite being a plentiful power source, research indicates that it contributes to global warming. Additionally, extraction It has been demonstrated that practices like fracking have a negative impact on the environment, specifically on earthquakes. Solar energy is one energy source that is being researched extensively. Until recently, solar energy collection via solar panels was not a practical way to replace energy from fossil fuels due to the low efficiency of these panels. Thanks to developments in materials science, solar energy is now a renewable resource that is gradually supplying the world's energy needs. Transportation was responsible for 26% of all greenhouse gas emissions in 2014, according to the EPA [1]. The idea of a solar-powered car will be created and manufactured for this project. Since vehicles have already been altered to run on alternate fuels, in order to this In order to meet the requirements for the Shell Eco-marathon Urban Concept Battery Electric competition, a project, an urban application solar car, will be built. The main goal of the project is to create an electric car with solar energy technology for power regeneration. The need for gasoline would significantly decline if this kind of vehicle were to become the norm for commercial use. Making this car as practical as possible is the main challenge. In order to limit the size of the motor needed to meet urban transportation needs, the vehicle must be lightweight. Although the car is only intended to carry one driver, more room would really be needed for supplies and additional passengers. A solar panel's ability to provide enough power for propulsion in an acceptable length of time is another factor to take into account when using solar energy to power a car. This results in a number of For the project, both mechanical and electrical engineering concerns are necessary. The components must to be appropriate for the Shell Eco-marathon's urban idea section. We'll buy components and have them made from raw materials that match the application. The vehicle's unusual size means that some parts must be machined to specifications. Based on available funds and the viability of manufacture, decisions will be taken.

II.Structure/System

Approach To accomplish the goals of any design project, a variety of software programs and research will need to be used. All of the modeling, drawing, and assembly work will be done in SolidWorks. the lements. Journals and websites will be used in the research on electrical components for performance and purchase. The right motor size and other relevant safety factor analyses were determined by a parametric analysis using Microsoft Excel and the Engineering Equation Solver (EES). Vsusp, an online program, was used to calculate the suspension and steering settings. Any vehicle's fundamental structure is known as the chassis. All other parts are connected to it as it is the primary component. In addition to providing structural integrity, this fundamental component of the car will shield the Understanding every rule pertaining to the chassis in the competition was the first step in designing the chassis. Basic regulations pertaining to the chassis allow for some design freedom. Nevertheless, additional limitations were imposed during the manufacturing process, which was carried out by a nearby welding business. To allow for the welding processes, for instance, the business asked that a tiny space be provided between each connecting element. As a result, after identifying every restriction, we had to choose our chassis type. Our choice was to use a spaceframe chassis. This kind of chassis is made up of a larger frame that is derived from a configuration of small, basic elements (Fig. 1).

Figure 1. Example of Spaceframe.

Figure 2. Go Kart with Chassis Designed to be Flexible.

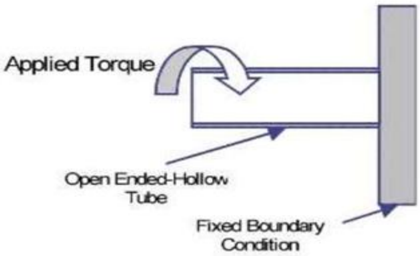
A truss construction, which is made up of several tiny members arranged in a triangle and either under tension or compression, is very similar to a spaceframe chassis. Naturally, this is in a perfect scenario. This feature guarantees that there are no minimal bending moments in the members, enabling Small cross-section members are to be used in the design of the frame [3]. The car's efficiency would rise as a result of the lighter structure. As per Newton's Second Law,

Force= Mass * Acceleration

In all circumstances, a lighter solar car will accelerate more quickly when given an equal force. The solar car will accelerate more quickly, increase its speed, and contribute to meeting the Shell Eco-marathon's performance requirements. Furthermore, the spaceframe is less expensive than other kinds of chassis. very simple to construct and alter. It was time to choose the material to employ, keeping this kind of frame in mind. The choice was made to use Aluminum 6061 as the previous team had purchased it as a raw material. It was a wise decision to use aluminum 6061 since it offered a lightweight structure that was sturdy enough to handle several driving loads. Understanding various loads that an automobile may encounter is essential for designing an automotive chassis.

• Longitudinal Torsion • Vertical Bending • Lateral Bending • Lozenging Horizontal

See Appendix C for a comprehensive discussion of the loads mentioned above. A car's behavior will be directly impacted by various loads acting on it; so, if the vehicle is not stiff enough, it will have an impact on direction control in addition to the passenger comfort and safety. When a vehicle is less stiff, it will respond to the driver's movements less strongly. Stated otherwise, it will pose a challenge to ascertain the vehicle's compliance with traffic laws. Still, there are situations in which not enough rigidity is advantageous. Go Karts are an exception since their frames must function as suspension systems because they lack suspension (Fig. 2). Therefore, understanding the rigidity of the chassis—more especially, its torsional rigidity—is crucial. When a car The spaceframe's modeling was mostly finished by trial and error with the goal of moving rapidly through the design and utilizing the materials already acquired by the previous senior design team. The decisions made by the team were based on a number of designs that were evaluated in light of various variables. Finite element analysis (FEA) was used to examine the car's torsional rigidity in order to make sure the final design was ideal. The SolidWorks finite element package was the program utilized for this investigation. A square tube with one extremity fixed and the other receiving a torque applied in respect to the longitudinal axis serves as the theoretical model for studying longitudinal torsion (Fig. 3) [6].



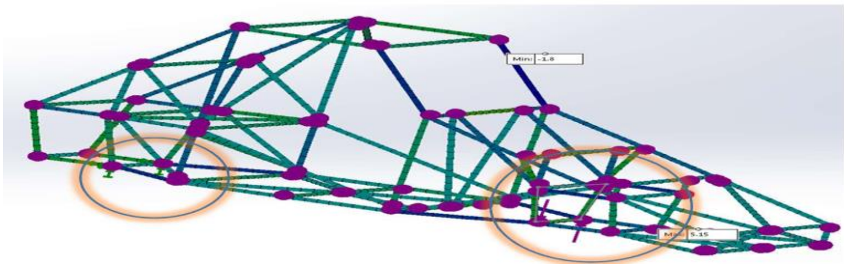


Figure 3. Theory Model to Exemplify Torsional Rigidity Parameter [6]. Figure 4. Theory Model Applied to the Solar Car Chassis.
Torsional rigidity can be evaluated by dividing the torque applied on the chassis by the angular deflection. The mathematical representation is as follows:

$$K_t = \frac{T}{\theta}$$

Where, • Kt - Torsional rigidity • T - Applied torque • θ - Angular deflection

The following recommendations were followed when performing the finite element technique simulation: • The model was limited by applying a geometry fixture on the rear suspension In every node, a force of 1000N was exerted in the opposite direction along the vertical plane. of the suspension up front. The frame becomes twisted as a result. When constructing the frame, torsional stiffness was simply one of the many considerations. A requirement of the Shell Eco-marathon is that the vehicle can sustain a force of 700N applied to the roll bar in all three directions. The roll bar can be understood as a beam with both ends fixed and a vertical force applied (Fig. 5), to help illustrate this.

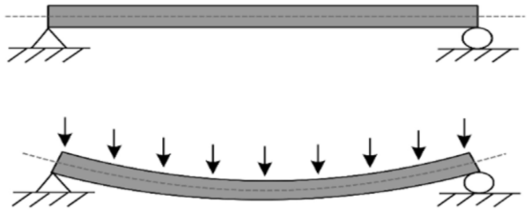


Figure 5. Roll Bar Simplified Model.

The roll bar analysis was performed using the same software used for torsional rigidity. The FEA static simulation was performed in accordance with the following guidelines: • Both the rear and front suspension were fully fixed • A 700N force was applied to the roll bar in all three directions (one in each simulation)

III. Fabrication of Frame

The group was in charge of the frame's manufacturing process in addition to its design. In cooperation with Chicago Heights, Illinois-based Arrow Pin and Product Inc., the team worked. The group learned via doing manual labor and experiencing new things during this process. Drafting possibilities. To build the frame, the team adhered to a certain procedure (Fig. 6).

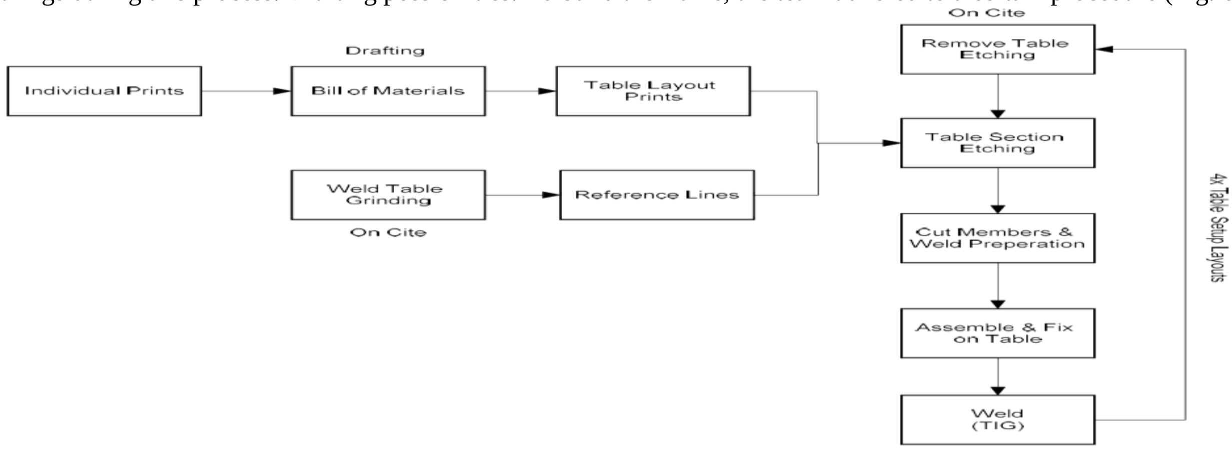


Figure 6. Frame Fabrication Process.

The fabrication process started as soon as the frame was created and refined to pass the structural analysis test, correlated to the Shell Eco-marathon regulations, and satisfied the feasibility requirements. Appendix D, the Bill of Materials (BOM), was produced. Every single frame component had a label attached to it. part number, quantity, and member length in inches that have been designated. The individual frame member designs were enhanced by this information (Fig. 7). This was also used to check if the prior design's material purchases were sufficient. It was calculated that, after manufacture, there would be around 27 feet of raw material left. SolidWorks was used to construct the drafting materials. Planar pieces were taken out of the main frame model in order to build the necessary models. Here are a few examples of planar sections: Individual Trapezoid Planar Surfaces, Bottom Section Planar Surfaces, Side Planar Surfaces, and Back Planar Surface. To arrange the pieces to utilize the entire platform, assembly files were made. In order to construct as many flat sections as feasible against the welding platform, different table configurations were made. As a result, the time needed for frame production would be reduced significantly. This method of building the entire frame made it possible for the frame construction to resemble the modeled frame as closely as possible. Given that this procedure could result in minute differences in the finished welding when the portions Table setup drawings were made for the weld shop using the assembly files (Appendix E). It was crucial to make the drawings clean and precise because the weld shop lacks 3D modeling tools. The table setup drawings contain details like dimensions, notes, and part numbers. Four distinct table configurations were present. The planar sections were formed in the first three setups, all of which were done against the table; the fourth setup involved merging all of the created sections and adding the cross members. Rust and top level were removed in order to establish a level surface as the first phase in the table preparation process. The crew used the table setup drawings to etch the locations of the members after establishing the reference and center lines. 1" square aluminum tubing was used as the raw material, and it was cut to size using the BOM and individual member drawings. Following that, the members were placed on the table and TIG welded together. The surface of the areas that were to be welded was wiped clean to get rid of any oxidation before welding. In order to ensure the section was straight, the joints had to be welded, allowed to cool, and then inspected. The four table configuration drawings were followed during the welding operation. After portions were completed, they were kept in the fourth table setup drawings until they were required. In the fourth table configuration, sections were fused together (Fig. 8). After that, the frame was returned to Purdue University Northwest and kept in the Anderson 164. After being acquired or manufactured, systems including the powertrain, suspension, and steering will be installed one after the other on the frame.

Figure 7. Individual Drawing Example.

Figure 8. Etching Section in Table Setup #1.

Powertrain

The system that transfers power from the motor to the wheels will define the vehicle's powertrain. For the application, a "V" belt drive system was selected because of its durability and efficiency of transmission. A belt drive system will respect the frame's specified spatial limitations and is also reasonably priced. Parts for the powertrain were methodically chosen using a methodology (Fig. 9).

Figure 9. Overall Powertrain Process.

To confirm each component's functionality and safety, calculations are needed. The belt, shaft, and bearings are the specific parts that need to be calculated. The intended performance, motor characteristics, and frame spatial limitations were used as calculation inputs. (Figure 10). The factor of safety and component sizing were ascertained by a variety of analytical techniques.

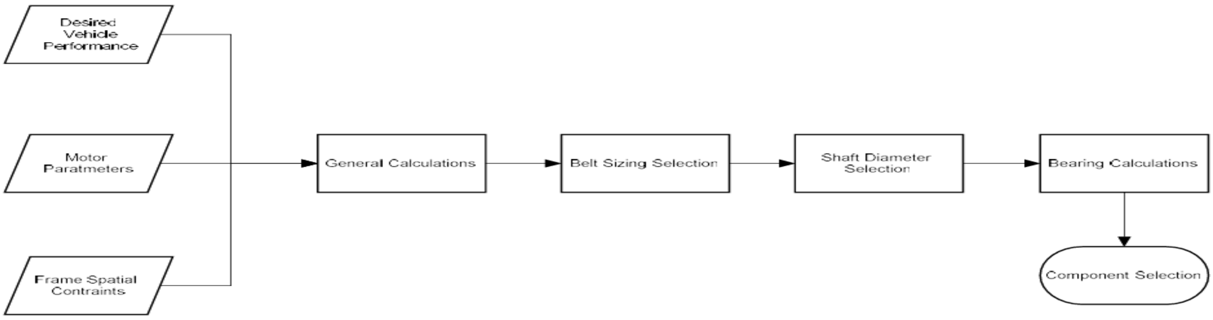


Figure 10. Powertrain Calculations Process.

The gear ratio needed for the vehicle's performance was calculated generally. The tire's radius (r) and the equation for calculating the arc length of a circle (=) can be used to determine the arc length (s) the tire will go through in one revolution. The greatest distance traveled per unit time (velocity) is obtained by multiplying the distance traveled each revolution by the maximum RPMs of the motor, then dividing the result by two. The gear ratio was changed to change the vehicle's top speed since, in the absence of gear reduction, it may travel faster than 100 mph, which is dangerous. It was found that a minimum gear ratio of 2.4 would enable the vehicle to reach its maximum speed. Belt speed, application, and horsepower all affect belt sizing. There is no steady state running speed for vehicle operation. The driver will set the speed, which will change over time. For this application, a V belt was selected due to its affordability and ease of use. Along with the parameters are established, a suitable "V" belt for the application can be chosen. When using a powertrain, information on the "V" belt needs to be confirmed. These parameters consist of the minimum pulley sheave diameter and the initial tension. Research and design were used to change these factors. Finding the right size for the main shaft was the next task. The forces operating on the shaft must be identified before the shaft size can be calculated. Next, the modified Goodman Theory criterion was used. Parts were selected using the McMaster-Carr website. Owing to time constraints, parts that didn't require additional machining were bought. The final SolidWorks model and a purchase list were updated with the selected components (Fig. 11). When the engine component arrived, the powertrain components were assembled, and a test stand for the drivetrain was built.

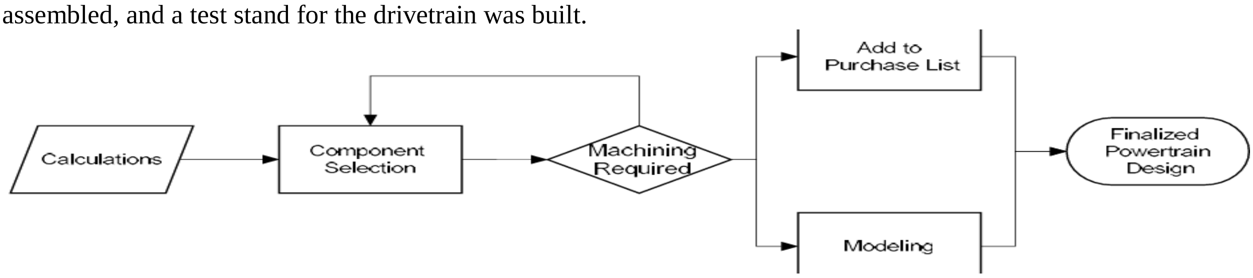


Figure 11. Powertrain Component Selection & Inclusion Process.

Solar Panel

In today's world, a variety of energy sources are viable possibilities for utilization. Despite the fact that burning coal, using gas, and oil are the primary sources of energy, people are looking for alternate sources of energy because gas and oil are so inconvenient. Non renewable energy sources and have a detrimental impact on the ecosystem. These alternative energy sources include solar, wind, hydropower, tidal wave, and biofuel. Each of these alternative energy sources has pros and cons of its own, and there are limitations on how feasible it is. For instance, using wind turbines in large, open spaces with regular wind gusts makes more sense than attempting to locate them in crowded towns. Adding to When French physicist Edmund Bequerel found that some materials will generate an electric current when exposed to sunshine in 1839, it was the first time that solar energy was recognized. Albert Einstein then received a Nobel Prize following his collaboration with solar energy technologies in 1905. Bell Laboratories created the first photovoltaic module in 1954, but because to a lack of knowledge about its potential, it was never widely used. In the 1960s, solar energy was employed to power a spacecraft, increasing its dependability and practicality for use. Eventually, during the energy crisis of the 1970s, solar energy was made suitable for commercial use [7]. So what is the true mechanism of photovoltaic, or solar, cells? For solar cells, a thin wafer made of semiconductors The solar panel will be mounted on the car's bonnet and face direct sunshine. Its size is 1,440 square inches, or around 1 square meter. Professor David Kozel of Purdue University Northwest gave this solar panel to the Solar Car Vehicle team, and the Department of Electrical Engineering. A series of tests and experiments were conducted to ascertain the solar module's capabilities in order to ascertain the functioning and efficiency of the solar panel. The current can be monitored because the panel has a positive and a negative electrical wire connected to its back. Data can be gathered with a solar analyzer and its companion software to construct the voltage and current curves.

Options for Choosing Batteries

The battery is one of the most crucial parts in the conception and construction of the solar vehicle. For the vehicle to run and be propelled, the battery needs to be able to charged by the solar panel. The driver of the vehicle must feel safe operating this setup. When selecting a battery, keep these three things in mind. These requirements are met by two battery types: deep cycle lead acid and lithium ion. The choice of battery type was determined by taking into account these variables, but the most crucial consideration was whether the battery would work with the car's chosen motor. The ultimate choice regarding the battery was determined by means of

Lead Acid in Deep Cycle

Lead acid batteries were the first kind of battery that was taken into consideration. A solar-powered electric vehicle can be powered by specific types of lead acid batteries, but not just any Any kind of lead acid battery could work. For instance, this idea would not be able to use the battery that most gasoline-powered cars use to start their engines. Only one brief energy burst may be produced by starter batteries, which are then replenished by the alternator while the vehicle is moving. Deep cycle batteries are the kind that must be utilized in any electric car. Deep cycle batteries are designed specifically to deliver reliable power.

Sealed and flooded batteries are the two varieties of deep cycle lead acid batteries that are suitable for use in electric cars. To preserve longevity and efficiency, flooded batteries require routine maintenance. To maintain the system, fill each individual cell of the purified water is added to the battery to maintain the ideal specific gravity, which is determined using a hydrometer. The casing needs to be removed, and this needs to be done around once a month in order to maintain the battery functioning effectively [8]. This is not required with a sealed battery because, as the name implies, the battery is sealed forever. When thinking about a flooded battery, a safety issue occurs because, even with the best of intentions, exposed acid can still cause harm.

Lithium Ion

Lithium ion batteries were the second kind of battery that was taken into consideration for this project. Electric vehicles that run on solar power are best suited for lithium-ion batteries. If finances were not a barrier, Lithium ion batteries would be the choice. Because lithium has the highest specific energy and electrochemical potential of any metal, pound for pound, most lithium batteries, regardless of the cathode material, can be cycled well over a thousand times. The chemistry of many lithium ion batteries was created expressly to be charged by sun panels; all that's needed is a basic controller. The solar panel being used is the only factor influencing the rate of charge. The incredibly little maintenance required by lithium ion batteries is another benefit of using them. Selecting the sort of Lithium ion battery to be utilized was the first step in analyzing Lithium ion because there are numerous varieties. There are six main kinds of lithium ion batteries that are often used: Nickel Cobalt Manganese (NCA), Nickel Cobalt Oxide (LCO), and Nickel Cobalt Aluminum Oxide (NCA) Iron phosphate (LFP), titanate (LTO), manganese oxide (LMO), and oxide (NCM). The active components, or cathodes, that give lithium ion batteries their distinct qualities are the source of the battery's name. These various cathode materials each provide unique benefits to the battery. For instance, cobalt oxide has poor thermal stability but iron phosphate provides the battery with great thermal stability. The first step involved removing any lithium ion battery types that are inappropriate for use in electric vehicles. Oxide of Lithium Cobalt

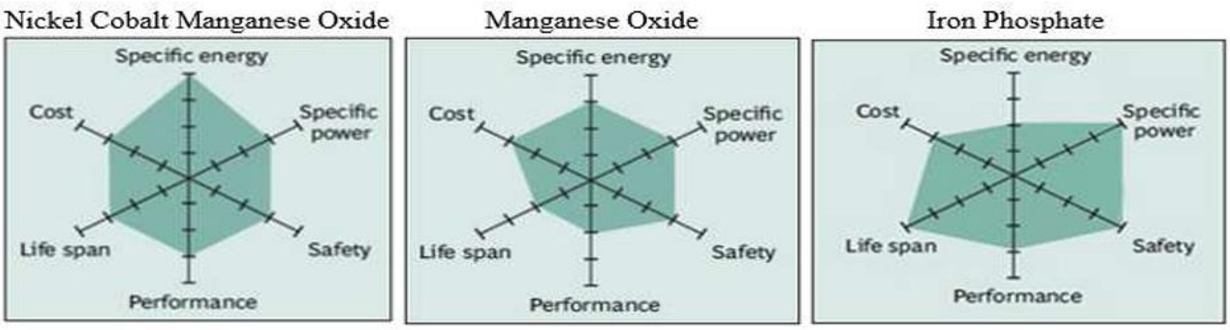


Figure 12. Lithium Ion Battery Type Comparison.

Examining the several battery types revealed that their prices and performances were comparable, thus life expectancy and safety were prioritized instead. The Iron Phosphate battery was identified as superior, which makes sense given that it was initially created in an attempt to swap out your lead acid batteries. Since it was intended to be used at high temperatures, it is by far the safest choice. voltages for an extended period of time; under these circumstances, other batteries would fail [10]. The battery has about 2000 cycles of use if it is used and stored correctly. Compared to Nickel Cobalt Manganese Oxide and Manganese Oxide, this is significantly greater. Apart from the benefits associated with longevity and safety, iron phosphate also

Motor Selection and Sizing

The Shell Eco-marathon competition is focused on efficiency, thus it's essential to size the motor right. If the motor is sized too large or too small, there can be significant decreases in efficiency and could result in a shorter lifespan and more expensive maintenance. Typically, electric motors are made to operate at between 50% and 100% of their rated full load. Motor efficiency drops sharply when they are operated at less than 50% of their rated load or when they are overloaded (Fig. 13).

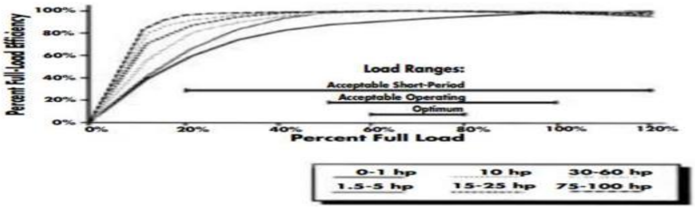


Figure 13. Motor Part-Load Efficiency (as a Function of % Full-Load Efficiency) [11].

Additionally, motors often achieve maximum efficiency when run around 75% of full load [11]. For these reasons, choosing a motor that will provide the proper power output is necessary for an efficient vehicle. Mechanical power can be calculated using the motor toque and the revolutions per minute (RPM) of the output shaft.

$Power\ (hp) = Torque\ (ft - lbs)\ x\ RPM/5252$ A parametric scenario study can be used to evaluate the power required from the motor in order to establish the appropriate size motor for the solar car competition application. The car can be analyzed by approaching it like a free body diagram (Fig. 14). Every single The total external force acting on the vehicle can be calculated by adding together the external forces that are now acting on it. The motor's power output that is required to offset the external forces can then be measured. One may compute each of the separate forces from the free body diagram.

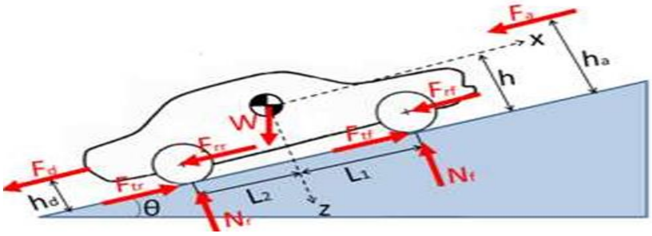
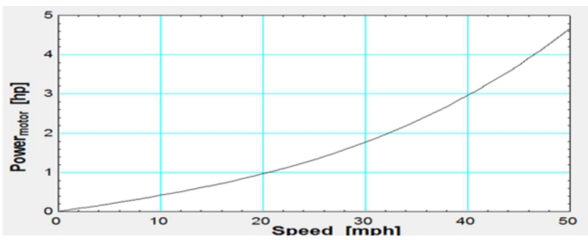


Figure 14. Vehicle Free Body Diagram [12].

The following are the forces influencing the car:

• Rolling Resistance: This force is brought on by tire deformation. The rubber tire will bulge as a result of the tires' deformation. A moment is produced in the deformation by the tire rotation's opposite direction. This makes it more difficult for the tire to roll. The vehicle's weight, the state of the road, and the inclination angle all affect this resistance. The standard rolling resistance coefficient of 0.018 was applied for analytical purposes [13]. The normal force applied on the tires decreases with increasing angle of inclination. There is less deformation in the tires the lower the typical force operating on them. • Resistance to Climbing: This force results from Acceleration Resistance: To put it simply, Newton's Second Law applies to this resistance. Since a force is needed to accelerate a mass, the vehicle is experiencing an external force while it accelerates. The resistance to acceleration is determined by the inertial coefficient, acceleration, and the vehicle's weight. The mass and number of rotating components determine the inertial coefficient. Since there won't be many moving components in the electric vehicle's drive system, an estimated inertial coefficient of 1.06 can be used [13].The car is traveling through the air due to the aerodynamic drag force. Since air is a gas, it has certain characteristics. On the back of the car, low pressure air pockets are formed as air travels over it. The result of this is the aerodynamic drag force phenomena. The air density, frontal area, velocity, and drag coefficient all affect aerodynamic drag force. The analysis will take into account the air density under standard atmospheric circumstances, and the vehicle's frontal area will be regarded as the maximum frontal area as specified by the Shell Eco-Marathon regulations [14]. It is possible to reduce the coefficient of drag when designing the vehicle's body. It is presumed for analytical purposes that this vehicle Note that max extremes were used in the calculations for quantities that have not yet been determined, like vehicle weight, frontal area, inertial coefficient, etc. This means that the frontal area utilized in the computations was the maximum frontal area provided by the Shell Eco Marathon rules. This will cause a slight overcompensation for the different forces operating on the car, but the computed motor horsepower will be sufficient to carry out all of the stated functions. The motor torque was also computed after accounting for all external factors and determining the moment needed from the tire. It was also possible to determine the engine rpm because the tire rpm is known. Based on these values and the presumptions required for the mechanical effectiveness of the For every example, utilization made parametric analysis possible. When changing just one parameter in a parametric analysis, EES is quite helpful. It is possible to generate code that does the computations needed for analysis, complete with restrictions, presumptions, and equations. The user can create parametric tables and visualizations of the required parameters using EES. The vehicle's force, torque, and speed can all be computed for a variety of situations. One possible method to determine the motor's size capabilities is through parametric analysis. The following were the several cases that were taken into consideration: • Case 1. Level ground with no acceleration (Fig. 15) (Steady State) • Case 2. Level ground and acceleration of 2 mph/s • Case 3. Incline of 5 degrees with no acceleration • Case 4. Incline of 5 degrees with 2mph/s acceleration From the analysis, motor sizing was determined based on the required functionality for the vehicle provided by the Shell Eco-marathon rules and track. The steady state for the application can be considered as flat ground with no acceleration (Fig. 15). Plots for all other cases can be viewed in Appendix F



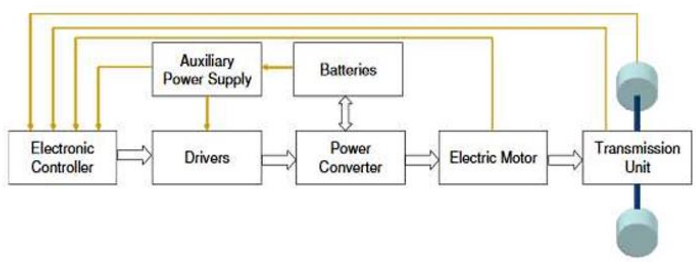
.

Figure 15. Power vs. Speed (Level Ground with no Acceleration).

It was discovered that a 2-horsepower motor would be ideal for the application using this kind of analysis. The car will be able to fulfill the Shell Eco-marathon's performance requirements. Choosing the type of motor to use for the solar car comes after calculating the amount of power needed. has to be done. The motor or motors to be utilized on this vehicle were the subject of three different choices. Brushless direct current (BLDC), alternating current induction (AC), and brushed direct current (DC) motors were the options. It was necessary to decide whether to utilize one or two motors in addition to the type of motor. The consequent consequences on the drive train system had to be taken into account in order to make this conclusion. Utilizing a single motor would Permanent magnet DC (PMDC) motors were the main consideration while thinking about brushed DC motors. Because permanent magnets rather than windings are used in the field section of PMDC motors, they are distinct from other kinds of DC motors. This construction's drawback is that the field magnets can diminish in magnetism with time, which reduces the amount of torque produced. PMDC motors are frequently used in applications that demand quick response times. Because it doesn't require a field supply, this kind of motor requires less energy to run than conventional DC motors and can deliver up to 300 percent of its maximum torque for brief periods of time. DC motors not only create torque that is greater than rated, but they also maintain torque throughout a wide range of speeds [15]. prompt reaction Alternating current is used by AC motors, as the name implies. The magnetic field's strength varies in proportion to the current due to this alternating current. An AC motor consists of two primary components: the rotor and the stator. The stator, which consists of several electromagnets, is immobile. put in a way to create a hollow cylinder. As a result, the motor's rotating component, the rotor, is fixed to the shaft. Magnetic induction is the means by which AC induction motors rotate [16]. The rotor rotates when current is supplied to the stator because it modifies the magnetic field. Because induction generates rotation, the motor is simple and long-lasting without the need for brushes or a commutator. Consequently, Without a brush DC motors are rotated without the use of brushes or a commutator, much like AC induction motors. Nevertheless, instead of using alternating current, they are powered by direct current that is managed by a step controller. In the construction industry, BLDC motors and AC motors are similar, but maintain a number of PMDC features, such as a linear speed/torque relationship and high beginning torque, while providing increased efficiency in the absence of brushes and a commutator [13]. Once more, the commutator and carbon brushless design offer greater dependability and increased efficiency with over 10,000 hours of life expectancy. In addition, compared to a traditional brushed motor, they run quieter and with less electromagnetic interference. Although BLDC motors have the same uses as brushed DC motors, they are more frequently utilized in electric vehicles and model airplanes due to their.

Logic of Control

Any electric vehicle has roughly the same control logic when seen from a macroscopic standpoint. There are numerous varieties of motors and control methods for them; the various An electric vehicle's parts are combined into a single system (Fig. 16). The Electronic Controller feeds data to the Drivers, who then feed data to the Power Converter, as shown by the forward path (white arrows). Information is sent from the Power Converter to the battery and the electric motor, and the electric motor then sends information to the wheel-turning mechanism, the Transmission Unit. Information travels over the reverse way (yellow lines) from the batteries to the power supply, which then connects to the driver and the electronic controller. The Electronic Controller receives information directly from the Wheels, Transmission Unit, and Electric Motor. The wheels communicate with the Electronic Controller through an instrument (often a tachometer) to transmit information, allowing the RPMs of the wheels to be changed in accordance with the driver's intended output based on data obtained via a The system needs to use Space Vector Pulse Width Modulation (SVPM), which requires a very complicated mathematical framework and would make controller programming extremely challenging, in order to operate properly with an alternating current. Furthermore, the system needs Several additional parts are needed for the circuit to operate properly. A system with a brushless DC (BLDC) motor is significantly easier to operate. Brushless DC motors still operate on the induction principle; they are not truly DC motors. To generate a rotating magnetic field, they feed pulsed DC into the stator windings. Even while the motor still employs electronic commutators, which makes programming challenging, it is still far less complicated than an AC motor. For discussion's sake, the control The electronic commutation between the three pairs of stator coils and the three-phase supply are produced by a six-step inverter (Fig. 18). Only two of the six inverter switches are conducting at any given time because only two of the three pole pairs are electrified at any given moment. moment. The pulse frequency regulates the rotational speed, whereas the pulse current controls the torque. A signal (from the microcontroller) that indicates the rotor's instantaneous angular location causes the inverter current pulses. A pulse width modulated controller (PWM), which supplies a changeable DC voltage to the inverter, is used for power management. In order to operate at a changing speed, the pulsed DC supply voltage



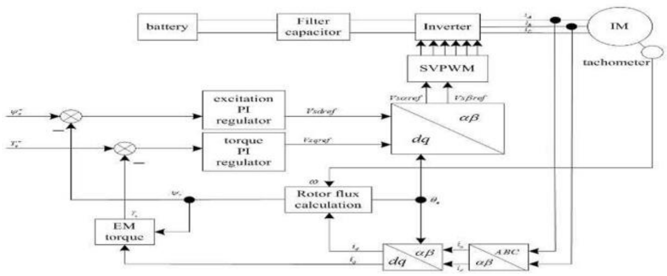


Figure 16. Major Components of an Electric Vehicle [18]. Figure 17. Control Scheme of an EV Vehicle Driven by an Induction Motor with Vector Control [18].

To achieve the intended reverse electro-magnetic force (EMF), the overlap of the phase current at different angles needs to be precisely scheduled for the programming of the variable current steps as a function of the rotor electrical angle. After a motor has been chosen, this idea was investigated in further information, and executed in accordance with the unique features of the motor.

Although some steps can be skipped based on user requirements, the following design (Fig. 19) served as a valuable foundation for regulating the logic flow of the controller.

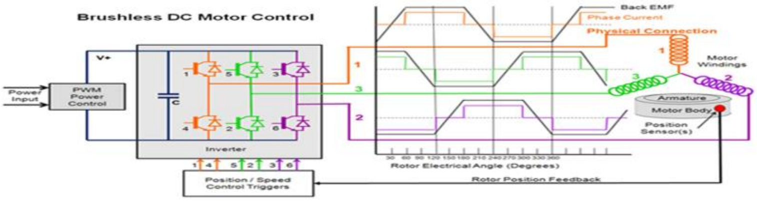


Figure 18. Controlling Voltage and Speed [19].

Conclusion

The first iteration of the solar car design is finished. This was achieved by separately creating each subsystem and then combining them into the overall design. The following are the components of these subsystems: • Frame: The vehicle's frame is designed and manufactured. Steering: Creating a design for the steering knuckles and modeling the components that were purchased in three dimensions. The design of the mounting locations for control arms in suspension. • Drivetrain: Test stand fabrication, drivetrain design, and motor controller programming. Power: Assessing Solar Efficiency and Investing in Charge Storage Equipment

The parts that were required to achieve the goals were bought and ranked. The following were the main elements obtained, along with their corresponding features: Frame: The fabrication was finished and delivered to the campus. o Used to mount components in conjunction with plating strategy. The battery was purchased and came with a charger.

References

[1] Greenhouse Gas Admissions," EPA, 06 10 2016. [Online]. Available: https://www.epa.gov/ghgemissions/sources-greenhouse-gas emissions. [Accessed 22 11 2016].
[2] Shell Global, "Official Rules Chapter," 2016. [Online]. Available: http://www.shell.com/energy-and-innovation/shell ecomarathon/for-participants/rules-and-competition-overview.html. [Accessed 1 September 2016].
[3]F. Beer, E. D. Johnston and D. Mazurek, Mechanics of Materials, New York: McGraw-Hill Education, 2015.
[4] G. Weiss, "Analise Computacional e Experimental de Rigidez a Torcao de um Chassi de Formula SAE," Rio de Janeiro, 2010.
[5] W. Milliken and D. Milliken, Race Car Vehicle Dynamics, Warrendale: Society of Automotive Engineers, 1995.
[6] W. Riley and A. George, "Design, Analysis and Testin of Formula SAE Car Chassis," in Motorsports Engineering Conference and Exhibition, Indianapolis , 2002.
[7] G. Knier, "Science Beta," 06 August 2008. [Online]. Available: https://science.nasa.gov/science-news/science-at nasa/2002/solarcells. [Accessed 22 November 2016].
[8] B. Darden, "Battery Basics," 22 January 2012. [Online]. Available: https://www.batterystuff.com/kb/articles/battery articles/battery-basics.html. [Accessed 27 October 2016].
[9] Cadex, "Understanding Lithium Ion," 3 May 2016. [Online]. Available: http://batteryuniversity.com/learn/article/lithium_based_batteries. [Accessed 6 Novemver 2016].
[10] Cadex, "Types of Lithium-ion," 7 October 2016. [Online]. Available: http://batteryuniversity.com/learn/article/types_of_lithium_ion. [Accessed 1 November 2016].
[11] Motor Challenge a Program of the U.S. Department of Energy, "Fact Sheet: Determining Electric Motor Load and Efficiency," U.S. Department of Energy.
[12] National Instruments, "Vehicle Performance Analysis," 22 December 2015. [Online]. Available: http://www.ni.com/white paper/13014/en/. [Accessed September 2016].
[13] S. Leitman and B. Brant, Build Your Own Electric Vehicle, Third ed., New York, New York: McGraw-Hill Education, 2013.
[14] J. Wong, Theory of Ground Vehicles, 4th ed., Honoken,, New Jersey: Wiley & Sons, 2008, pp. 221-226.
[15] Galco Industrial Electronics, "DC Motors - Advnatages and Hazards of Running DC Motors," [Online]. Available: https://www.galco.com/comp/prod/moto-dc.htm. [Accessed 12 October 2016].
[16] Galco Industrial Electronics, "AC Motor Diagrams - Basic Stator and Rotor Operation," [Online]. Available: https://www.galco.com/comp/prod/moto-ac.htm. [Accessed 12 October 2016].
[17] NMB Technologies Corporation | A Minebea Group Company, "Brushless DC Motors," Minebea Co., LTD, [Online]. Available: http://www.nmbtc.com/brushless-dc-motors/why-brushless-motors/. [Accessed 12 October 2016].
[18] J. L. a. Y. C. Qi Huang, "Control of Electric Vehicle," in Urban Transport and Hybrid Vehicles, Chengdu, Sichuan, Sciyo, 2010, pp. 163 190.
[19] "Battery and Energy Technologies," [Online]. Available: http://www.mpoweruk.com/motorsbrushless.htm. [Accessed November 2016].
[20] G. Li, W. Hong, D. Zhang and C. Zong, "Research on Control Strategy of Two Independent Rear Wheels Drive Electric Vehicle," Physics Procedia, vol. 24, pp. 87-93, 2012.
[21] C. J. Longhurst, " Christopher J Longhurst," [Online]. Available: http://www.carbibles.com/steering_bible.html. [Accessed 20 november 2016].
[22] H. B. Pacejka, in Tyre and vehicle dynamics, Butterworth-Heinemann, 2006.
[23] G. Weiss, "Analise Computacional e Experimental de Rigidez a Torcao de um Chassi de Formula SAE," Rio de Janeiro, 2010.
[24] PowerTech Systems, "Lithium Iron Phosphate (LiFePO4)," PowerTech Systems, 2016. [Online]. Available: http://www.powertechsystems.eu/home/tech-corner/lithium-iron-phosphate-lifepo4/. [Accessed 20 November 2016].
[25] PowerTech Systems, "Lithium Iron Phosphate (LiFePO4)," PowerTech Systems, 2016. [Online]. Available: http://www.powertechsystems.eu/home/tech-corner/lithium-iron-phosphate-lifepo4/. [Accessed 20 November 2016].
[26] "Vsusp," [Online]. Available: http://www.vsusp.com. [Accessed November 2016].
[27] "Spring Rate Calculator," MW Industries, [Online]. Available: http://www.hypercoils.com/spring-calculator. [Accessed 20 11 2016].
[28] R. Singh, "Structural Performance Analysis of a Formula SAE Car," Jurnal Mekanikal , no. 31, pp. 46-61, 2010.
[29] K. Nice, ""How Car Steering Works"," 31 May 2001. [Online]. Available: . [Accessed 5 december 2016].
[30] "www.motor.org.uk," September 2009. [Online]. Available: https://web.archive.org/web/20130518220840/http://www.motor.org.uk/documentlibrary/Sep%2009/TT%20_%20Sept%2009.pdf . [Accessed 5 December 2016].
[31] "www.quora.com," [Online]. Available: https://www.quora.com/Which-kind-of-steering-system-should-be-used-in-go-kart. [Accessed 05 December 2016].