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MOTOR ASSISTED APPROACH LEADING TO SOLAR CAR/VEHICLE

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Abstract—
Now-a-days, demand natural resources like fuel, coal etc. are the increasing. Therefore, to carry out this demand it is quite necessary to make a new exploration of natural resource of energy and power. The renewable energy is vital for today's world as in near future the non renewable sources that we are using are going to get exhausted. Sunlight is now-a-days considered to be a source of energy which is implemented in various day to day applications. Solar energy is being used to produce electricity through sunlight. The solar vehicle is a step in saving these non renewable sources of energy. The basic principle of solar car is to use energy that is stored in a battery during and after charging it from a solar panel. The charged batteries are used to drive the motor which serves here as an engine and moves the vehicle in reverse or forward direction. The speed controller is installed to control the motor speed braking and acceleration system is also associated with the motor controller which aids in the operation of the motor. The fabricated vehicle uses a 650W/ 48V motor that is powered by four 12 Volt, 90 AH batteries. The performance of the vehicle was found to be satisfactory for the load of five (5) people in 25 degree gradient surfaces with the average speed of 30 km/h. However, it still needs modifications and improvements.

1. INTRODUCTION

The fossil fuel such as petrol and diesel have been extracted and used in an erratic and expensive way. The use of fossil fuel based vehicles is one of the major ways that has accelerated the extraction of these non-renewable resources in an unsustainable way. Also the use of these vehicles causes air and noise pollution especially petrol-powered two and three wheelers. For example, in India there are close to 18 million petrol powered two wheelers and about 1.5 million petrol and diesel powered three wheelers and their population is growing at a healthy rate of about 15% per annum. Besides being a major hazard to people's health, these machines are guzzling huge amounts of petrol and diesel for which the country has to pay dearly in foreign exchange outflow. In fact it is a common sight in developing countries that during traffic jams in congested areas of cities these vehicles produce tremendous pollution.

Considering the overall prevailing situation, development of a solar vehicle is a vital effort where solar energy and its advantages are taken into account.

Solar Vehicles can provide a non-polluting and a very silent transport system for urban and rural areas of India and other countries. Solar powered vehicle will be a power generating and storing vehicle. It will use solar panels to extract the solar energy through photo voltaic cells. The generated energy will be stored in Lead-acid batteries and these batteries will be paired up in series to increase the capacity and thus the mileage of the Vehicle. These Vehicles are expected to ensure a mileage of maximum 40 km (30km average) with 48 Volts of battery with full capacity.

2 PRESENT SCENARIOS (life of three wheeler puller)

Now a days the population are going on increasing and hence the pollution are increasing .Also if we talk about the life of three wheeler puller (either that is auto rickshaw or simply manually pulled rickshaws). There are guesstimates that close to 1 million cycle rickshaws ply the Indian roads carrying about 3-4 billion passenger-

km/year . In some cities they are the major means of transport. They provide employment to about 700,000 rickshaw pullers, are very maneuverable and are completely non-polluting and hence environmentally friendly means of transport.

These non-polluting vehicles are being replaced by polluting (both air and noise wise) petrol and diesel powered three wheelers. Our data show that three wheeler diesel tempos in city produce close to 70-80 decibel noise at a distance of 1-2 m, besides belching out huge amounts of particulates into the air.

Now if we talk about the earning of these rickshaws puller then according to our survey:

(i) Discussions with rickshaw puller in various cities reveal that they ply the rickshaws to a maximum of 25-30 km/day. During hot season (which is majority time of the year) they can only go to 15-20 km/day. On an average they charge Rs. 3-5/km. Hence they can make between Rs. 75--125/day. After giving Rs. 15/day as rickshaw hiring charges they can earn about Rs. 60-110/day.

(ii) Presently the petrol auto rickshaws charge Rs. 4.50/km and that the rickshaw will go to 70 km/day. That means 315-350 rupees per day. Also some of owner of auto rickshaw has told that they have purchased auto at the cost of 2.15 lakh on loan having interest of 12.25% per annum and to fulfill that they take about 5 years.

Solar car /rickshaw is efficient in our daily life because now day's pollution and fuel rate is very big problem, many people having petrol cars. Use of solar energy is being used for vehicles, besides the control of vehicular pollution in the city, less consumption of fuel. Also the cost of this solar vehicle is comparatively (petrol/diesel/CNG Auto rickshaw) low. i.e.; 60,000/- but require high maintenance.

3. PROSPECT OF SOLAR THREE-WHEELER

Scarcity of energy is a common problem in all over the globe due to lack of conventional energy sources. So, Eco-friendly renewable energy like solar power can be the alternative and solve the power problem to some extent. Availability of solar energy radiation is the most vital consideration for designing and development of a solar system or solar equipment at any location on the earth. Rated solar radiation power received by the earth surface is (global radiation flux) 1000 W/m² (AM 1.5, sun at about 48 □ from overhead position). Availability of solar energy radiation in all over the country is very much encouraging for developing a solar three-wheeler for disabled people in Bangladesh. The geo-location of Bangladesh is in favor of receiving highest amount of solar radiation round the year. It is situated between 20.30-26.38 degrees north latitude and 88.04 - 92.44 degrees east, which is an ideal location for solar energy utilization. Solar radiation mapping shows that the daily average solar radiation varies between 4-6.5 kWh/m². Maximum amount of radiation is available on the month of March-April and minimum on December-January [5].

The researches have been going on to produce solar car, solar plane and so on. In the transportation sector, the use of solar energy faces different problems, such as the limited space for panel, batteries, transmission problems etc. Many in the world attempted to carry out the idea of a solar car, jointly forming as association and establishing a yearly race for solar powered cars, in different county each year.

Since the solar power system suits well with the minimal power consumption, the development of the solar three-wheeler would be very much feasible as it as mini transport needs comparatively smaller power for the power system. A 80-100 W solar panel is good enough to support the daily power requirement. However, the most challenging part of the solar three-wheeler project is to use the limited solar energy effectively, maximize its

efficiency and ensure suitability/traffic ability on our terrain. Successful implementation of the project will depend on how successfully and exactly the problems are indentified.

4. DESIGNING THE SOLAR VEHICLE.

Designing of the solar vehicle has two major parts/aspects. Firstly, Designing the vehicle and it's components from mechanical and biomechanics point of view and secondly, incorporation of solar power system to the improved manual vehicle to achieve automation.

4.1 DESIGN PHASE

The overall designing of the solar Vehicle is done through different phases as: recognition of the needs, definition of problem, synthesis, analysis and optimization, evaluation and presentation. The human requirements are translated to technical requirements, which include all the specifications or characteristics for the solar Vehicle to be designed. Then the solar Vehicle under design has been analyzed to whether it complies with specifications.

4.2 DESIGN CONSIDERATIONS

Design considerations refer to some characteristics, which influence the design of the element or, perhaps the entire system. The strength of each element, its dimension and geometry are important design consideration from the mechanical point of view. As a transport for the people the overall safety, stability, reliability, control, comforts etc are a very much important and taken in to consideration while de-signing it. However, the general points of consideration during the designing of the solar vehicle are: simplicity, strength, stability, safety, corrosion and wear, weight, size, flexibility, ease of control, modularity, efficient extraction of solar energy, effective use of solar energy and energy storage, all terrain tires for all terrain traffic ability/mobility, increased suspensions, biomechanics and comforts and cost.

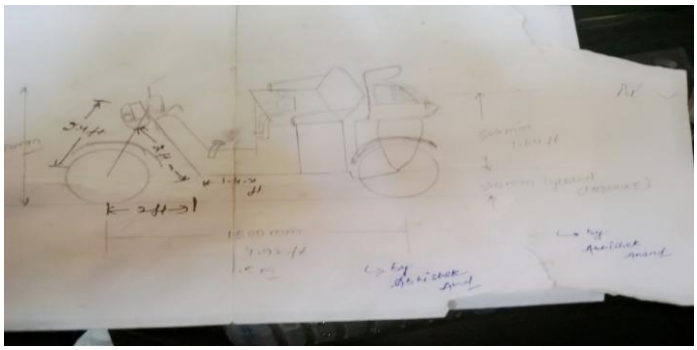

Fig.:1
Simple design paper work for vehicle

4.3 MECHANICAL DESIGN

4.3.1 CHASSIS AND RIM (WHEEL& TYRE)

The Chassis/Frame of the presently available vehicle is heavy and wheels are of big sizes. So while designing, unnecessary weight is reduced to meet the requirement. Comparatively smaller wheels are selected; keeping in mind that the weight of the solar vehicle should be as low as possible and must have required strength.

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Fig.:2
Figure showing chassis and wheel of proposed solar vehicle

The chassis can withstand necessary loads as well as absorbs shocks. The overall length and width are also reduced to some extent. Finally, the chassis is made by iron strips and angles with 2 mm thickness. Overall road condition including bumps, pot-holes etc. around the country is duly considered while choosing the wheel as well as its size. All wheels are of equal size having the diameter of 1265 mm each. All terrain tyres are used for better traffic ability having dimension for front 2.75 X 18 – 4 PR / 42P and the rear tyre size is 2.75 X 18 – 6 PR / 48P. The solar vehicle should of specific dimension and specific ground clearance.

4.3.2 CENTER OF GRAVITY LOCATION AND YAW RESPONSE

In designing a vehicle location of center of gravity and Yaw response is very important. A crucial vehicle property is the location of the vehicle center of gravity (CG). If it is located properly, the vehicle will be "stable" in terms of:

a. Resistance to "losing the rear end" in turns and crosswinds.
b. Ability to travel at high speed without continual steering corrections to counteract weaving.
c. Resistance to tipping over in turns and in encountering changes in road surfaces if sliding.
d. Resistance to swapping ends in hard braking due to weight transfer from the rear to front.

If the CG is in the "wrong place", the vehicle may exhibit all these unstable behaviors.

The yaw response of the vehicle refers its tendency to rotate about a vertical axis through the CG, or "spin". A stable vehicle can undergo side loads as in cornering or wind gusts, and not suddenly yaw in such a way as to amplify the tendency to spin. It is possible to yaw slightly in a self-corrective manner. The type of response depends largely upon the location of the CG.

4.3.3 STEERING AND BRAKING SYSTEM

A normal handle bar decorated with brake lever, accelerator, switches etc. and attached with front wheel is used here as steering as shown in figure 3 and figure 4. The speed of the solar three-wheeler is controlled by accelerator through continuous change in voltage by a twist throttle. Due to voltage change the motor power also

changes and thereby speed is controlled by increasing or decreasing the voltage. Normal drum brakes (brake pedal is shown in fig.4) is used in front as well as in rear-left wheel of this solar vehicle for better safety.

Fig.:3

Handle used as a steering in the solar vehicle

Fig.:4

Rear braking system pedal utilized in the vehicle

4.3.4 Desired speed and Power Requirement

If our load capacity is 300 to 350 kg (3-4 persons) , we require 650 watt motor whose speed will be 780 rpm . Now as per our calculation, Torque produced will be 7.95 N-m and for this diameter of shaft will be 32mm. That will equal to 649.36watt. Speed/Velocity for the vehicle will be 81.68 rad/sec (23.85 m/s).

4.4 DESIGNING OF ELECTRICAL & SOLAR SYSTEM

4.4.1 MOTOR DRIVE FOR THE VEHICLE

Selection of electric motor drives for solar vehicles is a very important step that requires special attention. The basic requirements are summarized as follows:

- High instant power and a high power density
- High torque at low speed for starting and climbing, as well high power at high speed for cruising
- Very wide speed range with constant-power region
- Fast torque response
- High efficiency over the wide speed range with constant torque and constant power regions
- High efficiency for regenerative braking
- Downsizing, weight reduction, and lower moment of inertia

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As according to our requirements we use special kind of brushless DC motor. It is radial-flux Brushless DC machines shown in Fig.5 that have an array of permanent magnets on the inside surface of the hub. The stator windings are attached to the axle, and the hub is made to rotate by alternating currents through these windings. In a DC hub motor, the magnets are on the axle, and the windings are actually spinning on the inside of the hub. A controller must present with BLDC (brushless direct current) motor .In a BLDC motor, the permanent magnets (rotor) rotate and the armature remains static. Transfer of the current in stator electromagnets are achieved by electronic controller. The controller performs the same power distribution found in a brushed DC motor, but using a solid-state circuit rather than a commutate or /brush system.

At standard load condition, the motor needs 650 Watts. This power will cover the required power needed to run the solar vehicle at speed of 25 to 30 km/hr.

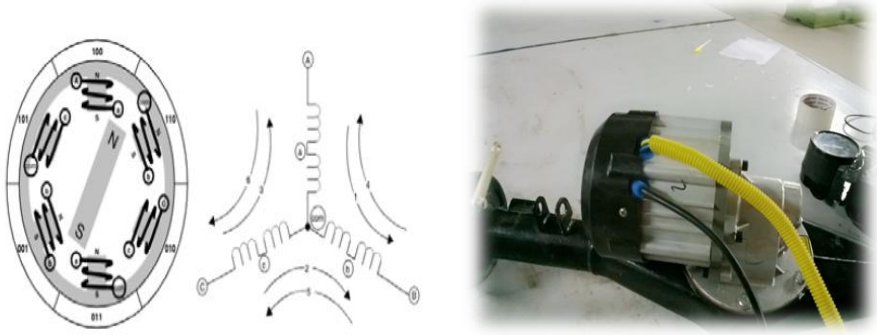

Fig.:5
Brush less DC Motor

4.4.2 MOTOR AND CHARGE CONTROLLER

4.4.2.1 CHARGE CONTROLLER

Charge controller consists of a circuitry that controls the DOD (Depth of Discharge) of the battery shown in Fig.6. The DOD and the battery life have inverse relationship. The battery that is discharged more has lesser life than that which is discharged less. Trade off is done in between the hours of operation and battery life cycles. Taking into consideration all the related factors, 85% of DOD was chosen for this system. The charge controller prevents the battery to be over charged or over discharged. If the battery voltage reaches at 54 V while charging, the charging circuit is cut off. While supplying power to the motor when the voltage reaches 44 V, the supply to the motor is cut off and the charging circuit is connected again.

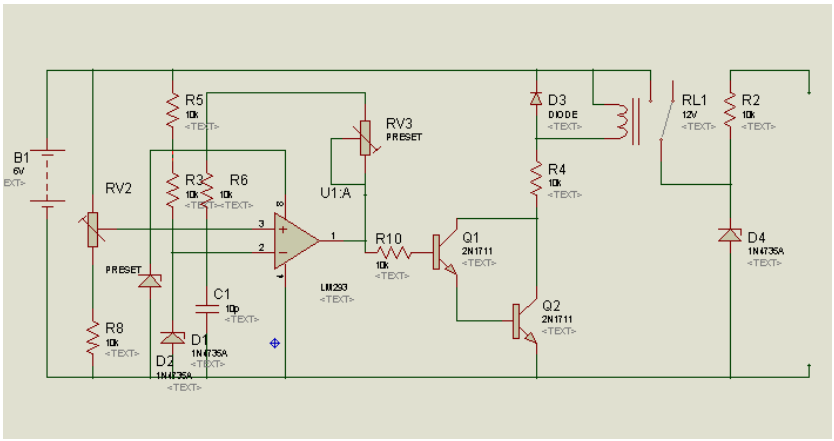

Fig.:6 Charge Controller

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4.4.2.2 SOLAR CHARGE CONTROLLER (MPPT TYPE)

A MPPT solar charge controller is chosen for the solar power system of the solar three-wheeler to extract maximum power from solar panel throughout the day. This is operated by microprocessors for sensing and recording the panel voltage and current at frequent intervals for computing and adjusting the power output. This solar charge controller takes the uncertain voltage from the solar panel and conditions it to charge the lead-acid battery safely. It cuts out the batteries from the load when the lead acid batteries are depleted to prevent damage to the battery and also protect the panels from the batteries after the sun goes down. Here, it collects charges from solar panels and charges the 12 volt lead-acid battery. It has LED bar readout to show the status of the solar charging system and batteries. With the help of this MPPT solar charge controller about 20 to 30% more energy can be generated than that of a common type charge controller.

4.4.2.3 MOTOR CONTROLLER

The simple motor-drive model of a BLDC motor-header consists of a three-phase power stage plus a brushless DC motor as shown in Fig.7. The power for the system is provided by a voltage source (Ud). Six semiconductor switches (SA/B/C t/b) allow the rectangular voltage waveforms to be applied. The semiconductor switches and diodes are simulated as ideal devices. The trapezoidal control of the BLDC motor is based on energizing only two phases at a time.

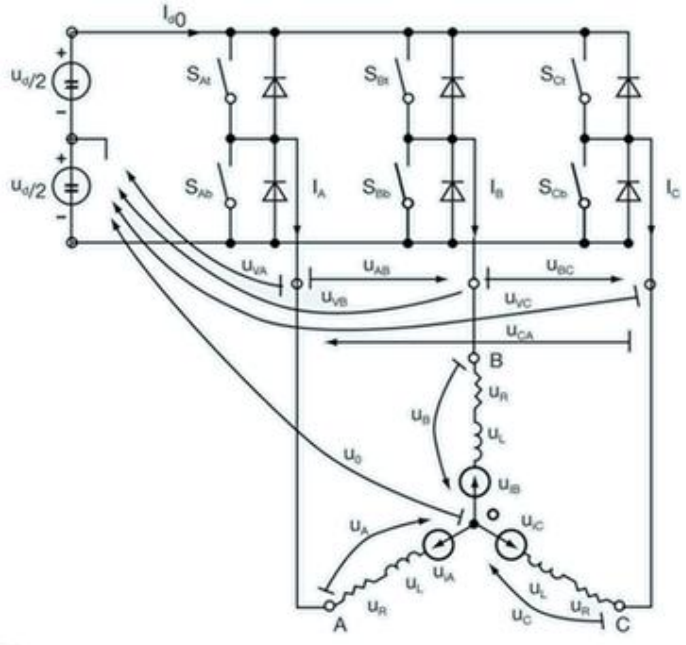

Fig.:7
Motor controller

4.4.3 BATTERY

A solar three-wheeler is the stand-alone system. To make practical use of the solar energy generated from solar panels, batteries are used to store the energy to meet up motor power requirement as needed at any time either in day or night. A 12-volt, 80 A-hr lead-acid battery is preferred and used here in solar three-wheeler power system as used in most of the PV systems. Main reason of using such lead acid battery is its availability and comparatively cheaper cost.

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4.4.4 SOLAR PANEL DETAILS

The solar panel used in the solar vehicle is of the rating of 80*4 WP. The main point that should be kept in mind while making a solar vehicle is the mounting of the solar panel. The panel should be mounted in such a way that it receives maximum sun rays so that it gives its maximum efficiency. For the vehicle designed, we have mounted the solar panel in SOUTH-EAST direction during the time 6 AM to 11.30 AM. After that the panel is changed to a SOUTH-WEST direction. We have used the conventional roof-top mounting technique for the solar panel A 6 feet by 4 feet plywood has been used and mounted on the top of vehicle. The solar cell used in the vehicle is multi-crystalline. The reason behind using the multi crystalline cell is that it is more efficient than the mono-crystalline cell and the rate of conversion of energy is faster in the former. 36 cells are used in the PV module of this vehicle. The upper frame of this solar module is covered with thick glass to avoid breakage of the solar panel.

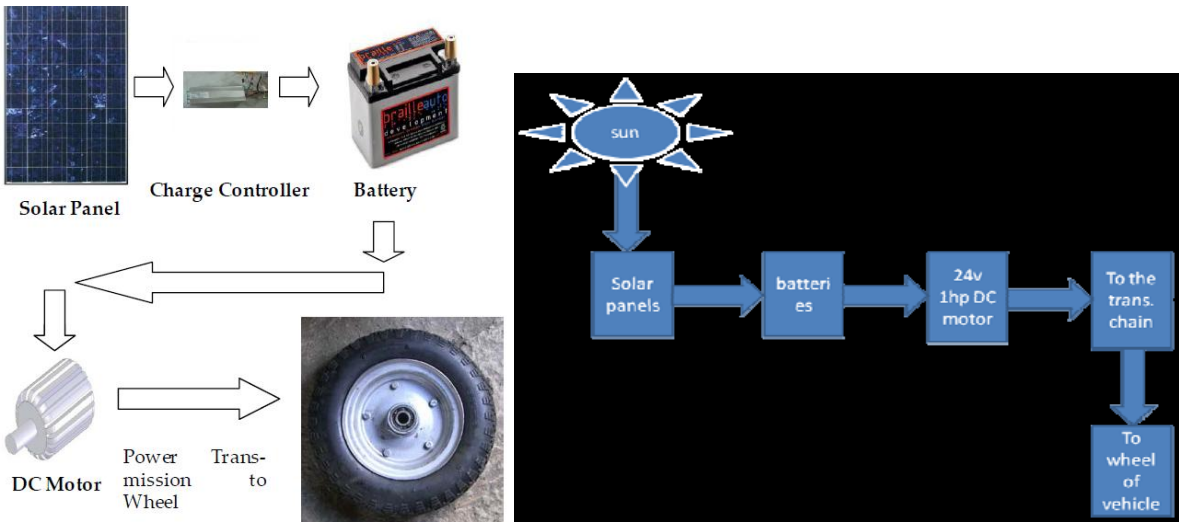

Fig.:8
Diagram of overall view solar power system in the vehicle

ADVANTAGES OF THE VEHICLE

The solar vehicles (shown in fig.) are the future of the automobile industry. They are highly feasible and can be manufactured with ease. The main advantages of a solar vehicle are that they are pollution less and are very economical. Since they cause no pollution they are very eco-friendly and are the only answer to the increasing pollution levels from automobiles in the present scenario. By harvesting the renewable sources of energy like the solar energy we are helping in preserving the non-renewable sources of energy.

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5 CONCLUSIONS

The project on solar vehicle has been satisfactorily completed the vehicle can run in normal dry surface with a maximum speed of 30 km/h with a total weight of 300 to 350 kg (3-4 persons) , The vehicle can show satisfactory results on slope less than 25°. When the battery of the vehicle is fully charged it can run continuously at an average speed of 20 km/h for four-five hours with an average running cost of 20 paisa per km.

Total Cost per Vehicle

Sr. No.	Components	Cost
1.	Main chaise+ wheel	6500/-
2.	DC motor	8000/-
3.	Motor Controller	8000/-
4.	Wires	500/-
5.	Battery (4)	16800/-
6.	Solar Panel	15000/-
7.	Misc.	1200/-
	Total	55800/-

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