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Graduation Project

Solar hybrid Electric vehicle

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المخلص

إن تطور المركبات ذات محرك الاحتراق الداخلي وخاصة السيارات هي واحدة من أعظم إنجازات التكنولوجيا الحديثة حيث ساهمت السيارات في نمو المجتمع الحديث بشكل كبير من خلال تلبية العديد من احتياجاته من التنقل في الحياة اليومية.

ساهم التطور السريع في صناعة السيارات وعلى عكس أي صناعة أخرى في دفع تقدم المجتمع البشري من حياة بدائية إلى مجتمع صناعي متطور للغاية ومن ناحية أخرى تُشكل صناعة السيارات وغيرها من الصناعات العمود الفقري للاقتصاد كما ويساعد على توظيف نسبة كبيرة من القوى العاملة ومع ذلك تسبب استخدام عدد كبير من السيارات في جميع أنحاء العالم في مشاكل خطيرة على البيئة وحياة الإنسان وما زالت هذه المشاكل تشكل الشغل الشاغل للعالم في العقود الأخيرة مثل تلوث الهواء والاحتباس الحراري والاستنزاف السريع لموارد البترول وفي الآونة الأخيرة ، وبضغط من الحكومات تم التركيز في كافة البحوث وأنشطة التطوير المتعلقة في مجال النقل على تطوير وسيلة نقل ذات كفاءة عالية ونظيفة وآمنة وقد اقترحت السيارات الكهربائية. تم عرض السيارات الكهربائية الهجينة والسيارات التي تعمل بخلايا الوقود لتحل محل السيارات التقليدية في المستقبل القريب ونحن من خلال هذا البحث المنجز نعمل على وصف تصميم وتصنيع سيارة كهربائية أوتوماتيكية وتعمل على الطاقة الشمسية صُممت خصيصاً لذوي الاحتياجات الخاصة حيث لا تقتصر على هذه الميزة فقط، بل يمكن ان تستخدم لأغراض متعددة.

من هنا فأننا في هذا المشروع اتجهنا الى فكرة مركبة تعمل على الطاقة الشمسية تتسع لراكب واحد وهي عبارة عن مركبة مزودة بالواح شمسية على سطحها تقوم باستقبال اشعة الشمس وتحويلها الى طاقة كهربائية تمر هذه الطاقة خلال دوائر تحكم وبطاريات و تنظيم للتيار الكهربائي بما يناسب المحرك الذي يدير عجلات هذه المركبة ، وراعينا في تصميم هذه المركبة عدة امور منها خفة الوزن و المتانة و الاعتمادية في اختيار المواد المكونة لمثل هذه العربة و هذا المشروع قابل للتطوير و التعديل .

Abstract

The development of vehicles with internal combustion engine, especially automobiles, is one of the greatest achievements of modern technology. Automobiles have made great contributions to the growth of modern society by satisfying many of its needs for mobility in everyday life.

The rapid development of the automotive industry, unlike any other industry, has prompted the progress of human society from a primitive life to a highly developed industrial society. The automotive industry and the other industries are the backbone of the world's economy as it employs the greatest share of the working population. However, the large number of automobiles in use around the world has caused and continues to cause serious problems for the environment and human life. Air pollution, global warming, and the rapid depletion of the Earth's petroleum resources, these problems are now problems of paramount concern. In recent decades, most governments are focusing on researches and developed activities related to transportation. The researches have emphasized on producing high efficiency, clean, and safe transportation, like the Electric vehicles .

From here, we are discussing in this project the concept of a solar car that can accommodate a single passenger. This vehicle is equipped with solar panels on the top of it in order to let the energy from the sun enter and then transfer it to an electric energy that passes through energy control circuits, batteries to regulate the electric to suit the engine that manages the wheels of this vehicle. We believe in this design of this vehicle for several reasons, first light weight, durability and reliability in the selection of materials.

1.1 Introduction

The development of internal combustion engine vehicles, especially automobiles, is one of the greatest achievements of modern technology. Automobiles have made great contributions to the growth of modern society by satisfying many of its needs for mobility in everyday life. The rapid development of the automotive industry, unlike that of any other industry, has prompted the progress of human society from a primitive one to a highly developed industrial society. The automotive industry and the other industries that serve it constitute the backbone of the world's economy and employ the greatest share of the working population. However, the large number of automobiles in use around the world has caused and continues to cause serious problems for the environment and human life. Air pollution, global warming, and the rapid depletion of the Earth's petroleum resources are now problems of paramount concern. In recent decades, the research and development activities related to transportation have emphasized the development of high efficiency, clean, and safe transportation. Electric vehicles, hybrid electric vehicles, and fuel cell vehicles have been typically proposed to replace conventional vehicles in the near future [1].

The first electric vehicle was built by Frenchman Gustave Trouvé in 1881. It was a tricycle powered by a 0.1 hp DC motor fed by lead-acid batteries. The whole vehicle and its driver weighed approximately 160 kg. A vehicle similar to this was built in 1883 by two British professors [2].

These early realizations did not attract much attention from the public because the technology was not mature enough to compete with horse carriages. Speeds of 15 km/h and a range of 16 km were not exciting for potential customers. The 1864 Paris to Rouen race changed it all: the 1135 km were run in 48 h and 53 min at an average speed of 23.3 km/h. This speed was by far superior to that possible with horse-drawn carriages. The general public became interested in horseless carriages or automobiles, as these vehicles were now called [2].

The following 20 years were an era during which electric vehicles competed with their gasoline counterparts. This was particularly true in America, where there were not many paved roads outside a few cities. The limited range of electric vehicles was not a problem. However, in Europe, the rapidly increasing number of paved roads called for extended ranges, thus favoring gasoline vehicles [2].

The first commercial electric vehicle was Morris and Salom's Electroboat this vehicle was operated as a taxi in New York City. The Electroboat proved to be more profitable than horse cabs despite a higher purchase price (around \$3000 vs. \$1200). It could be used for three shifts of 4 h with 90-min recharging periods in between. It was powered by two 1.5 hp motors that allowed a maximum speed of 32 km/h and a 40-km range [2].

The most significant technical advance of that era was the invention of regenerative braking by Frenchman M.A. Darracq on his 1897 coupe. This method allows recuperating the vehicle's kinetic energy while braking and recharging the batteries, which greatly enhances the driving range. It is one of the most significant contributions to electric and hybrid electric vehicle technology as it contributes to energy efficiency more than anything else in urban driving. In addition, among the most significant electric vehicles of that era was the first vehicle ever to reach 100 km/h. It was "La Jamais Contente" built by Frenchman Camille Jenatzy. Note that Studebaker and Oldsmobile first started in business by building electric vehicles. As gasoline automobiles became more powerful, more flexible, and, above all, easier to handle, electric vehicles started to disappear. The last commercially significant electric vehicles were released around 1905. During nearly 60 years, the only electric vehicles sold were common golf carts and delivery vehicles [3].

In 1945, three researchers at Bell Laboratories invented a device that was meant to revolutionize the world of electronics and electricity. It quickly replaced vacuum tubes for signal electronics and soon the thyristor was invented, which allowed switching high currents at high voltages. This made it possible to regulate the power fed to an electric motor without the very inefficient rheostats, and allowed the running of AC motors at variable frequency. In 1966, General Motors (GM) built the Electrovan, which was propelled by induction motors that were fed by inverters built with thyristors [3].

The most significant electric vehicle of that era was the Lunar Roving Vehicle, which the Apollo astronauts used on the Moon. The vehicle itself weighed 209 kg and could carry a payload of 490 kg. The range was around 65 km. The design of this extraterrestrial vehicle,

however, has very little significance down on Earth. The absence of air and the lower gravity on the Moon, and the low speed made it easier for engineers to reach an extended range with limited technology [3].

During the 1960s and 1970s, concerns about the environment triggered some research on electric vehicles. However, despite advances in battery technology and power electronics, their range and performance were still obstacles [3].

The modern electric vehicle era culminated during the 1980s and early 1990s with the release of a few realistic vehicles by firms such as GM with the EV1 and PSA with the 106 Electric. Although these vehicles represented a real achievement, especially when compared with early realizations, it became clear during the early 1990s that electric automobiles could never compete with gasoline automobiles for range and performance. The reason is that in batteries the energy is stored in the metal of electrodes, which weigh far more than gasoline for the same energy content. The automotive industry abandoned the electric vehicle to conduct research on hybrid electric vehicles. After a few years of development, these are far closer to the assembly line for mass production than electric vehicles have ever been [3].

In the context of the development of the electric vehicle, it is battery technology that is the weakest. Blocking the way of electric vehicles to market. Great effort and investment have been put into battery research, with the intention of improving performance to meet the electric vehicle's requirement [4].

Unfortunately, progress has been very limited. Performance is far behind the requirement, especially energy storage capacity per unit weight and volume. This poor energy storage capability of batteries limits electric vehicles only to some specific applications, such as at airports and railroad stations, on mail delivery routes, and on golf courses, etc. In fact, basic study shows that electric vehicles will never be able to challenge liquid fueled vehicles even with the optimistic value of battery energy capacity [4].

1.2 Air pollution

The combustion of Hydrocarbon fuel in combustion engines is never ideal. Besides Carbon dioxide and water, the combustion products contain a certain amount of Nitrogen Oxides (NO_x), Carbon monoxides (CO), and unburned Hydrocarbons (HC), all of which are toxic to human health [4].

The effect of pollutants (NO_x) on the human body, animals and environment is illustrated in Fig 1.

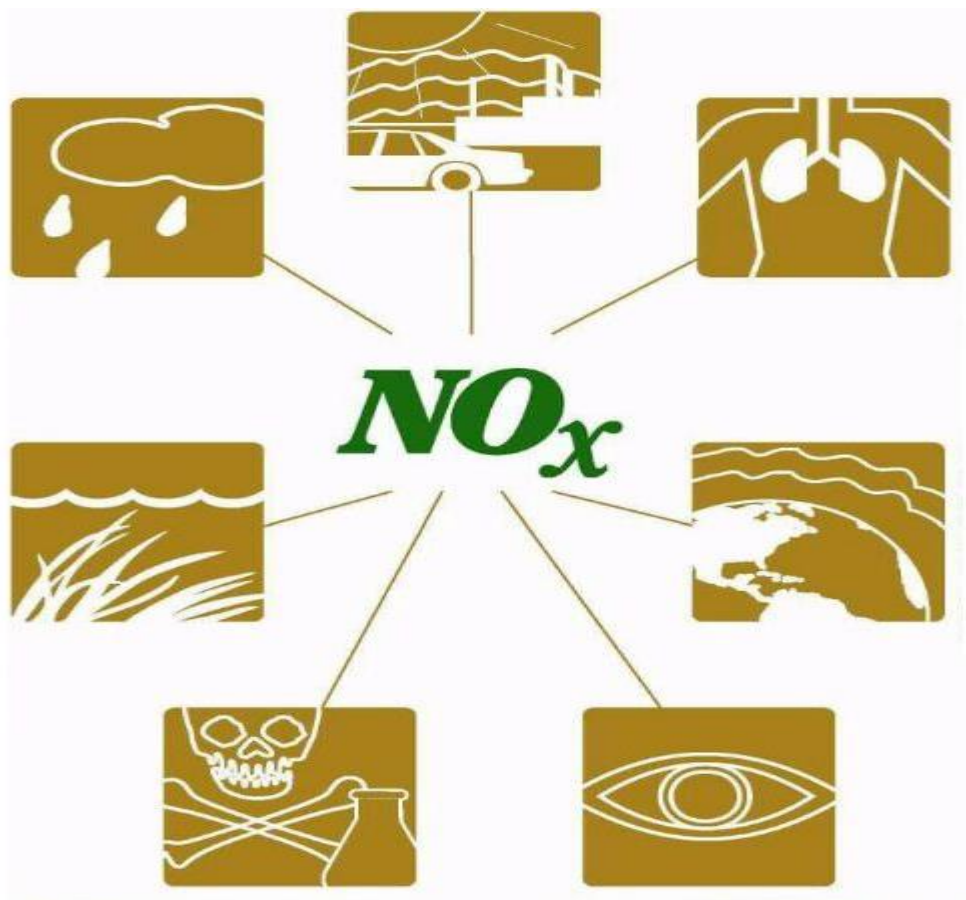


Figure 1: Air pollution and effect of (NO_x)

1.3 Why emissions?

Nitrogen Oxides (NO_x) result from the reaction between Nitrogen in the air and Oxygen. Theoretically, Nitrogen is an inert gas. However, the high temperatures and pressures in engines create favorable conditions for the formation of Nitrogen Oxides. Temperature is by far the most important parameter in Nitrogen Oxide formation. The most commonly found Nitrogen Oxide is Nitric Oxide (NO), although small amounts of Nitrogen dioxide (NO₂) and traces of Nitrous Oxide (N₂O) are also present. Once released into the atmosphere, (NO) reacts with Oxygen to form (NO₂). This is later decomposed by the Sun's ultraviolet radiation back to (NO) and highly reactive Oxygen atoms that attack the membranes of living cells. Nitrogen dioxide is partly responsible for smog; its brownish color makes smog visible. It also reacts with atmospheric water to form Nitric Acid (HNO₃), which dilutes in rain. This phenomenon is referred to as "Acid Rain" and is responsible for the destruction of forests in industrialized countries. Acid Rain also contributes to the degradation of historical monuments made of marble [5].

The impact of pollutants on the climate and be Acid Rain and environment as indicated in Fig 2.

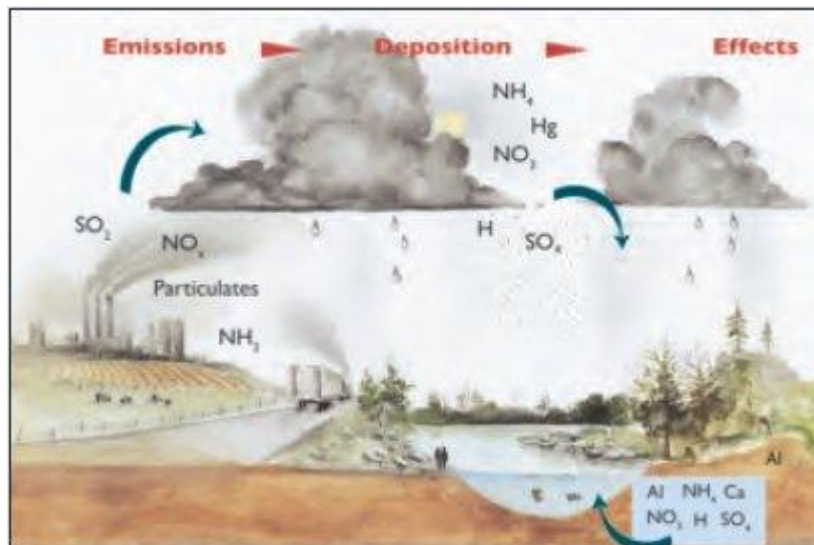


Figure 2: Acid Rain and effect of (NO_x, SO₂)

figure (3) shows the statistics on the sources of production of oxides of nitrogen in the environment:

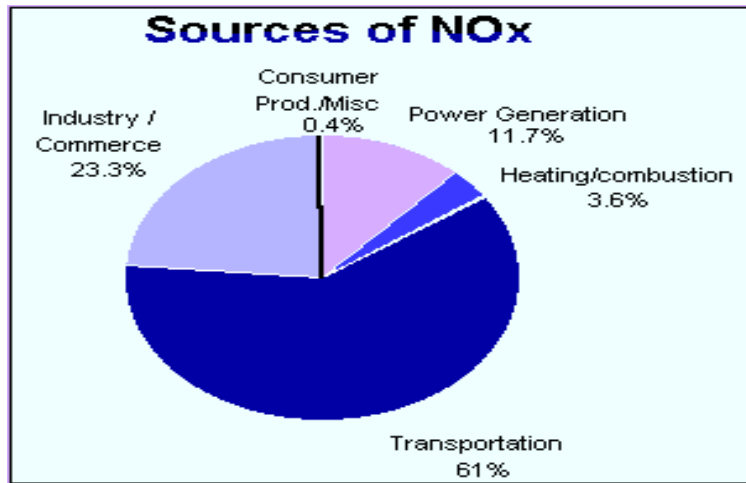


Figure 3: Statistics on production sources of(NO_x) in the environment [3].

1.4 Carbon Monoxide

figure 4 shows the graph of the combustion process and the results of ratios and combustion pollutants [6].

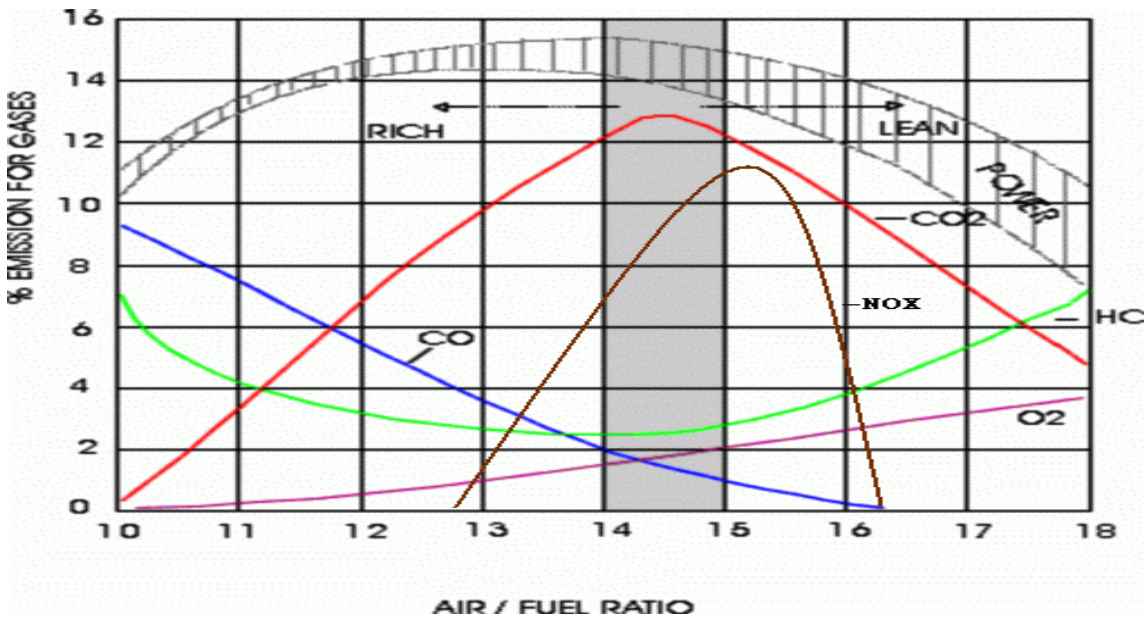


Figure 4: indicating graph of combustion output and internal combustion scheme
Chemical equation for combustion[6].

Carbon monoxide results from the incomplete combustion of hydrocarbons due to a lack of Oxygen. It is a poison to human and animal beings that breathe it. Once Carbon monoxide reaches the blood cells, it fixes to the hemoglobin in place of Oxygen, thus diminishing the quantity of Oxygen that reaches the organs and reducing the physical and mental abilities of affected living beings. Dizziness is the first symptom of Carbon monoxide poisoning, which can rapidly lead to death. Persons intoxicated by carbon monoxide must be treated in pressurized chambers, where the pressure makes the carbon monoxide–hemoglobin bonds easier to break , figure (5) between dioxide emissions [5].

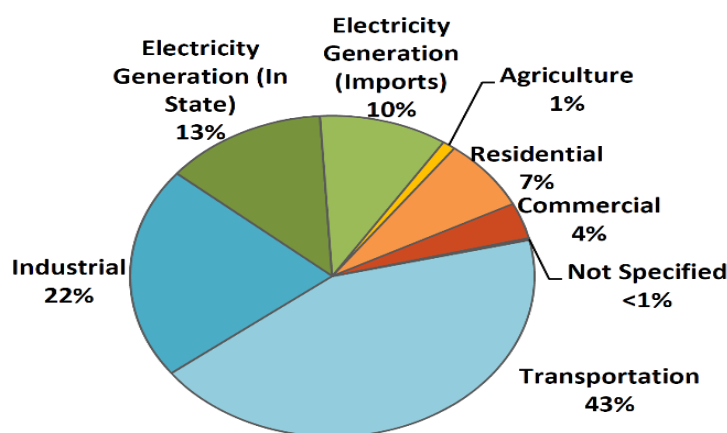


Figure 5: Carbon dioxide emission distribution [2] .

1.5 Other Pollutants

Impurities in fuels result in the emission of pollutants. The major impurity is sulfur, which is mostly found in diesel and jet fuel and also in gasoline and natural gas. The combustion of sulfur (or sulfur compounds such as hydrogen sulfide) with oxygen releases sulfur oxides (SO_x). Sulfur dioxide (SO_2) is the major product of this combustion. Upon contact with air, it forms sulfur trioxide, which later reacts with water to form sulfuric acid, a major component of acid rain. It should be noted that sulfur oxide emissions originate from transportation sources, but also largely from the combustion of coal in power plants and steel factories. In addition, there is debate over the exact contribution of natural sources such as volcanoes. Petroleum companies add chemical compounds to their fuels in order to improve the performance or lifetime of engines [1].

Tetraethyl lead, often referred to simply as “lead,” was used to improve the knock resistance of gasoline and therefore allow for better engine performance. However, the combustion of this chemical releases lead metal, which is responsible for a neurological disease called “saturnism.” Its use is now forbidden in most developed countries and it has been replaced by other chemicals [1].

Green house gas emission is distressing worldwide as in 2013 the transport sector contribution to emission globally is 21.9% .Transport sector plays almost role in world wide emission so it’s become of everybody major objective to control emission from vehicle because it’s leading towards global warming, health hazards and several many other troubles [3] .

One of the best surrogate to reduce emission is electric and hybrid vehicles, these vehicle customarily have low or zero emissions as compared to conventional vehicles and many countries encouraging the use of a hybrid electric .

Hybrid electric vehicle is more or less twice as high as the efficiency of a conventional petrol internal combustion engine . The average emission from a conventional vehicle is about 191gm/km which is very high as compared to hybrid electric . It is clearly seen that hybrid vehicle has less emission as compared to conventional vehicle that why these vehicle are the best alternative to diminish Carbon emissions, see figure (6) [6].

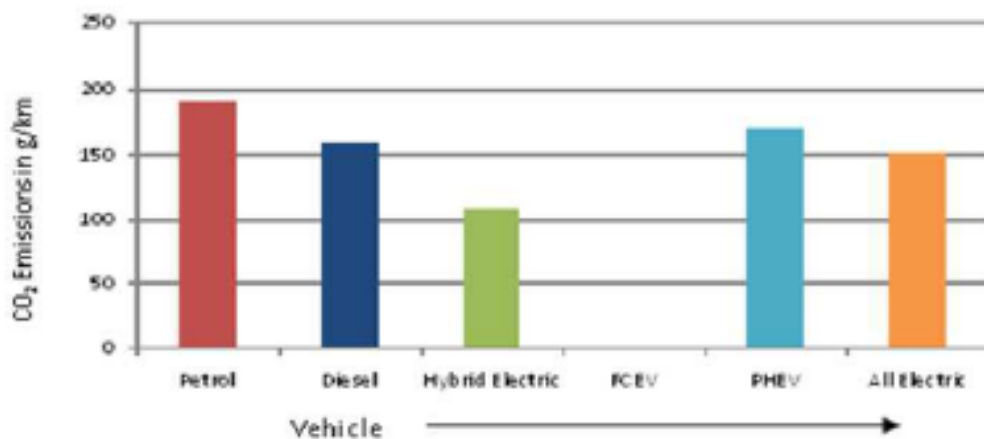


Figure 6: Comparison of (CO₂) Emission of Different Fuel Using in Vehicle

The appraisal of all electric vehicle emission is on the basis of well-to-wheel emissions there are also tail pipe emission from electric vehicle but over all emissions is lower as compare to conventional vehicle. Distinctly hybrid vehicle has less emission as compare to petrol or diesel

operated vehicle so there is almost requirement of adopting hybrid vehicle to reduce carbon footprint globally [7].

1.6 Fossil fuels and solar vehicles

The increase in the demand for fossil fuels has become a major factor in the high price and thus the increase in prices, and as previously stated in the use of such species working on the increase in pollution and threatens to increase the Ozone hole and global warming, so it was necessary to find alternative ways to get renewable energy and working to reduce dependence on fossil fuels and reduce pollution of the ways in which frequent use in the last decade are hybrid vehicles as it works to reduce fuel consumption, whether gasoline or diesel fuel at rates ranging between 35% and 45% so it has become a different research work on innovative and new in production methods solar cars are considered where these cars are the future cars they are working to reduce the emission of harmful gases ratios and reduce reliance on fossil fuels[6].

1.7 Research Goal

- The long-term goal to reduce global warming .
- Exploitation of alternative energy..

1.8 Research Methodology :

The Search is about the causes of pollution

We have Conducted a questionnaire on the use of hybrid cars and the people's ability to use them.

To introduce the advantages of solar energy vehicles and their impact on the environment

1.9 The importance of the project

The Fossil fuels(Gasoline Petrol Gasoline) is polluting the environment. It pollutes the waterways (rivers and seas) and the groundwater. It also affect the ozone layer and causes global warming so we were thinking to take advantage of renewable and clean energy and use the solar energy for the vehicle. Our project idea is to build Hybrid vehicle that operate on electric energy with the help of solar cells..

1. 10 Time Table :

Search that this requires a different period of time, but can be judged through the time period set forth
PHP Nine-week take the search process that was the following table:

1.11. Cost :

The cost of the project was approximately \$ 3500 according to the following table:

Table 2 the cost of project

Number	Statement	Cost
1	A research study on the radiation laboratory in Palestine (Energy and voltages account) by installing a solar cell on the top of the vehicle that was moved in Hebron .	\$500
2	An electric motor	\$400
3	Parts to build a vehicle chassis	\$1000
4	Coating materials	\$300
5	Lighting parts (lamps and controls) -	\$300
6	Solar cells	\$500
7	Batteries & Charging Adapter	\$500
	Total	\$3500

Chapter Two

2.1 Introduction.

2.2 Hybrid Vehicles and solar power.

2.3 Solar Vehicles.

2.4 The advantages and disadvantages of Hybrid Vehicles .

2.4.1 Advantages.

2.4.2 Disadvantages.

2.1 Introduction

Many companies have used electric motors instead of internal combustion engines due to environmental pollution and the phenomenon of global warming. Moreover, Many conferences have been held to study the pollution and global warming, in order to look for quick solutions to solve these problems as they have great impact on the safety of citizens. [8].

2.2 Hybrid Vehicles and solar power

After conducting a study on radiation projection in the Hebron by installing a solar cell. This vehicle traveled all Hebron govern orate for a week in different times to measure the radiation project coefficient and the amount of voltages and amperes. We found that the ability resulting from the use of the solar cell is relatively small and need more solar cells that is bigger than the .vehicle. As a conclusion, we use the electric charging system as another source of power

2.3 Solar Vehicles

Solar cars have been developed in the last twenty years and are powered by energy from the sun. Although they are not a practical or economic form of transportation at present, in the future they may play a part in reducing our reliance on burning fossil fuels such as petrol and diesel [8].

These Vehicles are expensive to produce and usually have one seat or two. The main cost is due to the large number of expensive and delicate photovoltaic solar panels that are needed to power the vehicle. Also, many of the solar powered cars used in races today are composed of expensive, lightweight materials such as titanium composites. These materials are normally used to manufacture fighter jets. Carbon fiber and fiber glass are also used for much of the bodywork. Most of the cars used in races are hand made by specialist teams and this adds to the expense [9].

A solar powered vehicle can only run efficiently when the sun shines, although most vehicles of this type have a battery backup. Electricity is stored in the batteries when the sun is shining and this power can be used when sun light is restricted (cloudy). The batteries are normally nickel-metal hydride batteries (NiMH), Nickel-Cadmium batteries (NiCd), Lithium ion batteries or

Lithium polymer batteries. Common lead acid batteries of the type used in the average family car are too heavy. Solar powered cars normally operate in a range of 80 to 170 volts. To reduce friction with the ground the wheels are extremely narrow and there are usually only three [9].

Some solar powered cars are practical as one the shown in Figure (7). This is a solar powered golf cart and it can be used in sunny climates to carry golfers from one hole to the next. When it is standing still the solar panels charge up the batteries and it is the batteries that power the electric motors, directly. As the vehicle is not in continuous use the batteries have time to charge up before they are needed [9].



Figure 7: The solar energy plant using in vehicle

One of the more realistic ways in which that solar powered cars could become practical is to charge up their batteries when they are parked, during the day. Imagine driving the short distance to work and plugging the car into a set of photovoltaic solar panels. Whilst you are working the batteries charge up ready for use for the journey home. The same procedure could be carried out when the car is parked at home. A combination of solar power and wind power may prove to be a method of charging the batteries of 'electric cars, The figure(8) shows how to generate solar power [9].

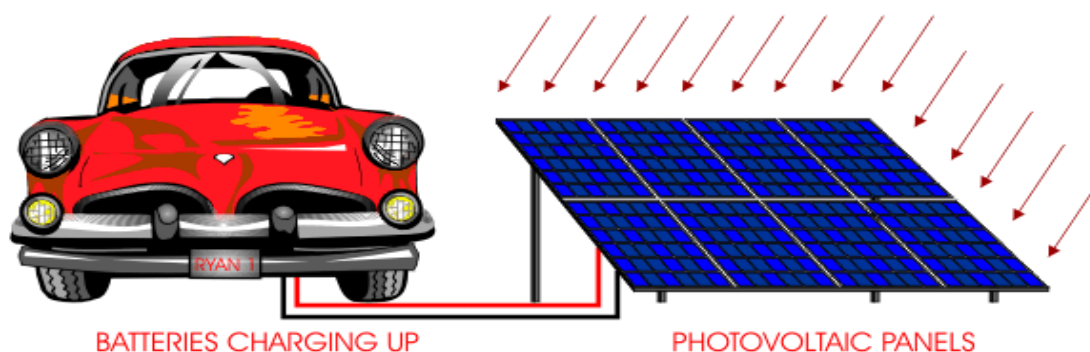


Figure 8: The Electric Car

2.4 The advantages and disadvantages of Hybrid solar Vehicles

2.4.1 Advantages

An electric car is a great way for you, as a consumer, to save a lot of money on gas. However, there are so many different reasons why you should invest in an electric car in the modern day of technology [8].

1. **No Gas Required:** Electric cars are entirely charged by the electricity you provide, meaning you don't need to buy any gas ever again. Driving fuel based cars can burn a hole in your pocket as prices of fuel have gone all time high. With electric cars, this cost can be avoided as an average American spends \$2000 – \$4000 on gas each year. Though electricity isn't free, an electric car is far cheaper to run [9].
2. **Savings:** These cars can be fuelled for very cheap prices, and many new cars will offer great incentives for you to get money back from the government for going green. Electric cars can also be a great way to save money in your own life [9].
3. **No Emissions:** Electric cars are 100 percent eco-friendly as they run on electrically powered engines. It does not emit toxic gases or smoke in the environment as it runs on clean energy source. They are even better than hybrid cars as hybrids running on gas produce emissions. You'll be contributing to a healthy and green climate [9].
4. **Popularity:** EV's are growing in popularity. With popularity comes all new types of cars being put on the market that are each unique, providing you with a wealth of choices moving forward [9].
5. **Safe to Drive:** Electric cars undergo same fitness and testing procedures test as other fuel powered cars. In case an accident occurs, one can expect airbags to open up and electricity supply to cut from battery. This can prevent you and other passengers in the car from serious injuries [9].
6. **Cost Effective:** Earlier, owning an electric car would cost a bomb. But with more technological advancements, both cost and maintenance have gone down. The mass production of batteries and available tax incentives have further brought down the cost, thus, making it much more cost effective [9].
7. **Low Maintenance:** Electric cars runs on electrically powered engines and hence there is no need to lubricate the engines. Other expensive engine work is a thing of past. Therefore, the maintenance cost of these cars has come down. You don't need to send it to service station often as you do with normal gasoline powered car [9].

8. **Reduced Noise Pollution:** Electric cars put curb on noise pollution as they are much quieter. Electric motors are capable of providing smooth drive with higher acceleration over longer distances [9].

Many owners of electric cars have reported positive savings of up to tens of thousands of dollars a year. Considering the demand for oil will only be going up as the supplies run out, an electric car will most likely be the normal mode of transportation in the coming future. Companies like Nissan and Tesla offer great electric models with an outstanding amount of benefits for people who decide to invest. You'll be saving not only yourself, but also your family a huge amount of money. The impact of an electric car is zero, as well meaning you are reducing your carbon footprint and positively affecting the economy [9].

2.4.2 Disadvantages

Although the evidence of the positives has become very clear, there are also some downsides that each individual needs to consider before they decide to make an electric car their next big investment. These reasons are:

1. **Recharge Points:** Electric fuelling stations are still in the development stages. Not a lot of places you go to on a daily basis will have electric fuelling stations for your vehicle, meaning that if you're on a long trip and run out of a charge, you may be stuck where you are [9].
2. **Electricity isn't Free:** Electric cars can also be a hassle on your energy bill if you're not considering the options carefully. If you haven't done your research into the electric car you want to purchase, then you may be making an unwise investment. Sometimes electric cars require a huge charge in order to function properly – which may reflect poorly on your electricity bill each month [9].
3. **Short Driving Range and Speed:** Electric cars are limited by range and speed. Most of these cars have range about 50-100 miles and need to be recharged again. You just can't use them for long journeys as of now, although it is expected to improve in future [10].
4. **Longer Recharge Time:** While it takes couple of minutes to fuel your gasoline powered car, an electric car take about 4-6 hours to get fully charged. Therefore, you need dedicated power stations as the time taken to recharge them is quite long [10].

5. Silence as Disadvantage: Silence can be a bit disadvantage as people like to hear noise if they are coming from behind them. An electric car is however silent and can lead to accidents in some cases [10].
6. Normally 2 Seaters: Most of the electric cars available today are small and 2 seated only. They are not meant for entire family and a third person can make journey for other two passengers bit uncomfortable [10].
7. Battery Replacement: Depending on the type and usage of battery, batteries of almost all electric cars are required to be changed every 3-10 years [9].
8. Not Suitable for Cities Facing Shortage of Power: As electric cars need power to charge up, cities already facing acute power shortage are not suitable for electric cars. The consumption of more power would hamper their daily power needs [10].
9. Some governments do not provide money saving initiatives in order to encourage you to buy an electric car [10].
10. Some base models of electric cars are still very expensive because of how new they are and the technology it took to develop them [10].

Chapter Three

Hybrid Solar vehicle components

- **The Main Components of an Electric Vehicle The electric vehicle drive system includes:**

3.1 Chassis and body

3.2 Steering

3.3 Solar panels

3.4 Transmission including the differential

3.5 Electric motor/generator with electronic control (power electronics) [10].

3.6 High-voltage battery with control unit for battery regulation and charger

3.7 Brake system

3.8 Tire

3.1 Chassis and body

The automotive chassis is tasked with holding all the components together while driving and transferring vertical and lateral loads caused by accelerations on the chassis through the wheels.

The Automotive chassis has two main goals :

- 1- Hold the weight of the components.
- 2- To rigidly fix the components together when moving.

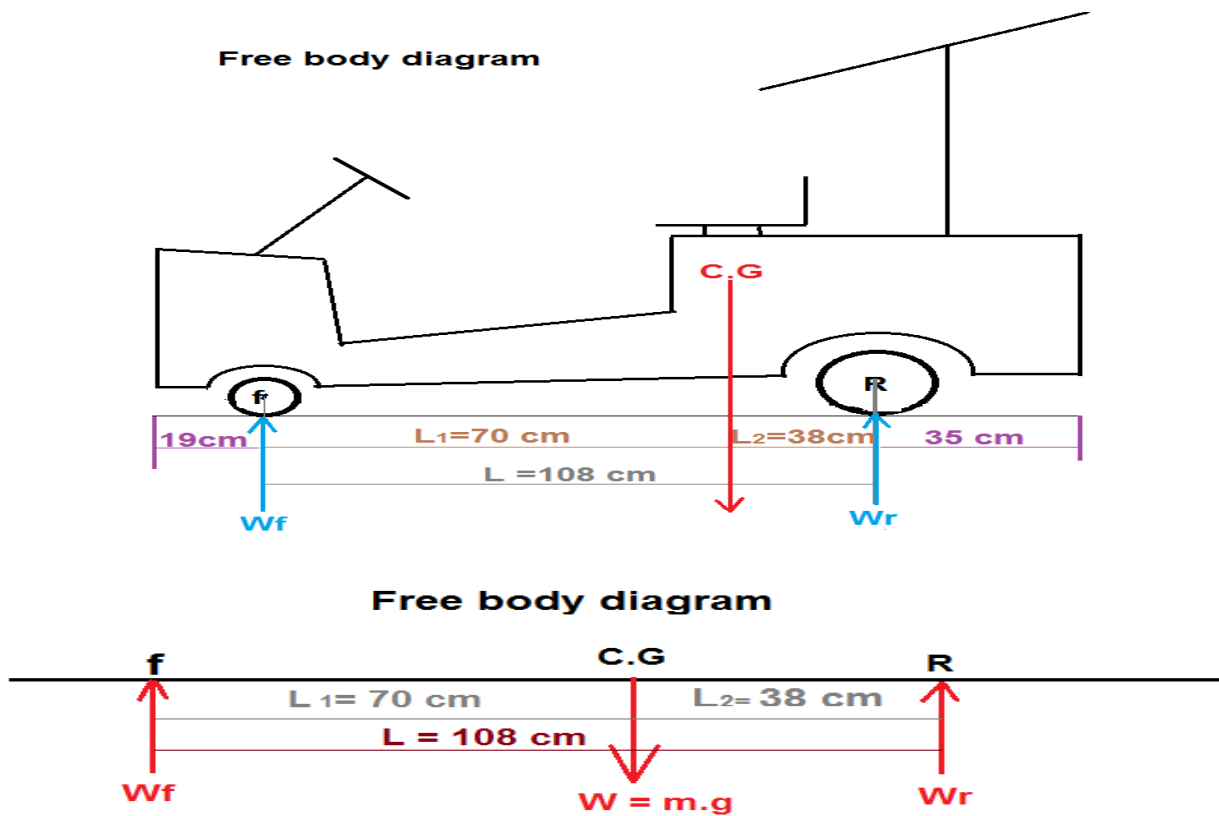
There are many types of chassis used in vehicles

- Unibody
- Ladder frame

We used unibody frame in our design because the unibody is lighter weight and more rigid wheel body resists flexing , figure (9) .



figure (9): unibody frame



● $m = 171 \text{ kg}$ $L = 162 \text{ cm}$ $L_1 = 70 \text{ cm}$ $L_2 = 38 \text{ cm}$

* $\sum M_f = 0$

$$W_r * 1.08 - W * 0.7 = 0$$

$$W_r = (W * 0.7) / 1.08 = (171 * 9.81 * 0.7) / 1.08 = 1087.275 \text{ N}$$

$$W_r = 1087.275 \text{ N}$$

* $\sum F_y = 0$

$$W_f + W_r - W = 0$$

$$W_f = W - W_r = 171 * 9.81 - 1087.275 = 590.235 \text{ N}$$

$$W_f = 590.235 \text{ N}$$



Figure 10: design frame

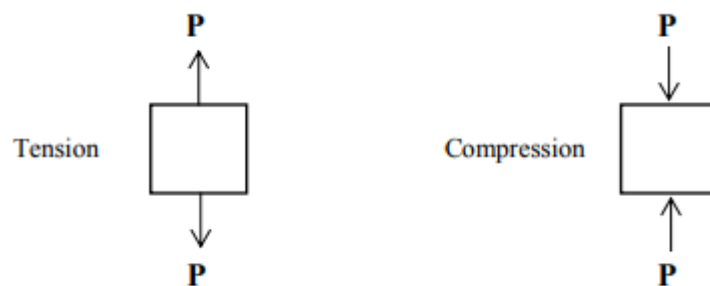
Normal Stress: is the stress normal to the section, and could be tension or compression stress

$$\sigma = p/A \text{ Where:}$$

σ : Normal stress

P: Applied load

A: Cross sectional area



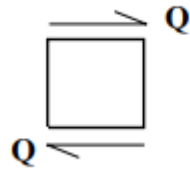
Shear stress : Is the tangential stress.

$$\tau = Q/A \text{ Where:}$$

τ : Shear stress.

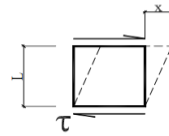
Q : Shearing (tangential) force.

A : Cross-sectional area.



Shear strain

Is the ratio between the change in length in lateral direction to the original length.



Shear Strain = Deformation/ Couple arm

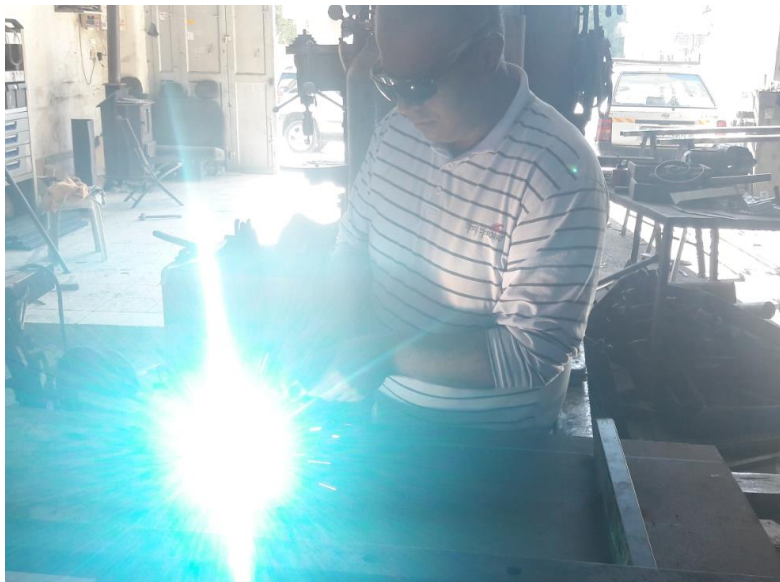


Figure 11: design frame



Figure 12: design frame

3.2 Steering

Steering system: It is the system which provides directional change in the performance of an automobile. This system converts rotary movement of the steering wheel into angular movement of the front wheels. It multiplies driver's effort by mechanical advantage, enabling him to turn the wheels easily

Steering system requirements and functions

For proper and smooth operation and performance of the system, the steering system of any vehicle should fulfill the following requirements:

1. It should multiply the turning effort applied on the steering wheel by the driver.
2. It should be to a certain extent irreversible. In other words, the shocks of the road surface encountered by the wheels should not be transmitted to the driver's hands

.3. The mechanism should have self-rightening effect i.e., when the driver releases the steering wheel after negotiating the turn, the wheel should try to achieve straight-ahead position. Functions of the steering system are as follows:

- a) It helps in swinging the wheels to the left or right.
- b) It helps in turning the vehicle at the will of the driver.
- c) It provides directional stability.
- d) It helps in controlling wear and tear of tyres.
- e) It helps in achieving the self-rightening effect.
- f) It converts the rotary movement of the steering wheel into an angular turn of the front wheels.
- g) It multiplies the effort of the driver by leverage in order to make it fairly easy to turn the wheels.

- h) It absorbs a major part of the road shocks thereby preventing them to get transmitted to the hands of the driver.

Rack and pinion steering mechanism

It is very simple and common type mechanism Figure (13), the system is shown in simplified sketch .This type is very well suitable in an independent suspension system. The system consists of a rack housed in a tubular casing. The casing is supported on the frame near its ends. The ends of the rack are connected to the track rods with the help of ball and socket joints. The pinion shaft is carried in the plain bearings housed in casing. The pinion is meshed with the rack and the clearance is adjusted with the adjusting screw. When the pinion is given rotary motion with the steering wheel, then the rack slides in either sides. This sliding motion of the rack is used through the track rods to turn the wheels in desired side.



Figure 15: steering system



Figure 16: steering system



Figure 17: steering system

3.3 Solar panels

Solar cells come in various sizes. Some are tinier than a stamp. Some are 5 inches (12 centimeters) across. The cells are made of a type of material known as a semiconductor. Often, they are made of silicon. Semiconductors can conduct, or carry, electricity. They don't do this as well as metals, however. That is why they are called "semi." Because they only "semi" conduct electricity, they can be used to control electric current. On their top and bottom they typically have metal contacts through which current can flow. A typical simple cell has two layers of silicon. One is known as n-type. The other is p-type. The layers are different from each other.

How Solar Cells Make Electricity ?

The process of making electricity begins when the silicon atoms absorb some light. The light's energy knocks some electrons out of the atoms. The electrons flow between the two layers. The current can leave the cell through the metal contacts and be used. When light hits a solar cell, much of its energy is wasted. Some light bounces off or passes through the cell. Some is turned into heat. Only light with the right wavelengths, or colors, is absorbed and then turned into electricity. , figure (11)

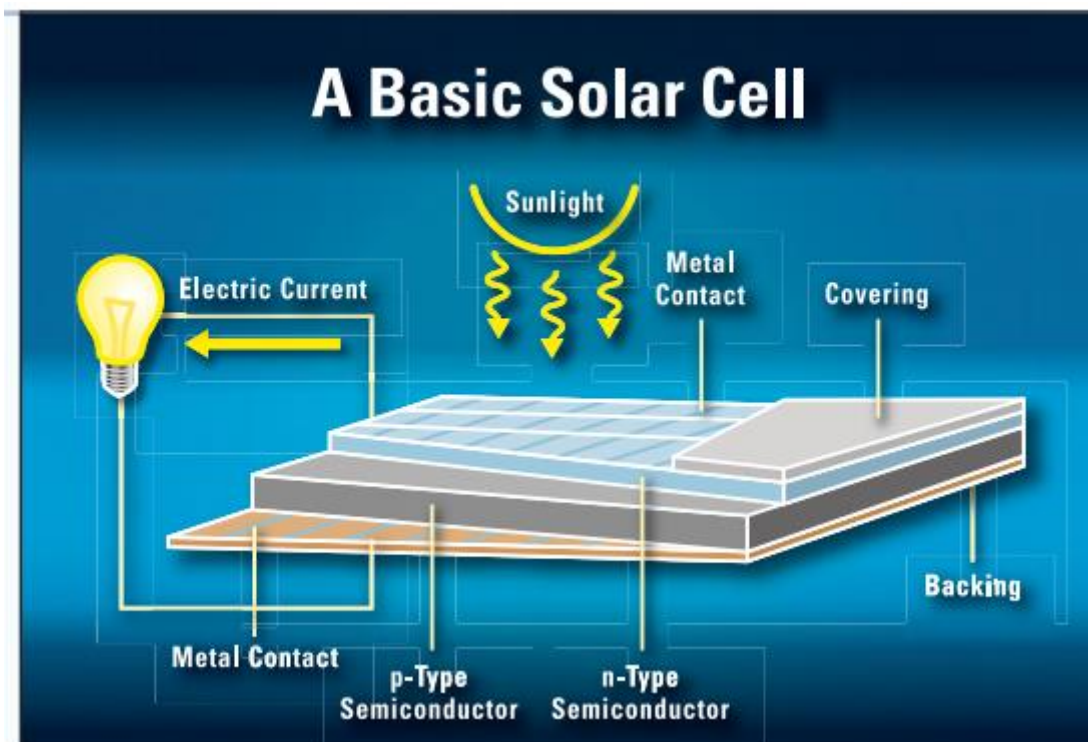


Figure 18: solar panels using in the vehicles

Installing PV System

Hebron is situated at {31°.4” latitude and 35°.1” longitudes}. Daily average solar radiation varies between (2.83 to 7.5) kWh per square meter. Maximum amount of radiation is available on the month of June -July and minimum on December-January. Monthly global solar insolation and daily average bright sunshine hour in Hebron city are presented in the table 2 these values are a 22-year ago Average solar insolation from the PV system software.

Table 3: Monthly global solar insolation at Hebron

Month	Solar insolation (kwh/m2)
January	3.097
February	3.607
March	4.735
April	5.322
May	7.052
June	7.48
July	7.65
August	7.19

September	6.44
October	5.35
November	4.1
December	2.835
Total PSH/year	64.808
Average insolation	5.401 (KWh/m2)

Calculations Of Solar Panel

- Energy needed from p.v system to charge the batteries is 1680 Wh

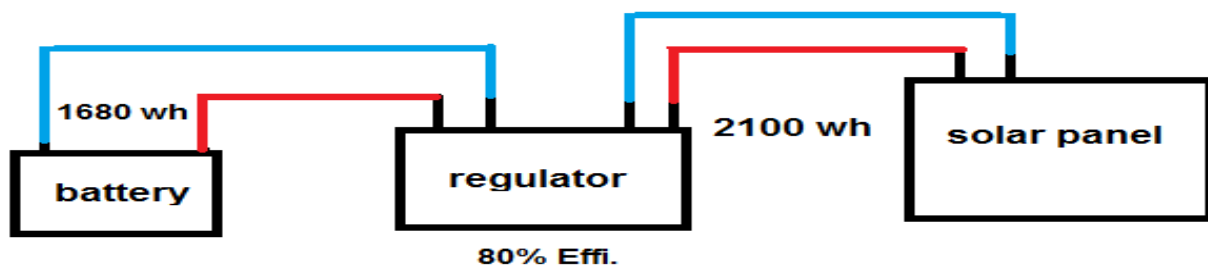
$$P = I \cdot V = 70 \cdot 24 = 1680 \text{ wh.}$$

- $P = \text{Power Battery} / \text{Efficiency Regulator}$

$$P = 1680 / 0.8 = 2100 \text{ Wh} \quad \text{Power of P.V}$$

- $E_{pv} = \text{Power (pv)} * t$

$$t = E / P = 2100 / 80 = 26.5 \text{ h}$$



3.4 Continuously Variable (Step less) Transmissions (CVT)

With growing socioeconomic and environmental concern, automobile energy consumption has become a key element in the current debate on global warming. Over the past few decades, vehicle fuel economy plays a crucial role in determining the emission of greenhouse gases from an automobile. There are three fundamental ways to reduce greenhouse gas emissions from the transportation sector[11].

(a) increase the energy efficiency of transportation vehicles,

(b) substitute energy sources that are low in carbon for carbon-intensive sources (i.e. the use of alternative fuel technologies),

(c) reduce transportation activity. With tremendous growth in consumerism and urbanization, there is little scope for emissions reduction to occur through a decrease in the amount of vehicle use. In order to achieve lower emissions and better performance, it is necessary to capture and understand the detailed dynamic interactions in a CVT system so that efficient controllers could be designed to overcome the existing losses and enhance the fuel economy of a vehicle[11].

The basic configuration of a CVT comprises two variable diameter pulleys kept at a fixed distance apart and connected by a power-transmitting device like belt or chain. The pulley on the engine side is called the driver pulley and the one on the final drive side is called the driven pulley. Figure (14) depict the basic layout of a metal V-belt CVT and a chain CVT. In a metal V-belt CVT, torque is transmitted from the driver to the driven pulley by the pushing action of belt elements. Since there is friction between bands and belt elements, the bands, like flat rubber belts, also participate in torque transmission. Hence, there is a combined push–pull action in the belt that enables torque transmission in a metal V-belt CVT system [11], Figure 19.

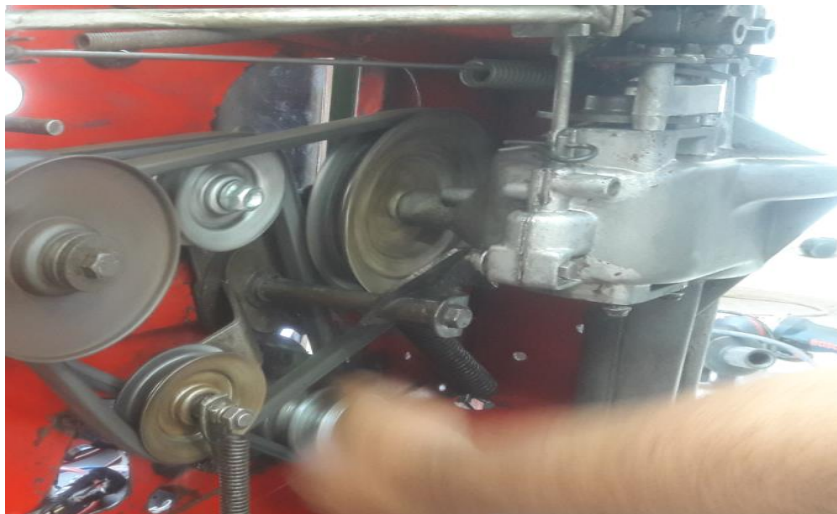


Figure 19: Transmissions (CVT)in the vehicles

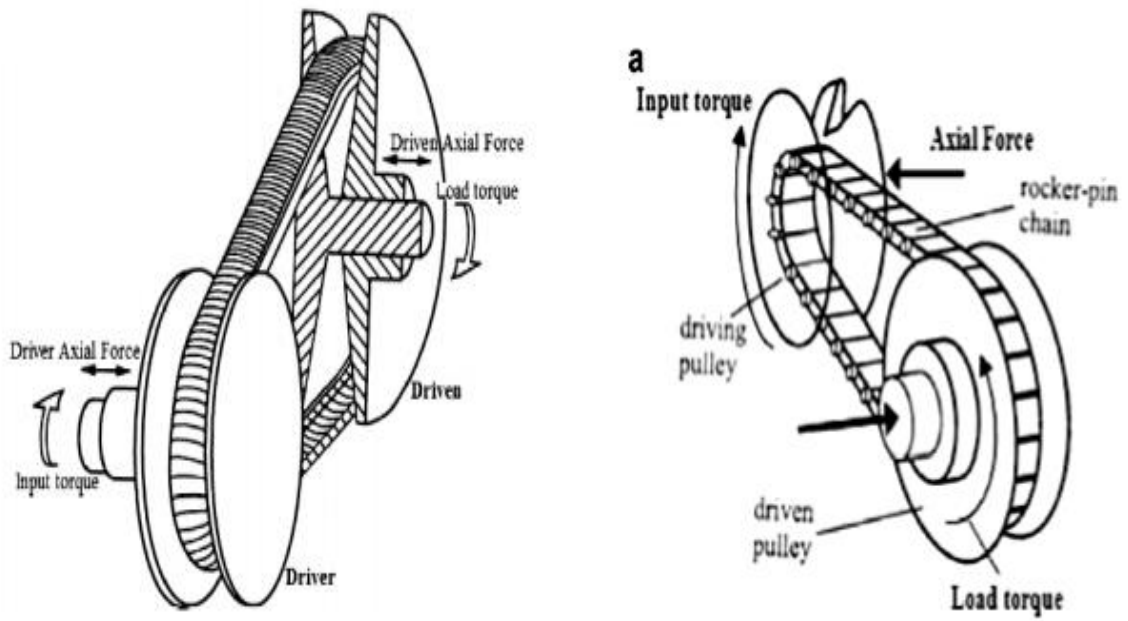


Figure 20: Transmissions (CVT)in the vehicles

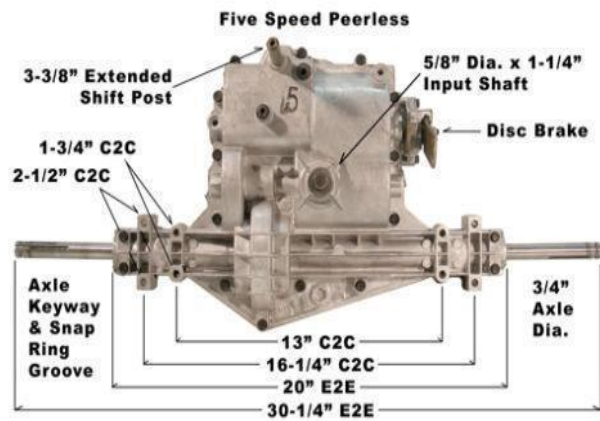


Figure 21: Transmissions (CVT)in the vehicles



Figure 22: Transmissions (CVT)in the vehicles

3.5 DC Motor

Almost every mechanical movement that we see around us is accomplished by an electric motor. Electric machines are a means of converting energy. Motors take electrical energy and produce mechanical energy. Electric motors are used to power hundreds of devices we use in everyday life. Motors come in various sizes. Huge motors that can take loads of 1000's of Horsepower are typically used in the industry. Some examples of large motor applications include elevators, electric trains, hoists, and heavy metal rolling mills. Examples of small motor applications include motors used in automobiles, robots, hand power tools and food blenders. Micro-machines are electric machines with parts the size of red blood cells, and find many applications in medicine. Electric motors are broadly classified into two different categories: DC (Direct Current) and AC (Alternating Current). Within these categories are numerous types, each offering unique abilities that suit them well for specific applications. In most cases, regardless of type, electric motors consist of a stator (stationary field) and a rotor (the rotating field or armature) and operate through the interaction of magnetic flux and electric current to produce rotational speed and torque, Figure (23).

DC motors are distinguished by their ability to operate from direct current. There are different kinds of D.C. motors, but they all work on the same principles.

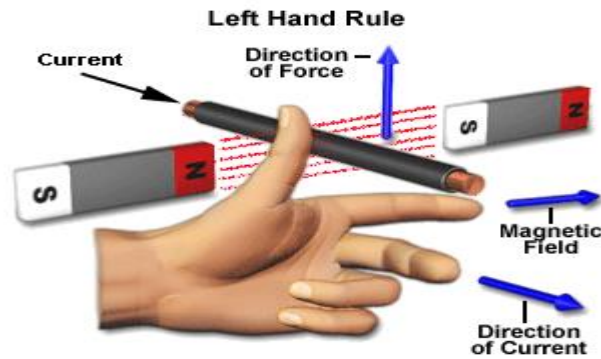


Figure 23: Principle of DC Motor in the vehicles

The direction of rotation of a this motor is given by Fleming’s left hand rule, which states that if the index finger, middle finger and thumb of your left hand are extended mutually perpendicular to each other and if the index finger represents the direction of magnetic field, middle finger indicates the direction of current, then the thumb represents the direction in which force is experienced by the shaft of the DC motor.

Structurally and construction wise a direct current motor is exactly similar to a DC generator, but electrically it is just the opposite. Here we unlike a generator we supply electrical energy to the input port and derive mechanical energy from the output port. We can represent it by the block diagram shown below [10]. The following figure(24) illustrates the conversion of electrical energy to mechanical.

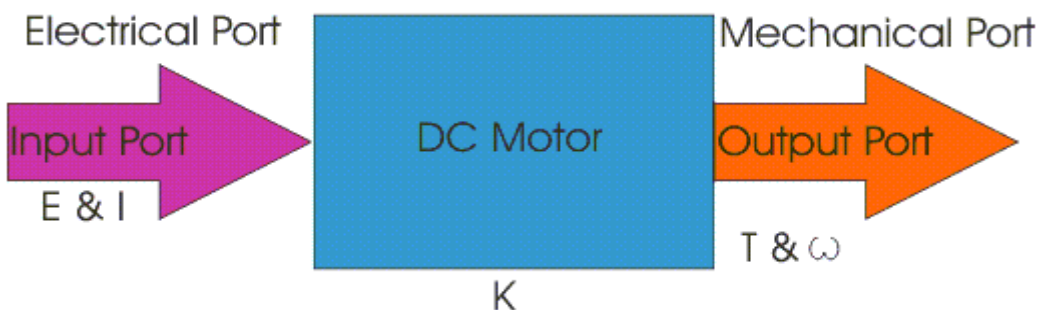


Figure 24: Block of DC Motor in the vehicles

Here in a DC motor, the supply voltage (E) and current (I) is given to the electrical port or the input port and we derive the mechanical output i.e. torque T and speed ω from the mechanical port or output port [10].

The input and output port variables of the direct current motor are related by the parameter K.

$$T = KI \text{ and } E = K\omega \dots \dots \dots (1-9)$$

So from the picture above we can well understand that motor is just the opposite phenomena of a DC generator, and we can derive both motoring and generating operation from the same machine by simply reversing the ports [10].

Detailed Description of a DC Motor

To understand the DC motor in details lets consider the diagram below, The following figure (25) illustrates the electrical circuit connected to the electric motor [10].

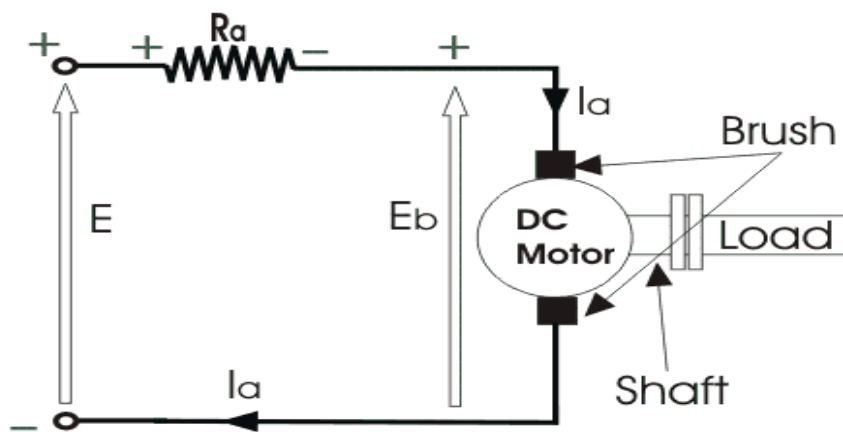


Figure 25: Detailed Description of a DC Motor

The direct current motor is represented by the circle in the center, on which is mounted the brushes, where we connect the external terminals, from where supply voltage is given. On the mechanical terminal we have a shaft coming out of the Motor, and connected to the armature, and the armature-shaft is coupled to the mechanical load. On the supply terminals we represent the armature resistance R_a in series. Now, let the input voltage E, is applied across the brushes. Electric current which flows through the rotor armature via brushes, in presence of the magnetic field, produces a torque(T_g). Due to this torque (T_g) the dc motor armature rotates. As the armature conductors are carrying currents and the armature rotates inside the stator magnetic field, it also produces an(Eemf E_b) in the manner very similar to that of a generator. The

generated(Emf E_b) is directed opposite to the supplied voltage and is known as the back(Emf), as it counters the forward voltage [10].

The back(Emf) like in case of a generator is represented by equations

Where, P = no of poles ϕ = flux per pole Z = No. of conductors A = No. of parallel paths and N is the speed of the DC Motor. So, from the above equation we can see(E_b) is proportional to speed 'N'. That is whenever a direct current motor rotates, it results in the generation of back (Emf). Now lets represent the rotor speed by ω in rad/sec.

So(E_b) is proportional to ω . So, when the speed of the motor is reduced by the application of load, (E_b) decreases. Thus the voltage difference between supply voltage and back (Emf increases that means($E - E_b$) increases. Due to this increased voltage difference, armature current will increase and therefore torque and hence speed increases. Thus a DC Motor is capable of maintaining the same speed under variable load. Now armature current I_a is represented by equations

$$I_a = (E - E_b) \div R_a \dots\dots\dots(3-9)$$

Now at starting, speed $\omega = 0$ so at starting $E_b = 0$.

$$I_a = (E) \div R_a \dots\dots\dots(4-9)$$

Now since the armature winding electrical resistance R_a is small, this motor has a very high starting current in the absence of back(Emf). As a result we need to use a starter for starting a DC Motor[10].

Now as the motor continues to rotate, the back Emf starts being generated and gradually the current decreases as the motor picks up speed.

Speed Regulation of DC Motor

On application of load the speed of a DC motor decreases gradually. This is not at all desirable. So the difference between no load and full load speed should be very less. The motor

capable of maintaining a nearly constant speed for varying load is said to have good speed regulation i.e the difference between no load and full load speed is quite less. The speed regulation of a permanent magnet DC motor is good ranging from 10 - 15% whereas for DC shunt motor it is somewhat less than 10 %. DC series motor has poor value of regulation. In case of compound DC motor for DC cumulative compound the speed regulation is around 25 % while differential compound has its excellent value of 5 % [10].

The speed regulation is defined as the change in speed from no load to full load, expressed as a fraction or percentage of full load speed. Therefore, as per definition per unit (p.u) speed regulation of DC motor is given as,

$$\text{Speed Regulation}_{pu} = \frac{N_{no\ load} - N_{full\ load}}{N_{full\ load}}$$

Similarly, percentage (%) speed regulation is given as,

$$\text{Speed Regulation}(\%) = \frac{N_{no\ load} - N_{full\ load}}{N_{full\ load}} \times 100\%$$

Where, ($N_{no\ load}$) = no load speed and ($N_{full\ load}$) = full load speed of DC motor. Therefore, Percent speed regulation = Per unit (p.u) speed regulation \times 100 %. A motor which has nearly constant speed at all load below full rated load, have good speed regulation [9].

The following figure(26) is an DC motor:



Figure 26: DC Motor

Here, N = speed of rotation in rpm. P = number of poles. A = number of parallel paths. Z = total no. conductors in armature.

Thus, speed of rotation $N = \frac{60A}{PZ} \times \frac{E}{\phi}$

$\Rightarrow N = \frac{E}{k\phi}$ Where $k = \frac{PZ}{60A}$ is a constant

Electric Motor (DC motor)

- An electric motor is a device using electrical energy to produce mechanical energy.
- An electric motor is the basic and the most important part of a solar car.
- It should work with optimal power and the efficiency should be high.
- It is used to drives the wheels.
- The motor controller adjusts the amount of energy that flows to the motor to correspond to the throttle.
- The motor uses that energy to drive the wheels.



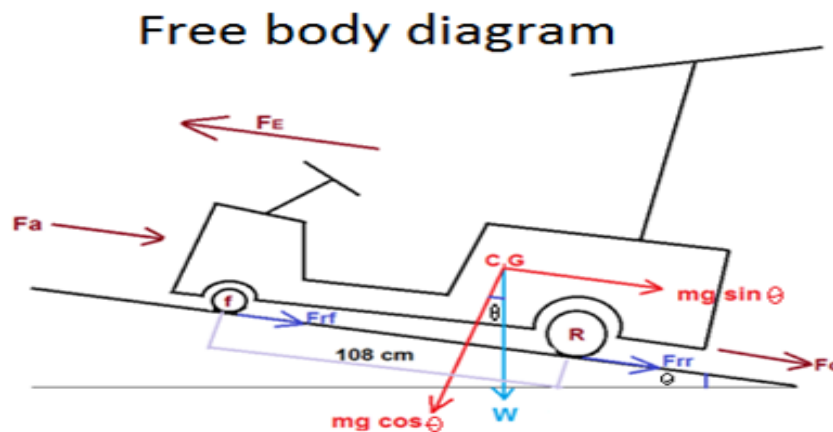
Figure 27: DC Motor

Electric Motor (DC motor) selection for an electric vehicle

- $\Sigma F = ma$

$$F_E - F_a - F_c - F_{ad} - F_r = ma$$

$$F_E = F_a + F_c + F_{ad} + F_r + ma$$



- Acceleration force

$$F_a = (1 + 0.05) \cdot m \cdot a$$

- Climbing force

$$F_c = m \cdot g \cdot \sin(\theta)$$

- Aerodynamic drag force

$$F_{ad} = (1 + C_w) \cdot (1/2 \cdot \rho \cdot A \cdot C_d \cdot v^2)$$

- Rolling resistance force

$$F_r = (C_r) \cdot (m \cdot g \cdot \cos \theta) = (0.012 \cdot (1 + v/100)) \cdot (m \cdot g \cdot \cos \theta)$$

where

- **F_a** (Acceleration force) is in (N).
- **F_c** (Climbing force) is in (N).
- **F_{ad}** is the aerodynamic drag force in (N).
- **F_r** is the rolling resistance in (N).
- **m** is the mass in (kg).
- **v** is the speed in (m/s).
- **a** is the acceleration in (m/s²).
- **g** is the acceleration due to gravity in (m/s²).
- **θ** is the angle of inline to the horizontal which is 12 degrees .
- **ρ** is the density of air in (kg/m³) taken here at (1.2 kg /m³).
- **A** is the effective area in (m²) , taken here as (2 m²) .
- **t** is the time in (sec).

- **C_w** is the relative wind factor at wind speed of 30 (km/h). (Dimensionless) taken here as (0.062) .
- **C_d** is the drag coefficient (dimensionless) taken here at 0.3.
- **C_r** is the coefficient of rolling resistance (dimensionless) and is speed dependent.

● **Acceleration force**

- **F_a = (1+ 0.05)·(m· a)**
- Where
- m = 171 kg
- V= 30km / h = 8.3 m/sec.
- t= (0-60) sec
- v_f = v₀ + at
- a = v_f / t = 8.3/60 = 0.13833 m/s².
- F_a = (1+0.05)* (171)*(0.13833) = 24.837 N

● **Climbing force**

$$F_c = m \cdot g \cdot \sin(\theta)$$

Where

- θ is the angle of inline to the horizontal which is 12 degrees.
- g=9.81 (m/s²)

$$F_c = m \cdot g \cdot \sin(\theta)$$

$$F_c = 171 * 9.81 * \sin(10)$$

$$F_c = 171 * 9.81 * 0.1736$$

$$F_c = 291.215 \text{ N}$$

● **Aerodynamic drag force**

$$F_{ad} = (1+C_w) * (1/2 * \rho * A * C_d * v^2)$$

where

- * C_w = (0.062) .
- * C_d is taken here at 0.3.
- * A is taken here as (2 m²) .
- * ρ is taken here at (1.2 kg /m³).

$$F_{ad} = (1+C_w) * (1/2 * \rho * A * C_d * v^2)$$

$$F_{ad} = (1+0.062) * (0.5 * 1.2 * 2 * 0.3 * 8.3^2)$$

$$F_{ad} = 26.77 \text{ N}$$

● **Rolling resistance force**

$$Fr = (Cr) * (m.g.\cos\theta) = (0.012 * (1 + v/100)) * (m.g.\cos\theta)$$

where

Cr is the coefficient of rolling resistance (dimensionless) and is speed dependent (0.012)

$$Fr = (Cr) * (m.g.\cos\theta) = (0.012 * (1 + v/100)) * (m.g.\cos\theta)$$

$$Fr = (0.012 * (1 + 8.3/100)) * (171 * 9.81 * \cos 10)$$

$$Fr = (0.012 * (1 + 8.3/100)) * (171 * 9.81 * 0.9848)$$

$$Fr = 21.4695 \text{ N}$$

$$\square \quad \mathbf{FE} = Fa + Fc + Fad + Fr + ma$$

$$FE = 24.837 + 291.215 + 26.77 + 21.4695 + (171 * 0.13833)$$

$$FE = 387.945 \text{ N.} = 388 \text{ N}$$

$$\square \quad \mathbf{Torque}$$

$$TO = F * r \quad \text{where } r = 0.216 \text{ m}$$

$$TO = 388 * 0.216 = 83.808 \text{ N. m}$$

$$Tout = TO * \text{gear ratio}$$

$$Tout = 83.808 * (6/30) = 16.76 \text{ N.m}$$

$$\square \quad \mathbf{Power}$$

$$P = T * \omega \quad \text{where } \omega = (2 * \pi * N / 180) = (2 * 3.14 * 2000) / 180 = 69.7778 \text{ rad /sec}$$

$$P = 16.76 * 69.7778 = 1169.475 \text{ watt}$$

$$\square \quad \mathbf{hp} = \text{power} / 746$$

$$\text{hp} = 1169.475 / 746 = 1.567 \text{ hp}$$

Advantages

- Speed control over a wide range both above and below the rated speed: The attractive feature of the dc motor is that it offers the wide range of speed control both above and below the rated speeds. This can be achieved in dc shunt motors by methods such as armature control method and field control method. This is one of the main applications in which dc motors are widely used in fine speed applications such as in rolling mills and in paper mills.

- High starting torque: dc series motors are termed as best suited drives for electrical traction applications used for driving heavy loads in starting conditions. DC series motors will have a starting torque as high as 500% compared to normal operating torque. Therefore dc series motors are used in the applications such as in electric trains and cranes.
- Accurate speed less speed with constant torque: Constant torque drives is one such the drives will have motor shaft torque constant over a given speed range. In such drives shaft power varies with speed.
- Quick starting, stopping, reversing and acceleration
- Free from harmonics, reactive power consumption and many factors which makes dc motors more advantageous compared to ac induction motors [12].

Disadvantages of DC motors:

- High initial cost
- Increased operation and maintenance cost due to presence of commutator and brush gear [12].
- Cannot operate in explosive and hazard conditions due to sparking occur at brush (risk in commutation failure).

3.6 Batteries

A Lead-acid store battery is an electrochemical device that produces voltage and delivers electrical current the battery is the primary source of electrical energy used in vehicle today

It is important to remember that a battery does not store electricity but rather it stores of chemicals and through a chemical process electricity is produced .

Basically two different types of lead in an acid mixture react to produce an electric pressure called voltage .

This electrochemical reaction change chemical energy to electrical energy and is the basis for all automotive batteries ,Figure (17).



Figure 28: Battery

Calculation Battery

- To calculate the number of battery that needed for design off grid PV system, power of the system 1300 W DC and to cover load for one hour we have 1300 watt .h
- Nominal (C20,25 C10 battery capacity = Usable battery capacity / (MDOD)(T,DR).
- With a 24 V system voltage, the batteries need to supply
- Load (Ah) = $1300 / 24 = 54.2$ Amp.h
- Nominal (C20,25 C10 battery capacity = $54.2 / (0.8 * 0.97) = 69.84$ Amp. h (at 24v).



Figure 29: Battery



Figure 30: Battery

3.7 Tire

Wheels must be strong enough to support the vehicle and withstand the forces caused by normal operation. At the same time, they must be as light as possible, to help keep un-sprung weight to a minimum. The tire provides a cushion between the vehicle and the road to reduce the transmission of road shocks. It also provides friction to allow the vehicle perform its normal operations. Modern tires are manufactured from a range of materials. The rubber is mainly synthetic. This unit will cover the key components associated with the Wheels and Tires and the relevant environment, health and safety, Figure(18)

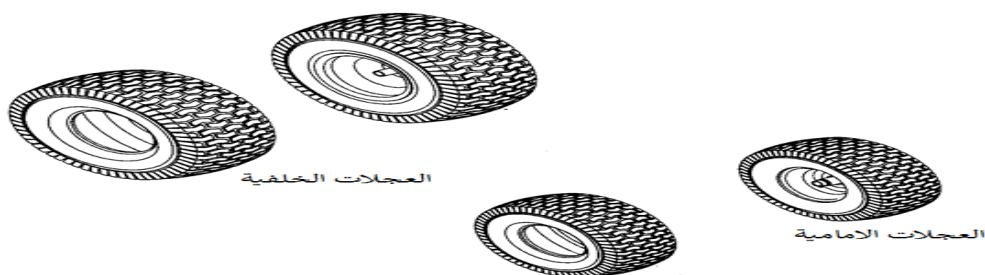


Figure 31: Tire

3.8 Break system.

The brake system is the most important system on a vehicle from a safety standpoint, as the mechanic, are trusted to do every service and repair operation correctly, When working on a brake system, always keep in mind that a brake system failure, could result in a fatal vehicle accident. It is up to you to make sure the vehicle brake, [11] ,Figure (19).



Figure 32: Break system

In this experience, We have used two brake systems The first system is a helping BRAKE which we put on the gearbox .The braking process is done by installing a device that separates the movement from the DC drive to the gearbox while the lime remains in the interlock state The second system is an electric braking system where it cuts off the power supply of the DC engine but the DC motor is still interleaved with the gearbox .

- Friction brake is a type of automotive that restore heat in the rotating part brake during the application and then release it in the air..
- Disc brake this one brake all the wheels together and make the car slow down or stop at that moment

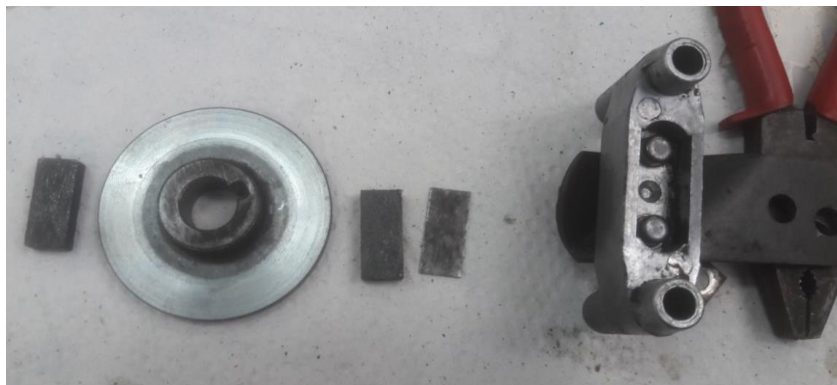


Figure 33: Break system

Chapter Four

4.1 Design of vehicle Body using Autocade app.

4.2 Building Frame work \ Body work of vehicle.

4.3 Installation of mechanical and electronic parts on vehicles .

4.4 Testing avehicle .

4.5 Future plans .

4.1 Design of vehicle

We Used of AutoCAD to draw the vehicle frame as shown in , Figure (34).

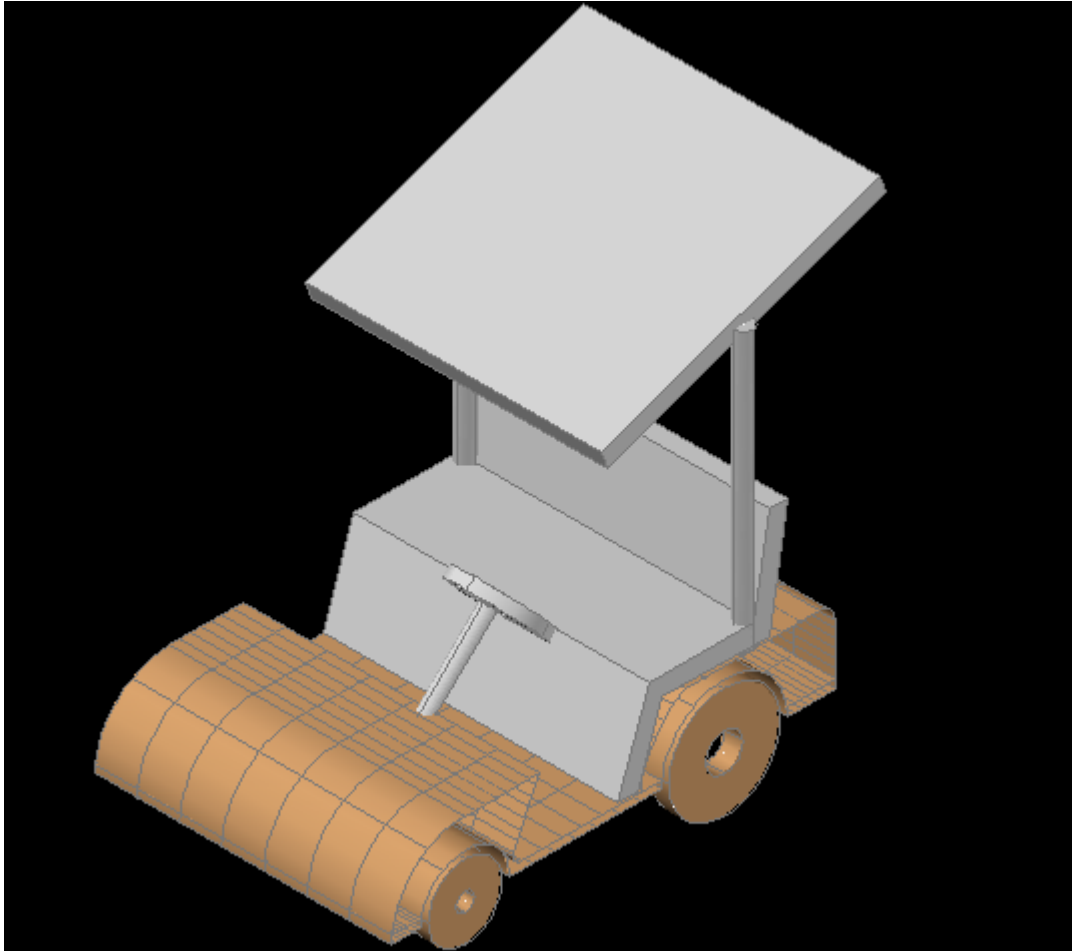


Figure34: Exterior design of the vehicle is expected

4.2 Building Frame work \ Body work of vehicle

The following in figure (35) shows the side section of a vehicle with dimensions .

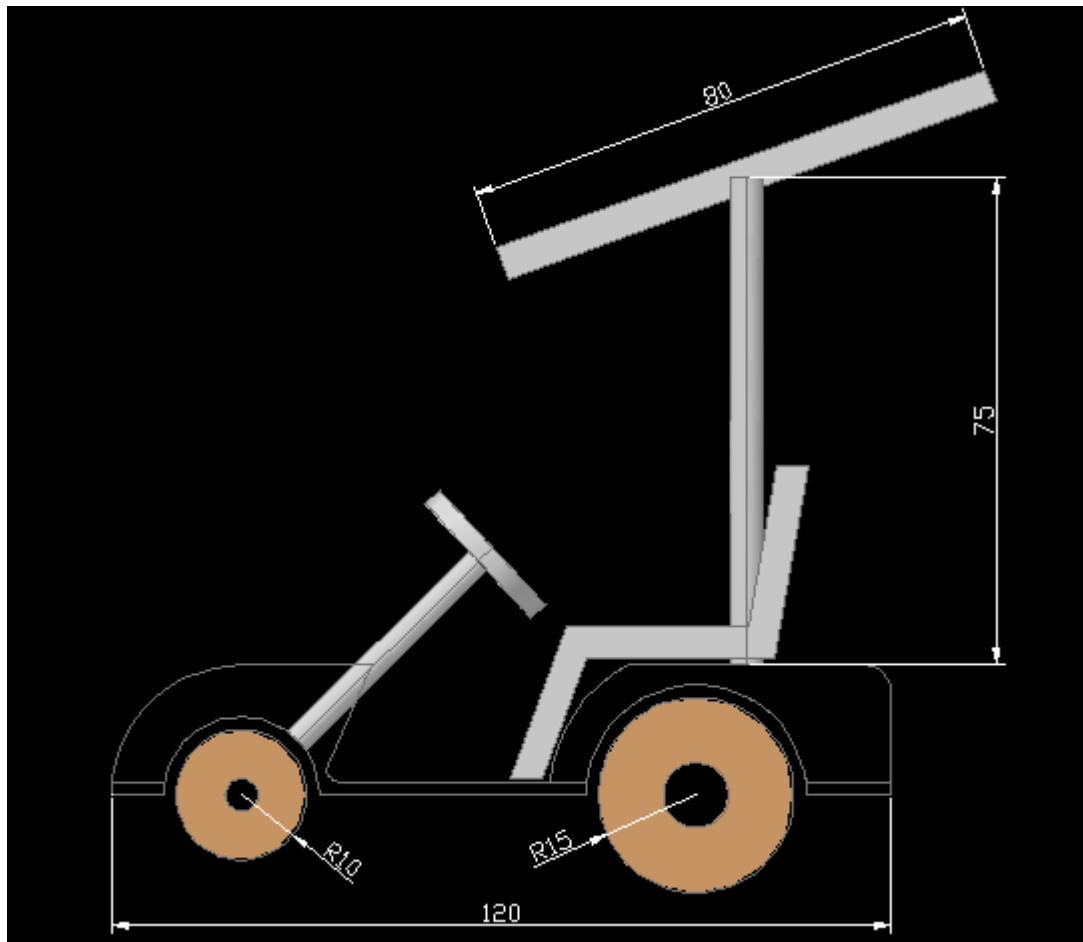


Figure 35: Engineering plan

How solar hybrid car works ???

- Then the energy passes to the motor controller or the batteries for storage.
- And it can be used to power the motor which will make the car to move.
- If the car is in running position then the sunlight will directly pass to the motor controller but if it receives more energy that will get stored in the batteries in **Figure 36** .

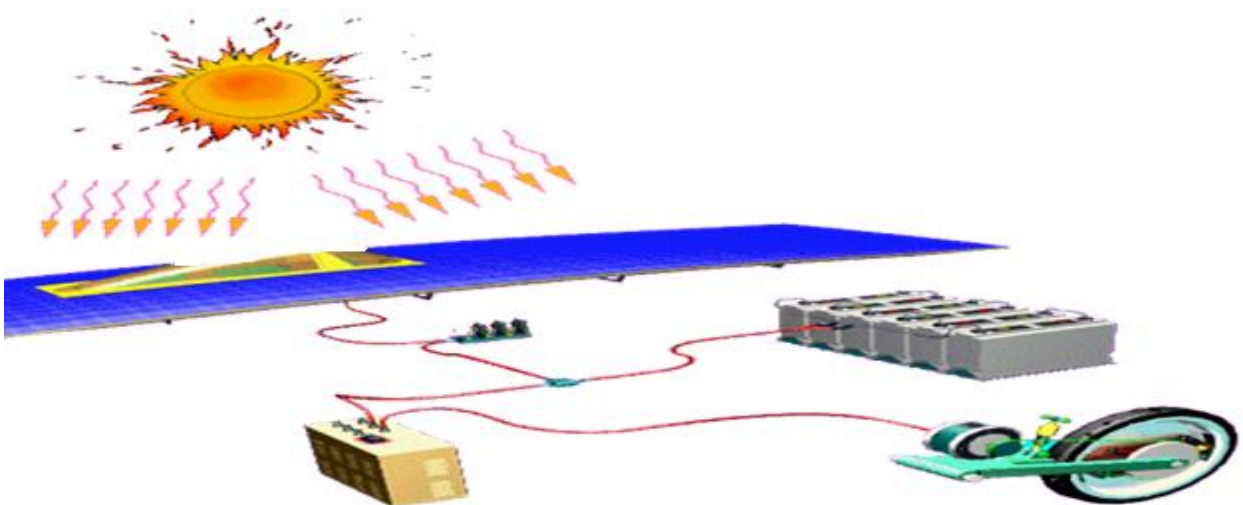
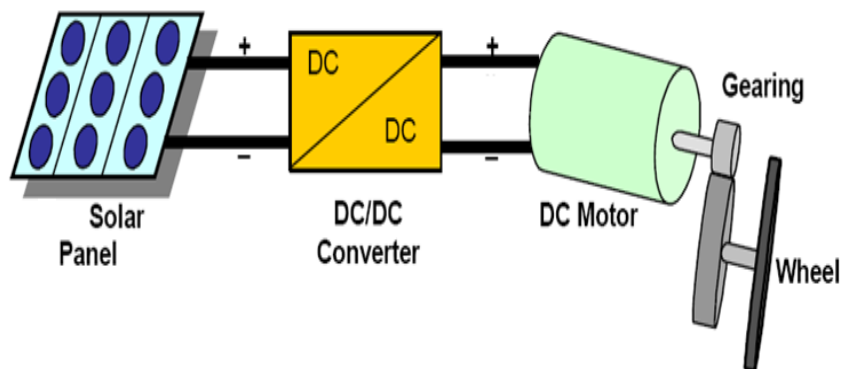
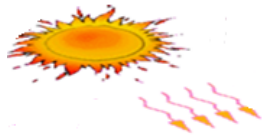


Figure 36: **diagram** shet

52

4.3 Installation pieces

The following figure(37) shows the engineering diagram of a vehicle and the horizontal section of the vehicle and shown the pully transmissions' and wheels.

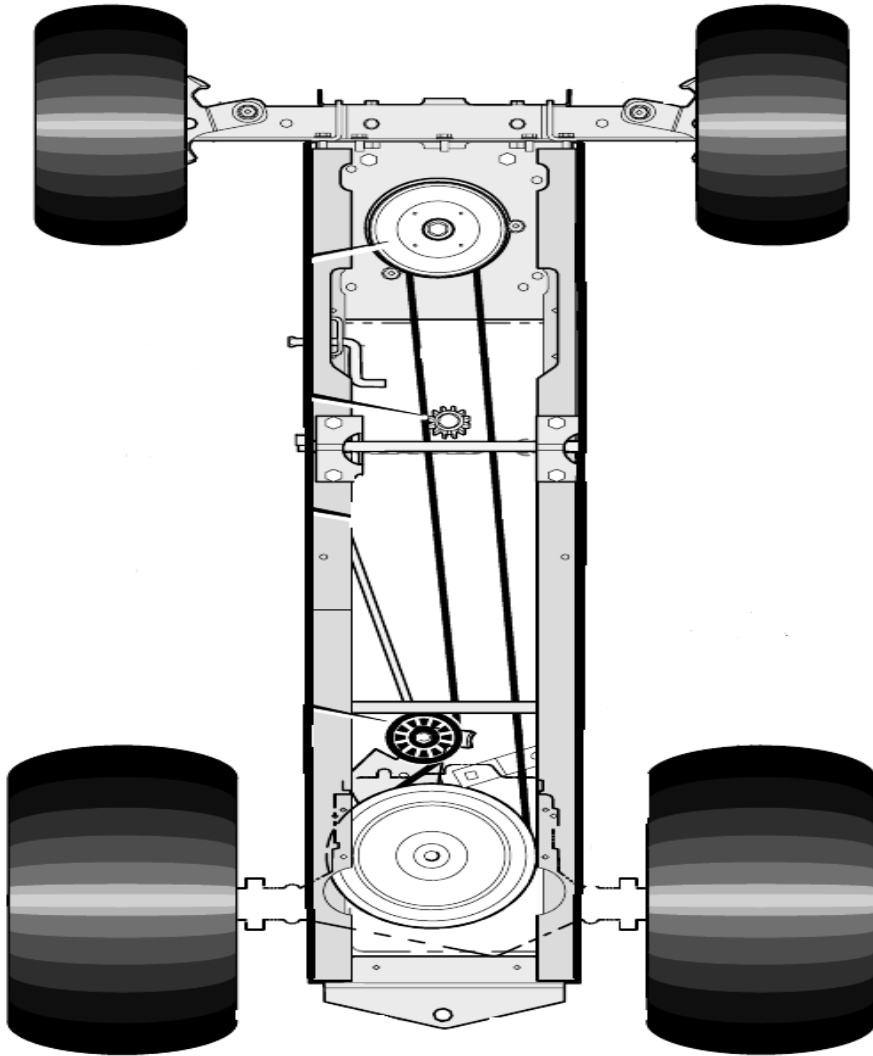


Figure 37: engineering diagram

4.4 Future Plan

- 1- Measuring the amount of solar radiation and taking the reading of the difference between voltage and current. Then, calculating the resulting capacity of the solar cell.
- 2 - Making graphs (diagrams) for the time period in which the previous readings were taken and take the arithmetic average of these readings.
- 3- Building the structure and the external body.
- 4- Installations mechanical parts (lime + steering + wheels + seat + solar cell + charging circuit).
- 5 - Taking the readings on the original vehicle of the solar radiation, current and voltage difference. Then, calculating the energy coming out of the solar panel.
- 6- It will be determined whether the vehicle is capable of operating by solar cell alone or whether it needs another source and another auxiliary system .

Chapter 5

5.1. Practical measurements of solar energy calculation.

5.2. The Structure and exterior body of the vehicle.

5.3 . Choosing the color of the vehicle.

5.4. Designing the charge circuit for batteries.

5.5. Installation the mechanical parts of the vehicle.

5.6. Installation of electrical parts (lighting).

5.7. Installation of the solar cell on the vehicle.

5.8. Installation of the electric charging adapter.

5.9. Operation of the vehicle.

5.10 . Performing the Preliminary tests on the vehicle.

5.11. Conclusion .

5.12 Advantages & Disadvantages .

5.13 Applications .

5.1. Practical measurements of solar energy calculation.

Before starting building the vehicle, we brought the solar cell that was installed according to the following conditions:



Figure 38:of the solar cell





		WARNING	
		HAZARDOUS ELECTRICITY CAN SHOCK, BURN OR CAUSE DEATH, DO NOT TOUCH TERMINALS	
PHOTOVOLTAIC MODULE			
MODEL		ST	
IRRADIANCE AND CELL TEMPERATURE		1000W m ⁻² AM1.5 25°C	
Voc 42V/Vpm 34V			
5W		50W	
10W		55W	
15W		60W	
20W		75W	
25W		80W	
30W		90W	
40W		100W	
		 ETL SEMKO	
IP65		IEC61215	
REF: NoJSH0411366-001			

Figure 39: The specifications of the solar cell

We installed the cell on the back of a vehicle as shown in the following picture, and we started moving in Hebron governorate.



Figure40: of car with solar

We did a table for the previous readings and they were according to the following table:

Table Experience number 1

No	Area name	Time	Voltmeter	Ameter	Solar radiation coefficient 2W/m	Power
		h-mint	v	A		
1	Municipality of halhul	07:48	5.75	0.66	153	3.795
2	Exhibaition muharram	08:18	10.9	0.845	253	9.211
3	Licensing Department	08:30	14.22	0.955	329	13.580
4	Al salam street	09:00	26.02	1.267	315	32.967
5	Al salam street Morabat sebta	09:05	32.02	1.39	480	44.508
6	AL HAWOZ	09:15	34.57	1.461	522	50.507
7	PPU	10:15	37.6	1.519	655	57.114
8	Mafraq alajoli	10:30	37.9	1.526	748	57.835
9	Al salaam street Alansar	10:45	38.2	1.531	660	58.484
10	Ras Aljora	10:55	38.9	1.545	686	60.101
11	Halhul - seder	11:10	38.1	1.531	682	58.331
12	Municipality of halhul	12:10	36.2	1.505	670	54.481
13	Halhul - seder	13:00	36.4	1.501	728	54.636
14	Municipality of halhul	13:30	37	1.512	643	55.944
15	Hlhul alqanb	13:50	38	1.525	422	57.950
16	Hlhul alqanb	14:35	32.55	1.422	371	46.286
17	AL nabe yuones	15:34	8.63	0.763	234	6.585
18	Halhul ALSafa	16:10	0.482	0.201	64	0.097

In the next day we according the following table.

Table Experience number 2

No	Area name	Time	Voltmeter	Ameter	Solar radiation coefficient 2W/m	Power
		h-mint	v	A		
1	Municipality of halhul	07:50	4.61	0.609	180	2.807
2	Licensing Department	08:38	17.5	1.031	336	18.043
3	Al salam street	08:45	19.8	1.1	355	21.780
4	Al salam street Morabat sebta	08:50	23.15	1.193	405	27.618
5	the guard	09:00	26.34	1.267	430	33.373
6	AL HAWOZ	09:40	29.28	1.338	494	39.177
7	Corner door	10:00	32	1.4	560	44.800
8	Mafraq alajoli	10:30	13.58	0.961	370	13.050
9	Al salaam street Alansar	11:15	9.75	0.795	268	7.751
10	Ras Aljora	11:25	6.57	0.682	129	4.481
11	Municipality of halhul	11:40	4.91	0.615	216	3.020
12	Hlhul alqanb	12:38	1.619	0.425	166	0.688
13	Hlhul alqanb	01:45	0.44	0.191	80	0.084
14	Hlhul alqanb	02:42	0.89	0.33	120	0.294

In the third day we according the following table

Table Experience number 3

No	Area name	Time	Voltmeter	Ameter	Solar radiation coefficient 2W/m	Power
		h-mint	v	A		
1	Ras Al-Jura	09:48	0.441	0.606	134	0.267
2	Ras Al-Jura	10:27	39.4	1.564	655	61.622
3	A tiger	10:38	37.6	1.535	597	57.716
4	Sarah Bravoa Mall appointed	10:40	38	1.543	720	58.634
5	County	10:52	38.4	1.552	733	59.597
6	Salam Street	11:28	36.3	1.5	687	54.450
7	Salam Street	11:35	36.75	1.513	688	55.603
8	AL HAWOZ	11:43	37.9	1.539	693	58.328
9	Rotor al-Tahrir	11:57	35.96	1.598	597	57.464
10	Ras Aljora	12:15	36	1.494	703	53.784
11	PPU	12:53	36.1	1.498	592	54.078
12	PPU	15:10	8.38	0.755	258	6.327
13	PPU	13:45	0.44	0.191	80	0.084

In the fourth day we according the following table.

Table Experience number 4

No	Area name	Time	Voltmeter	Ameter	Solar radiation coefficient 2W/m	Power
		h-mint	v	A		
1	ppu	09:45	33.13	1.432	521	47.442
2	ppu	11:26	35.4	1.48	685	52.392
3	Ras Al-Jura	12:16	36.4	1.5	742	54.600
4	Ras Al-Jura	13:25	34.39	1.453	602	49.969
5	Valley of the Faq	14:05	29.19	1.342	431	39.173
6	Ras Al-Jura	16:05	28.5	1.31	440	37.335

We did a table for the average of the previous readings and they were according to the following table:

A table for average calculation for the previous tables during measurement period.

No	Time	Voltmeter	Ameter	Solar radiation coefficient W/m²	Power
	h-mint	v	A	W/m²	p
1	07:48	5.45	5.45	0.68	153
2	08:18	11	11	1.8	253
3	08:30	14.13	14.13	1.124	412
4	09:00	25.42	25.42	1.267	315
5	09:05	31.9	31.9	1.51	480
6	09:15	34.6	34.6	1.461	522
7	10:15	37.1	37.1	1.541	655
8	10:30	38.2	38.2	1.526	748
9	10:45	38.3	38.3	1.531	724
10	10:55	38.9	38.9	1.63	686
11	11:10	38.1	38.1	1.531	653
12	12:10	36.2	36.2	1.505	670
13	13:00	36.4	36.4	1.57	728
14	13:30	37.4	37.4	1.61	643
15	13:50	38.1	38.1	1.525	425
16	14:35	32.5	32.5	1.543	367
17	15:34	8.63	8.63	0.867	234
18	16:10	0.482	0.482	0.234	64

We then made a graphic table between the radiation factor and the resulting block of experiments. The results were according to the following forms:

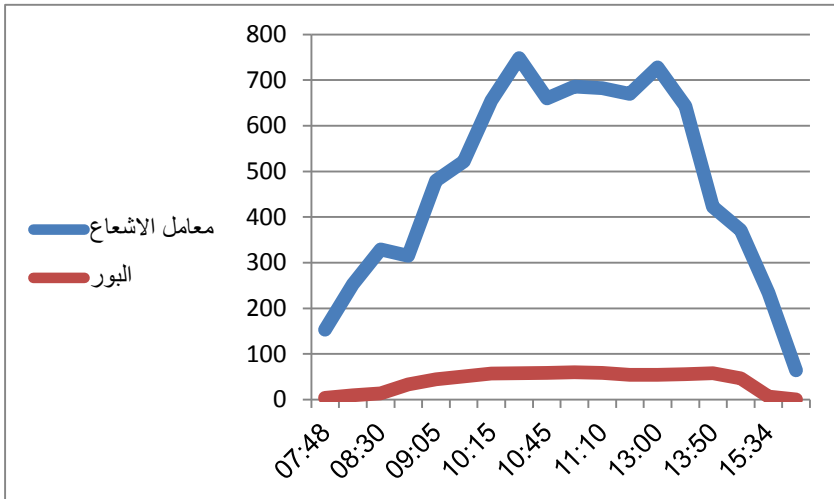


Figure41:Experience number1 graph

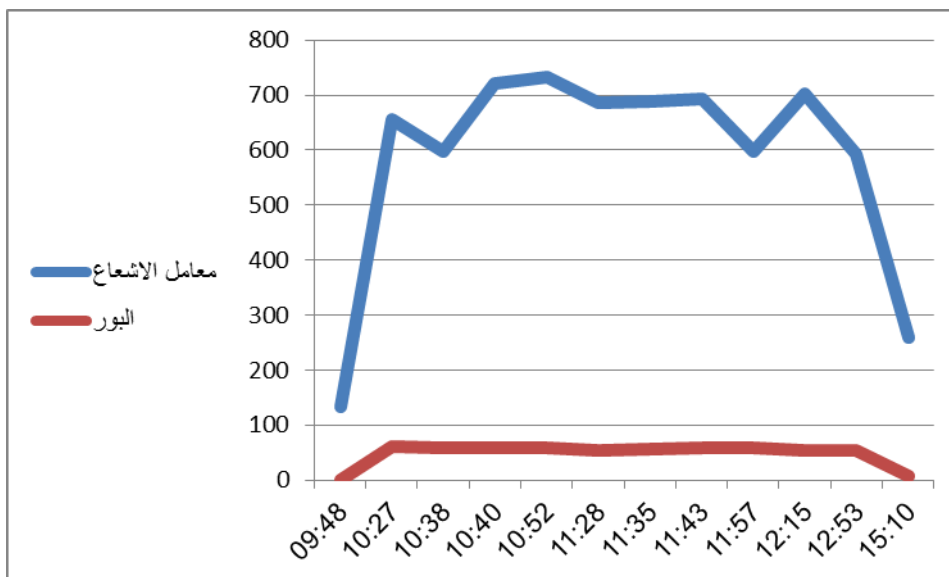


Figure42:Experience number2graph

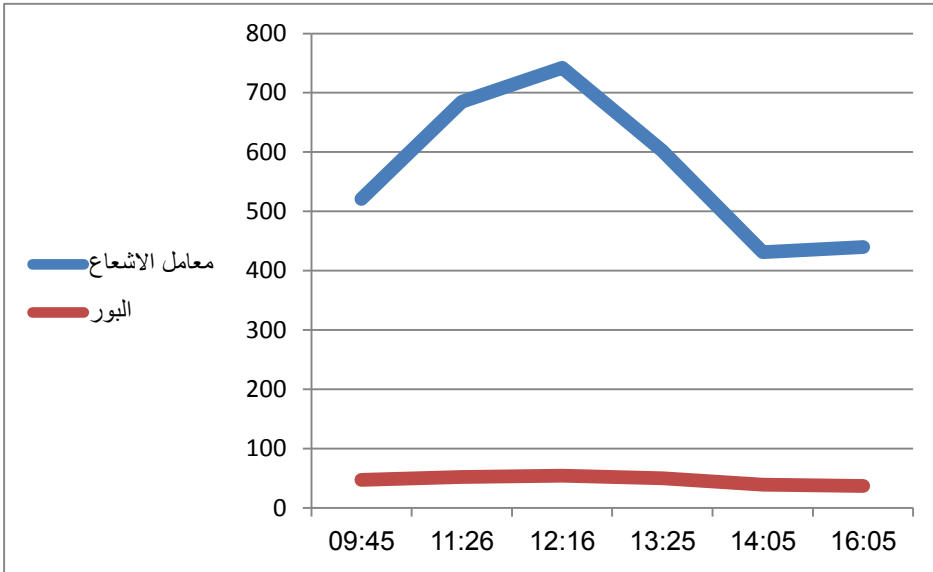
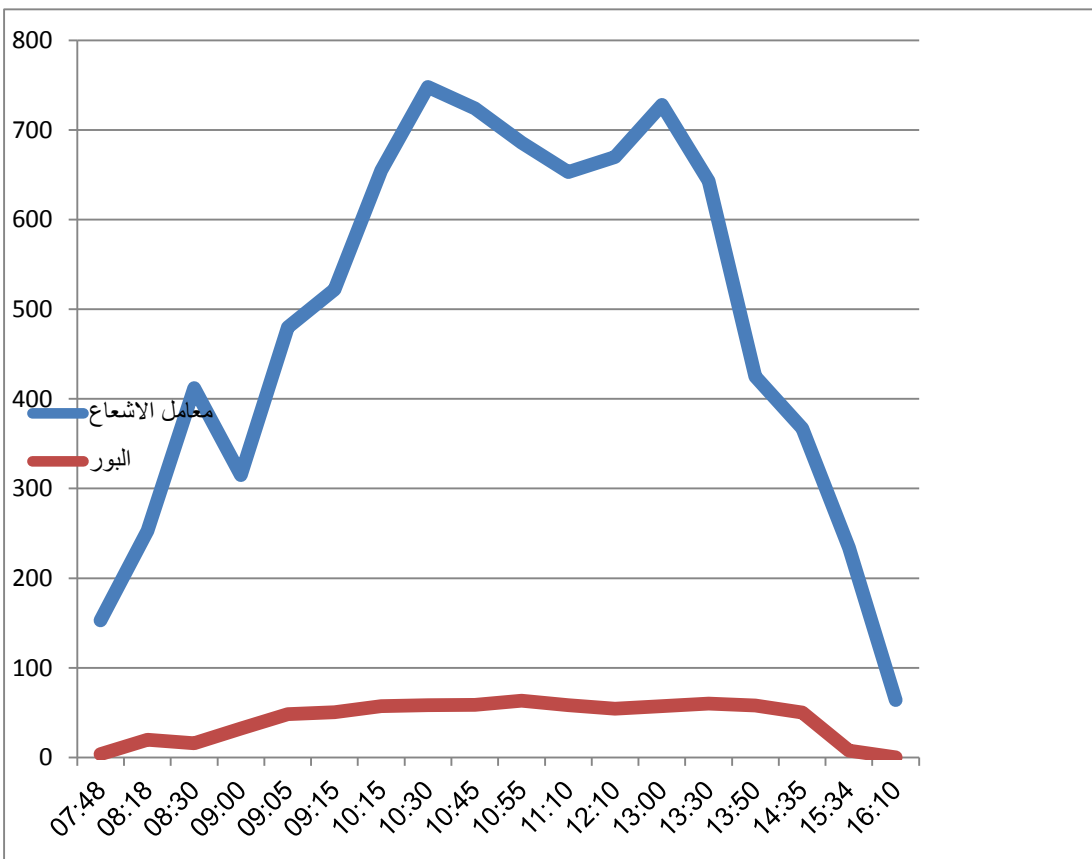


Figure 43: Experience number4 graph

The following graphic is for the average calculation which was:

The arithmetic mean of the study:



5.2. Structure and the outer body of the vehicle

We brought a sheet of fish (0.7) mm and we used hydraulic presses to form the sheet and to implement the above plan. According to the measurements given and according to the design that we have previously presented, we came with this shape:



Figure45:the vehicle before the painting process

5.3. Choosing the color of the vehicle

We did grinded the sheet, and we did for it some preparations for printing. We chose the color of the vehicle, which is the green, in order to indicate that the vehicle is environmentally friendly and does not produce any kind of harmful emissions.



Figure46: Vehicle after painting



Figure 47:the grinding process

5.4 .Designing the charge circuit for batteries.

We seek the help of electronic engineer from the Hebron school of industrial studies, named Othman Khalil Irfa'yeh. He helped us designing the lay out of the charge and to plan the voltage circle.

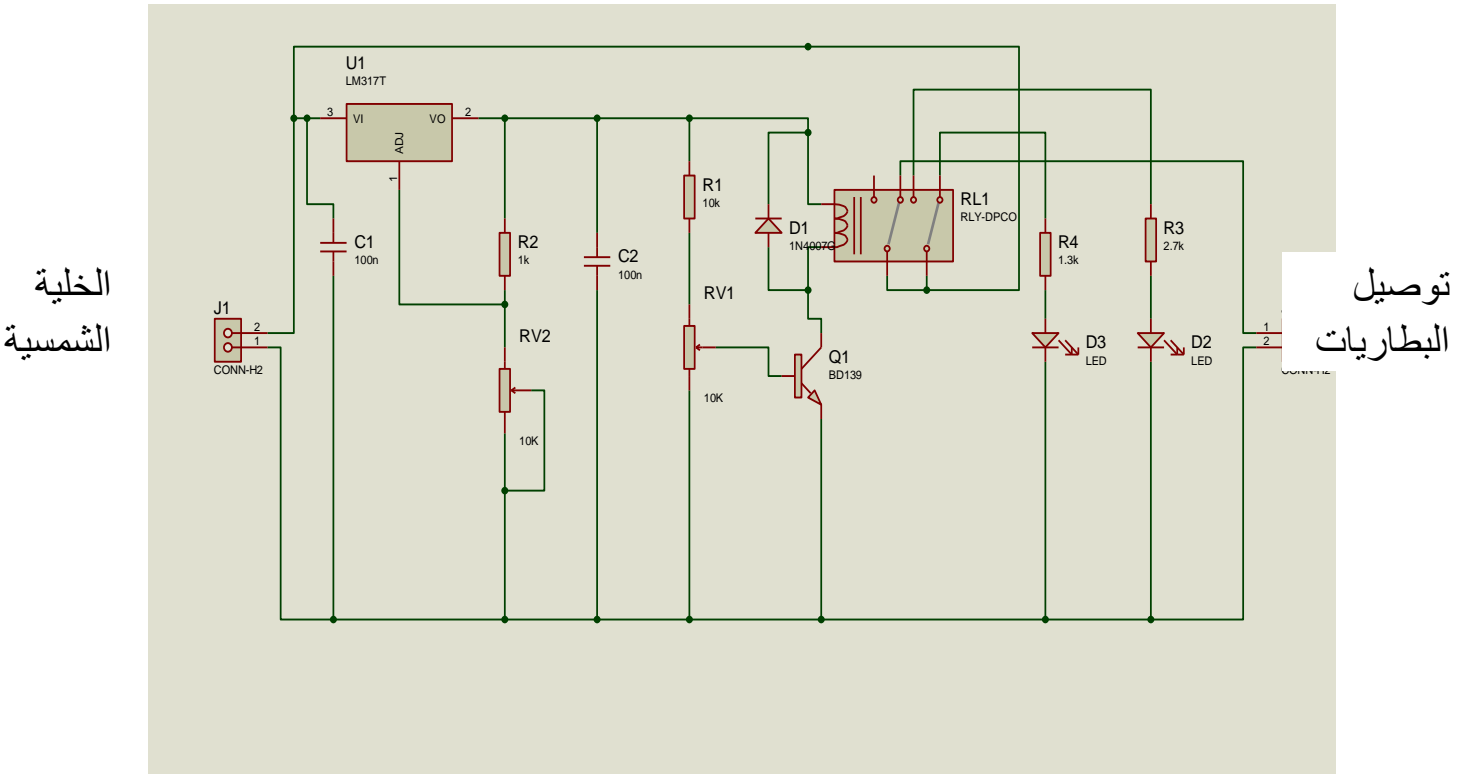


Figure 48:Circuit charging batteries from the solar cell

D2 LED The charging icon

D3 LED The icon that shows that the charging is stopped when the voltage is high on the batteries.

The circuit batteries charge up to 28 volts in two batteries respectively. When the voltage is high on the batteries, the relay separates the charge.

The charging voltage is adjusted by RV1 variable resistance.

Voltage regulator LM317 for controlling the voltage

When the voltage is short in the batteries, the relay is in separation status and it works to charge the batteries. When the battery voltage is high, the relay is disconnected by adjusting the voltage of the transistor.

5.5. Installation of mechanical parts of the vehicle

We brought the electric motor that was previously mentioned and we took it to the lathe as shown in the figure, where we designed a reel to move the motor from the engine to the gearbox.



Figure49: electric motor

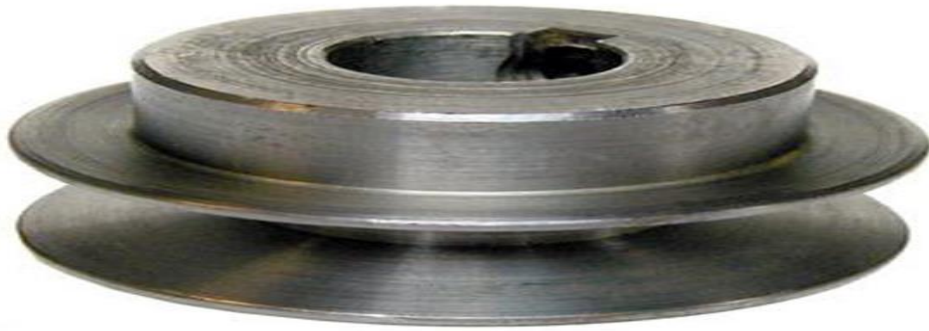


Figure50:Reel electric motor

After that, we assembled the electric motor on the vehicle. The engine roller was assembled with the gearbox built and the gearbox was assembled with the differential another road as follows.

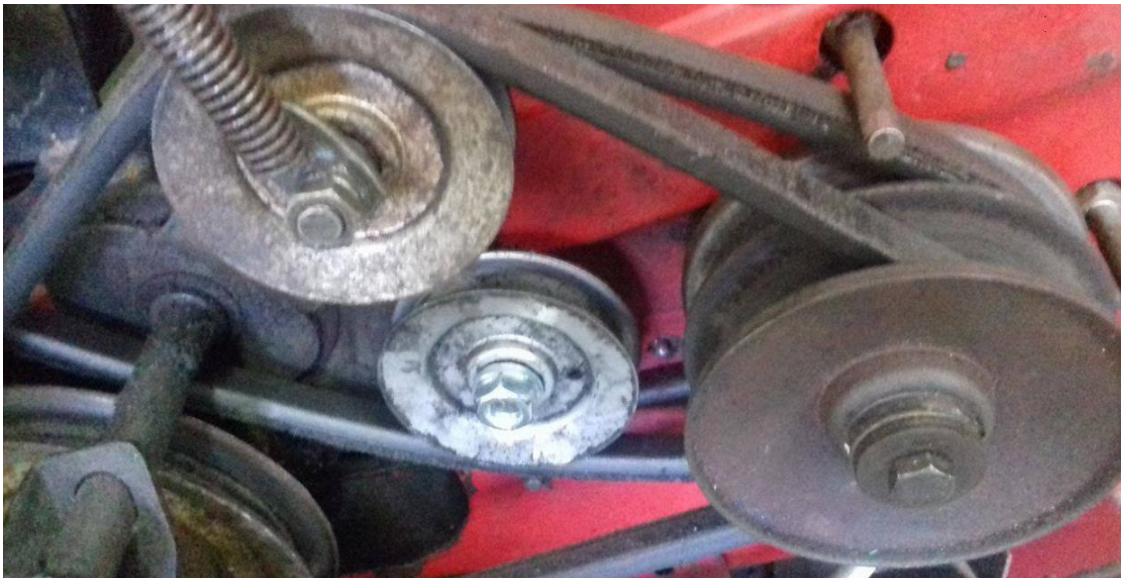


Figure 51: The gearbox was then assembled with the driving wheels

Vehicle control mechanism

The vehicle is controlled by separating the engine rollers from the wheel rollers and also by separating the power from the motor.

Steering wheel:

As the steering mechanism has been clarified previously, some things need to be clarified as the existing steering is of the type (RACK AND PINION) as shown in the following figure.

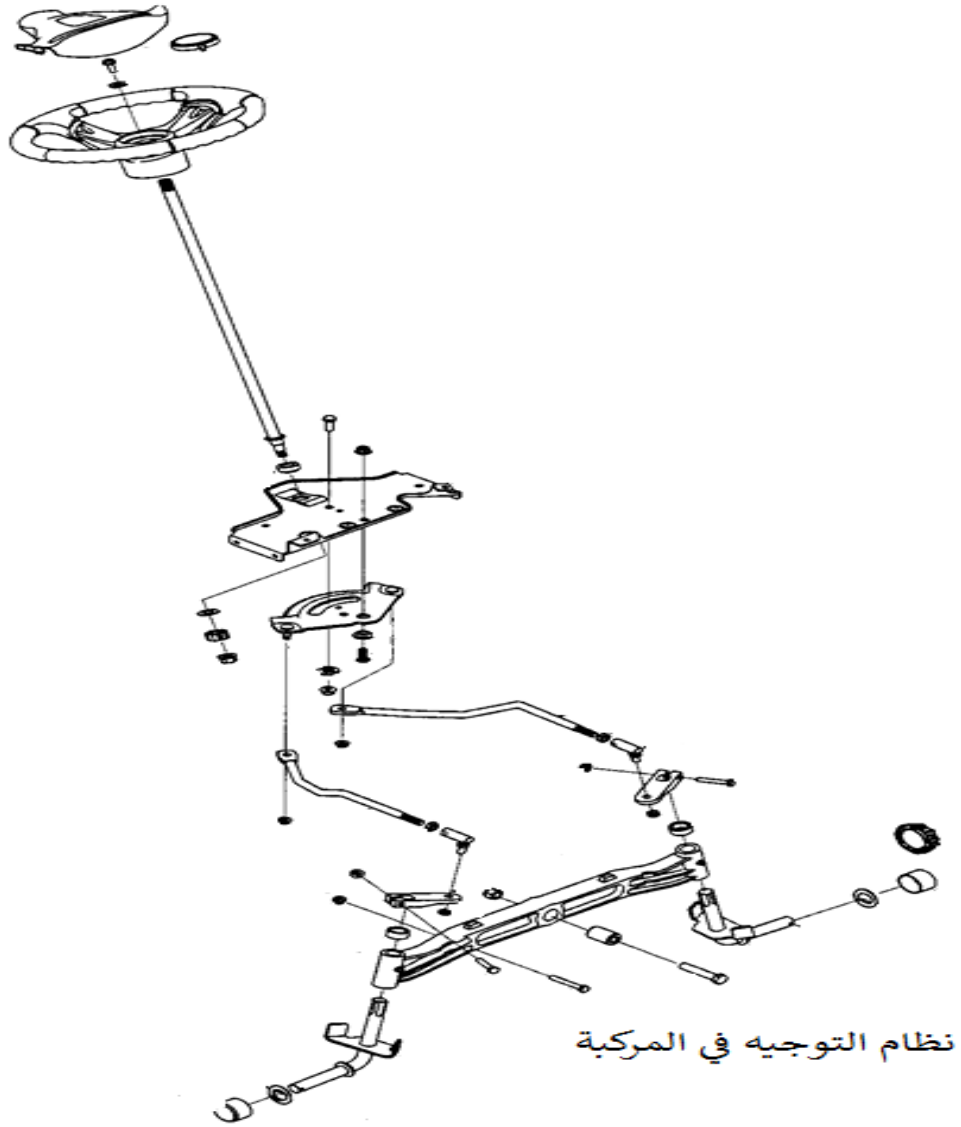


Figure52:Steering wheel

5.6. Installation of electrical lighting fixtures

Front and rear lights and signs of LED were installed to provide electricity consumption as shown in Fig.



Figure53: Vehicle and light

.5.7 Install the solar cell on the vehicle

We brought a solar cell according to the following specifications, as shown in the figure, where we installed them on the back of the vehicle appropriately, observing the rules of the dynamics of vehicles.



Figure54: Vehicle and solar cell

5.8. Installation charging Adapter:

We have brought in a charging adapter from the local market that works to charge the batteries of the vehicle. It converts the voltage from 220 V AC to 24 V DC as shown in Fig.



Figure55: a charging adapter

5.9. Operating the Vehicle

After assembling the vehicle and installing all the mechanical and electrical parts, we operated the vehicle in the yard of Hebron Industrial School as shown in the figure.



Figure56: Operating the Vehicle

5.10. Performing the primary tests of the vehicle:

- We examined the vehicle during the driving and tested also the gearbox where we examined the mechanism of transport, separation of movement and the separation of clutch.
- We tested the different and the expected speeds of the vehicle. The vehicle can drive fast according to the latest spare parts. A high rise was made to measure the different characteristics of the vehicle and to make sure that the vehicle was able to achieve the desired goal in the figure.



Figure57: tests of the vehicle



Figure57: tests of the vehicle



Figure57: tests of the vehicle

5.11 Conclusion

The team found that the vehicle needs two sources of energy as the solar energy and radiation plants in Hebron governorate are not enough to charge the batteries. So, we need a lot of solar cells. With the knowledge that the temperature of Hebron city is an average temperature based on information and previous studies obtained from the Department of Meteorology.

- The solar energy is insufficient (not enough) for the charging process because it takes a long time.
- The vehicle is travelling at a speed of 50-60 km per hour.

- The vehicle does not produce any kind of harmful emissions to the environment.
- Solar hybrid Car would be an amazing advancement in future car technology.
- They would allow free and pollution less travel with unlimited accessibility.
- If some minor drawbacks associated with Solar Car can be rectified, then for sure Solar Car will play a vital role in future transportation in the future.



Figure59: tests of the vehicle

5.12 Advantages & Disadvantages

1. Advantages

- **Reduced Pollution**



- **Reduced Energy Cost**



- **Produce less noise**



- **Unlimited Source**



2. Disadvantages

- **High initial Cost**



- Less efficient in cloudy weather



- Sun doesn't shine 24 hours



- Lesser speed than regular car



- Limited to Solar regions only



5.13 Applications

- This concept can be utilized to build a single sitter four wheel vehicles in practice.
- It can be extended to more commercial form of four wheeler vehicle.
- In industry where small vehicles are used to perform light weight conveys work from one place to other place.
- It can be used places where, fuel based vehicles are banned due to production of pollution and noise in the figure .



Applications .



Figure60: tests of the vehicle



Figure60: tests of the vehicle



Solar Panel in Future



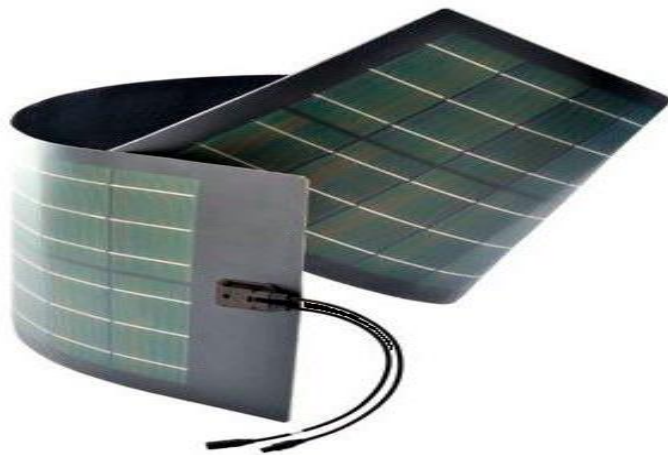


Figure60: tests of the vehicle

References

- 1- Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, Fundamentals, Theory, and Design, Muhammad H. Rashid.
- 2- E.H. Wakefield, History of the Electric Automobile: Battery-Only Powered Cars, Society of Automotive Engineers (SAE), Warrendale, PA, 1994.
- 3- E.H. Wakefield, History of the Electric Automobile: Hybrid Electric Vehicles, Society of Automotive Engineers (SAE), 1998.
- 4- Y. Gao and M. Ehsani, An investigation of battery technologies for the Army's hybrid vehicle application, in Proceedings of the IEEE 56th Vehicular Technology Conference, Vancouver, British Columbia, Canada, Sept. 2002.
- 5- C.R. Ferguson and A.T. Kirkpatrick, Internal Combustion Engines — Applied Thermo-Sciences, 2nd ed., John Wiley & Sons, New York 2001.
- 6- Abdulghani A., (2002): Fuel consumption of a spark ignition engine blended with MTBE, the 6th Saudi engineering conference, Kfupm, phahran, Vol.5, December, PP.641-648.
- 7- Sergeant N et al., "An environmental analysis of FCEV and H2-ICE vehicles using the Ecoscore methodology, World Electric Vehicle Journal Vol. 3 ISSN 2032-6653 - © Avere, 2009.
- 8- M. W. Daniels and P. R. Kumar, "The optimal use of the solar power Automobile " Control Systems Magazine, IEEE, vol. 19, no. 3, 2005.
- 9- "SOLAR VEHICLES AND BENEFITS OF THE TECHNOLOGY", by John Connors, ICCEP paper 2007.
- 10- [1]. Muhammad Mubeen, "Brushless DC Motor Primer," Motion Tech Trends, July, 2008.

11- McGarry, Ben. "A Proposed Durnin IVT Transmission - A Review by Dr. Ben McGarry, Principal Engineer at e3k Think" (PDF). Infinitely Variable Transmission Retrieved 11 August 2010.

12- <http://electricalquestionsguide.blogspot.com/2011/05/dc-motors-advantages-disadvantages-ac.html#ixzz4fpqsWhSg>.

13- www.wikipedia.com

14- www.solarcar.Stanford.edu

15- www.technologystudent.com

16- www.solarcar.engine.umich.edu