Use of Solar Energy in Electric Vehicles

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Abstract- In today's World, energy has a crucial importance for all countries. The countries search for both new energy resources and how they can use them. Energy resource is an important problem in our country, too. It is the sign of how it is important that we are mostly foreign dependent on energy. The most important energy problem is energy efficiency. When changing and developing automotive industry is handled, an important part of energy consumption consists of automobiles. So, it is clear that even small scale efficiency studies can save energy when thought in general basis (all automobiles). Practical solutions about efficiency increase in present vehicles, electrical efficiency and structure of vehicles working with energy taken from the sun is analyzed in our study.

Keywords- Hybrid vehicle; efficiency; solar car; electric vehicles; photovoltaic

1. Introduction

The effects of global warming and running out of energy resources with rapid growing energy in the World make the World countries seek solutions. So, energy has become main agenda for the World and it will be so. While the countries work for new energy resources, they also emphasize their efficient use. While other countries have some problems, it has become an important problem for our country if it is thought that we are mostly foreign dependent and the energy demand is a problem, too. Our country especially works on the policies about energy efficiency besides energy resource search. So, the most important thing in our country is energy efficiency. An important part of energy consumption consists of increasing number of vehicles. So, even very little energy save accounts for huge amounts of save when all vehicles are considered. The movements of the vehicles are accomplished with petrol consumption which is an fossil fuel resource today. The researchers seek different energy resources for long years because fossil fuel resources are limited, exhaustible and results in environmental pollution. In this concept, the thought of electrical vehicles is present for long years.

2. Energy Save by Making Use of Solar Energy

Many studies on electrical vehicles running by transforming solar energy to electrical energy have been conducted for many years. The infrastructure situations and high cost of electrical vehicles make it less possible to use electrical vehicles although electrical vehicles are important for researchers because of the increase in the cost of energy and the effects of global warming. Because of this and other similar reasons, vehicles running with electricity are widely used. So, the researchers generally have tendency towards systems which can save energy.

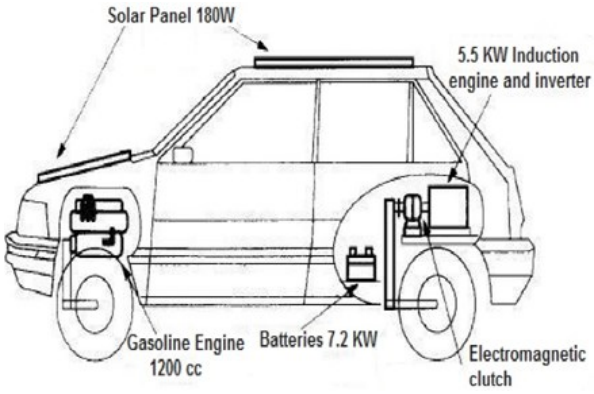

Fig. 1. Structural diagram of hybrid vehicle

The hybrid car shown in Figure 1 has two power sources which are hybrid electrical motor and petrol motor. Two power sources change automatically according to their drive values which can be set. For example; when the vehicle which can run with electrical in low speed reaches high speed, it can switch to petrol motor. The hybrid vehicle shown in Figure 1 is redesigned and a petrol with 1200cc, induction motor with 5.5 kW, a battery with 288 V and 25 Ah and a photovoltaic panels are added. This hybrid vehicle reaches 1200 kg by increasing 350 kg with hybrid vehicle load. There is a need for photovoltaic panel which has an average power of 1.6 kW to provide total electrical energy

from photovoltaic panels. The experimental results stated in Figure 2 show that travel distance with 1.1 m/ s² speed with hybrid vehicle electrical motor which can provide energy save occurring smoothly between petrol motor and electricity motor becomes 1.74 km. When it is thought that battery capacities have the power of 7.2 kWh, the travel distance of the car occurring with electricity motor reaches 40 km [1].

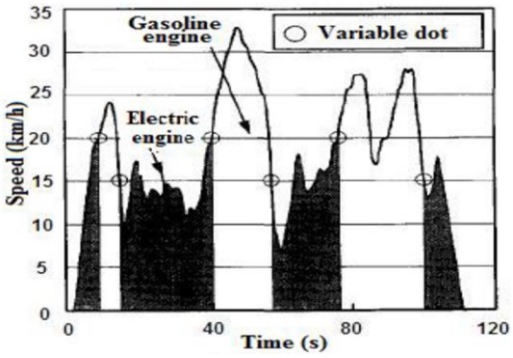

Fig. 2. Movement performance of hybrid car

A great amount of energy can be saved by using hybrid cars instead of the traditional cars running with petrol. Also, energy saving can be possible with a similar approach. The air conditioner of car can run without using petrol by placing a photovoltaic panel on it. Although it is a photovoltaic panel with low power because of the limited space on the car , the energy required for air conditioning system and indicators can be saved. Solar cars run by transforming solar energy into electrical energy. Solar vehicle one of the different types of transportation is a vehicle running with electricity consisting of rechargeable solar batteries and accumulators [2, 3]. The space for solar batteries for a solar vehicle is less than 8 m². So, solar vehicle which will be produced must be in low weight and energy efficient [1]. The control system in solar vehicles is very important. The follow-up and feedback control information of vehicles running with solar energy should be under constant follow-up. Information about voltage, current, power and heat of motor, accumulator and photovoltaic panels in the vehicles should be measured. The measured data should be handled with a feedback control system and evaluated by analysing them.

3. Electrical Structure of Solar Vehicles

3.1. Figure Properties

One of the most important equipment of solar vehicles is electricity motor. In order for electrical motor to have good performance, a motor with optimal power and efficiency should be chosen. Energy efficient motors should be analyzed. While the loss of electricity motor is tried to be minimized with the help of choosing efficient motor, a good couple should be provided with mechanical system motor which will be attached to motor at the same time that mechanical loss can be minimized. The motors in these vehicles are in 10-12 BG. The motor power comes from storage batteries. These motors are in the same structure and working system as in the electricity motors. The efficiency of electricity motors is quite better than that of internal combustion (max 96%). The motor in 10 BG is used in Halophile Pi developed by New Generation Motors. The efficiency of the motor is 90%. A sample vehicle motor with solar battery is shown in Figure 3 [1].

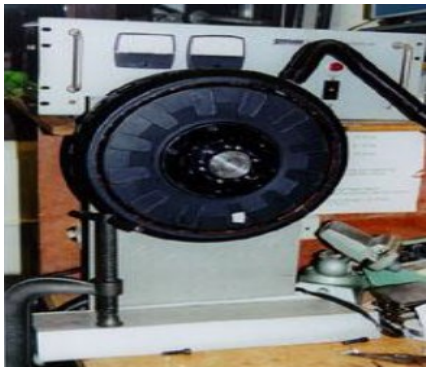

Fig. 3. Solar battery operated vehicle [6]

The photovoltaic panels transforming solar energy into electric energy store the electricity they produce in batteries. The stored energy make the vehicle's car move [4].

$$P = \left[V - E_a\right] i_a \text{ or } P = \left[V - E_a\right]^2 / R_a \quad (1)$$

The torch of the load is zero when there is no extra load and friction in the and so the output power is zero, too. The input power is low and electromotor back power is nearly equal to the input voltage. Only the power taken form battery consists loss torch [4].

$$P_{loss} = T_{loss}\Omega \quad (2)$$

When engine moves with torc input power becomes very high.

$$P = V^2 / R_a \quad (3)$$

But output power is zero as speed is zero. The power taken when the efficiency of the motor is defined as the amount of mechanical power can be found by dividing electrical input power [4].

$$Efficiency = \frac{Power\ Output}{Power\ Input} \quad (4)$$

Efficiency changes in contrast to load torch. In Figure 4, changing efficiency of Iskra shunt motor with torch [1].

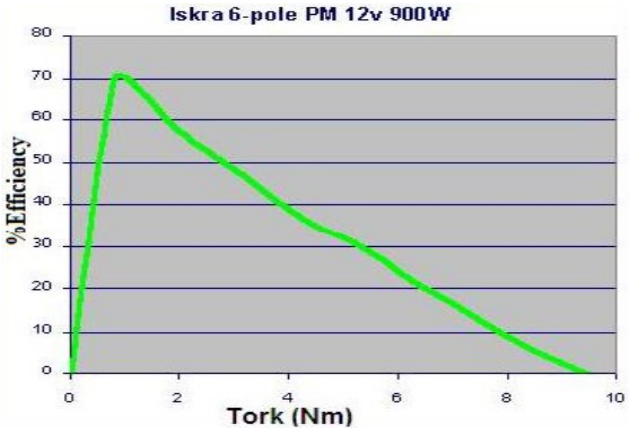

Fig. 4. Graphic of iskra shunt efficiency–torch [1]

3.2. Battery

Drive battery is the main power source of a vehicle. It is required to meet surplus power need and store surplus energy. The battery group is formed by connecting batteries parallel or series for appropriate tension and capacity. Lead acid accumulators are not preferred because of their low capacity for unit mass and low charge and discharge efficiency in solar vehicles. The developed battery systems such as nickel metal hydride, lithium ion, lithium polymer are used. Charging control cycle which will help the batteries to charge rapidly and securely should be used. The procedures used in battery choice [4];

- Firstly types of batteries are researched.
- The voltage with which the system will work is determined.
- In this voltage, cell combination which will provide proximate values to limit capacity is formed according to the accumulator types and models.
- The ones which meet the highest current demand are chosen.
- Total weight of these combinations is calculated.
- Total cost of chosen combinations is calculated.
- Cycle production/supply for accumulator types which can be used for secure electronic cycle and its cost are added to the calculation.
- Maximum amount for all battery groups in budget is determined.
- Light combination with the highest capacity which is not over the budget is chosen.
- The suitability/methods of montage and connection of the type chosen.
- The things such as appropriateness to race rules and power (electricity) system, mechanical durability are checked for the last time and it is ordered.

3.3. Solar Panel

One of the important equipment of the solar electricity cars is photovoltaic battery. The photovoltaic batteries produce electricity current by using photon energy in the sunlight with the help of movements of electrons with semiconductor technology [4]. The photovoltaic batteries are used in many fields such as electricity power stations, satellite communication, etc. We examine the photovoltaic batteries in solar cars without talking about detailed information about photovoltaic batteries. The widely used photovoltaic batteries are silicon and gallium arsenide solar batteries. While the satellites use gallium arsenide, silicon ones are usually used in the earth. Silicon batteries are used in the cars which have storage features. Numerous cells come together one by one to constitute solar panel. These panels can give power between 12 and 1000 voltage and endless watt depending on the motor used. The intensity of sunlight, clouds and the temperature effects the power produced by the panels. Any solar cell can be used in other type of solar cars. Because of this flexibility, many solar cars team use gallium arsenide solar cells used in space. These are usually more expensive and smaller than the traditional batteries. But they are more efficient. Power difference between than may reach to 1000 watt while the cost is 10 times more [5]. The solar batteries used in vehicles are usually 14%. The solar battery is brazed and cleaned carefully one by one before using in car. Another preparation is putting solar batteries in composite panels (usually 8-12 pcs). The weight of the panels is usually low. The solar batteries are sticked to the panels by a special vacuum technique to increase security. The panel is both protected against external factors and becomes waterproof with the help of it. Panels are designed to be changed easily in case of a breakdown. (only in a few minutes). Later, electronic circuit in the batteries is attached to the whole panel and a power output of 800-960 W can be accomplished [1].

3.4. MPPT (Maximum Power Point Follow-up)

In Figure 5, I-V and P-V graphics of temperature changes under stable lightening.

[1].

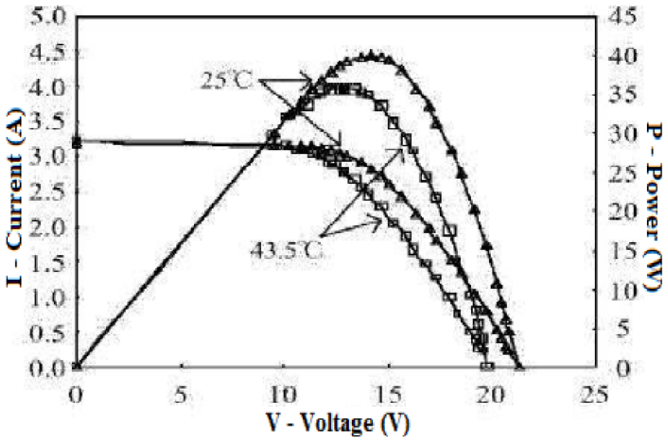

Fig. 5. I-V and P-V characteristics of solar battery [6]

Approximate statements of I – V characteristics shown in Figure 5;

$$Y = 1 - X^n \tag{5}$$

Power;

$$P = V_{OC} X . I_{SC} Y = V_{OC} I_{SC} . X(1 - X^n) \tag{6}$$

V_{OC} is open circuit voltage. I_{SC} is short circuit current. Power is maximum in the summit. In the summit $Pd(t) = 0$. When X is solved maximum, maximum $X_{p\max}$ operation electricity power point is max.

$$X_{p\max} = \{1/(n+1)\}^{1/n} \tag{7}$$

I-V characteristic changes because of heat and temperature if n parameter is given in the maximum power point stated in equation 7. The effects of these should be taken into consideration in n parameter change. N parameter stated in equation 6 goes on like this [6];

$$n = \frac{\log(1 - \frac{P}{V_{OC} I_{SC} X})}{\log X} \quad (8)$$

The equation stated in Equality 8 is very complicated. A clear statement of the equation is given in Figure 6 by calculating the values measured from the equation. Figure 6 shows n values calculated according to lightening and temperature.

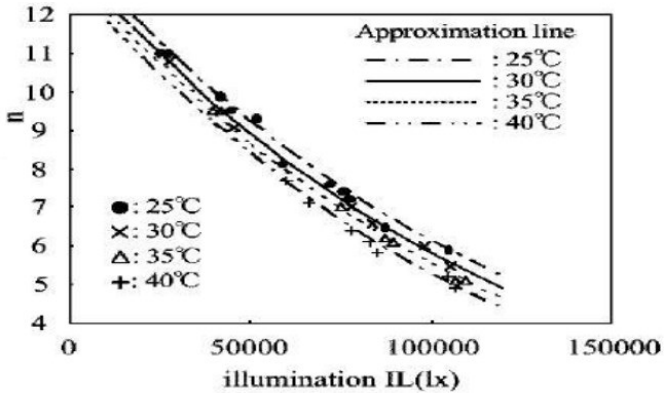

Fig. 6. Change of the parameters with measured values [6]

3.5. Advanced Control Systems

- Momentum control prevents unnecessary power use by keeping momentum in certain values in vehicle's take-off and acceleration. The system controls the change of time according to time and sends warning to decrease power in case it is over certain level.
- The cruise control system immobilizes and changes its speed or energy use automatically in desired levels in phases during its course. Holding wheel and watching whether the system works appropriately or not by the pilot is enough as long as the system runs. It is a system which analyzes data such as speed, position (GPS or the way), used/remaining energy, solar energy and decides and arranges vehicle according to these. It requires detailed energy calculations.

4. Conclusions

When energy consumption is thought, automobiles have an important share. We examine electrical efficiency in cars by studying on new generation electricity cars. Additionally, we try to determine a way for possible new designs for new cars. As the infrastructure of cars running by converting the energy taken from sun into electricity cannot reach desired levels, it is quiet costly today. Saving which can be done with small changes in present cars should not be ignored. Practical approaches should be developed by making detailed researches on these approaches.

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