SAVONIA

Solar Energy Automobile

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SAVONIA UNIVERSITY OF APPLIED SCIENCES **THESIS**
Abstract

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Abstract

The thesis was to design a solar energy automobile, which is using solar power as energy resource. At the moment, Finland was chosen as an example place. It was necessary to calculate the related data, which are the solar angle and the day length when designing the solar energy automobile. Also the seats and dashboard to improve the performance.

Actually, in Finland it is possible to use solar energy automobile in summer. But in winter, the day length is so short and the solar constant is so weakness, so solar panel cannot provide enough energy for solar energy automobile.

Keywords

solar battery, solar panel, solar controller, solar array, dashboard, chassis

CONTENTS

SYMBOLS AND ABBREVIATIONS

DC	Direct current
AC	Alternating current
PV	Photovoltaic
MPPT	Maximum Power Point Tracking
RPM	Revolution Per minute
GPRS	General Packer Radio Service
LCD monitor	Liquid crystal display monitor
Rxx	Regulated output voltage

1 INTRODUCTION TO THE THESIS

Because of the non-renewable energy resources should be reduced sharply and the air pollution increasing impair the quality of the life and environment of the people gradually, more and more people have the awareness to protect the environment. For instance, many people are willing to go to work by bike. Nowadays, renewable energy attracts a high attention by people who are in business areas and science and technology areas, they think there will be a huge market with the development of technology and improvement of renewable energy products qualities. Of course, solar energy automobile is a renewable energy product which helps to protect the environment.

Solar energy automobile is using solar power as the energy resource, so that it has some good points, just like safety, zero pollution and saving energy. According to the development of technology and the variety of requirements of customers, the design of seats and dashboard are more reasonable and comfortable to improve the performance of solar energy automobile.

2 SOLAR ENERGY

2.1 Introduction to solar energy

There is a close relationship between solar with human and most of energy consumption by human directly or indirectly from the solar. Solar energy is the energy of nuclear fusion reactions inside the sun generated continuously. Solar energy is a renewable energy and can be used in many ways including solar street light, solar mobile batteries and solar buildings as well as solar energy automobiles.

There already has been 3000 years history for the use of solar by human beings. The history of the development of solar technology can be separated into periods, in 20th century. In these periods, the solar energy technology really experienced a huge improvement. Of course, human get lots of benefits from this technology, not only the money but also to save the non-renewable resources.

Solar energy is generated by fusion of hydrogen atoms, releasing tremendous internal nuclear generated energy. It is a renewable energy and can be used in two ways including photo thermal conversion and photoelectric conversion.

On a global scale, incoming solar radiation exceeds the entire global demand for energy by a factor of 10,000. A surface area of just 130,000 km^2 could produce 10,000 Mtoe equivalent of energy, which could satisfy all final energy needs. [Satu Helynen & Martti Aho, 2009,78]

2.2 Advantages of solar energy

Solar energy has become an important part of human energy consumption in the condition of diminishing fossil fuels. The technology of solar energy used in the car will play a key role in the respect of decreasing the global environmental pollution and creating a clean living environment with the development of world economy.

The cars burning gasoline is an important resource of pollution in cities. The vehicle releases harmful gas including CO_2 and NO_2, which can pollute the environment and affect our health. Nowadays, many scientists in the world are committed to develop the little pollution of solar car and try then instead of the traditional cars. Because the solar cars do not use fossil fuels, there will be no pollution gas when driving a solar car.

Nowadays, with the decreasing of the resources such as coal and oil as well as gas, it is time to use the renewable energy (solar power, wind power and ocean power, etc) instead of the traditional energy. Solar energy is a safer energy when compared with nuclear energy. We also do not need to worry about the solar energy adequacy. As a renewable energy, we can use it forever.

3 THE DEVELOPMENT OF SOLAR ENERGY AUTOMOBILE IN THE WORLD

In 1982, the world's first solar car was driven across Australia by Tholstrup, a Danish adventure, from Perth to Sydney, in 20 days. His passion in motor sport and the experiences he gained from the journey has inspired him to introduce the world solar challenge event. This event requires participating team to race over 3000 km through central Australia from Darwin to Adelaide. 23 teams from seven countries participated in the first event in 1987, with General Motors' solar car racer winning the race in 44 hours, with an average speed of 67 km/h. (Rossi Passarella, 31)

There also have been two solar car races to play an important role in the development of solar car which not only let people to research and develop the performance of solar car to improve the speed and safety but also appeal more attentions from publics by variety of races, including the World Solar Challenge and the North American Solar Challenge, which are the overland road rally-style competitions contested by a variety of university and corporate teams.

The World Solar Challenge features a field of competitors from around the world who race to cross the Australian continent, over a distance of 3,000 kilometers. So the performance of solar energy automobile is more and more important, for the designers not only need to improve the speed of solar car, but also need to design the car to be more comfortable and safety.

With the increasing level of requirements which are the safety, performance and looks, solar energy automobile has experienced lots of reforms. Until today, solar energy automobile also need to get improvement to satisfy the requirements of customers.

4 SOLAR POWER SYSTEM

Solar power system is consisted of a solar cell, a solar controller and a battery (See Figure 1).

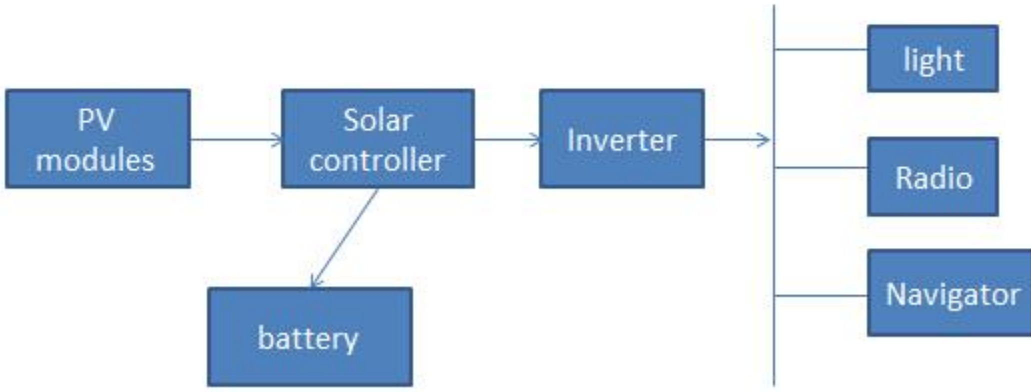

Figure1. The schematic picture of a solar power system

4.1 Solar panels and battery

4.1.1 Theory of Solar panels and battery

The heart of the solar energy automobile is a solar panel and a battery as well as the operating system. The operating system is composed by power supplying and electric controlling. Solar panel is the most important part in key technology, which is semiconductor device that can transform light energy into electrical energy.

Solar panel is photovoltaic elements, which can converse energy. Silicon is the basic material of the semiconductor, for it cannot conduct (deliver) the electricity. It can be made the semiconductor as P-type and N-type if incorporation various impurities in the semiconductor. Because the current is produced by the potential difference of electric hole of P-type semiconductor and one freedom electric of N-type semiconductor. Therefore when the sun light is irradiated, sun light energy cans excitation the electron out of silicon atom. The convection of electrons and holes are generated. These electrons and holes are influenced by build-in potential and attracted by N-type and P-type semiconductor respectively, gathered at both ends. At this time, there will be a loop when electrodes are used to connect the two sides. This is the principle of solar power generation (See Figure 2).

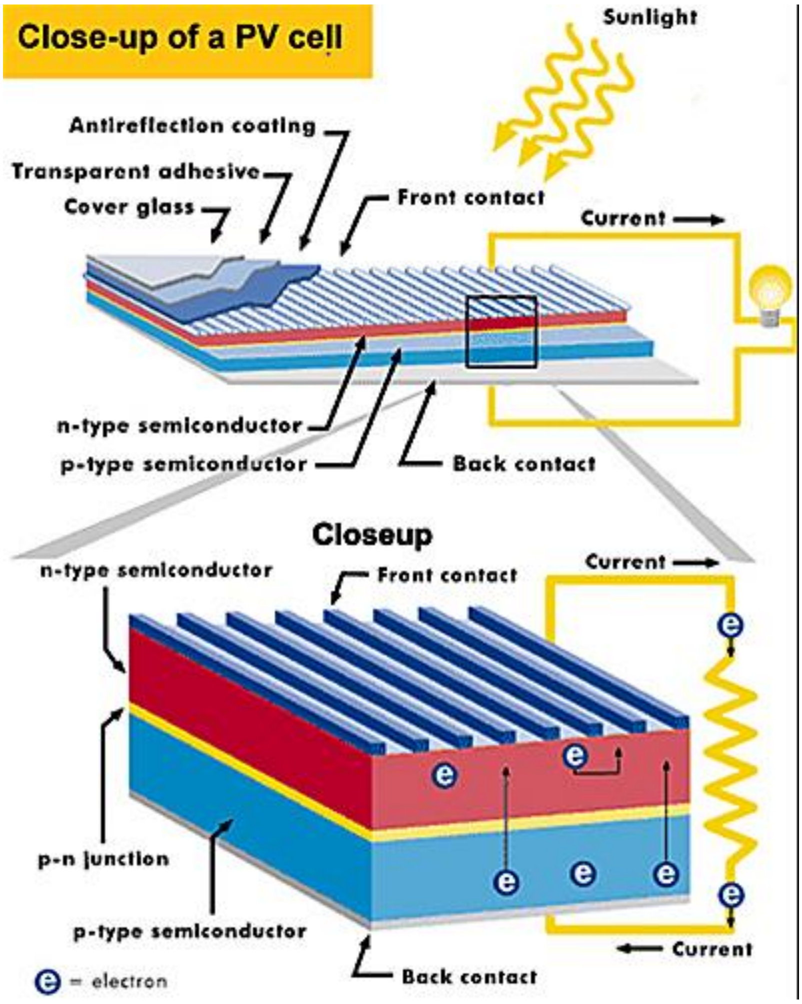

Figure 2.Solar cell operating principles (Solar cell central 2013)

4.1.2 The types of solar panels

The most commonly available solar cells are made from high-grade silicon that is treated with negatively and positively charged semi-conductors, phosphorous and boron. According to the crystalline structure, solar panels can be separated into the following categories:

1. Mono/crystalline silicon panel

The silicon has a single and continuous crystal lattice structure with almost no defects or impurities. The principal advantage of mono/crystalline cells is their high efficiency, typically around 15 percent, although the manufacturing process required to produce mono/crystalline silicon is complicated, resulting in slightly higher costs than other technologies. Different manufacturing methods are used, depending largely upon the method of growing, or pulling a perfect crystal that has a solid, cylindrical shape. (DEO PRASAD & MARK SNOW 2005, 23)

2. Poly-or multi-crystalline silicon panel

Poly-crystalline panels are produced using ingots of multi-crystalline silicon. They are cheaper to produce than mono-crystalline panels, due to the simple manufacturing process. They tend to be slightly less efficient, however, with average efficiencies of around 12 percent. (DEO PRASAD & MARK SNOW 2005, 23)

3. Amorphous silicon panel

Amorphous silicon panels are composed of silicon atoms in a thin homogeneous layer, rather than a crystal structure. Amorphous silicon is produced by deposition onto a substrate, rather than wafer sawing, so the cells can be thinner. For this reason, amorphous silicon is also known as a thin film PV technology. However, the efficiency of amorphous panels is less than crystalline-based cells, with typical efficiencies of around 6 percent, but they require less material and cheaper to produce. The low cost makes them ideally suited for many applications where high efficiency is not required and low cost is important. For instance, their early market has been in appliances such as calculators and watches. (DEO PRASAD & MARK SNOW 2005, 23)

4. Dye-sensitised solar panel

Dye-sensitised solar panel technology is best considered as artificial photosynthesis. It performs well under indirect radiation, during cloud conditions, and when temporarily or permanently partially shaded. Efficiencies over time are still to be established but technically that could achieve around 10 percent or more, and they are very effective over a wide range of sunlight conditions. (DEO PRASAD & MARK SNOW 2005, 23)

In Table 1 it is Compared the typical efficiencies of PV technology on the market and looked into the future, by seeing what can be achieved in the laboratory.

Table 1 Comparison of solar panel efficiencies

	Typical efficiencies %	Maximum recorded outdoors	Maximum recorded laboratory efficiency %
Mono-crystalline panel	12—15	22.7% ± 0.6	24.7
Poly-crystalline panel	11—14	15.3% ± 0.4	19.8
Amorphous silicon panel	6—8	10.4% ± 0.5	12.7
Dye-sensitised solar panel	10		

4.1.3 Related calculation

The life of the solar panel depends on the material of cell, TPT and EVA as well as tempered glass. According to the different factors, which are the price and working efficiency as well as the quality, we choose NG 145 TP3 SAW Module. The product code is N00986. The information of solar panel is on the below:

Main application: general off-grid PV systems
Maximum power point: 145 Watts, 8.08 Amps at 17.9 Volts.
Short Circuit: 8.59 Amps. Open circuit: 22.4 Volts.
Length: 1480mm. Width: 670mm. Thickness at edge: 34mm. Weight: 10.5kg.
Normal operating cell temperature is 47+/- 2^{o}C.
Efficiencies based on Standard Test Conditions Rating:
Module: 14.6%, Laminated area: 14.8%, cells alone: 16.6%.

Because the location of Finland is in the north part of the earth and the angle of sun-light has a huge change in a year, in order to get correct data, we have to calculate the angles in months by Solar Angle Calculator (See Figure 3):

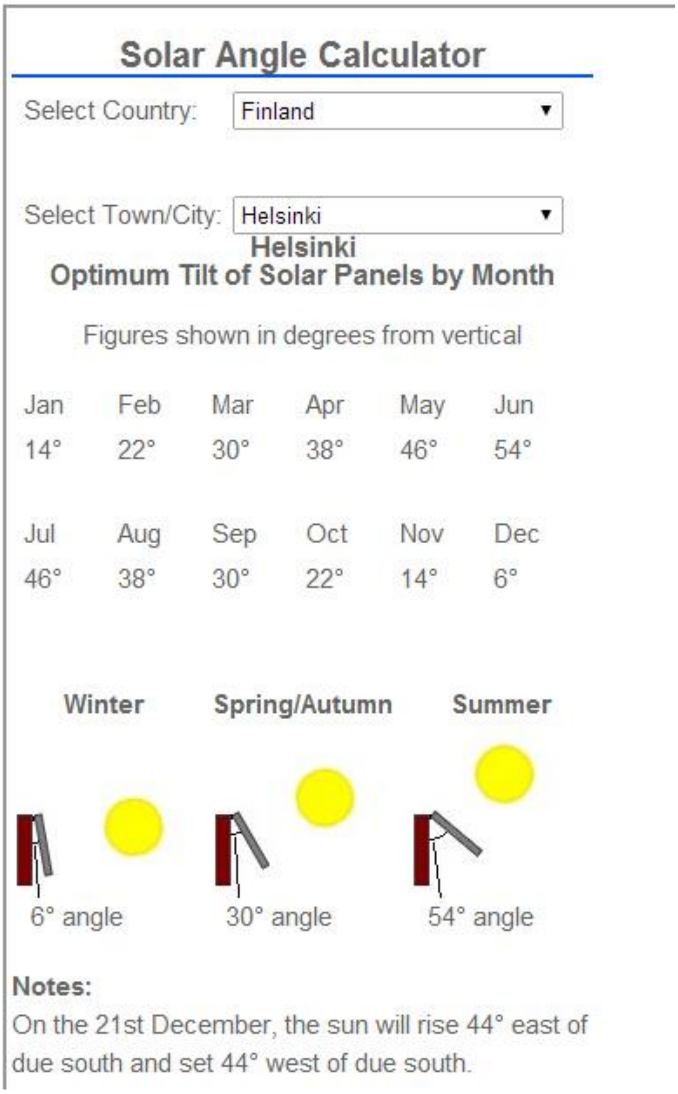

Figure 3. Solar angle in different month in Helsinki

C_H = C X sin A^0 and C is 1.366 X 10^3

So this year, solar constants in Helsinki are

January 1.366 X10^3 X sin14^0 =330.572 W/m^2 ≈0.33 kw/m^2

February 1.366 X10^3 X sin22^0 =512.25 W/m^2 ≈0.51 kw/m^2

March 1.366 X10^3 X sin30^0 =638 W/m^2 ≈0.64 kw/m^2

April 1.366 X10^3 X sin38^0 =841.456 W/m^2 ≈0.84 kw/m^2

May 1.366 X10^3 X sin46^0 =982.154 W/m^2 ≈0.98 kw/m^2

June 1.366 X10^3 X sin54^0 =1105.094 W/m^2 ≈1.11 kw/m^2

July 1.366 X10^3 X sin46^0 =982.154 W/m^2 ≈0.98 kw/m^2

August 1.366 X10^3 X sin38^0 =841.456 W/m^2 ≈0.84 kw/m^2

September 1.366 X10^3 X sin30^0 =638 W/m^2 ≈0.64 kw/m^2

October 1.366 X10^3 X sin22^0 =512.25 W/m^2 ≈0.51 kw/m^2

November $1.366\ X10^3\ X\ \sin 14^0 = 330.572\ W/m^2 \approx 0.33\ kw/m^2$

December $1.366\ X10^3\ X\ \sin 6^0 = 143.43\ W/m^2 \approx 0.14\ kw/m^2$

The solar constant per month is shown in Figure 4.

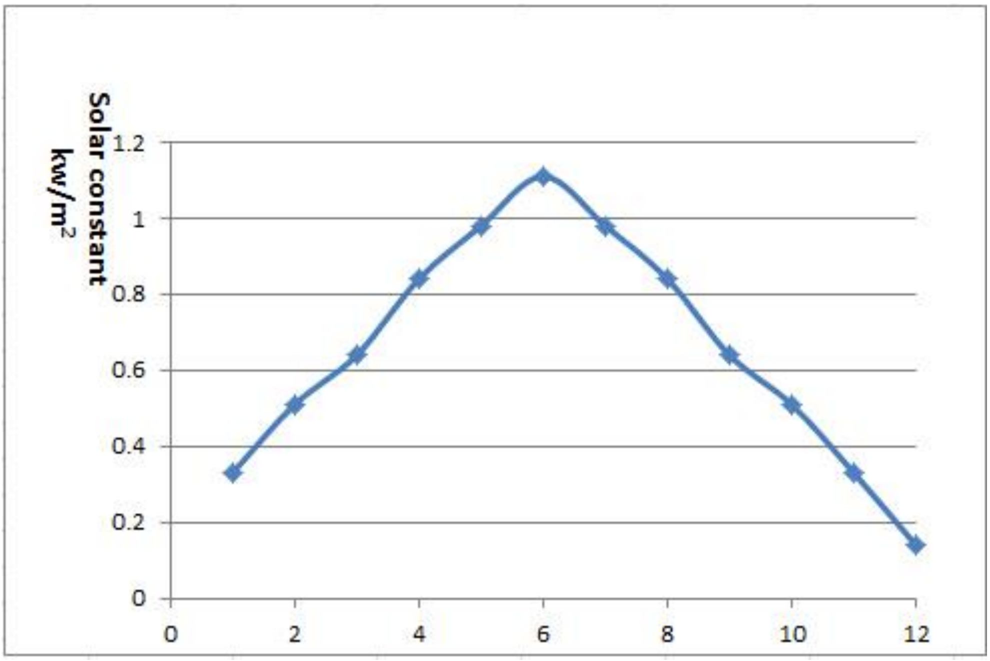

Figure 4.The graph of solar constant in 2013

The day length is also necessary to calculate in one day (timeanddate.com 2013) (See figure 5):

2013	Sunrise/set		Daylength	
Jan	Sunrise	Sunset	Length	Diff.
8	09:18 ↘ (137°)	15:36 ↙ (223°)	6:17:35	+2:57
9	09:17 ↘ (137°)	15:38 ↙ (223°)	6:20:41	+3:05
10	09:16 ↘ (136°)	15:40 ↙ (224°)	6:23:55	+3:13
11	09:15 ↘ (136°)	15:42 ↙ (224°)	6:27:17	+3:21
12	09:13 ↘ (136°)	15:44 ↙ (224°)	6:30:45	+3:28
13	09:12 ↘ (135°)	15:46 ↙ (225°)	6:34:21	+3:35
14	09:11 ↘ (135°)	15:49 ↙ (225°)	6:38:03	+3:42
15	09:09 ↘ (134°)	15:51 ↙ (226°)	6:41:52	+3:48
16	09:07 ↘ (134°)	15:53 ↙ (226°)	6:45:47	+3:54
17	09:06 ↘ (133°)	15:56 ↙ (227°)	6:49:47	+4:00
18	09:04 ↘ (133°)	15:58 ↙ (227°)	6:53:53	+4:05
19	09:02 ↘ (132°)	16:00 ↙ (228°)	6:58:05	+4:11
20	09:00 ↘ (132°)	16:03 ↙ (229°)	7:02:22	+4:16
21	08:59 ↘ (131°)	16:05 ↙ (229°)	7:06:43	+4:21
22	08:57 ↘ (131°)	16:08 ↙ (230°)	7:11:09	+4:25

Figure 5. The picture of daylength in Jannuary 2013 in Helsinki

It is necessary to calculate the average of day length in every month and make a graph.

January：The day length is around 6.6 hours.

February：The day length is around 9.2 hours.

March：The day length is around 11.7 hours.

April：The day length is around 14.5 hours.

May：The day length is around 17.2 hours.

June：The day length is around 18.8 hours.

July：The day length is around 18.1 hours.

August：The day length is around 15.1 hours.

September：The day length is around 12.6 hours.

October：The day length is around 10.1 hours.

November：The day length is around 7.5 hours.

December：The day length is around 5.8 hours.

According to the observation and testing, just at the period of middle time in one day, sun light is strong and solar panel can transform solar energy into electric energy. The efficiencies of time length which can transform solar energy are different in four seasons including: spring, summer, autumn and winter. They are 40%, 60%, 50%, 20%, respectively.

So the average hours which solar panel can transform solar energy into electric energy in January, February, March, April, May, June, July, August, September, October, November, December are 1.98 hours, 2.76 hours, 4.68 hours, 5.8 hours, 6.88 hours, 11.28 hours, 10.86 hours, 9.06 hours, 6.3 hours, 5.02 hours, 3.75 hours, 1.74 hours, respectively.

Table 2 to summary theses data and get the information easier and cleanly

Table 2 Comparison of the average hours in different month

Month	January	February	March	April	May	June
Average hours	1.98	2.76	4.68	5.8	6.88	11.28
Month	July	August	September	October	Novem-ber	Decem-ber
Average hours	10.86	9.06	6.3	5.02	3.75	1.74

The average effective hours per day are shown in Figure 6.

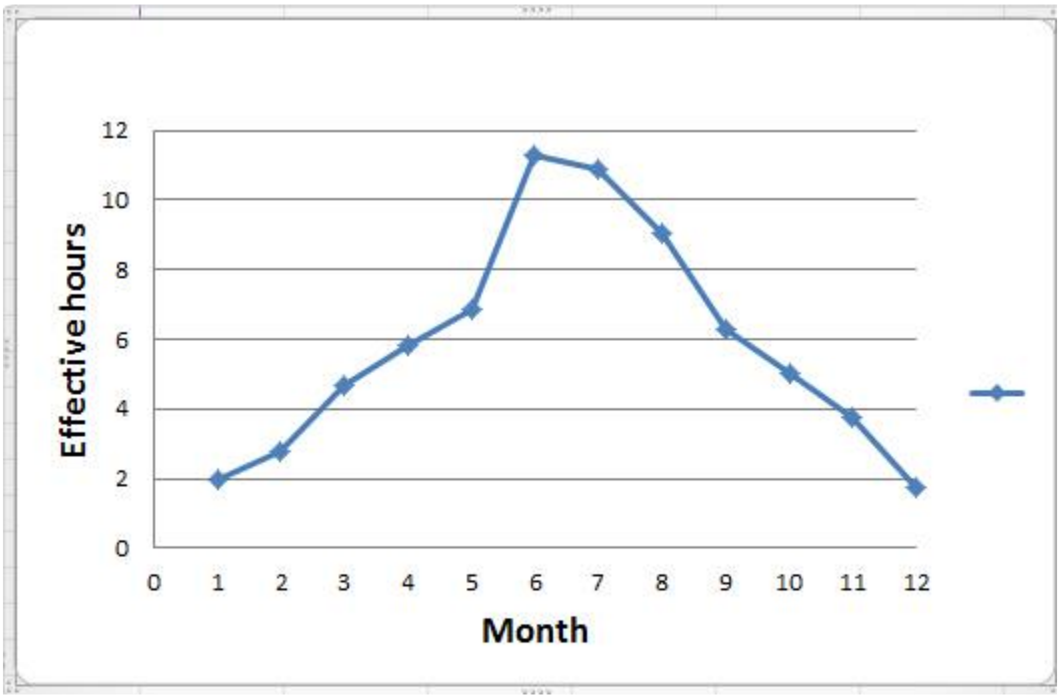

Figure 6.The effective hours with solar in every day in different months

And average solar energy collected by solar panel in every month in 2013 is like below:

W= Length (m) X Width (m) X Constant (w/m^2) X Time (s) X Efficiency

January：W=1.48 X 0.67 X 0.33 X10^3 X 1.98 X 3600 X 14.6% ≈2.22 X10^6J

February：W=1.48 X 0.67 X 0.51 X10^3 X 2.76 X 3600 X 14.6% ≈4.79 X10^6J

March：W=1.48 X 0.67 X 0.64 X10^3 X 4.68 X 3600 X 14.6% ≈10.20 X10^6J

April：W=1.48 X 0.67 X 0.84 X10^3 X 5.8 X 3600 X 14.6% ≈16.59 X10^6J

May：W=1.48 X 0.67 X 0.98 X10^3 X 6.88 X 14.6% ≈22.96 X10^6J

June：W=1.48 X 0.67 X 1.11 X10^3 X 11.28 X 14.6% ≈42.63 X10^6J

July：W=1.48 X 0.67 X 0.98 X10^3 X 10.86 X 14.6% ≈36.24 X10^6J

August：W=1.48 X 0.67 X 0.84 X10^3 X 9.06 X 14.6% ≈25.91 X10^6J

September：W=1.48 X 0.67 X 0.64 X10^3 X 6.3 X 14.6% ≈13.73 X10^6J

October：W=1.48 X 0.67 X 0.51 X10^3 X 5.02 X 14.6% ≈8.72 X10^6J

November：W=1.48 X 0.67 X 0.33 X10^3 X 3.75 X 14.6% ≈4.21 X10^6J

December：W=1.48 X 0.67 X 0.14 X10^3 X 1.74 X14.6% ≈0.83 X10^6J

The average electric energy produced by solar panel per day in different months is shown in Figure 7.

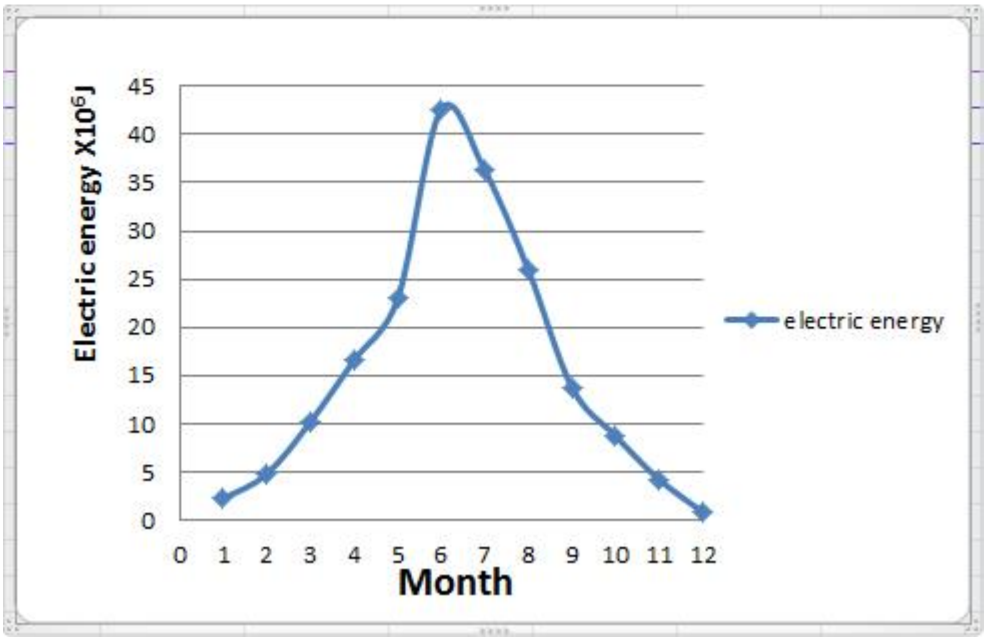

Figure 7.The average electric energy per day transformed by solar panel

According to the information, typically for solar car to move 100 km, it needs to consume 6.7 $X10^4$J. So the average moving distance in per day in January, February, March, April, May, June, July, August, September, October, November, December are 33.1km, 71.5 km, 152.2km, 247.6km, 342.7km, 636.3km, 540.9km, 368.7km, 204.9km, 130.1km, 62.8km, 12.4km, respectively (See figure 8).

Table 3 to summary theses data and get the information easier

Table 2 Comparison of the average hours in different month

Month	January	February	March	April	May	June
Moving distance	33.1	71.5	152.2	247.6	342.7	636.3
Month	July	August	September	October	November	December
Moving distance	540.9	368.7	204.9	130.1	62.8	12.4

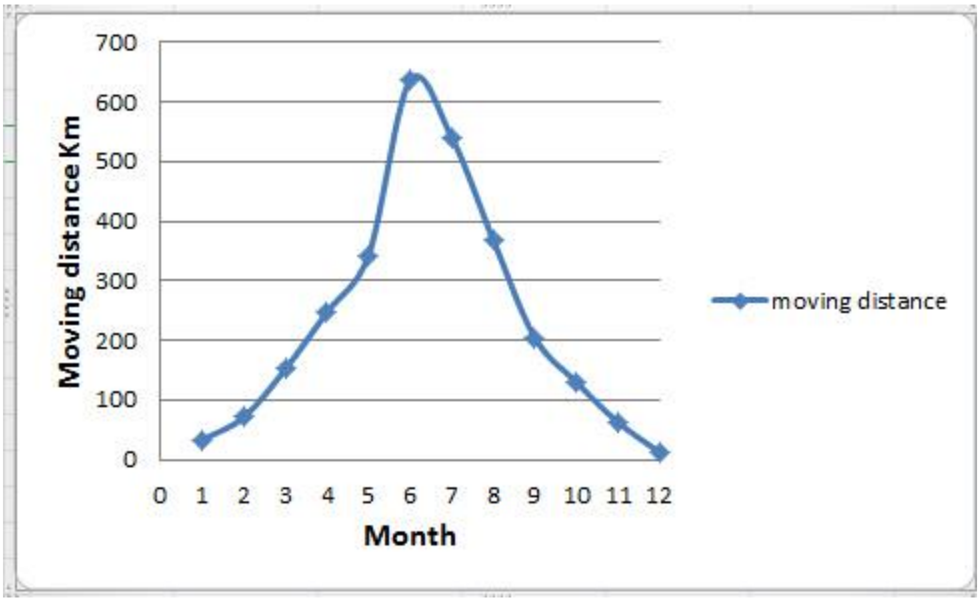

Figure 8.The everyday moving distance in different months

4.1.4 The application of solar panel

Solar panel is consisted by many photovoltaic cells.

There are a very wide field in the application of solar panels:

1. As a compact power (10W-100W), this is used for lighting and watching TV as well as listening radio.
2. Transport area: Supplying the power for beacon lights, traffic warning lights and high speed road.
3. Solar building: The solar power generation and materials of constructions are combined to make the solar building to achieve the self-sufficiency in the area of electricity.
4. Other areas, such as solar energy automobiles, electric cars, satellites, solar power stations, etc.

4.2 Solar controller

The functions of a solar controller are to control the working state of the system and protect the battery when it is charging or recharging.

1. Voltage protection: When the voltage of battery is below the voltage protection value, the controller will shut down the circuit of two sides and stop to supply power to the voltage loads. For instance, both the CD player and lights cannot continue to work.

2. Temperature compensation: a solar controller can give voltage compensation to ensure the battery to work in a constant voltage environment when the environment temperature is lower.

4.3 Inverter

Inverters are so highly advanced and are available in so many sizes that every cabin cottage and off grid home can afford one. This eliminates the need for following in the steps of renewable energy old timers who had no choice but to use 12V recreational vehicle appliances. (William H. Kemp 2009, 332)

In many cases, it is necessary to purchase a DC to DC voltage converter that can efficiently drop the higher direct current to the desired lower one. The units will ensure that electrical power drained from the batteries is applied evenly across the entire battery bank. (William H. Kemp 2009, 332)

Finally, the reasonable product code is PPT 12/24-2 Rxx. The PPT can handle resistive or inductive loads with high inrush currents. The unit is current limited and has a low voltage disconnect to protect the battery. This product has another good point that is you can design and order the number of output voltage when you are buying it.

Electrical specifications are presented in Table 4.

Table 4.The table for product specifications in details (solar converters)

Input Voltage (nominal battery)	24V
Low Voltage Disconnect	22V
Output Voltage	5V – Approximately Input Voltage
Output current	2A Current Limited
Ripple at load	30mV rms
Efficiency	>95%
Dimensions	43cm X 32 cm X 16cm
Temperature range	-40 ^{0}C to 60 ^{0}C

5 STRUCTURE AND THEORY OF SOLAR ENERGY AUTOMOBILE

5.1 The basic structure of solar car

The solar energy automobile is consisted of a solar panel and energy storage device as well as a motor system. (See Figure 10.)

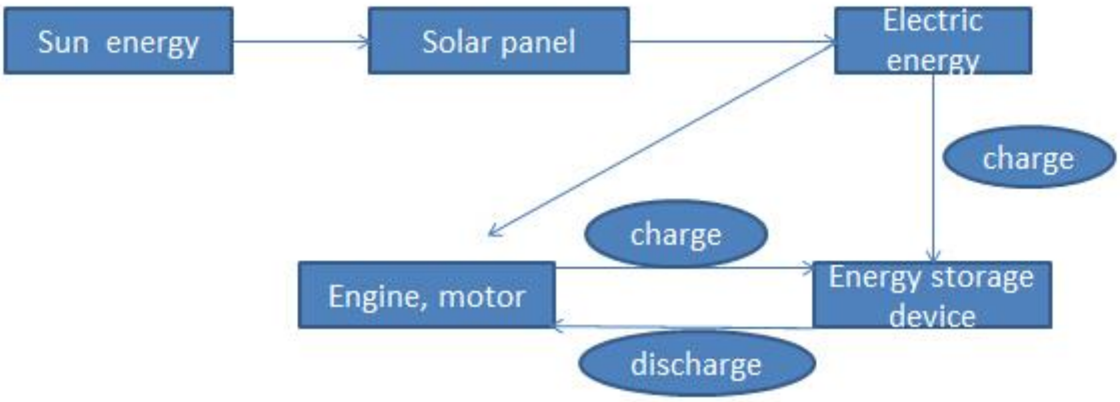

Figure 10. The relationship between the constructs

5.2 Theory of solar energy automobile

Light irradiation on the electric board can produce current. The light delivered to the storage battery or delivered to the motor directly it is through battery charge controller and peak power tracker. When solar energy automobile is moving, the light intensity is not enough and solar energy cannot keep the car moving. The solar energy automobile will use the energy stored in the battery and solar energy to drive the motor. When the car is not moving, energy will be stored in energy storage device. (See Figure 11.)

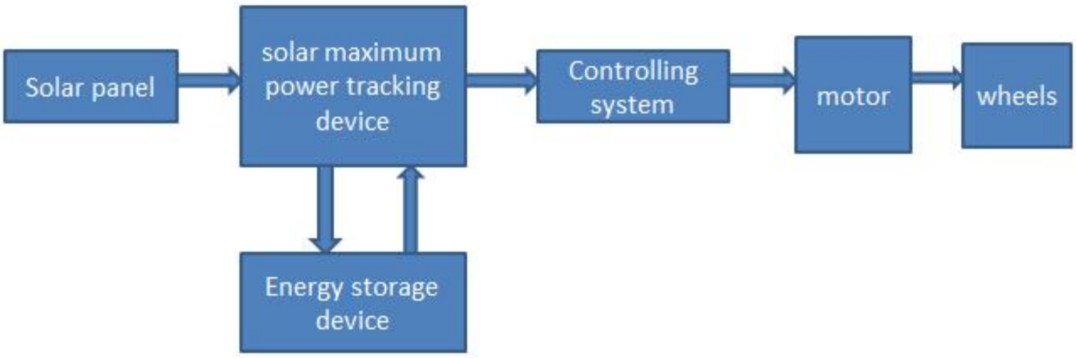

Figure 11. The energy flow chart

In order to improve the utilization of solar energy, it is necessary to install some electrics which are responsible for monitoring and controlling power in the system, so they are very important and useful components in solar energy automobiles, including solar maximum power tracking device (MPPT) and motor controller as well as data acquisition system.

The power tracking device is controlling the power, which is the solar array to maximize the resulting power and deliver it to the energy storage device or deliver power to the motor controller that generates propulsion. When solar array is working to charge the battery, the peak power tracker will help to protect the battery against the overload damage. It is worth to know that to keep a high working efficiency, different kinds of motors needs to match with the only motor controller.

6 THE DESIGN PROCESS OF SOLAR ENERGY AUTOMOBILE

6.1 The design of whole framework

Actually, it is a huge work to design a solar car. It was need to spend lots of time and energy on this project. In order to accomplish the project easier, a work plan was made when the project was started and the plan should always change in the period of the project. But it gave us a right direction, which is to achieve the initial purpose, and accomplish the project. The plan was a time chart, which was used to formulate the project outline so that it could be decided how much time to spend on these design steps, respectively. Because the solar energy automobile will face to different kind of consumer groups, different kind of marketing models need to be built, which depend on the individual needs of consumers and the enterprise features.

6.1.1 Making plans for the developments of automotive product

Development plans were need to be made for the product before beginning the technology design of the automotive product. First, need to know product what kind of solar car is and do some surveys, like questionnaire. With the help of requirements from customers, the market condition, production technology, crafts analysis and the cost estimate, to make sure the product is meeting the requirements.

Second was to simulate the primary design of an automobile. This was according to drawing the scheme figure and related performance calculations to decide the performance parameter of the automobile. Finally it was to write the book of task design, which is to write the specific requirements for the type of solar energy automobile, the dimension of some important parts, the requirements of the car mass and the performance indicators.

The preliminary work in product development is to analyze the influence factors in related areas and to clear and formulate the purpose of the product development and the direction of the work. Otherwise, the products will face too many problems, just like the security risks and no markets. So the concept design is also an important part in the early work, which is the summary description for the next generation models and future models, determining the design of the basic parameters of solar car, basic structure and basic performance. Maybe the concept just stays in the drawing or the description of the file, called “the virtual concept car”, and it is also probably being produced for the research. So the concept design is not only as a reference for product development but also can be the key part of the planning of product development, and to become the preliminary design of a new generation of models.

6.1.2 Initial designing

The main assignment of the initial design of solar car was to design the image of the structure of vehicles. The structure of the car determines the future of the car, because all of customers like the cool car, which influenced the sale in directly.

6.1.3 Initial modeling

According to the related calculations and rational design, it was determined the numbers of people in the car and the space was distributed rationally, so that the customer feels comfortable. In order to keep the rational relationships with each part, it was necessary to draw the whole structure arrangement, to ensure the specific location for the motor, chassis, operating sites and chairs. So some important measurements and the picture of basic car structure can be got after designing the initial models.

6.2 Driving control system

Drivers make the right judgment depending on the information shown on the cab dash and on the traffic information to make right more like switching lights or braking the car, to make sure the car drives normally and safely. So the reasonable driving control system takes the important part for driving.

6.2.1 The requirements of cab seat design

To ensure the seats are more comfortable, it is necessary to focus on the following:

1. Design the pillow on the chair to reduce neck fatigue and it also can protect hindbrain and cervical damage in the accident.

2. The design requires that the seat can be moved back and forth and the angle of the seat can be changed to decrease the level of back tired ness and to improve the seats comfort.

3. The seat heat system is also a good idea to improve the performance.

4. The construction materials and decoration materials need to satisfy the requirements. They must be durable, non-flammable and non-toxic. We also need to select soft, skid, good air permeability and non-conductive materials as the covering of cushions, handrails and lumbar.

6.2.2 The design of cab seat parameters

1. The sitting height refers to the height of the surface of the ground to the part of seat support. The rational sitting height makes enough space for legs. It is necessary, to avoid the leg dangling, blood in the legs not circulating or the low height increasing the pressure of back muscles.

2. Due to the space limitations of the cab, the width of seat cannot influence the size and operation of shift lever and parking brake. The size of the seat should satisfy the requirements of consumers, so that the driver can change the posture easier.

3. The seat inclination refers to the angle between the seats horizontally. It has two functions: first, because of the role of body weight and the angle, people will lean against the chair and the back gets relaxed. Second is to prevent driver slide from the front seat when the road is not flat. According to the many times required test, to get the rational angle is 4^{o} to 8^{o}.

4. The height of the backrest is related to the height and width of waist, shoulder and head. The function of backrest is to make the spine keeps a relaxed posture, because everyone’s spine is not the same length and stature is also the different. The four types of backrest are needed, including low back, backrest, high back and full back.

5. The angle of backrest refers to the angle between seats with backrest. To improve the comfort, the angle is better around 115^{o}. (See Figure 12.)

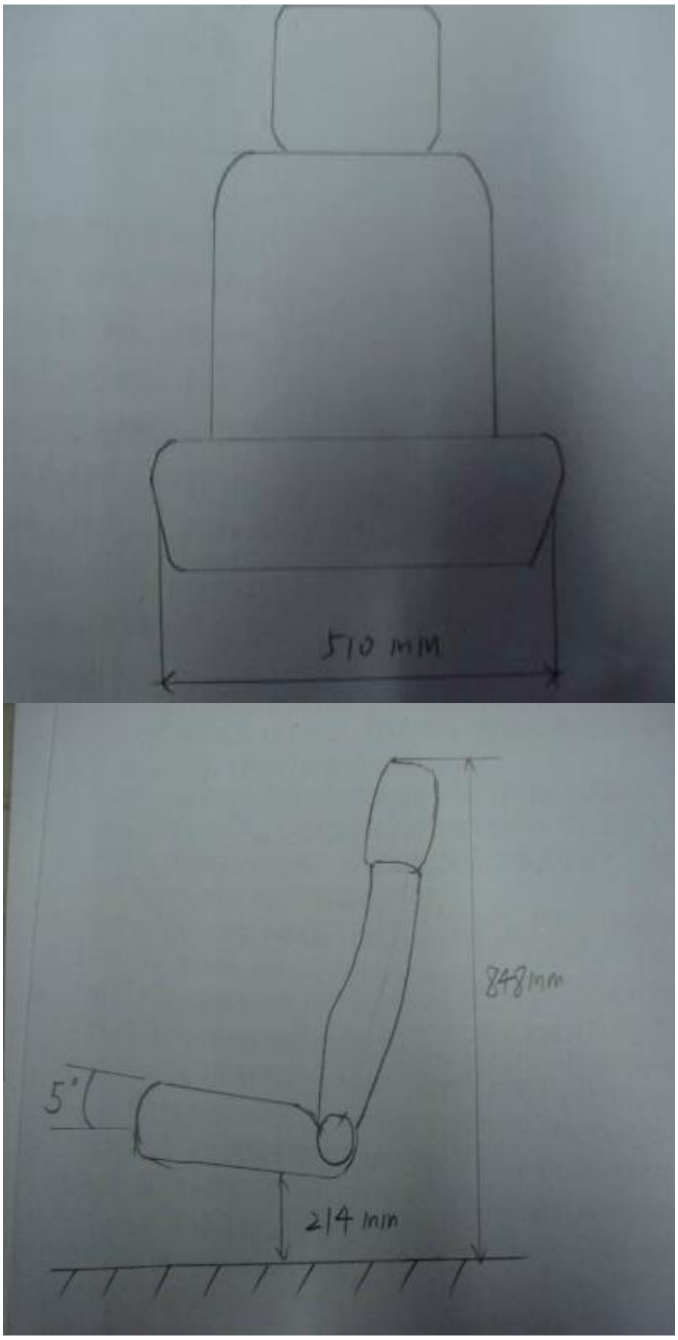

Figure 12.The pictures of seat design

6.2.3 Steering wheel design

Steering wheel is used to control the driving direction; it plays a key role in vehicles and personal security. Nowadays, the material of steering wheel is magnesium alloy, so it has a light weight and good performance.

The normal steering wheel can be divided into two types: a steering wheel with airbag and a steering wheel without an airbag. The difference between two kinds of steering wheels is the bottom, which is the steering wheel without an airbag has a special fork structure. It function is to switch turning light. For example, when the car turning right, toggle switch upward shift. At this moment, the return switch will move to corresponding position and it will switch the light with the steering wheel return to the initial position. And the steering wheel design requirements are all the components to be wear-resistant and durable characteristic and thermal stability at the extreme environments.

6.2.4 Dashboard design

For drivers, a simple and intuitive dashboard is important which not only display the automobile and road conditions but also can help to reduce the driver fatigue feeling. With the development of science and technology, more and more people accept and use LCD monitors. With the software program of an LCD monitor, instead of traditional analogue dashboard, it can improve accuracy and sensitivity of driving control system and reduce costs.

Most drivers have the habit of watching the dashboard and get useful information. We need to use the horizon model to decide the positional relationship between the steering wheel and instrument, which let drivers watch the dashboard easier. The American Henry has recommended that the maximum visual distance and best visual distance is 711 mm and 500 mm, respectively. We also need to think about the outline and color of dashboard and the light size as well as the intensity of indicator light to avoid adverse effects.

In order to facilitate the driver’s operation, the location of carious switch button should be within the range of activities in the driver’s hand. The variety of switch button should be designed at two sides of steering wheel depending on the different functions, to avoid the erroneous operation.

Because of the dash board is made for LCD monitor, the original software program which are the traditional layout design including tachometer, speedometer, water table and oil table when GPRS is off and the middle side is map, right side are tachometer and speedometer when GPRS is open. The brightness and displayed content of dashboard can be changed by drivers depending on their interest. (See figure 13 and 14.)

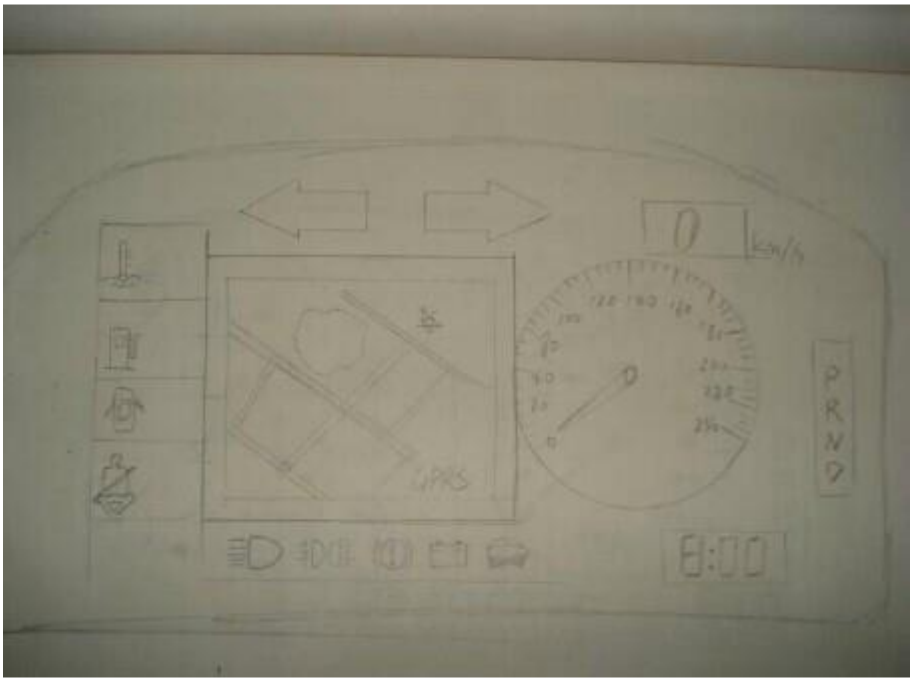

Figure 13.GPRS is opening

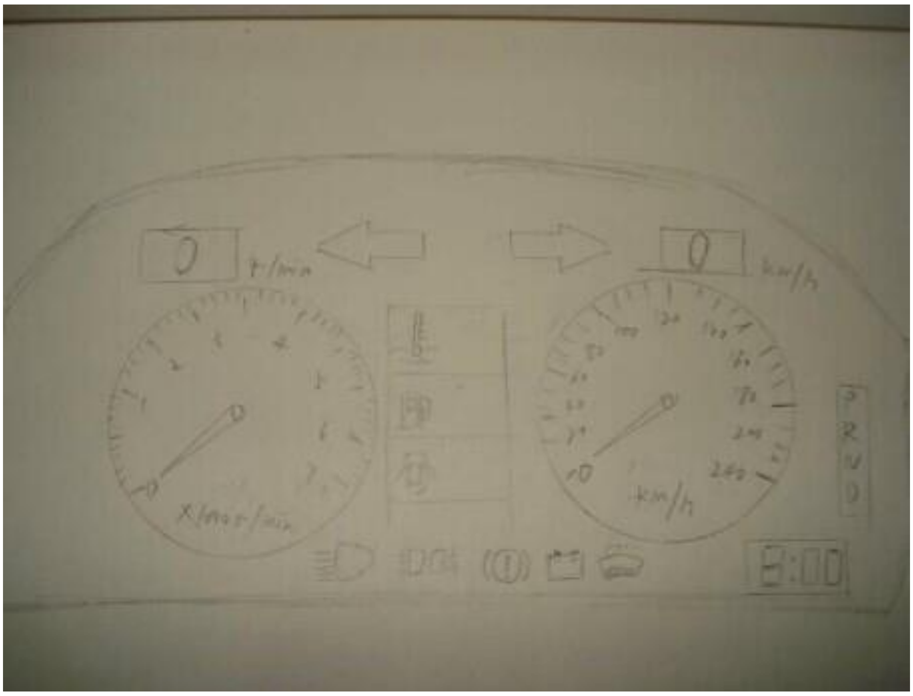

Figure 14.GPRS is off

6.2.5 Pedal design

The solar energy automobile just has a brake pedal and an accelerator pedal, which are responsible for increasing the speed of the solar energy automobile and decreasing the speed of the solar energy automobile, respectively. To be a reasonable design, the brake pedal should be installed at the left side, controlled by left foot and the accelerator pedal should be installed at right side, controlled by right foot. And the altitude difference between brake pedal and accelerator pedal is 25 ~ 60 mm.

6.3 Drive system

Most of solar energy automobiles use the AC brushless machine with double coil, which is made from lightweight material. The usage efficiency can reach 98 percent at the rated speed (RPM). Of course the price is higher than for a public motor.

There are three basic types of driving force in solar energy automobiles including single reduction guided drive, variable frequency drive crawler and shaft drive. Since 1995, people have started to use the shaft engine to design the solar energy automobile and the high speed and comfortable driving are welcomed by customers. Using the shaft engine can reduce the number of transmission equipment and so that decreases the energy consumption. The reason for shaft engine with low speed is the reduced gearing which just has a little influence on the efficiency and it works with 95% efficiency.

6.4 Mechanical systems

In the design of solar energy automobile, it is necessary to reduce the friction and weight. Aluminum and synthetic metals are commonly used by designers, which can improve the performance and intensity of solar energy automobiles to the maximum. The mechanical system is consisted by a brake, steering wheel and tires. Solar vehicles must have an efficiency braking performance to guarantee the safe driving and advanced tires. Light weight and strong friction can also improve the security and performance of solar vehicles.

7 THE DESIGN AND MANUFACTURE OF SOLAR CAR

7.1 The body and chassis of a solar car

The most attractive part of the solar energy car is the body. The solar car is consisted of some main components and the smooth and exotic appearance makes attractive. Because the market of solar energy automobiles does not make a unified standard for car body, every car has the particular appearance. They are different from each other. We not only design the particular appearance but also try to improve the performance, like speed. When we are designing a car body, we also need to keep the minimize air resistance, maximize the area to absorb solar energy, reduce the mass of solar car and improve the safety.

To reach these goals, I did not only depend on the theory and data but also did some practical design. A better appearance of a solar car can save several hundred watts, so it is necessary to design a better solar car.

Chassis is also a key component in solar cars. It must satisfy the strict force and safety requirements. We also need to keep weight minimum, because of the extra weight needs more energy, when the car is moving. Generally, there are three kinds of chassis that can be used in solar cars. The first type is called space frame, which is using the welding or coupling tubular structure to support the car. The car body is a lightweight modular housing, which is installed on the chassis respectively. The second type is using the bulkhead to support the car. The third type is using the structure of car body to support load. Using these three kinds of chassis can produce high-strength and low-weight solar cars.

7.2 Space frame structure

The space frame is used by welding and structure of protection tube, so the mass of this kind of a solar car is light, and it is helps to improve the performance of solar car.

There are also some factors influencing the performance and speed of solar cars. So it is necessary for us to spend time and money on the research, which is how to reduce the air resistance.

According to the information, which collected by professional teams, we found some useful ways for reducing air resistance.

1. Designing and producing the horizontal section is airfoil.
2. Reducing the side width of the car tail.
3. Using three-dimensional geometric model to simulate the external air flow field analysis and optimization. Controlling the coefficient of air resistance and the front projection area, until satisfied with the design requirements.

7.3 Solar array

Solar array is consisted of a number of PV photovoltaic panels (generally around hundreds). These photovoltaic panels convert solar energy into electrical energy.
Solar photovoltaic panels are connected by wires. According to the series connection and parallel connection with photovoltaic panels, the specified voltage is achieved. We found many ways to connect the photovoltaic panels and the basic purpose is to save the roof area and install more photovoltaic panels.

Because of the influence of weather and air pressure, the photovoltaic panels are easily damaged. We tried to find ways to protect it, just like compress photovoltaic panels to increase the density. In the sunny day, a good solar array can produce more energy than 1000W. This energy can be used by motors or stored in the battery.

8 CONCLUSION

The thesis was to design a solar energy automobile and according to the related information and data to choose a reasonable solar panel for the car so that it can provide maximum energy for the solar car. The reasonable designs included dashboard design, seats design and steering wheel design, which are different from the other cars.

Actually, in Finland it is possible to use solar energy automobile in summer. But in winter, the day length is so short and the solar constant is so weakness, so solar panel cannot transform and provide enough energy for solar energy automobile.

And solar energy automobile still has a huge potential market, because there are so many girls that want to buy the mini types of car and the safety is also a good reason for girls to buy it.

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