جامعة الأمير محمد بن فهد
PRINCE MOHAMMAD BIN FAHD UNIVERSITY

College of Engineering

Department of Mechanical Engineering

Spring – 2020

Senior Project Report

Solar Car – Body (structure)

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List of Acronyms

Speed	v
Volume	V
Mass	m
Density	ρ
Young's modules	E
Stress	σ
Strain	ε
Kinetic Energy	KE
Load	P

Abstract

This report presents about the senior design project that the team was involved in during the semester of spring 2020 at the College of Engineering, Department of Mechanical Engineering, Prince Muhammad Bin Fahd University. As the senior students enrolled within this program, we were very much obliged to carry out a lead in designing and manufacturing of a Solar Car's Body for the Project of Solar Car being done by a group of senior mechanical engineering students. This paper provides a deep insight on the steps involved and the milestones achieved after working committedly to produce something that would be for the alternative green energy sector as little details will be effective in the bigger picture. Moreover, it has also provided an opportunity to provide our creativity, imagination, and ideas towards the successful achievement of this project so we can be authenticated as engineer graduates in the future.

Acknowledgments

First of all, we would declare that we are very thankful to Allah who has blessed us with wisdom, knowledge and courage to complete our four year engineering program and provided us with the ability to work on our senior design project report.

Secondly, we would like to pay our sincere appreciation and innumerable thanks to our Advisors, Dr. Fraj Alshmri, Dr. Bouchaib Zazmoum, Dr. Muhammad Azhar whose guidance, constructive comments, support, and advice has enabled us to gain profound understanding throughout this period. We would also like to express my sincere thanks to all the faculty member of the department, who have helped us at times and in many ways and made this whole process pleasant.

In the last we would like to express our acknowledgement to our parents for their everlasting love, dreams and sacrifices they made throughout their lives to make us see this day,

Chapter 1: Introduction

1.1 Project Definition

As the world fuel reserves are at a stake and can encounter a considerable amount of shortage in the upcoming decades, the population worldwide, especially in fuel dependent countries need to look forward towards credible alternatives in order to keep the life cycle going without causing too much harm to the environment. And, as we know of today, cars are most widely used fuel operated machines in the world right now which make up a lot of part in consumption of fuel and producing harmful emissions for our planet.

As senior students, working with other teams collectively, we are given the task of building a solar car that is practical, comfortable and completely diminishes the need of any kind of fuel source for its operation. Moreover, since each team has been given each a specific area to work on in this project, our team will be focusing towards the most prominent and visible part of the solar car, its body.

The team will be strictly involved in designing and manufacturing a body for the solar powered car, practical and feasible with the design of its related components and solar panel placement. Because the whole group is determined to extract as much efficiency possible from this section of the build as possible in order to obtain desired results.

1.2 Project Objectives

Since this project has been laid upon the foundation of saving fuel resources and decrease our dependency on fuel consumption, the solar car body this team intends on designing has some clear and transparent set of objectives to be followed in order for it to function effectively and efficiently:

1. The solar car's body should be aerodynamic and has minimum drag possible.

2. The body should be constructed of a material that is economical as well as light in weight.
3. The body should be sturdy enough to maintain the structural rigidity.
4. The body should have a proper placement area of the solar panels so it can be the most exposed to sunlight.

The above-mentioned objectives are what the group intends on achieving at the end of the project's completion for the society to get inspired and ponder upon fuel saving economical alternatives.

1.3 Project specifications

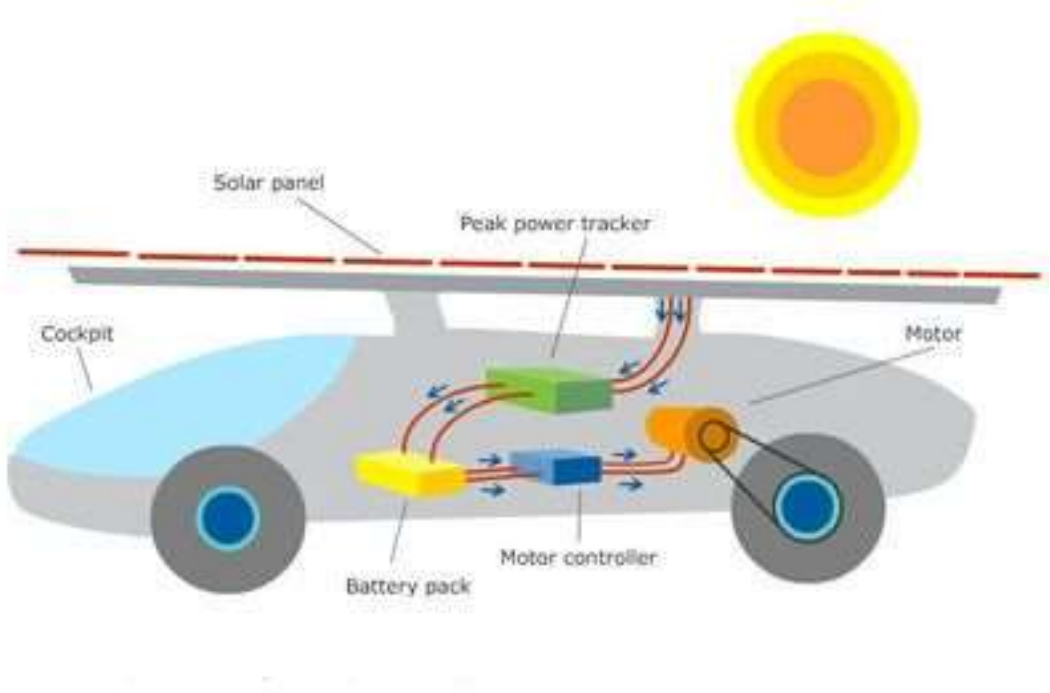


Figure 1: <u>Basic Design of solar car</u>

As shown in the figure above the basic design of solar car is consisting of Solar panel, Motor, and Battery. In addition, the solar car consists of anther components. components that are used in conventional cars. Such that, Body, Tires, Seats, and wheel. A solar-powered car uses energy from the sun with the help of solar panels to recharge their batteries. These cars depend on photovoltaic cells that help them in converting sunlight into electricity. The table below shows some specifications that will we use in our project.

CHARACTERISTICS	SPECIFICATIONS
Vehicle type	2 seat solar car
Drive form	Rear wheel drive
Battery	16 kWh
Maximum speed	80 km/h
Solar panel area	4 m^2
Weight	500 Kg
Dimension	5 m * 2 m * 1.2 m

Table 1: Specifications of the solar car

1.4 Project Applications

Based on the idea and the set of aims projected above, there are a considerable amount of applications that can be looked forward into the development and usage of the solar car's body the team will be designing. Since, the body of any car is one of its essential and the most visible component, even comparing it with the most area covered on a car and covering the car, the body in general actually provides rigidity, structure and strength to the whole system or machine, which is then called a car technically. Moreover, the car's body in our case of a solar powered car, need to be much more aerodynamic than conventional fuel powered car so it can have the least resistance possible and drag against the wind which would help a lot in solar power consumption and the overall performance of the car in discharging. Another application that is extremely important in this case is to have a maximum range of travel and for that, high number or placement of solar panels are required to store solar energy which can then subsequently dictate the maximum possible range that can be squeezed out of it. Finally, the possible amount of structural integrity that it needs to provide from the environmental conditions like g-forces and wind resistance, the body should be constructed of a material that has a good strength while keeping as low weight as possible to avoid extra load on the consumption during operation. These numerous applications related to our project can provide us with the proper amount of support and motivation that is enough in order to carry out such a milestone.

Chapter 2: literature review

2.1 Project background

Solar energy is referred to as renewable and sustainable energy because it will be available if the sun continues to shine. Estimate for the life of the main stage of the sun are another 4-5 billion years. The energy from the sunshine electromagnetic radiation, is referred to as insulation. The emergence of interest in solar energy utilization has taken place since 1970, principally is the world's most abundant and permanent energy source. The amount of solar energy received by the surface of the earth per minute is greater than the energy utilization by the entire population in one year. The most known fact about solar energy is that it represents a clean, green source of energy. Solar power is a great way to reduce the carbon in air. There is nothing about solar power that pollutes mother nature. Solar power does not release any greenhouse gasses, and except for needing a source of clean water to function, it uses no other resources. Hence, it's safe and environmentally friendly. In addition, Electricity needs to be transported from big power plants to end-consumers via extensive networks. Long distance transmissions equal power losses. Ever wondered what are solar panels used for? They're on your roof to get energy from the sun. Rooftop solar power is helpful in increasing electricity efficiency, considering the short distance. Your energy becomes domestic and as a result you're in control of your own bills and energy usage. Furthermore, solar power systems are durable, thus chances of service interruption are reduced.

2.2 Previous work

Many prototypes of solar-powered cars are being tested now. Many big players and startups are involved in developing hybrid solar cars. If statistics are to be believed, the market for solar-powered cars is likely to be USD 1 billion by 2020. Automobile companies are already capitalizing on the popularity and are building solar car kits. These kits can help cars go long distances using solar energy. However, solar cars have design limitations because aesthetics need to be considered as well so that they can accommodate solar panels. Therefore, most solar vehicles have been developed to run in solar car races so far, and not for regular use. Sun swift IV is the fastest solar car that exists currently. This car was built by the students of the University of New South Wales for Solar Racing. The car uses technology that is like and a combination of the one used in a bicycle, aerospace, and the automotive industry. The body of a solar car should be designed to optimize the balance of generating capacity of solar cells and aerodynamic performance in order to have the highest overall efficiency. Generating capacity will be increased by shaping the vehicle body to minimize drag force, increasing the area of solar cell installed on body and, shaping the vehicle body to allow solar cells to receive more solar energy.

2.3 Material selection

Different body materials can reduce the weight of the vehicle, improving the vehicle power to weight ratio. Material selection can also provide advantages by reducing member deflection, increasing body strength and can determine the amount of reinforcement required. The materials which used to build this body is fiberglass. Fiberglas is a material which made from extremely fine fibers of glass. It is used as a reinforcing agent for many polymer products and resulting composite material known as fiber-reinforced polymer (FRP) or glass-reinforced plastic (GRP). It’s called as fiberglass due to popular usage. Fiber reinforced polymer (FRP) composites are thin laminates that are externally bonded to structural members using epoxy adhesive. The FRP significantly increases the members' load carrying capacity. These structural strengthening systems are made of high strength fibers (such as glass, Kevlar, and carbon) embedded in a resin

matrix. The resin protects the fibers, maintains them alignment, and distributes the loads evenly among them (FGS, 2010).

2.3.1 Fiberglass

Fiberglas is a material which made from extremely fine fibers of glass. It is used as a reinforcing agent for many polymer products and resulting composite material known as fiber-reinforced polymer (FRP) or glass-reinforced plastic (GRP). It's called as fiberglass due to popular usage. Fiber reinforced polymer (FRP) composites are thin laminates that are externally bonded to structural members using epoxy adhesive. The FRP significantly increases the members' load carrying capacity. These structural strengthening systems are made of high strength fibers (such as glass, Kevlar, and carbon) embedded in a resin matrix. The resin protects the fibers, maintains their alignment, and distributes the loads evenly among them (FGS, 2010). FRP's, which have been extensively used in industries such as aerospace, automotive, and sport equipment, are now becoming a mainstream technology for the structural upgrade of concrete structures. In addition to their high-strength and lightweight properties, important characteristics of FRPs for structural repair and strengthening applications are their non-corrosive properties, speed and ease of installation, lower cost, and aesthetics. FRP fabrics may be adhered to beams and slabs to increase their shear and flexural capacity and can be wrapped around columns to increase their load carrying capacity and ductility for seismic events. FRP has high degree of design flexibility. The practical uses of FRP are virtually endless. Its unique physical properties allow it to be easily tooled, molded and manufactured to meet almost any specifications. Because there are few constraints on size, shape, color or finish, the styling and appearance can take precedence over manufacturing costs. This design freedom and the easiness to work make FRP an economical alternative for the manufacture of any component or finished product in any quantity.

Material Properties					
Material	**Elastic modulus**	**Poisson's Ratio**	**Mass Density**	**Tensile Strength**	**Thermal coefficient**
Fiberglass	7200 MPa	0.2	40.85 Kg/m^3	3450 MPa	54

Table 2: Fiberglass Properties

2.3.2 Epoxy resins

The primary reason for epoxy's popularity is its superb mechanical strength. Welding is often the only alternative. Epoxy is nearly always cheaper and faster than welding. Epoxy also has excellent resistance to chemicals. After setting, there is no worry of a chemical reaction that will weaken the seal. It also resists heat. That resistance makes it ideal for electronics and electrical systems and other industrial applications. Those who use epoxy are aware of the superb mechanical strength and low curing contraction. They also know the epoxy resins are well-balanced industrial materials and suited to a broad range of applications. Engineers are faced with concerns about heat dissipation, electrical insulation, adhering dissimilar substrates, light weighting, sound dampening, vibration, and reduction corrosion. Appearance must be considered, as well as, assembling costs. Epoxy is an adhesive formulation that meets all those concerns. Its thermal and electrical properties, strength, and durability are what epoxy is noted for. Those properties along with the resistance to immersion and hostile chemical vapor are the reason epoxy often is chosen by engineers.

2.3.3 Campsites Preparation

Composites materials are made by combining two materials where one of the materials is a reinforcement (fiber) and the other material is a matrix (resin). The combination of the fiber and matrix provide characteristics superior to either of the materials utilized alone. Composite materials are very versatile and are utilized in a variety of applications. Composite parts provide superior strength, stiffness and light weight, and can be formed into any shape. An ideal application are large complex-shaped structures such as fiberglass covers. Composite products are ideal in applications where high-performance is required such as aerospace, race cars, boating, sporting goods, and industrial applications. The most widely used composite material is fiberglass in polyester resin, which is commonly referred to as fiberglass. Fiberglass is lightweight, corrosion resistant, economical, easily processed, has good mechanical properties, and has over 50 years of history. It is the dominant material in industries such as boat building and corrosion equipment, and it plays a major role in industries such as architecture, automotive, medical, recreational, and industrial equipment.

Procedure:

1. set up the mold.
2. Prepare the fiberglass mat or cloth in sheets cut to suitable sizes to cover your form.
3. Measure an appropriate amount of resin in a metal container.
4. Lay mat on or in your form and spread the resin mixture over it.
5. Repeat the steps of applying mat and resin until the finished project is as thick as you want it.
6. Finish your project by coating with gel coat or a smooth coat of resin.
7. Remove your fiberglass from the mold.

2.4 Save energy consumption

When manufacturing panels with same rigidity, FRP light weight ratio can be up to 36.7%. As FRP density of the body is only 1.7g/cm², about 1/5 of the steel. Although the FRP thickness and intensity increase, it's still lighter about 100kg than the metal auto body. Making FRP profiles, fiberglass fenders, DIY fiberglass hood, FRP carriage, FRP door and FRP cab, American Rockwell company do success. Depending on the light FRP density, it reduces the vehicle's weight by 227kg. Beijing 251 factory produced FRP cab of BJ121 car, FRP cab weight is only 1/3 of the original metal cab weight. We produced electric buses with full fiber car body, the total FRP weight of the vehicle reduced by 18% than its own design weight. As the decrease of body weight, it is bound to reduce energy consumption.

Chapter 3 : Design System

3.1 Design Constraints and Design Methodology

3.1.1 Geometrical Constraints:

There are some constraints which should be taken under consideration for manufacture the body of solar car to be effective. The main aim was to keep the weight of car lighter and compactly assembled so that it will cause less friction and in result will require lesser energy to accelerate and stay in motion. The project will keep its focus on the selection of the material of the body and how to manufacture it.

3.1.2 Engineering standards

The purpose of this specifications for design is to make users aware of various standards which may be considered during the design process. The American Society for Testing and Materials (ASTM) standards will be used for classifying what sort of material has been selected, as well as giving the dimensions and stating which material has been designated for each component. The engineering standards are mentioned in detail under the section 3.2 Engineering Standards.

3.1.3 Sustainability

The design is required to be able to last and function for the life of a solar car. The system needs to work for quite a while to make up the expense of the device and to make the system more cost productive. The solar car should be design in such a manner that no secondary maintenance should be received. To simplify the diagnosis and maintenance of body was one of the primary objectives.

3.1.4 Social Impact

The main purpose of this project the solar car is to reduce the dependency of Saudi Arabia on oil. This will intend to produce a solar car which consumes no patrol or diesel and emits no gas or emission. The project is to invoke the necessity of switching our cars from fossil fuel towards solar energy to save the world from pollution and stopping the degradation and depletion of oil reserves.

3.1.5 Economic

To design and fabricate a low-cost body was one of the main objectives of this project. To increase the chances of the system being highly remarkable the total cost of the project must be brought to a minimum.

3.1.6 Safety

While working on our system manufacture of the body of solar car during its functional life span, we have always also planned to sustain safety. While taking care of the safety non-toxic and hazardous material were used. Its fabrication and factor safety will be highly emphasized in the design. To minimize the accident, they are cons8rained to enclosed sections.

3.1.7 Ethics

There are many solar cars already introduced in the market which are either part of racing games or introductory model cars. This system manufacture of the body of solar car is an existing idea

but, in this project, we have done some modification to make it more effective and useful. This system depends completely and solely on solar energy no fossil fuel is used to power this car thus in result the main aim is to create a zero-emission car to make it a milestone in achieving Saudi Vision 2030 of going green.

3.2 Engineering Standards

3.2.1 Introduction

The purpose of this specifications for design is to make users aware of various standards which may be considered during the design process. The American Society for Testing and Materials (ASTM) standards will be used for classifying what sort of material has been selected, as well as giving the dimensions and stating which material has been designated for each component. Below is a list of all the materials used, along with the engineering standard for each component.

No	Dimension Type	Dimension
1	Length of the car	5 m
2	Width of the car	2 m
3	Height of the car	1.2 m
4	Length between tires	3 m
5	Width between tires	1.32 m

Table 3: Dimension type & Dimensions

No	Components	Engineering standards
1	Material for body	ASTM-D3299: Fiberglass
2	Material for body	ASTM- F1267: Expanded metal

Table 4: Engineering Standards

3.2.2 Expanded metal

Area	Thickness	Weight
2 m x 1 m	1.8 mm	18 Kg

Table 5: Dimension of expanded metal sheet

3.2.3 Fiberglass

Area	Thickness	Weight
2 m x 1 m	3 mm	0.6 g

Table 6: Dimension of Fiberglass sheet

3.3 Theory and Theoretical Calculations

Assessment of the design and the product is very important, and it is done by running some tests and calculations on the prototype. At this point we can only share the desired tests with hypothetical calculations.

Consider the following as the theoretical values:

- Speed of the car = 80 Km/hr = 22.2 m/s
- Weight of the car = 500 Kg (including the driver)

3.3.1 Theoretical Calculations

These are the theoretical calculations that we have used:

- **Kinetic energy** $\boldsymbol{KE = \frac{1}{2}mv^2}$

$$KE = \frac{1}{2}(500)(22.2)^2 = 123210 \text{ N}$$

- **Density of the fiberglass sheet**

In order to calculate the density, we first need to calculate the volume of the sheet, the volume is equal to length times width times height.

$$Volume = L * w * h = 2 * 1 * (3 * 10^{-3}) = 6 * 10^{-3}\ m^3$$

$$\rho = \frac{m}{V} = \frac{500 * 10^{-3}\ g}{6 * 10^{-3}\ m^3} = 83.33\ \frac{g}{m^3}$$

- **Young's modules of fiberglass**

Young's modulus is a measure of the ability of a material to withstand changes in length when under lengthwise tension or compression. To calculate it we need to look to the stress-strain curve for the fiberglass.

Stress : $\sigma = \frac{P}{A}$

Strain : $\varepsilon = \frac{\delta}{L_o}$

From stress-strain curve of fiberglass we find the young's modules is equal to 7200 MPa.

3.3.2 weight of the body

Approximation weight of the body:

- Body weight = weight of the Fiberglass + weight of the expanded metal
- Weight of expanded metal sheet (2 m x 1 m x 1.8 mm) = 18 kg

- Weight of Fiberglass sheet (2 m x 1m x 3 mm) = 620 g
- We need to use 9 sheets (Approximate)
- Body Weight = $[(620 * 10^{-3}) + (18)](9)$= 149 kg (Approximate)

3.4 Product Subsystems and selection of Components

Solar car is consisting of many components, our team is responsible for the body of the solar car. we have chosen the composite material to be the material of the body. Our composite material is consisting of two materials, fiberglass and expanded metal.

3.4.1 Fiberglass

Fiberglass is a versatile and cost-effective reinforcement for composites. Many processes, resins, and forms of fiberglass facilitate this versatility. The design, engineering, manufacture, and properties of fiberglass-reinforced composite products from diverse thermoset and thermoplastic resins are described. The attributes of fiberglass-reinforced composites include its mechanical and chemical properties, lightweight, corrosion resistance, longevity, low total system cost, and Class A surface properties. Specific examples illustrate the importance of the form of the fiberglass reinforcement and of the interfacial bond between the glass fibers and the matrix resin in optimizing composite properties. In addition, recent advances are described about the fabrication of fiberglass-reinforced wind turbine blades.

Figure 2: Fiberglass mat

Figure 3: Sample of fiberglass

3.4.2 Expanded metal

Expanded metal is a type of sheet metal which has been cut and stretched to form a regular pattern (often diamond-shaped) of metal mesh like material. In the market there are two types of expanded metal. One with 1.8 mm thickness and the other one with 2.7 mm thickness. We have chosen the one with the 1.8 mm thickness because it is lighter.

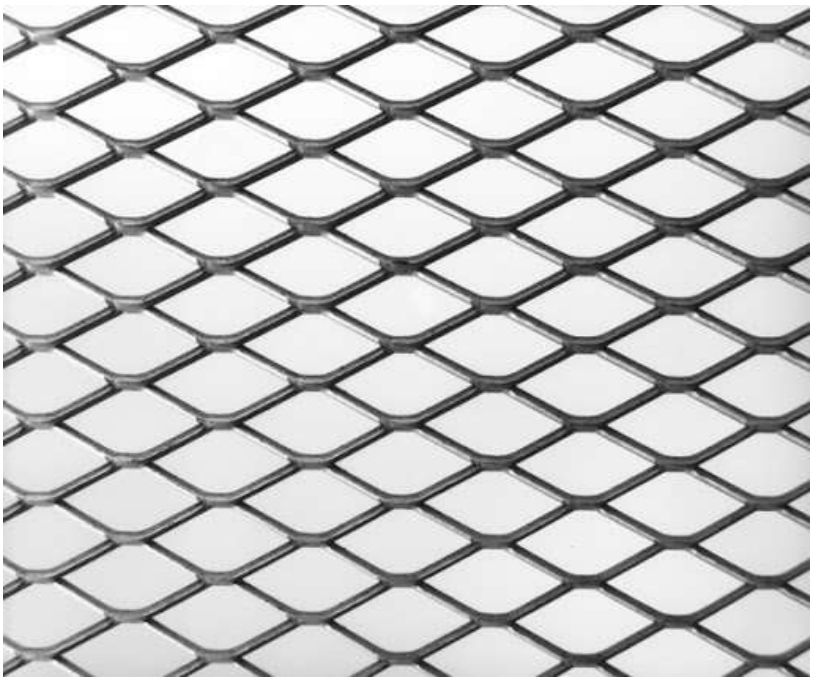


Figure 4: Expanded metal

3.5 CAD Modeling/Simulation

The CAD model we generated for our project in which the team is subjected and given the task to design and construct the body of a solar car, the design approach we actually admired was from tesla's recent cyber-truck which actually has a pretty smart design behind all those edgy-ness. That design is actually responsible for a greater amount of surface area all over the roof, windshield and as the trunk area is quite long and swooping at the back, there can be ample space for placement of solar panels to be mounted for maximum sunlight exposure and energy collection.

However, since the dimensions and most of the body's wheelbase was taken from Tesla's Cyber-Truck, the following figure given illustrates that progress through a 2D drawing produced on SolidWorks which the necessary dimensions clearly mentioned.

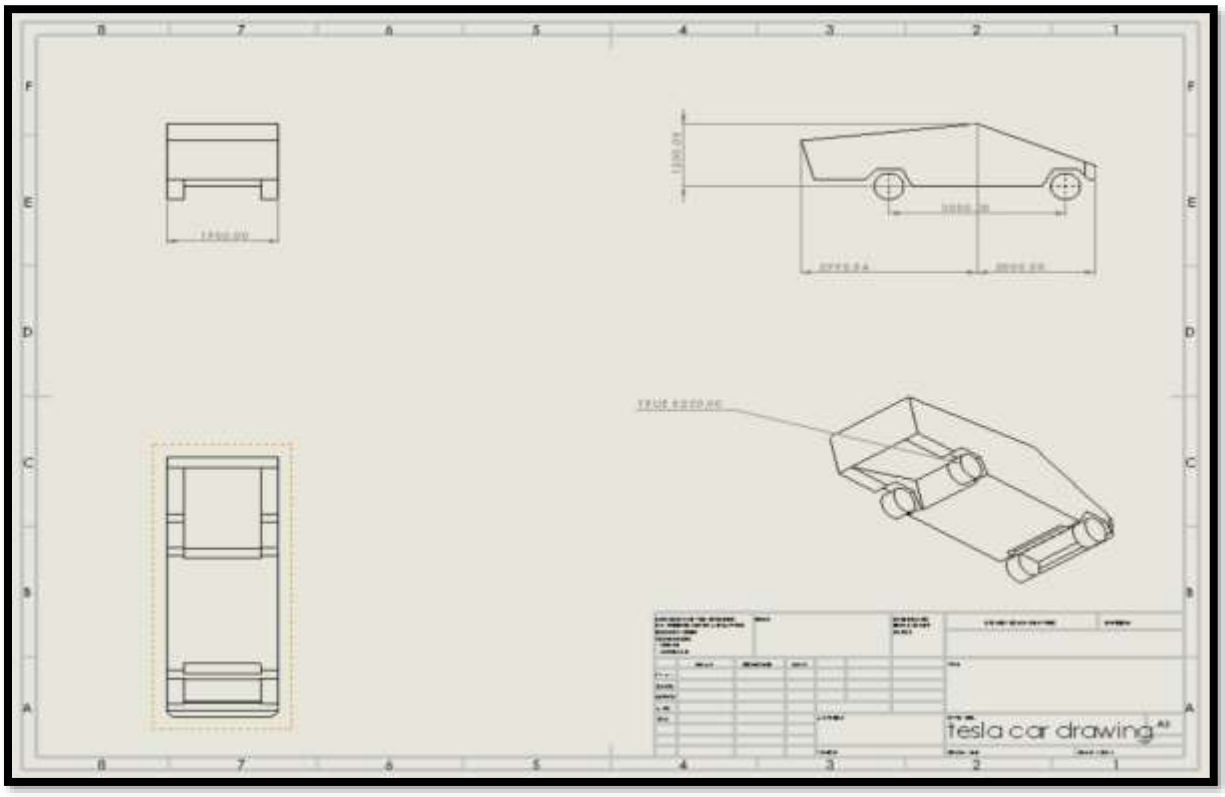


Figure 5: <u>2D Drawing of Solar Car Body</u>

From the above illustrated diagram, it was also extremely necessary to simulate a study based on different types of loading situations which will be putting the body to the ultimate test in determining its stresses, displacement and strain. Since, it will be under operation as a transportation, extra care was taken for its material and the material selection to obtain minimum stress exposure, strain growth and displacement upon an unfortunate incident of a crash or an impact. As, most of the crash tests are performed in real life in controlled environment and parameters, we were to take a much accessible option to perform a numerical simulation in our case.

The following parameters were set into the software as an initiation point for the solar car body's testing. A velocity impact test was performed under normal gravitation conditions; however, it was more of a drop test than a head on collision test and the drop test velocity was 22.22 meters per second.

Figure 6: <u>Parameters of the study</u>

From the given illustration of the simulation data, we had set our references according to the car body and plane in which several faces were selected to ensure it acts and simulates like a head on collision impact at the given velocity as illustrated. Additionally, it also provided damping options but we had kept it at zero to demonstrate the worst-case scenario for the car's body. The body was and should be considered a rigid body as it will be sustaining a lot of damage and needs to be physically feasible to absorb, deflect and deliver under stresses instead of absorbing all of it, which happens in case of a flexible body.

Consequently, upon running the experimental simulation, a series of results were generated giving us a lot of information about the loading mechanics which was illustrated in values of stresses and displacement.

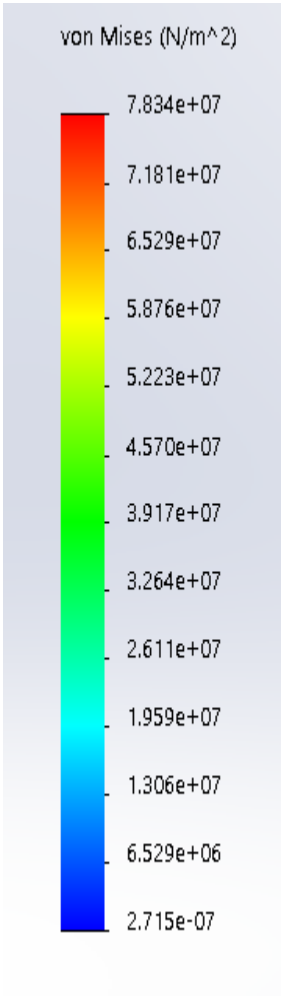
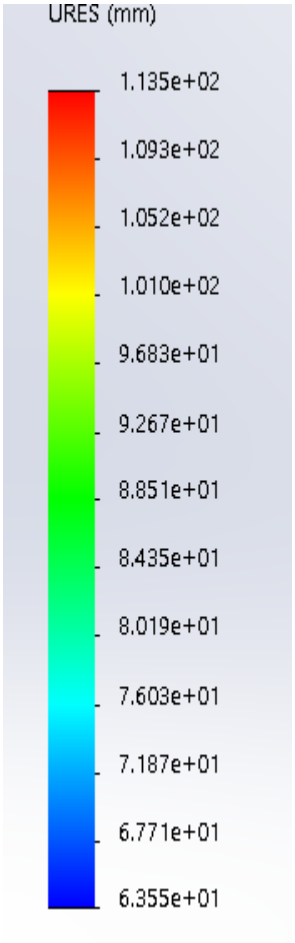
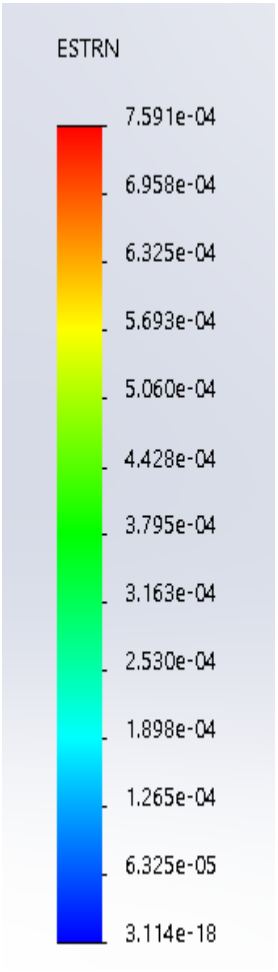
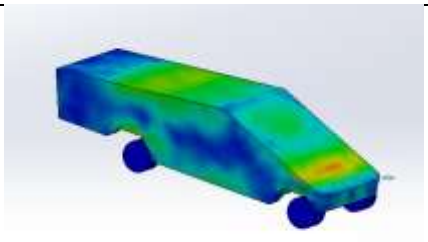
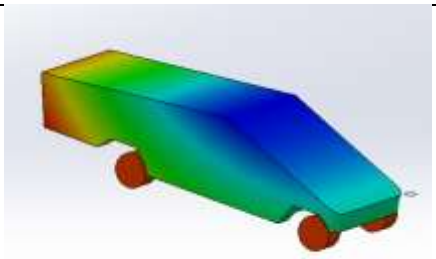
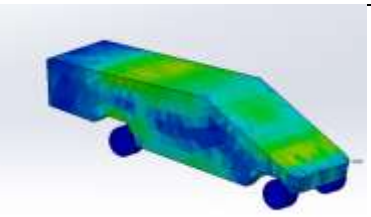
Type of result	Stress	Displacement	Strain
Maximum Value	$7.834 * 10^7\ Pa$	$1.135 * 10^2\ mm$	$7.591 * 10^{-4}$
Values			
Impact			

Table 7: Result of the crash analysis

The results displayed in above shown table shows us the severity of the test from the values which look quite reasonable. The stresses distributed in the front face of the body will dissipate the most stresses on the hood area where the values can reach to a maximum of $7.834 * 10^7 \text{N/m}^2$ and on the overall body they are in the safe range as the color green and blue is the most favorable in any kind of simulation data showing the region of safe operation. Furthermore, in the displacement results, since the body will be carrying a lot of inertia, the overhangs from the rear wheels are quite extended and has minimum support which would experience the most displacement under impact as well as the wheels. Since, they are the points of least resistance. However, in the strain region, the overall body seems to be unaffected by the impact, this is mainly due to the body structure, material and the parameters set for the simulation to be conducted. So, it is safe to claim that the solar car body for our team's solar car project is quite sustainable if any unfortunate is bound to happen. The safety of occupants is kept being at the maximum priority.

Chapter 4: Conclusions and Future Recommendations

4.1 Conclusions

To sum up, as senior students in the mechanical engineering department, this project of designing and manufacturing a solar car's body does a lot of testing of our knowledge which we have all learned over the past 6-7 semesters. A lot of support was provided to the students and the teams were working on the project from the advisors and instructors which gave an immense boost in our morals as the unfortunate event of pandemic has rushed some hurdles towards the smooth on-going of the project. However, we must apply every bit of engineering knowledge in towards the progress and achievement of the tasks that were necessary to complete the requirements for a solar car's body to take shape and be effective in the long run. Moreover, usage of different kind of materials were overwhelming since the main aim was to save energy and it directly implies on

using materials which are extremely efficient and does not drain a lot stored charge/energy that is required to power the whole system.

Additionally, the overall program and the completion of tasks went according to plan and due to unfavorable circumstances, some of the fine details were met. However, considering the design profile of the from Tesla's recent Cyber-Truck, we were able to utilize a lot of space for solar panel placement since we need long range driving capability with very minimum discharging. Also, aerodynamics was also quite a challenging task to fulfill but a reasonable amount of drag was still being produced which is fair for a project being produced by a group of undergraduate's students.

4.2 Future Recommendations

This project being an overall success towards the achievement of what a group of organized and coordinates students could do in each span of time. Since, the motive is to deviate from the traditional dependency on fossil fuel resources in our daily applications and especially her in the Kingdom of Saudi Arabia since the most fuel is consumed in the industry and the vehicles. So, to reduce such an impact from those resources there is a need to develop a commutable vehicle that is comfortable and uses solar energy instead of fossil fuels to run. Because we know the Kingdom gets sunshine quite abundantly annually and to use that into our benefit, the solar energy accumulation and consumption is all emission free.

Since, the team was responsible for the development of the body structure for the solar car itself, after a commendable amount of achievement in the tasks, there still are some rough points which can benefit a lot from an extra amount of attention like:

- The body can be made from non-traditional composite materials which has both extremely lightweight, has a lot of strength and demonstrates excellent structural rigidity.
- Instead of having a one to one imitation of Tesla's Cyber Truck's body design language, if the sharp edges could have been much smoother, it would have provided a completely improved and enhanced streamline, providing an exceptional decrease in the drag forces acting on it.
- As roof is the only place where the solar panels can be attached safely to ensure constant and undisturbed exposure to sunlight for solar energy, areas such as hood, trunk and the

doors can benefit from an incorporated positions for small sections of solar panels in still collect the solar energy in case of a sunset or sunrise situation.

Although the body may have its ups and downs, but even achieving to this level can be appreciated since nothing can be ever designed in a perfectly hundred percent flawless manner. And, being a senior undergraduate mechanical engineering student, we can assure that the amount of time, commitment, and dedication we have given towards the achievement of this milestone, it would surely be beneficial towards the betterment of earth and its environment.

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