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Heat Transfer Analysis Using Solar Panel

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Abstract

The sun provides an abundant source of energy, which can be harnessed through the use of solar panels to produce electricity. When photons of light from the sun strike the photovoltaic cells within the solar panel, they generate an electric current. However, losses occur during this process, with one of the most significant being the production of heat beneath the panel, which can reduce its efficiency. To counteract this, fluid is circulated through the ducts beneath the panel to absorb the heat and transfer it away. This convective heat transfer process can increase the power output of the solar panel beyond its typical levels.

Keywords: Solar Panel, Photovoltaic Cells, Sunlight, and Convection.

1. Introduction

Solar energy is an important renewable energy source that encompasses both radiant light and heat from the sun. Numerous technologies are available to tap into solar energy, including solar heating, photovoltaics, solar thermal energy, solar architecture, molten salt power plants, and artificial photosynthesis.Active and passive solar techniques are used to capture and distribute solar energy and convert it into solar power. Examples of active solar techniques include photovoltaic systems, concentrated solar power, and solar water heating, while passive solar techniques involve orienting buildings towards the sun, using materials with favorable thermal mass or light-dispersing properties, and designing spaces that encourage natural air circulation. indispensable. Budgeting is ubiquitous and has long been considered a necessary tool in managing a company.

Solar energy is a highly attractive source of electricity due to its vast potential. According to the United Nations Development Programme's 2000 World Energy Assessment, solar energy has an annual potential of 1,575-49,837 exajoules (EJ), which is several times greater than the world's total energy consumption of 559.8 EJ in 2012.

The importance of developing affordable, clean, and renewable solar energy technologies was acknowledged by the International Energy Agency in 2011. Such technology could provide long-term benefits by increasing a country's energy security with the use of a domestically available, renewable resource that is mostly independent of imports. Furthermore, it could help to reduce pollution, promote sustainability, and lower energy costs.lower the costs of mitigating global warming, and keep fossil fuel prices lower than they would otherwise be. These benefits are global and should be considered as wise investments in learning. The costs of incentives for early deployment must be widely shared and used appropriately.

2. Solar Power Generation And Its Potential

The upper atmosphere of Earth receives an estimated 174 petawatts of solar radiation, with approximately 30% being reflected back to space and the remainder absorbed by the planet's land masses, oceans, and atmosphere. The visible and near-infrared ranges make up most of the solar spectrum at the Earth's surface, with a small portion in the near-ultraviolet range. The insolation levels for most of the world's population range from 150-300 watts/m² or 3.5-7.0 kWh/m² per day.

Solar radiation is absorbed by Earth's land masses, oceans, and atmosphere, which leads to atmospheric circulation and convection. The evaporated water from the oceans creates warm air that rises, and when it reaches a high altitude, the temperature is low enough for water vapor to condense into clouds. The process of water condensation can intensify convection, resulting in various atmospheric events, such as wind, cyclones, and anti-cyclones. Green plants use photosynthesis to convert solar energy into chemically stored energy, which produces biomass, food, and wood, and is the source of fossil fuels.

The total amount of solar energy that is absorbed by the Earth's atmosphere, oceans, and land masses each year is estimated to be around 3,850,000 exajoules. Of this energy, approximately 3,000 EJ is captured through photosynthesis and converted into biomass. The amount of solar energy that reaches the planet's surface is so immense that it is believed to be twice as much as the total energy that can be obtained from all other sources, including fossil fuels, nuclear power, and renewable sources such as wind and hydro power.Solar power can be generated through photovoltaics or concentrated solar power, which uses lenses or mirrors and tracking systems to focus sunlight into a small beam.Solar power has been experiencing rapid growth in recent years, and it is predicted to become the largest source of electricity globally by 2050. Solar photovoltaics and concentrated solar power are expected to contribute 16% and 11%, respectively, to the world's overall consumption. As of 2016, solar power generated 1.3% of global power.

Solar power has been growing rapidly in recent years and is expected to continue its growth trajectory in the future. According to projections, solar power is expected to become the world's largest source of electricity by 2050, with solar photovoltaics and concentrated solar power contributing 16% and 11%, respectively, to the global overall consumption. In 2016, solar power generated 1.3% of global power, indicating its increasing significance as a source of renewable energy.

A solar cell or photovoltaic cell is a device that changes light energy into electricity. Photovoltaics are best known as a method for making electricity by using solar cells to change energy from the sun into a flow of electrons. This solar cell works on the principle of photovoltaic effect. The photovoltaic effect is the creation of voltage and electric current in a material upon exposure to light and it is a physical and chemical property/ phenomenon.

Figure.1. Solar Panel

3. Block Diagram

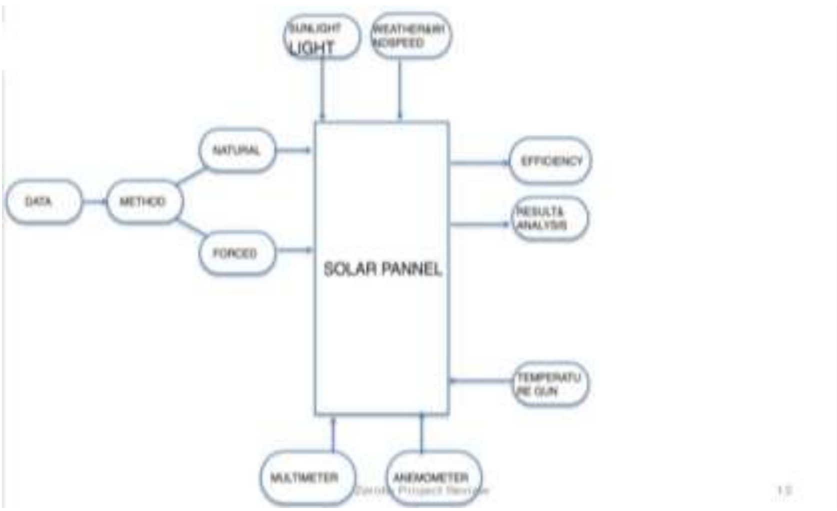


Figure.2. Block Diagram

4.Hardware Description

4.1. Multimeter:

A multimeter, also known as a multitester or a VOM (volt-ohm-milliammeter), is an electronic instrument that is capable of measuring various electrical quantities. These quantities include voltage, current, resistance, and sometimes other parameters like capacitance, frequency, and temperature. Multimeters come in two main types: analog and digital.Analog multimeters use a micro-ammeter with a moving pointer to display readings. These are relatively simple and inexpensive, but they may not provide the accuracy and precision that digital multimeters can offer. Digital multimeters, on the other hand, use a numeric display to show the measured values. They may also have additional features such as graphical displays, data logging, and connectivity options.

A multimeter typically has several measurement ranges and modes, which can be selected using switches or buttons. For example, to measure voltage, the user selects the appropriate range and probes the meter leads across the voltage source. The meter then displays the voltage reading. Similarly, to measure current, the meter is placed in series with the circuit, and the current flows through the meter, producing a reading.

Multimeters can be used in a variety of applications, including electrical and electronics troubleshooting, circuit design and testing, and quality control. They are an essential tool for anyone working with electrical or electronic systems, and their versatility and convenience make them a popular choice among professionals and hobbyists alike.

Figure.3. Multimeter

4.2. Anemometer

In addition to their use in weather monitoring, anemometers are also used in a variety of industries such as aviation, marine navigation, and wind energy. For example, pilots use anemometers to determine the wind speed and direction during takeoff and landing, while sailors use them to monitor wind conditions for safe navigation. Wind energy companies use anemometers to measure wind speed and direction to determine the best locations for wind turbines. Anemometers can also be used in environmental monitoring to measure air flow and ventilation in buildings or to assess air quality. Overall, anemometers are essential instruments for measuring and monitoring wind speed and pressure in a variety of applications.

4.3. Temperature Indicator

Temperature indicator is an electronic device which is used for measuring temperature by contact and Non-contact method.

Figure.4. Temperature Indicator

4.4. Solar Panel

Panel is placed on the table exposed to sunlight for the 6 hours and starting from 9:00 AM voltage reading is taken by using multimeter. Bottom temperature is measured by temperature indicator.

Figure.5. Solar Panel

4.5. Duct

Duct is a pipe, tube, or canal which carries a gas or liquid from one place to another.

Figure.6. Duct

4.6. Duct Specification

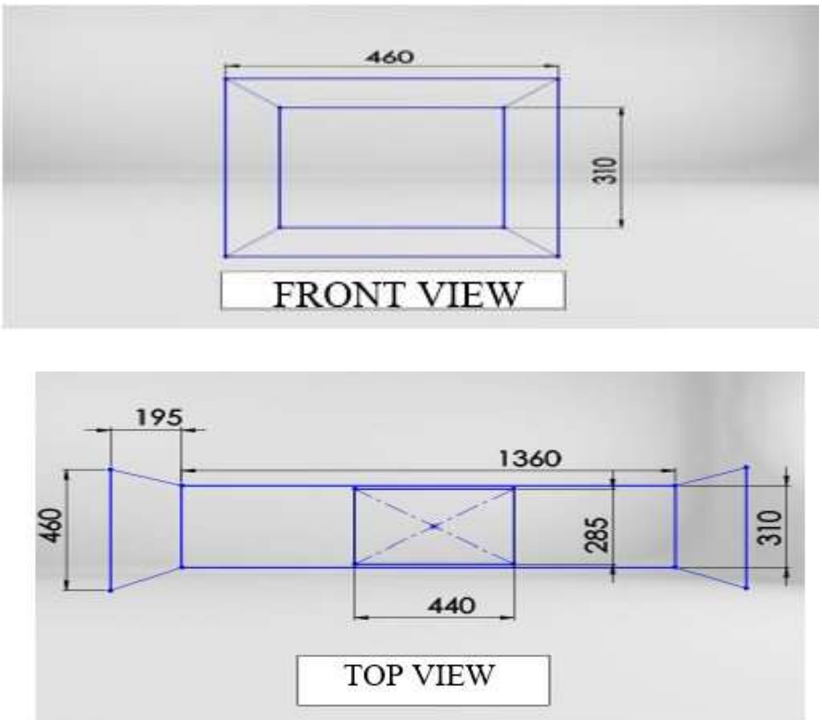


Figure.7. Duct Design

4.6. Exhaust Fan

Exhaust fan helps in ventilation and give us a proper set to keep the temperature at level

Figure.8. Exhaust Fan

4.7. Barriers

Barriers are Metal sheets carved to its duct measurements and used here to disturb the air flow in the duct to maintain a proper reading from the solar panel.

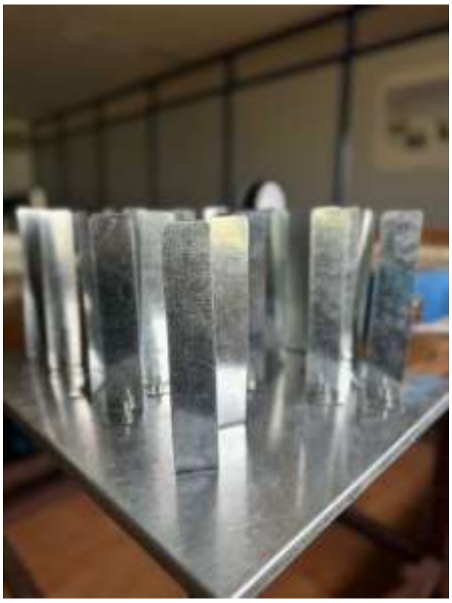
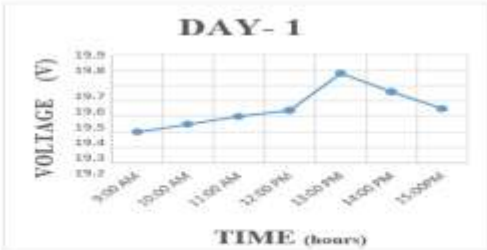
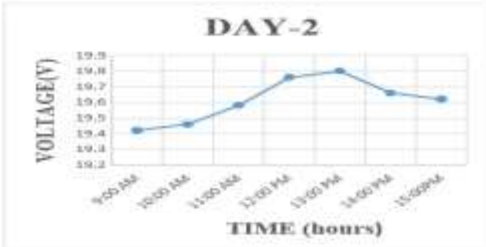


Figure.9. Barries

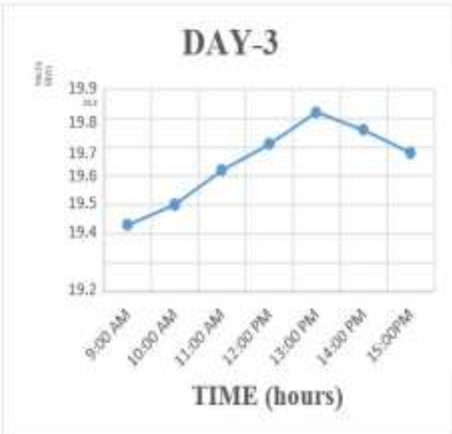
6. Results And Discussion



TIME(hours)	VOLTAGE(V)
9:00 AM	19.4
10:00 AM	19.45
11:00 AM	19.5
12:00 PM	19.54
13:00 PM	19.78
14:00 PM	19.66
15:00 PM	19.55



TIME(hours)	VOLTAGE(V)
9:00 AM	19.42
10:00 AM	19.46
11:00 AM	19.58
12:00 PM	19.76
13:00 PM	19.8
14:00 PM	19.66
15:00 PM	19.62



TIME(hours)	VOLTAGE(V)
13:00 PM	19.82
9:00 AM	19.43
10:00 AM	19.5
11:00 AM	19.62
12:00 PM	19.71
14:00 PM	19.76
15:00 PM	19.68

Figure.10. Result and Discussion

6.1. Solar Panel with Duct – Free Convection

Solar panel is placed in the duct exposed to the sunlight for 6 hours, starting from 9:00 AM to 3:00 PM voltage reading is taken by using multimeter. Bottom temperature is measured by temperature indicator.

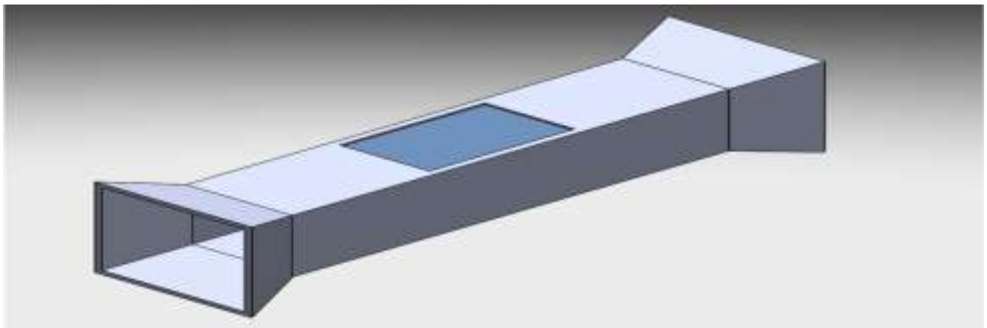
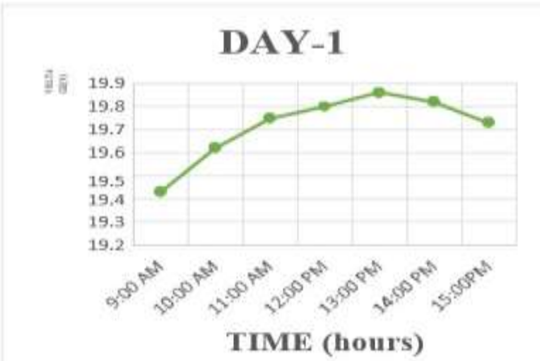
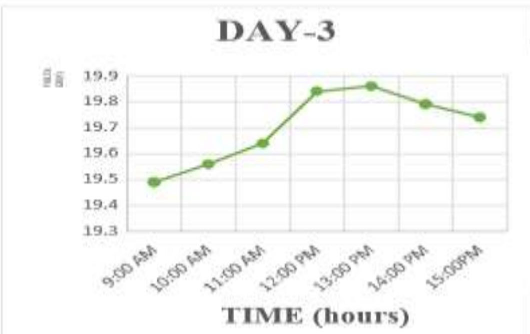


Figure.11. Solar panel with Duct



TIME(hours)	VOLTAGE(V)
9:00 AM	19.43
10:00 AM	19.62
11:00 AM	19.75
12:00 PM	19.8
13:00 PM	19.86
14:00 PM	19.82
15:00 PM	19.73

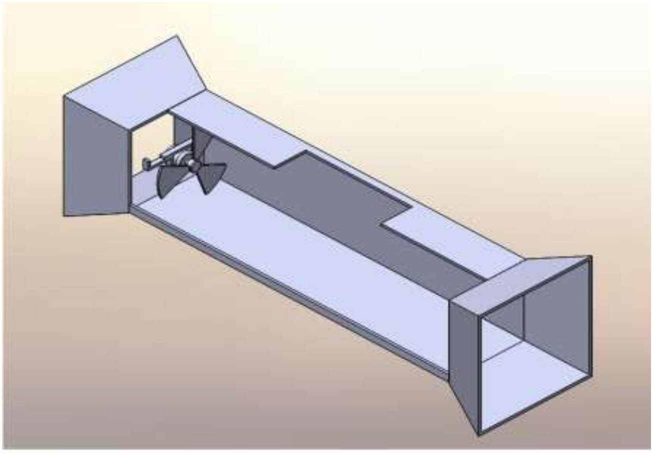
TIME(hours)	VOLTAGE(V)
9:00 AM	19.51
10:00 AM	19.59
11:00 AM	19.64
12:00 PM	19.77
13:00 PM	19.83
14:00 PM	19.79
15:00 PM	19.74

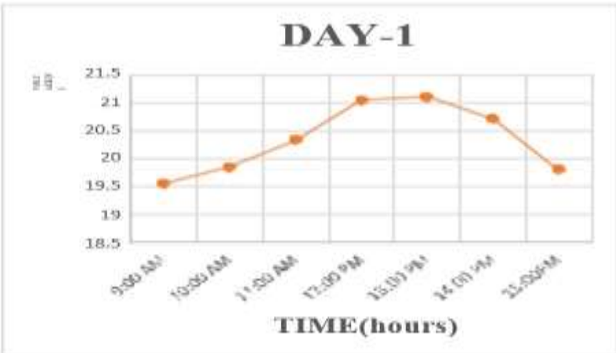


TIME(hours)	VOLTAGE(V)
9:00 AM	19.49
14:00 PM	19.79
10:00 AM	19.56
11:00 AM	19.64
12:00 PM	19.84
13:00 PM	19.86
15:00 PM	19.74

6.2 Solar Panel With Duct – Forecd Convection

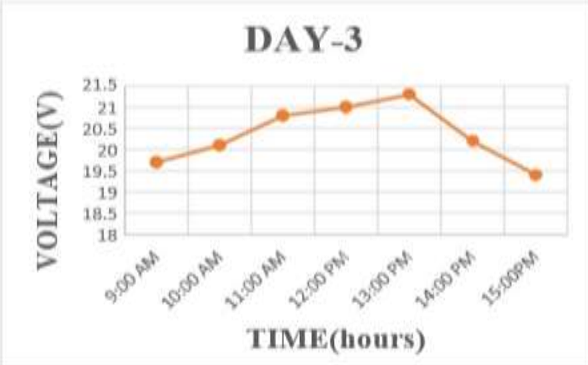
Solar panel is placed in the duct with electric fan and the setup is exposed to the sunlight for 6 hours, starting from 9:00 AM to 3:00 PM voltage reading is taken by using multimeter. Bottom temperature is measured by temperature indicator.





TIME(hours)	VOLTAGE(V)
9:00 AM	19.56
10:00 AM	19.85
11:00 AM	20.33
12:00 PM	21.04
13:00 PM	21.1
14:00 PM	20.7
15:00 PM	19.8

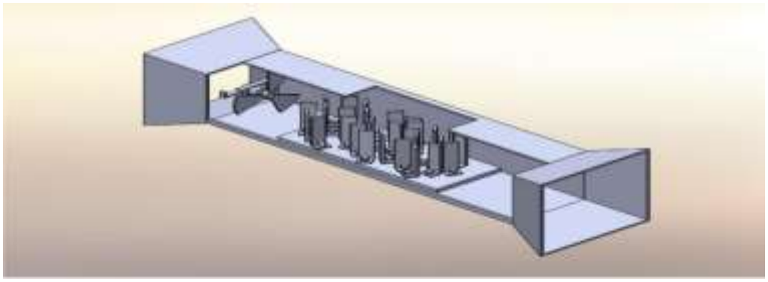
TIME(hours)	VOLTAGE(V)
9:00 AM	19.8
10:00 AM	20.9
11:00 AM	21
12:00 PM	21.1
13:00 PM	21.3
14:00 PM	20.8
15:00 PM	19.6

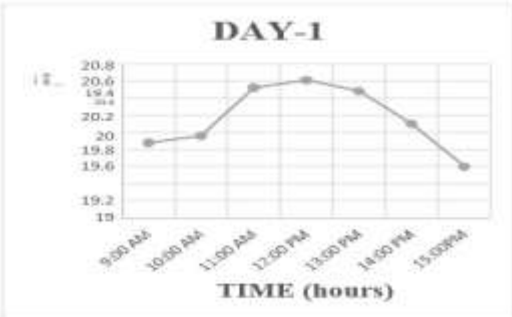


TIME(hours)	VOLTAGE(V)
9:00 AM	19.7
10:00 AM	20.1
11:00 AM	20.9
12:00 PM	21.14
13:00 PM	21.31
14:00 PM	20.47
15:00 PM	19.4

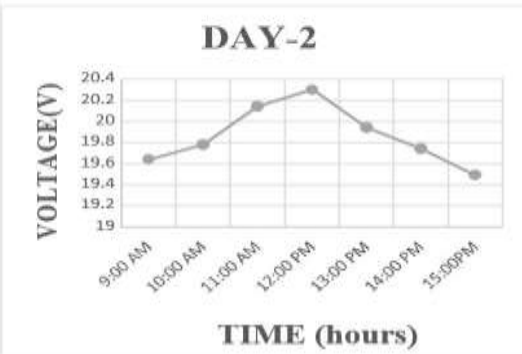
6.3. Solar Panel With Barriers

Solar panel is placed in the duct with electric fan and barriers and the setup is exposed to the sunlight for 6 hours,starting from 9:00 AM to 3:00 PM voltage reading is taken by using multimeter.Bottom temperature is measured by temperature indicator.

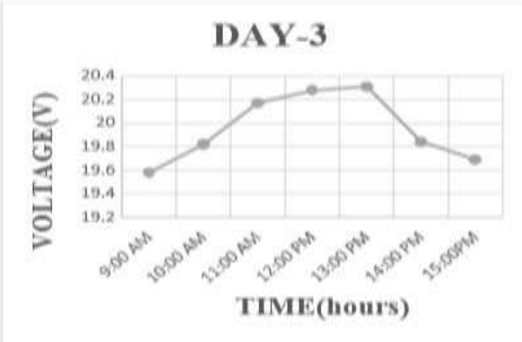




TIME(hours)	VOLTAGE(V)
9:00 AM	19.88
10:00 AM	19.96
11:00 AM	20.52
12:00 PM	20.61
14:00 PM	20.1
15:00 PM	19.6



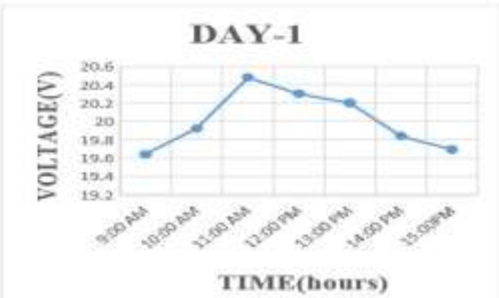
TIME(hours)	VOLTAGE(V)
9:00 AM	19.64
10:00 AM	19.78
11:00 AM	20.14
12:00 PM	20.3
13:00 PM	19.94
14:00 PM	19.74
15:00 PM	19.49



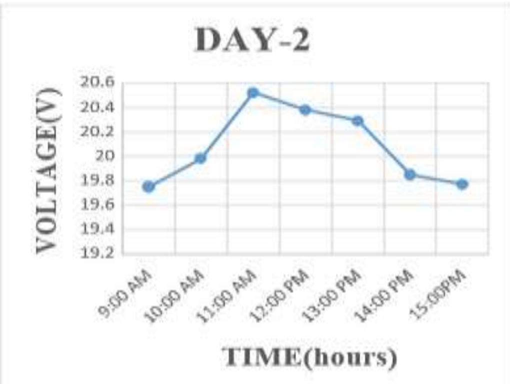
TIME(hours)	VOLTAGE(V)
9:00 AM	19.58
10:00 AM	19.82
11:00 AM	20.17
12:00 PM	20.28
13:00 PM	20.31
14:00 PM	19.84
15:00 PM	19.69

6.4 Solar Panel With Induced Draft Fan

Solar panel is placed in the ductwith induced draft fan and the setup is exposed to the sunlight for 6 hours, startingfrom 9:00 AM to 3:00 PM voltage reading is taken by using multimeter. Bottomtemperature is measured by temperature indicator.



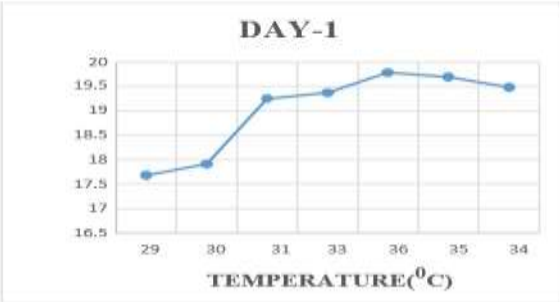
TIME(hours)	VOLTAGE(V)
9:00 AM	19.64
10:00 AM	19.92
11:00 AM	20.48
12:00 PM	20.3
13:00 PM	20.2
14:00 PM	19.84
15:00 PM	19.69



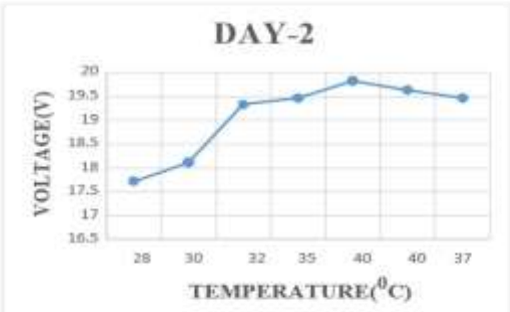
TIME(hours)	VOLTAGE(V)
9:00 AM	19.75
10:00 AM	19.98
11:00 AM	20.52
12:00 PM	20.38
13:00 PM	20.29
14:00 PM	19.85
15:00 PM	19.77

TIME(hours)	VOLTAGE(V)
9:00 AM	19.86
10:00 AM	19.98
11:00 AM	20.55
12:00 PM	20.4
13:00 PM	20.3
14:00 PM	19.9
15:00 PM	19.77

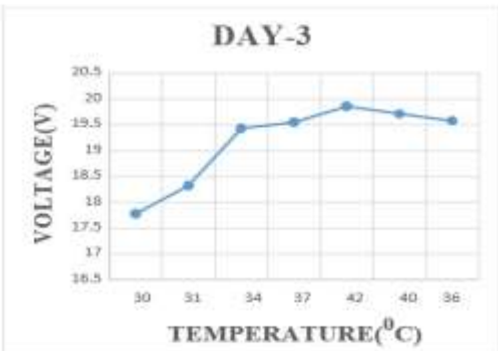
6.5. Solar Panel Without Duct



TEMPERATURE(⁰C)	VOLTAGE(V)
29	17.68
30	17.91
31	19.25
33	19.37
35	19.69
34	19.48

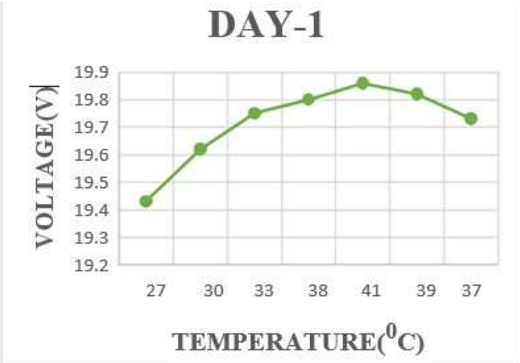


TEMPERATURE(⁰C)	VOLTAGE(V)
28	17.72
30	18.11
32	19.33
35	19.46
40	19.82
42	19.63
37	19.46

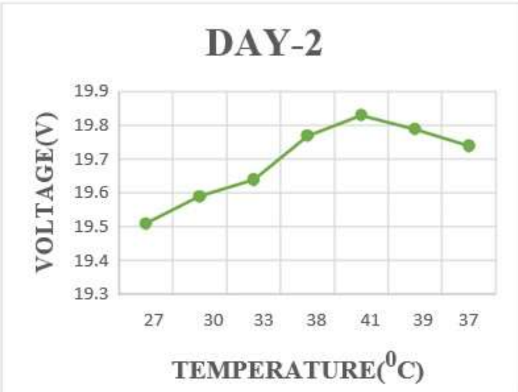


TEMPERATURE(⁰C)	VOLTAGE(V)
30	17.78
31	18.32
34	19.43
37	19.55
42	19.86
40	19.71
36	19.58

6.6. Solar Panel With Duct – Free Convection:



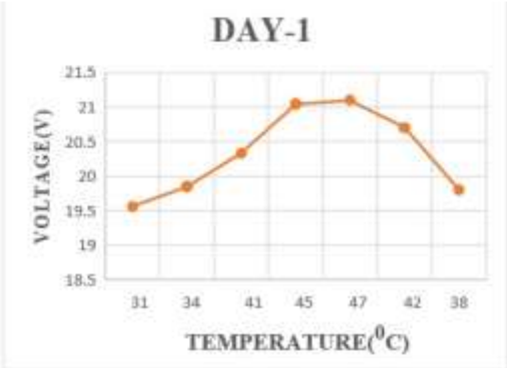
TEMPERATURE(^{0}C)	VOLTAGE(V)
27	19.43
30	19.62
33	19.75
38	19.8
41	19.86
39	19.82
37	19.73



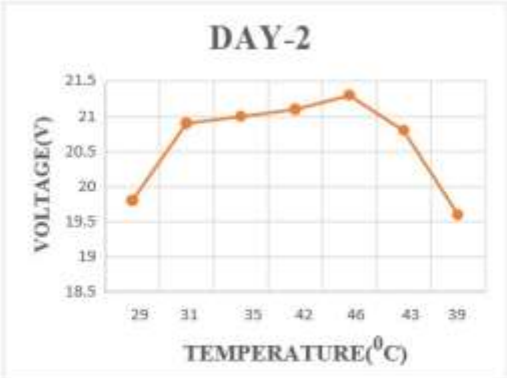
TEMPERATURE(^{0}C)	VOLTAGE(V)
27	19.51
30	19.59
33	19.64
38	19.77
41	19.83
39	19.79
37	19.74

TEMPERATURE(^{0}C)	VOLTAGE(V)
30	19.39
32	19.55
35	19.78
39	19.83
43	19.91
39	19.81
36	19.76

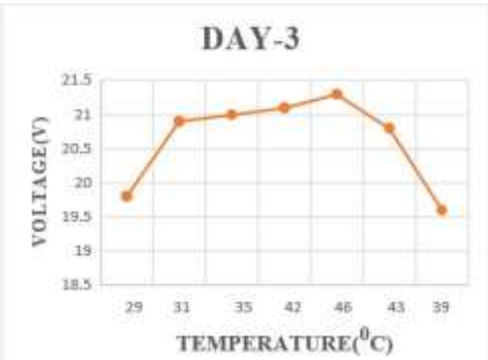
6.7. Solar Panel With Duct – Forced Convection



TEMPERATURE(^{0}C)	VOLTAGE(V)
31	19.56
34	19.85
41	20.33
45	21.04
47	21.1
42	20.7
38	19.8

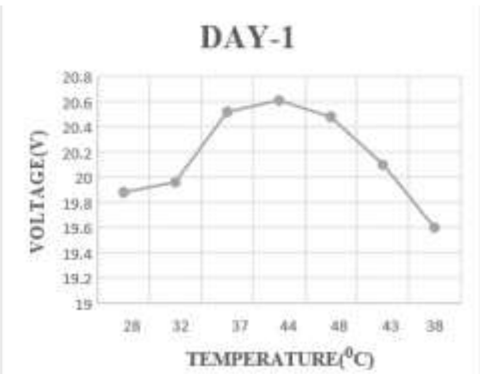


TEMPERATURE(^{0}C)	VOLTAGE(V)
31	19.8
34	20.9
41	21
45	21.1
47	21.3
42	20.8
38	19.6

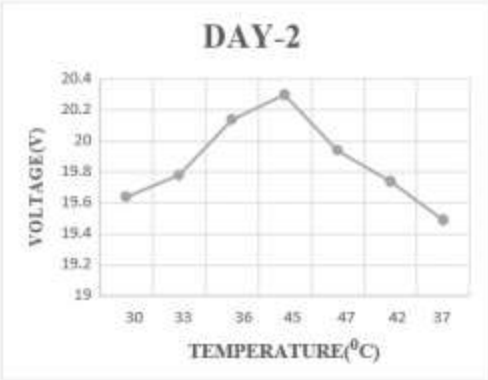


TEMPERATURE(^{0}C)	VOLTAGE(V)
31	19.7
34	20.1
41	20.9
45	21.14
47	21.31
42	20.47
38	19.4

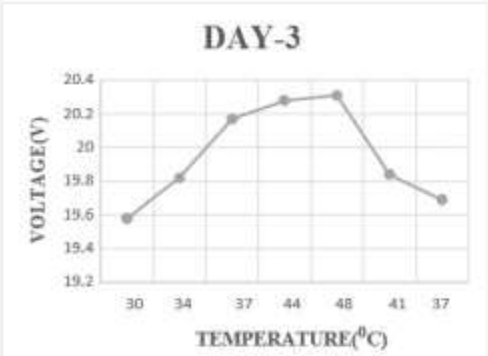
6.8. Solar Panel With Barriers



TEMPERATURE(^{0}C)	VOLTAGE(V)
28	19.88
32	19.96
37	20.52
44	20.61
48	20.48
43	20.1
38	19.6

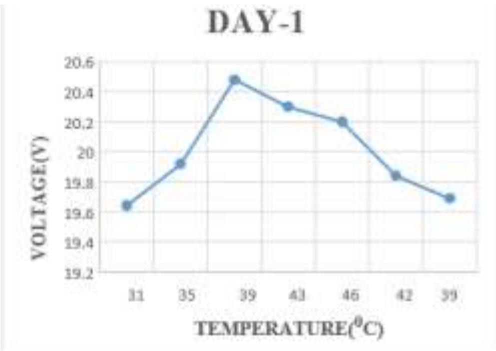


TEMPERATURE(^{0}C)	VOLTAGE(V)
30	19.64
33	19.78
36	20.14
45	20.3
47	19.94
42	19.74
37	19.49

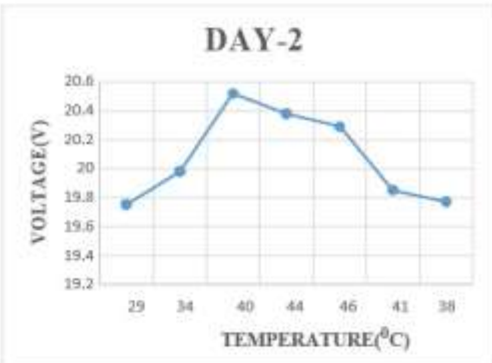


TEMPERATURE(^{0}C)	VOLTAGE(V)
30	19.64
33	19.78
36	20.14
45	20.3
47	19.94
42	19.74
37	19.49

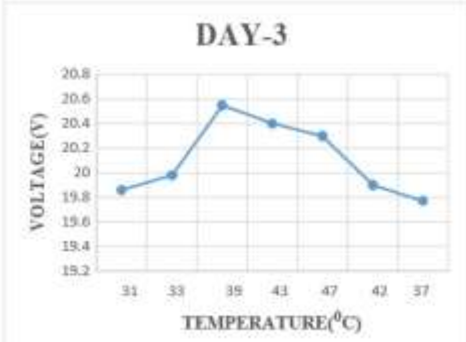
6.8. Solar Panel With Induced Draft Fan



TEMPERATURE(^{0}C)	VOLTAGE(V)
31	19.64
35	19.92
39	20.48
43	20.3
46	20.2
42	19.84
39	19.69



TEMPERATURE(^{0}C)	VOLTAGE(V)
29	19.75
34	19.98
40	20.52
44	20.38
46	20.29
41	19.85
38	19.77



TEMPERATURE(^{0}C)	VOLTAGE(V)
31	19.86
33	19.98
39	20.55
43	20.4
47	20.3
42	19.9
37	19.77

7. Conclusion

The study conducted experiments on a solar flat collector with and without duct using different convection modes. The analysis of the results showed that the mode of SOLAR PANEL WITH DUCT – FORCED CONVECTION produced the highest voltage compared to other modes. On the third day of forced convection experimentation, at 1:00 PM, the panel generated a voltage of 21.31V, which is the highest voltage generated among all the modes tested.

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