جامعة الأمير محمد بن فهد
PRINCE MOHAMMAD BIN FAHD UNIVERSITY

College of Engineering

Department of Mechanical Engineering

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Senior Design Project Report

Solar Car Body

In partial fulfillment of the requirements for the Degree of Bachelor of Science in Mechanical Engineering

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Abstract

Solar Energy has been around for decades. It has been around even before we discovered how to make it useful. By 3rd century started using solar energy through glass to start cooking fires. Also, Romans and Greeks used it to as a light using burning mirrors (Vivint. Solar History of solar energy). Solar power is considered one of the greatest options between all the other alternative of reenable energy sources. However, it is not as simple as it sounds; solar energy faces many challenges in order to become useful. likewise, solar cars need large amount of attention and work to become enough efficient to be reliable.

Our objective in this project is to improve solar cars to become more efficient, more useful, and more, reliable. Huge amount of the power in solar cars is lost as a waist as heat due to the heavy weight and drag force of the car. Therefore, we aiming to improve the aerodynamic

And the weight of the car. We are using solid work to design suitable body to minimize the drag force. In addition, using Ansys to test our design facing it against high wind force to simulate actual car driving on a high way. We have faced some difficulties due to lack of time and accurate equipment. Such a project companies with unlimited recourses spend years on developing a testing. However, we have done great job on designing great low drag force body. We are working on improving our design by going back and forth between improving the design using solid work and testing it using Ansys. Further study will include the actual Wind tunnel test results.

Acknowledgments

First of all, I would like to extend sincere thanks and respect to those who helped and motivated us to complete this project. We sincerely thank Dr. Panagiotis Sphicas for his kind assistance to us and the support he gave. We would like to extend our thanks and appreciation to Dr. Faramarz Djavanroodi, chair of the Mechanical Engineering Department at PMU, for his continued encouragement. Also, we would like to thank the university for allowing us to use the laboratory for our experimentation and measurements. Finally, we would like to deliver our thanks to our parents and family for the supporting and the motivation they gave to us to complete our final project.

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Chapter 1: Introduction

1.1. Project Definition

As student competency is one of the most important aspect in mechanical engineering department mission at PMU, part of department program for achieving that mission is learning assessment outcomes III course. In this course, students are required to work in teams to accomplish an engineering design project prototype or even a final mechanical product that can be tested in realty. However, the mechanical department at PMU has decided to manufacture a solar car that is capable to participate in a coming event at Saudi Arabia. Briefly, that event is a race among solar cars in the Kingdom of Saudi Arabia and the race will cover a long challenging distance in the Kingdom.

1.2. Project Objectives

Our group members with the help of our advisor (Dr. Panagiotis) are responsible to design the car body with the best aerodynamic features. The primary design will be design on the SolidWorks software and the aerodynamic simulation will be conducted through the ANSYS software. The desire car body design should be with the minimum drag force and the maximum car speed. Moreover, the final car body design will be printed by using a 3D printer then, the printed prototype will be tested finally in the wind tunnel to confirm the actual performance.

Chapter 2: Literature Review

2.1. Project background

The aerodynamics system of the solar car is one of the most affective factors of designing a solar car. It has to do with the external body of the car where we have to design the external shape in certain angles and curves in order to decrees the

drag force and the pressure. The aerodynamics system is needed in the all types of automotive where it helps the car to increase its velocity with less time so the acceleration of the car improved. There are important parameters that are affect the value of friction in the car which are the drag coefficient, the reference area, the density of the fluid, the flow velocity relative to the object. In the main time, we are working in the solid work to design the external shape of the solar car with respect of the given dimensions. We are trying to design the body in a way where we avoid to having a turbulent flow which will increase the value of the drag force and it will affect negatively in the aerodynamics of the car. We are trying to have a linear flow where we deign the car in certain angels and curves to smooth the surface enough and to give the ability of fitting the solar panels on the top surface of the solar car. After we finish from designing the external body of the solar car in the SolidWorks, we are going to take that design to the ANSYS software where we can do the flow analysis to calculate the drag force and the optimal dimensions in order to decrees the friction on the external body of the car. We are chosen this part of the solar car which is the aerodynamics system and the external body because we believe that it is the most important part that based on it the reaming part will be designed. Also we believe that our previous knowledge and skills in engineering design and airflow analysis are strong enough to carry out this part of the solar car.

2.2. Previous Work

First of all, we start our project by looking for a similar project that has been done perversely. Therefore, a member of the University of Johannesburg did a similar project; the Aerodynamic of a solar car. The project was meanly about building a solar racing car with an alternative energy solution. The result of their project is to improve the aerodynamic of the solar racing car by applying different software such as CFD. On the other hand, they want the solar racing car to achieve a speed of 100 km/h.

On the other hand, their project on the solar car was designed for one seat which is for the driver. Unlike our design which will be consist to fit to persons in the vehicle cabin, means the driver and one passenger. It is challenging to design a body with two passengers due to the high drag force and the air-flow over the

solar car. Even on one passenger it needs many accurate curves to avoid high drag force as shown in **Error! Reference source not found.**.

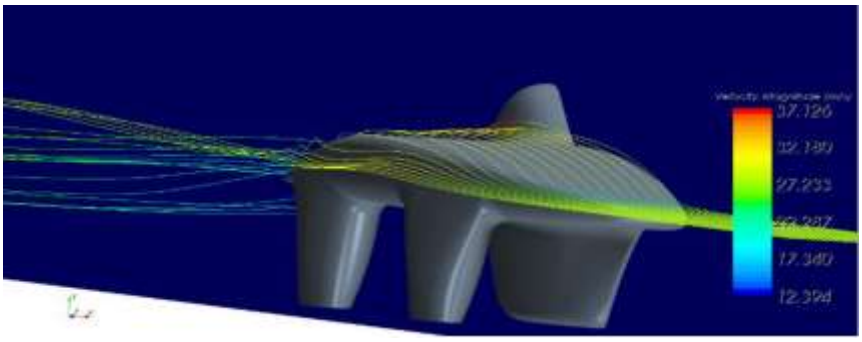


Figure 1: Five Fairing Design Flow Visualization

Chapter 3: System Design

3.1 Design Constraints and Design Methodology

3.1.1: Geometrical Constraints

Since our group's part in the project is to model the car's body meeting the best aerodynamic results, the main limitation was to model the body with the maximum roof surface that can handle the maximum solar panels to generate the maximum power for more running durability. In fact, the affected area is directly proportional to the drug force, so that we cannot model a roof with more surface area since it will affect the aerodynamics of the car. In addition, parking is another limitation with the car width, also the passenger capacity is directly proportional to car weight capacity, and we put into our consideration that the car looking should not be bad. Finally, we have designed the car geometry accordingly.

3.1.2: Sustainability

The project sustainability will be depending on many factors like: materials, parts quality, solar panels efficiency, design with international standers, preventive maintenance strategy and operational guidance.

3.1.3: Environmental

Our project is relaying on a source of clean energy (renewable energy) which is the solar power that will be generated through the solar panels on the top of the car roof. There will be no pollution to the environment.

3.1.4: Social

Socially solar cars can be a good choice for people, it will facilitate clean transportation with free power source. In addition, it can give an idea about the solar energy to people who are not familiar with that source of power by looking at the car while it is moving in the street.

3.1.5: Economic

Solar energy is one of the renewable energy sources, it will help the overall economy of the kingdom since it can reduce the consumption of fossil fuel as well as it can save the owner money.

3.1.6: Safety

in a solar energy point of view, care should be there with the solar panels as it is a normal electrical device, fire can occur or electrical surge can happen especially if they are low-quality panels, as well as the battery and the wiring system of the entire car. In a car point of view the international minimum safety requirement should be applied like the seat belt or the front and the rear lights, the details of those will be handled by another group in the project.

3.1.7: Ethical

The university has provided so many important facilities that we would not be able to do our part without them such as the SolidWorks software, the ANSYS software, the wind tunnel and the 3D printer. In addition of that there will be a financial cover to any amount of money that we would pay from our own.

3.2 Engineering Design standards

It is important in every project or device to follow international Engineering standards. Otherwise, this product will be useless. Where it will not be able to fit or used with other products around the world. That is why it has to follow international standards and units. in this project, there were two programs used; which are Solid Work and Ansys. Selecting more than one slandered will cause many problems with applying aerodynamic studies. Besides, it will cause issues with any complexity in manufacturing the components and body of the car. This project as a full project the solar car is divided into 8 groups, every group working on one subsystem. Not following one standard will cause the whole project to collapse and fail. Because parts will not fit together. Standards and details of both designs are shown in the tables below

Table 1: Engineering Standards for Design #1

Components	Engineering Standard	Details
Hight	ANSI metric	1 m
width	ANSI metric	2 m
tires	ANSI metric	0.25 m
length	ANSI metric	5 m

Table 2: Engineering Standards for Design #2

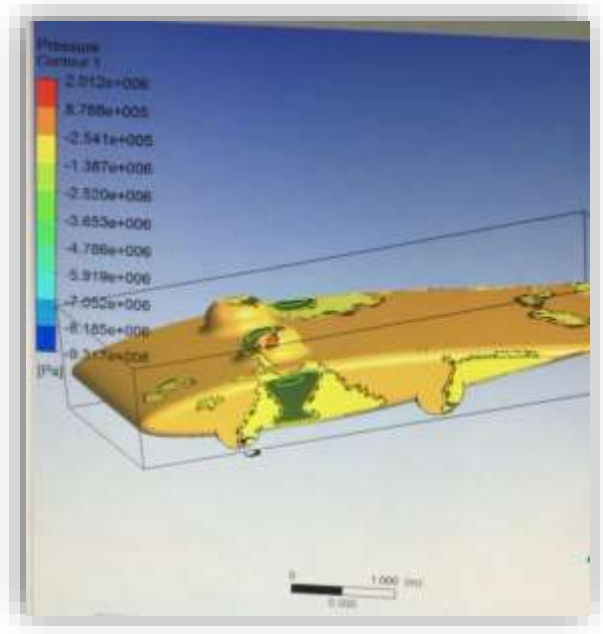
Components	Engineering Standard	Details
Hight	ANSI metric	1.2 m
width	ANSI metric	1.9 m
tires	ANSI metric	0.25 m
length	ANSI metric	5 m

3.3 Theory and Theoretical Calculations

3.3.1: The coefficient of lift force, and drag force:

The drag force plays an important role in our design of the solar car because, the less the drag force, the more efficient the car will be.

There are some factors are extremely important to take in consideration such as:



1) The pressure.

2) The velocity of the air.

3)The weight of the car.

4)The density.

5) The area of our car.

Figure 2: aerodynamic of Design #1

3.3.2: The calculation of drag force and lift force:

1) To calculate the drag force, and the lift force we need four components which are, the force, density, area, and velocity.

- We have calculated the force, density, and velocity by using the Ansys program.

$$2)\ cp = \frac{2*F}{\rho*A*V^2} = cp = \frac{2*(892.2)}{(1.225)*(1.32)*(26.8)^2} = 1.54$$

$$3)\ Cl = \frac{2*F}{\rho*A*V^2} = \frac{2*(34)}{(1.225)*(1.32)*(26.8)^2} = -0.06$$

3.3.3: The calculation of other design:

Our team has decided to draw four different designs, to determine which one of these four designs is going to be the best, but unfortunately, we face a lot of obstacles during out semester, and the most difficult one was Coronavirus.

3.4: Product Subsystems and selection of Components.

Every project or system, in general, is consists of parts put together to create one full system. When breaking one full system to small subsystems makes it easier to work on it and solve every problem by its self. Just like when you are trying to walk 1 Km it might seem too much work and scary. However, when you take it to step by step and walk 1 M then walk another 1 M, sounds way easier. PMU this semester is working on one full project; However, they have cut it into parts every group of students works on one Subsystem or Subproject. Within our group, we have subsystems distributed to be working on separately to makes it easier and less time working on it. Even though our part of the Solar Car is to design a body that has great aerodynamic for the car and it is basically one body and system. However, we have cutting It into parts and worked on every part by its self for a better quality of work. We have created two designs for a solar car, the first design as shown in figure @ separated into four main parts. Part one is the main body of the car. Part two is the wheels of the car. Part three is the cover covering the wheels of the car. And finally,

the last part is the glass for the passengers. While the second design of the car as showing in figure @ is much simpler. Where it contains only two parts, the body, and the wheels.

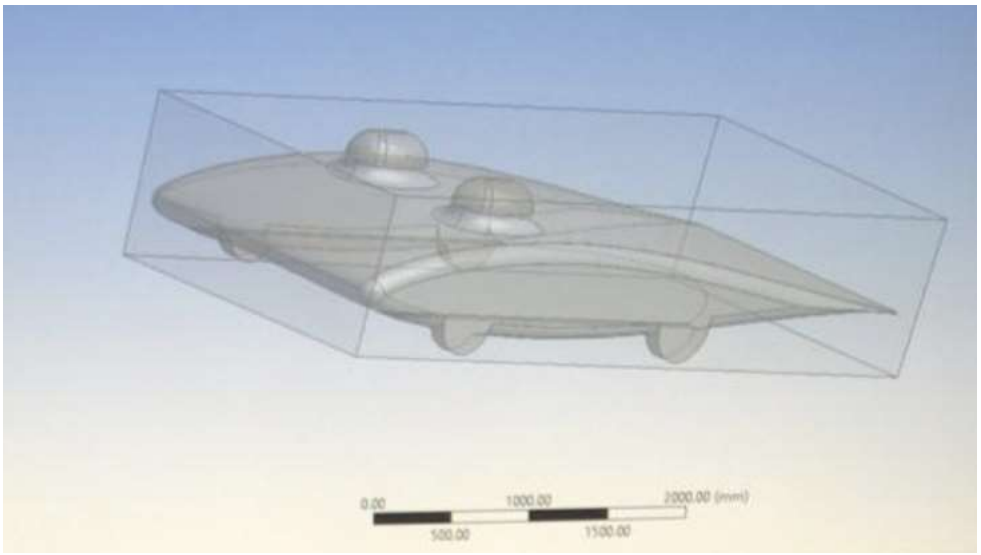


Figure 3: Design #1 of the solar car

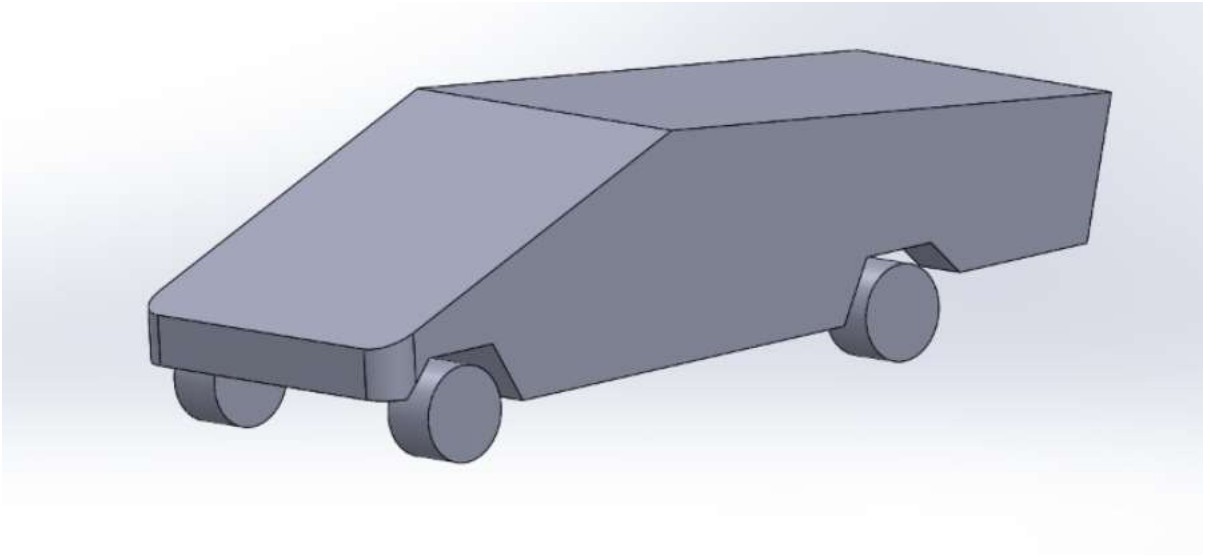


Figure 4: Design #2 of the solar car

3.5 Manufacturing and assembly (implementation)

The external body of the solar aerodynamics car has designed in solid works program where we were able to design it in certain angels and curves in order to decrease the drag force and not having turbulent flow, which is one of the most effective factors for increasing the value of the friction force. After all the parts of the solar car have completely finish and final design draft have been provided from each group, we are planning to dealing with one of great workshops to provide them the final design of the whole solar car and the materials that have been chosen for each part of the solar car to manufacture it and join the parts together in order to achieve the final draft of the solar car with all necessary requirements for perfect design.

Conclusion

Nowadays, worldwide everyone is looking for clean renewable energy such as wind turbines, solar energy, and hydropower. So, PMU chooses to build a solar car for many reasons not only for the environment it's also for economic reasons behind it. Due to the increase in the oil price we have to look for an alternative instead of cars. Also, solar cars cloud does the same work as the regular car in high efficiency and high quality. On the other hand, especially in Saudi Arabia, we had a sunny day almost all years, that's will help us to improve the solar energy gained by the sun.

Our part of building the solar car is the aerodynamic of the car in other word is the design of the car. Since aerodynamic is the most important factor in building a body that moves, we have to make sure to design shape by giving attention to the aerodynamic. Also, aerodynamic is the factor of reducing drag force, reducing wind noise and preventing undesired lift forces at high speeds. Moreover, the design goes into several stages so that takes time for us first we have to think of the shape then try to draw on paper then asking the team and advisor of their opinion then after all of that to the last stage which is drawing of the SolidWorks. In the beginning, we came with a design close to airfoil shape which is having a good drag force coefficient but due to the limitation of the manufacturer in our area we had to change the design to a shape close to tesla cyber track.

Future work and Recommendation

Refereeing back to the data that we have collected and the progress that we have made with our advisor Dr. Panagiotis. The good news is that we have reached to good aerodynamic features by using the CFD fluent test in the Workbench of ANSYS software and, we have got a good idea about the behavior of the car body in term of aerodynamics, but, unfortunately, we did not reach to a concluded body design. In fact, the best aerodynamics results can be achieved through the software modeling but, the difficulty is in manufacturing of that complicated body design, it will not be difficult in manufacturing the body only, it will include many challenges even with the car axillaries like the head lights and the steering system and even in the battery location and solar panels geometry. Our project has faced a big challenge in term of progress, the unfortunate situation of the corona virus (COVID-19) has impacted the whole world, the movement of people was restricted as well as the education was postponed. Our recommendation and the forward path to the next semester team is, to take the last modeled body of the car and, to put it in the CFD fluent test in the ANSYS Workbench software which is already provided at the university CAD lab. Finally, to get the results and submit them to the manufacturing team.

References

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