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Design and analysis of Concentrated Photovoltaic system in Electric Solar vehicle

Thombare Shreyash Shripad
Department of Mechanical Engineering, SPPU, Maharashtra

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ABSTRACT: In upcoming years, electric vehicles are the future of automobile industry. Electric vehicles will become good alternative for the conventional internal combustion engine vehicles. Electric vehicles having major advantages, as they are less pollutant, environment friendly, etc. but, this electric vehicles needs electricity for their operation in larger scale. To overcome the challenge of generating electricity from conventional process, renewable source of energy come in picture. In India, solar radiation of about 5000 trillion kWh per year is incident over India's land mass, with average daily solar power potential of 0.25 kwh/m2 of used land area with available commercially proven technologies. It is necessary to use the renewable energy sources for the daily applications. Hence, this research paper introduce the use of solar energy for the operation of electric vehicle.

Keywords: Solar Energy, Electric Vehicle, Concentrated Photovoltaic System, Fresnel lens, Solar Tracker, Renewable Energy Sources.

I. INTRODUCTION:

To generate electricity renewable energy sources are the good choice. In India, around 72% electricity generator plants running on coal fuel. To reduce the number of percentage of coal use in generation of electricity, it is necessary to increase the use of renewable energy sources for generation of electricity. Solar energy is the one of great renewable energy source for generating electricity. This research paper introduce the method of using solar energy for generating electricity for the electric vehicles. Concentrated photovoltaic principal is use achieving good efficiency goal for this electric vehicle. Concentrated photovoltaic system helps to increase the efficiency of electric vehicle around 20-25%. The electricity generation rate of solar panel is increase by 30-45%in this method.

II. PROBLEM STATEMENT:

Upcoming decade is the era of electrical vehicles in automobile industry and as the rise in the number of electrical vehicles; the demand of electricity is much more. In India around 1208 kWh electricity is consume in year per capita and the generation of electricity in India is around 1598 TWh. During the fiscal year 2019-20, the utility energy availability was 1284.44 billion KWh. The main source of electricity generation in India is coal. In 2019-20 yearly gross electricity generation by coal is around 994,197 GWh. India's electricity sector consumes about 72% of the coal produced in the country. For utility power generation, India consumed 622.22 million tons of coal during 2019-20.

This means that, for the electricity, generation coal is required and as the demand of electricity is higher, the required amount of coal is higher.

In upcoming years, Electric vehicles will be the main substitute of conventional internal combustion engine vehicles, but for the country like India, it is very difficult to generate more electricity as the following problems are there in present date.

1. Inadequate last mile connectivity
2. Demand build up measures
3. Unequal electricity distribution
4. Erratic power pricing
5. Over-rated capacity
6. Lack of timely information on load and demand
7. Lack of adequate coal supply
8. Poor gas pipeline connectivity and infrastructure
9. Transmission, distribution and consumer level losses
10. Resistance to energy efficiency in residential building sector
11. Resistance to hydroelectric power projects
12. Resistance to nuclear power generation

To avoid the inconvenience to handle the demand of electricity, this research develops

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the Concentrated Photovoltaic solar system for the electric vehicles.

III. RESEARCH AREA:

Solar Energy in India:

Solar radiation of about 5000 trillion kWh per year is incident over India's land mass, with average daily solar power potential of 0.25 kwh/m^2 of used land area with available commercially proven technologies.

Concentrated Photovoltaic Principle:

Concentrator Photovoltaic System uses Lenses or Curved Mirrors and Solar Tracker to focus large area of Sunlight onto Small Multi Junction Solar Cells. Small Multi Junction Solar Cells converts maximum amount of Solar Energy into required Electrical Energy. Systems using high-concentration photovoltaics possess the highest efficiency, achieving near 40% for production modules and 30% for systems. (As of December 2014, best lab cell efficiency reached 46% for multi-junction concentrator, 4+ junctions).

Hybrid vehicle:

Hybrid vehicle uses two or more distinct types of power, such as submarines that use diesel when surfaced and batteries when submerged. Other means to store energy include pressurized fluid in hydraulic hybrids. The basic principle with hybrid vehicles is that the different motors work better at different speeds; the electric motor is more efficient at producing torque, or turning power, and the combustion engine is better for maintaining high speed.

IV. LITERATURE SURVEY:

1. **Innovation in concentrated solar power by David Barlev, RuxandraVidu, Piter Stroeve (Solar energy materials and solar cells 2703-2725, 2011)**

The author of this research paper focuses on innovation in Concentrated Solar Power technologies over the last decade. A multiple of advancements has been develop during this period.

2. **Viability of a concentrated solar power system in a low sun belt prefecture by Rahul Bhattacharjee, SubhadeepBhattacharjee (Frontiers in Energy 14, 850-866)**

The author of this research paper conclude that, the viability of the adoption of the concentrated photovoltaic solar system in a low sun-belt region with a lower direct normal irradiance.

3. **Techno-economic evaluation of concentrating solar power generation in India by Purohit Ishan, PurohitPallav (Energy Policy vol. 38, issue 6, June 2010)**

The author examines the techno-economic feasibility of concentrated photovoltaic solar power technologies in Indian conditions on the basis on two projects namely PS-10 (based on power tower technology) and ANDASOL-1 (based on parabolic through collector technology).

V. METHODOLOGY:

Generally, electrical automobile industry is mainly depends on rechargeable batteries and motors for their entire performance. In future, the source of electricity is nothing but the renewable energy sources. Some of the solar vehicles are also present in current Society, but they able to use only 15-25% of solar energy amongst the entire performance. This Concentrated Photovoltaic System helps to generate more solar energy by using lenses or curved mirrors. Due to these lenses, the beam of sunrays (in the terms of number of sun) is concentrated on the solar cell and the cell produces more energy that is electric. Solar tracker allows changing the position of lenses as per the position of sun, and this is not possible for the solar cells. Hence, use of Concentrated Photovoltaic System helps to increase the production of electricity from solar energy.

The Concentrator Photovoltaic System concentrates Sunlight onto the Multi-Junction Solar Cells or simply Photovoltaic cells by using Energy Tracker or Solar Tracker. Then this solar energy is stored in the form of electric energy by using solar batteries. This energy is further use for running the vehicle.

VI. BASIC CONSTRUCTION:

The concentrated photovoltaic solar system mounted on the roof of vehicle. The solar tracker helps to find out the exact location of sun and adjust the module accordingly. The lens, which is use for concentrating solar energy on the panel, is place above the module with minimum distance of 300 mm to 500 mm. This gap between lens and module secures the solar panel or cell from damaging. Water is circulate from capillary tubes, which are place just below the panels for cooling the module. Temperature sensor is connect to module for sensing the accurate temperature of module. As the temperature rises above 54^0C, cooling process has to be start. The solar panel is further connect to rechargeable DC batteries for store the electricity, and the battery is use for running the vehicle. This research is primarily use for small to medium size vehicles. City bus is one of them. It having good area on the roof to mount the solar panel and entire construction of concentrating photovoltaic system.

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VII. ANALYSIS:

Typical solar panel converts solar radiations into heat first and then it further convert into electricity. Due to some losses in conversion, the efficiency of solar panel is something around 15-20%.

As from the experimental data at the end of year 2018, 41.4% module efficiency was announce. In 2019, efficiency was 48% identically. This research done with the small-scale parameters and the obtaining results are:

1. Increment in ampere value of solar panel
2. Slight increment in voltage value of solar panel
3. Increment in temperature of solar panel

From the above results, the concentrated photovoltaic cell produce more electricity than the regular solar panel and also, the efficiency of concentrated photovoltaic solar system is more than the efficiency of regular solar panel.

VIII. SYSTEM DESIGN (SMALL-SCALE DESIGN):

Photovoltaic Cell Panel specification:
Maximum Power 5W
Open Circuit Voltage 21.02V
Short Circuit Current 0.32A
Maximum Power Voltage 17V
Maximum Power Current 0.30A
Maximum System Voltage 600VDC
(All values are measure at STC: 250 C, 1000 W/m2)
Battery Pack Specification:
Total three Rechargeable 12V DC batteries connected in series.
Lens:
Fresnel lens having thickness 5mm.
Solar Tracker
Temperature Sensor:
W1209 (12V digital temperature sensor)
Cooling Agent:
Air (decrease temperature by 4.7^0C)
Water (decrease temperature by 8.3^0C)

IX. RESULT TABLE (FOR 5W SOLAR PANEL):

Parameter	Solar Panel (5W)	Concentrated Photovoltaic System
Maximum Power	4.72W	5.21W
Open Circuit Voltage	20.91V	21.47V
Short Circuit Current	0.28A	0.74A
Maximum Power voltage	16.47V	16.96V
Maximum Power Current	0.32A	0.81A

X. COOLING SYSTEM FOR MODULE:

Concentrated photovoltaic system reaches maximum temperature value, as the solar energy is possessed on the total area of module. This affects the lifespan of solar cell and the cell will be damage soon. To overcome this problem the cooling system is use. In a process the air or water is circulate around the solar cell, to prevent it from overheating. Temperature sensor is also add in the system for obtaining accurate temperature of solar panel. From the experimental data, water is more effective than air as the cooling capacity of cell is increase while water is act as coolant.

XI. FUNCTIONALITY:

Concentrated photovoltaic system for hybrid solar vehicle is the good choice in upcoming days for the automobile sector. In current situation, the system is possible for city bus, mini bus, small electric vehicles etc. due to the more weight of components of system. Using of lens is the good idea for concentrating more solar energy on the required area of module. As the maximum output from the solar panel, increases the possibilities of generating electricity. In present date, the maximum efficiency of this module at ideal conditions is 48%. This research provides the good idea of using solar energy for the vehicles.

XII. CONCLUSION:

Electric vehicles are good alternative for the conventional internal combustion engine vehicles. They are less pollutant, environment friendly and useful for all purposes. In present date, electric vehicles are good choice for automobile sector and private sector, but there are many

limitations for generating the mass amount of electricity in many non-developed and developing countries. Use of renewable energy sources for generating electricity is good option in upcoming years.

This research concludes that, the efficiency of using solar energy for generating electricity for the electric vehicle is increase by using concentrated photovoltaic principle.

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