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Design And Analysis of 200 W Solar Cell Using MATLAB and ANSYS

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Abstract

With the growing demand for renewable energy, the demand for PV electricity has expanded even more due to its abundant supply and ease of control. The most critical factor in PV system design is effective solar energy conversion and cost reduction. A photovoltaic system is proposed to be modelled and simulated in this work. The effect of temperature on the power is studied in this paper and for this different temperature were studied The proposed work also perform an analysis using Ansys workbench to check the thermal properties of material used for PV cell in order to make the solar PV cell design optimized. This work examines the impact of temperature on the maximum power thus the proposed model performs analysis for different temperature to evaluate the maximum power generated by the system.

Keywords: Renewable Energy, MATLAB, ANSYS, Thermal Properties and Design Optimization

I. INTRODUCTION

Solar photovoltaic system is a source of renewable energy. It is an emerging alternative that can play a vital role in supplying electricity for long-term sustainability. Nowadays a major problem in the power sector to deal with is the rise in the power demand on daily basis but the failure of conventional energy sources to meet the demand alone. PV cells offer great potential as solar energy is abundant and cell operation is noiseless, and free from harmful emissions. The major and traditional sources of electric power generation in India include coal, petroleum, natural gas, and other fossil fuels etc. But in recent years non-conventional/ renewable sources like solar energy in electric power generation is gaining interest due to many reasons. In solar power generation, the PV modules used are very costly hence optimal use of solar power is essential. This mandates an accurate and appropriate design of PV systems prior to installation.

The smallest block of PV system is termed as a PV cell. As a PV cell is capable of generating very small amount of current (around 30mA) and voltage (around 0.6V). So a PV module is designed with a number of series (for increasing voltage) and parallel (for increasing the current level) combination of PV cells and a PV panel with a series and parallel combination of PV arrays. This PV panel converts solar energy into electrical energy by using material having semiconductor properties. The arrangement is such that photo current is generated when light falls on the semiconductor crystal. Upon solar insulation electrons are emitted and when connected with load constitutes electric current. Materials used for PV Cell: Mostly the solar cells are made of a thin layer of silicon which forms an electric field when light energy strikes the cell. The kind of silicon are used for PV cell are Single crystalline silicon and Polycrystalline silicon. Now a day's other kind of materials are used for PV cell which are Silicon and Gallium Arsenide (GaAs).

PV CELL MODELLING when a solar cell exposed to sun light then a current which is proportional to solar irradiation is generated. A simple ideal solar cell can be modelled in a circuit as a current source connected to a diode in parallel. As no cell is ideal so for accurate modelling there are shunt and series resistance connected. In this project work some of the existing model with proposed model is designed in MATLAB/Simulink.

II. LITERATURE REVIEW

Kawamura et al [1] the influence of shade on the output of the SPV modules, as well as the resulting change in their properties, has also been explored. The characteristics of a single module, however, do not anticipate the occurrence of several steps and peaks, which are prevalent in the characteristics of large SPVAs that receive non-uniform insolation, according to their research. Patel and Agarwal at el [2] provide a MATLAB-based simulator and learning tool for large SPV arrays that may be used to improve understanding and forecast their features. It may be used to investigate the effects of temperature and insolation changes, different shading patterns (defined by several peaks in the power-voltage curves), and array design on SPV properties. The SPV array model may be interfaced with models of real systems (e.g. power electronic converters) to mimic whole SPV systems and their interactions with other systems, which is a significant benefit of their work. Silvestre and Chouder et al [3] offer a partly shaded technique for simulation and modeling the performance of the SPV module. Several shadow rates were tested on a single cell that was part of an SPV module with 36 solar cells serially coupled, and the effect of shadow rate on the majority of the significant SPV module characteristic characteristics was studied. The relationship between the reduction in SPV module output due to shadowing and the change in resistive losses is also discussed. Villalva et al [4] offer some changes to a single diode model, as well as a technique for modifying the parameters, to make this model ideal for power electronics designers searching for a simple and effective model to simulate SPV devices with power converters. Villalva et al [5] offer some changes to a single diode model, as well as a technique for modifying the parameters, to make this model ideal for power electronics designers searching for a simple and effective model to simulate SPV devices with power converters. Kuai and Yuvarajan [6] utilising linear metal oxide field effect transistors, presented a simple electronic load for evaluating a group of SPV panels (MOSFETs). By scanning the load in the first quadrant alone, the proposed test set up provides the current against voltage and power vs voltage characteristics of SPV panels.

III. METHODOLOGY

A solar PV cell turns sunlight directly into energy, which is a physical process known as the photovoltaic effect, which is explained in more detail below. According to the solar spectrum, energy is delivered in the form of light, which is formed of photons and contains a variety of various energy levels depending on the wavelength of the light. When sunlight is absorbed by a solar cell, the vast majority of the photons may be absorbed, but some may be reflected back into space. Only the light that has been absorbed is transformed to electricity [20]. There are many different kinds of semiconductor materials available on the market. Crystalline silicon (Si) is the most often utilised of these materials since its manufacturing technique is economically practical in large-scale production. Because of the way photons interact with the P-N junction, electrons in the N layer are able to escape from their initial positions and begin moving. The movement of electrons in an electric circuit is represented by the flow of current [13]. A solar PV module's ability to generate dynamic electricity is related to variations in ambient and climatic conditions, which are key aspects to consider when evaluating solar PV modules. It is the equivalent circuit characteristics that determine how accurate a solar PV module simulation will be when modelling and simulating a solar PV module. Any solar cell equivalent circuit that is primarily defined by a current source in parallel with a diode is referred to be an ideal equivalent circuit. The fundamental equation, which can be derived from semiconductor theory and quantitatively defines the current–voltage (I–V) characteristic of the ideal solar PV cell3, may be found in the literature.

$$I = Iph - Id919 \qquad (1)$$

$$Id = Io \times (\exp(\frac{qV}{AKT}) - 1) \qquad (2)$$

$$I = Iph - Io \times (\exp(\frac{qV}{AKT}) - 1) \qquad (3)$$

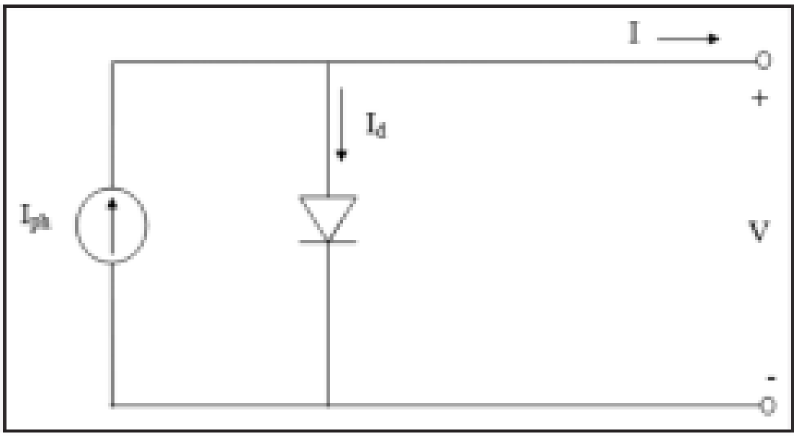

Fig 1. The ideal equivalent circuit.

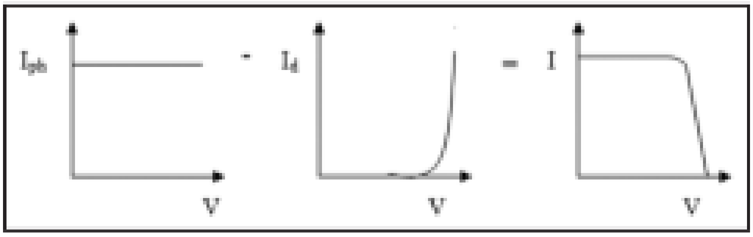

Fig. 2 Current–Voltage (I–V) characteristics of an ideal model.

IV. MODELLING AND ANALYSIS

SOLIDWORKS software was used to model the Solar cell Array and for the analysis of the proposed design, MATLAB and Ansys workbench was used. The following images shown below explain the different aspect of Modelling and analysis performed.

Fig. 3 Solid works model of Solar PV Array

1. Material: Silicon

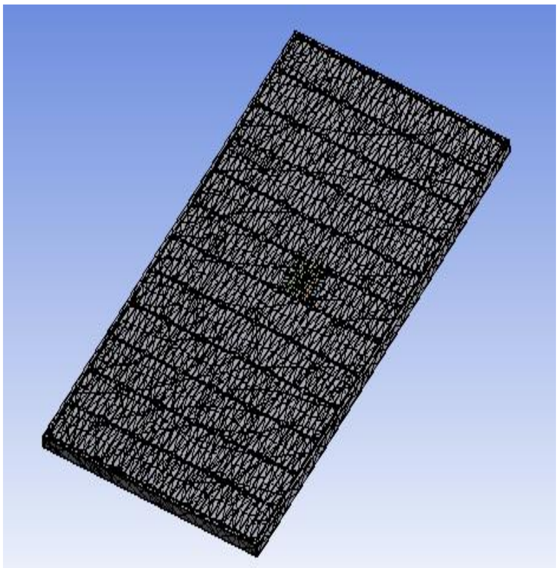

Fig. 4 Meshing of Silicon based Solar Cell

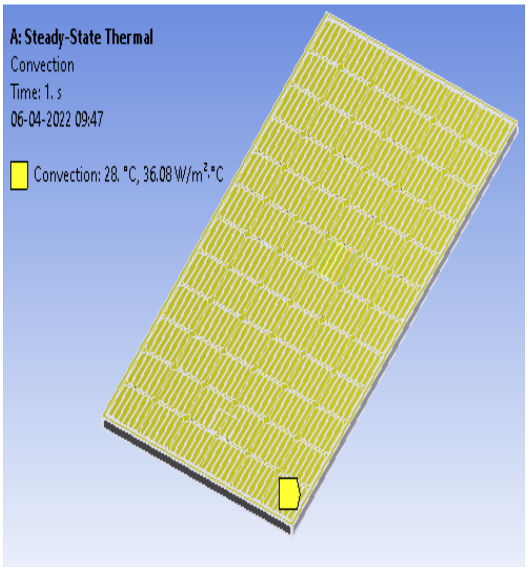

Fig. 5 Convection properties of Silicon Solar cell

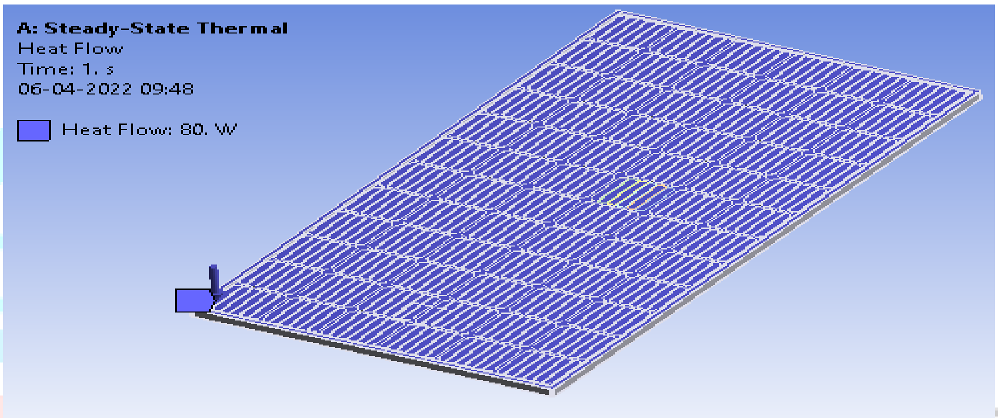

Fig. 6 Heat Flux of Silicon Solar Cell

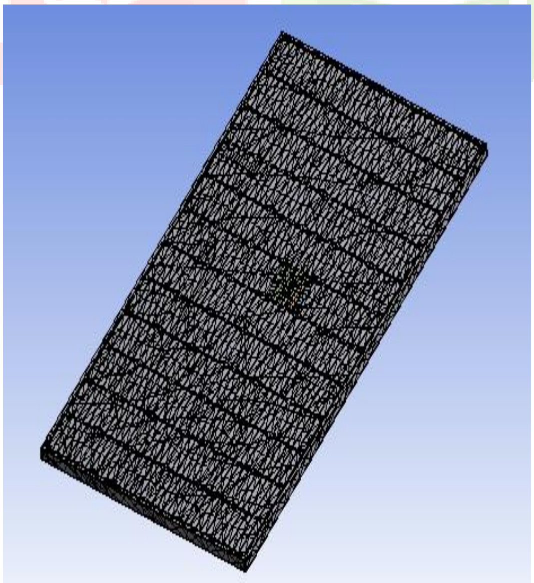

Fig. 7 Meshing of Gallium Arsenide Cell

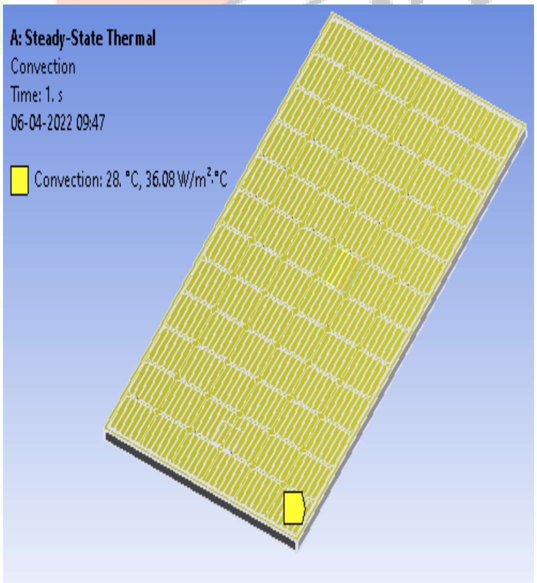

Fig. 8 Convection Properties of Gallium Arsenide Solar cell

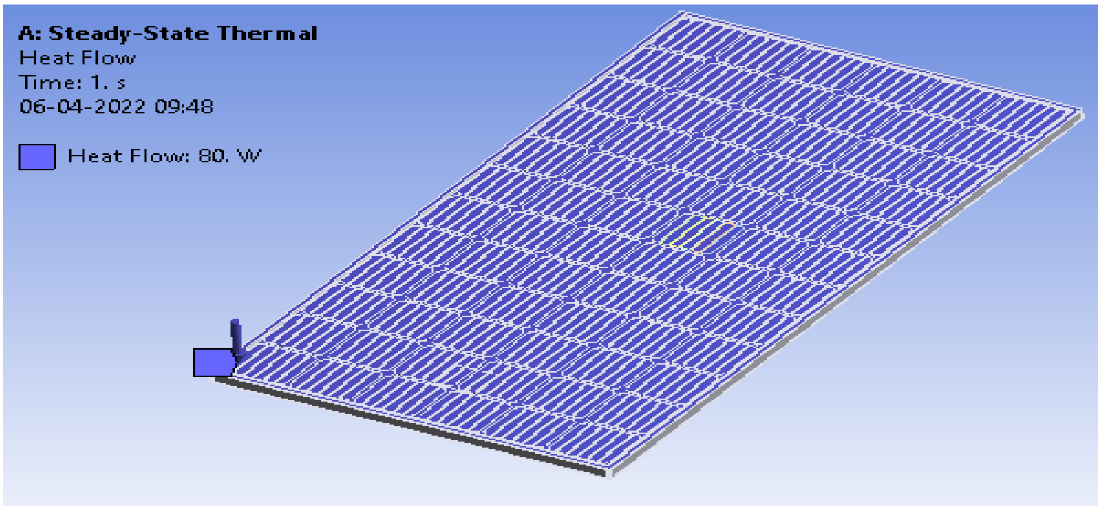

Fig. 9 Heat Flow of Gallium Arsenide Solar Cell

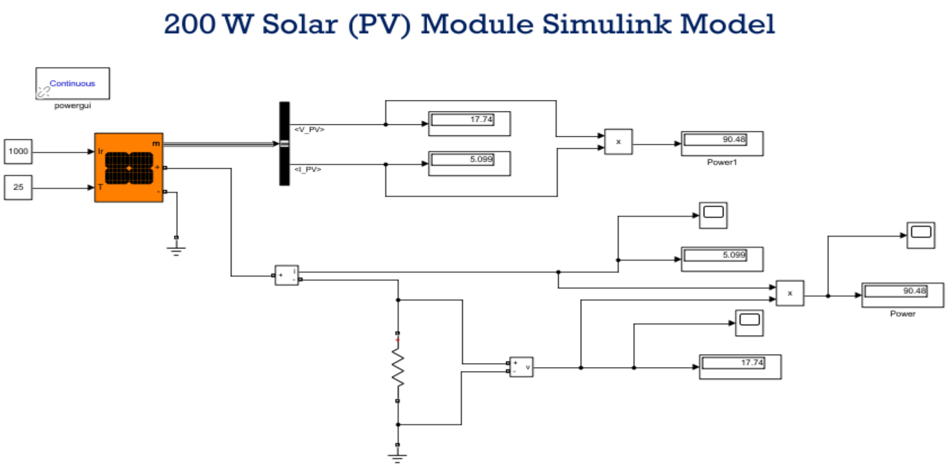

Fig. 10 MATLAB Simulink model of Solar Cell

V. RESULT AND DISCUSSION

Table no-1 Design Parameters

PARAMETER	RATED VALUE
Rated Power(Pmp)	200W
Voltage at Maximum Power(Vmp)	26.4V
Current at Maximum Power(Imp)	7.58A
Open Circuit Voltage(Voc)	32.9V
ShortCircuit Current (Isc)	8.21A
Total Number of cells in Series (Ns)	55
Total Number of cells in Parallel (Np)	1

$$R = \frac{V}{I} = \frac{26.4}{7.58} = 3.48\Omega$$

$$R = \frac{V^2}{P} = \frac{26.4^2}{200} = \frac{696.96}{200} = 3.48\Omega$$

Solar PV module model is developed under MATLAB/Simulink environment by using the previously discussed mathematical equations of solar cells. The final Solar PV model shown below as depicted in are simulated and obtained output results as current, voltage and power, due to the variation of radiation and temperature as input parameters.

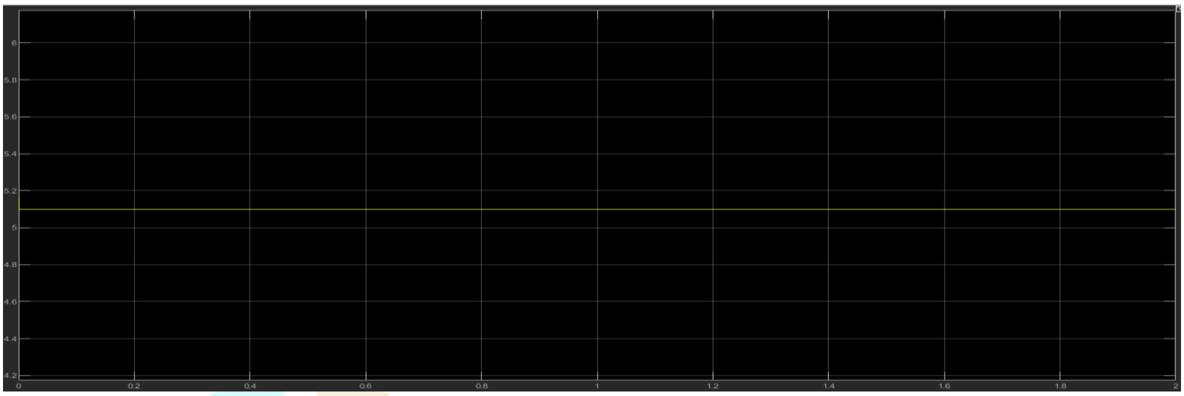

Fig. 11 I-V Characteristics Graph of MATLAB Model

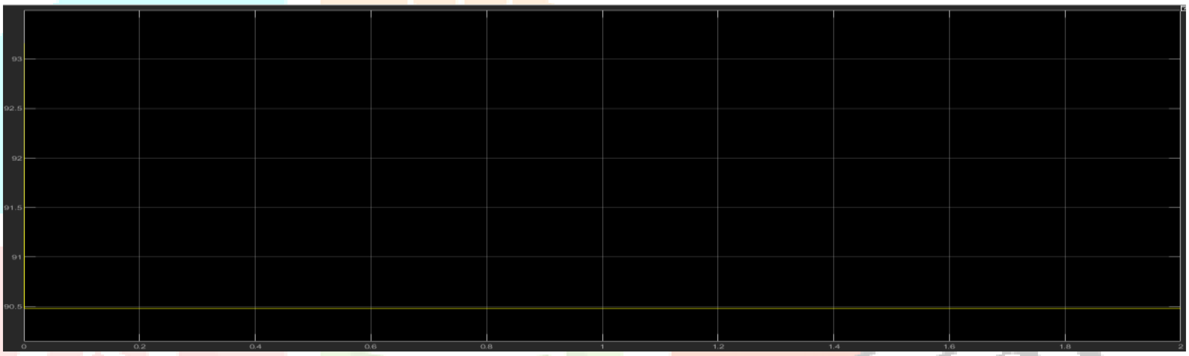

Fig. 12 I-V Characteristics Graph of MATLAB Model

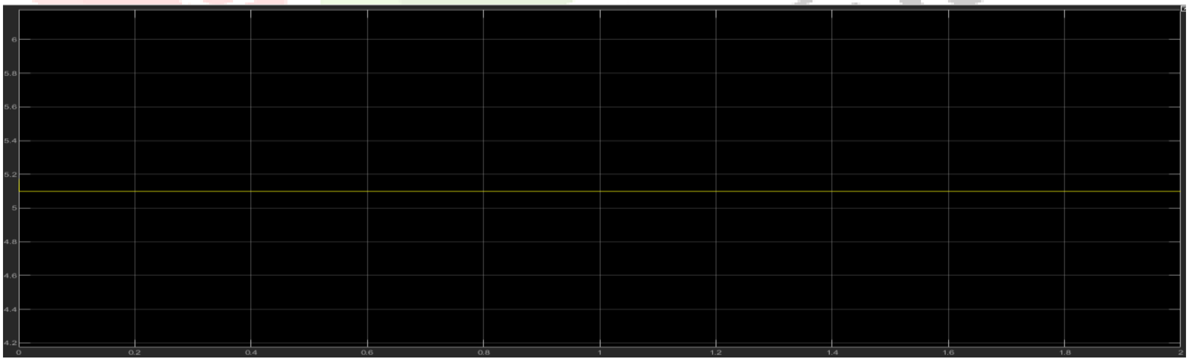

Fig. 13 I-V Characteristics Graph of MATLAB Model

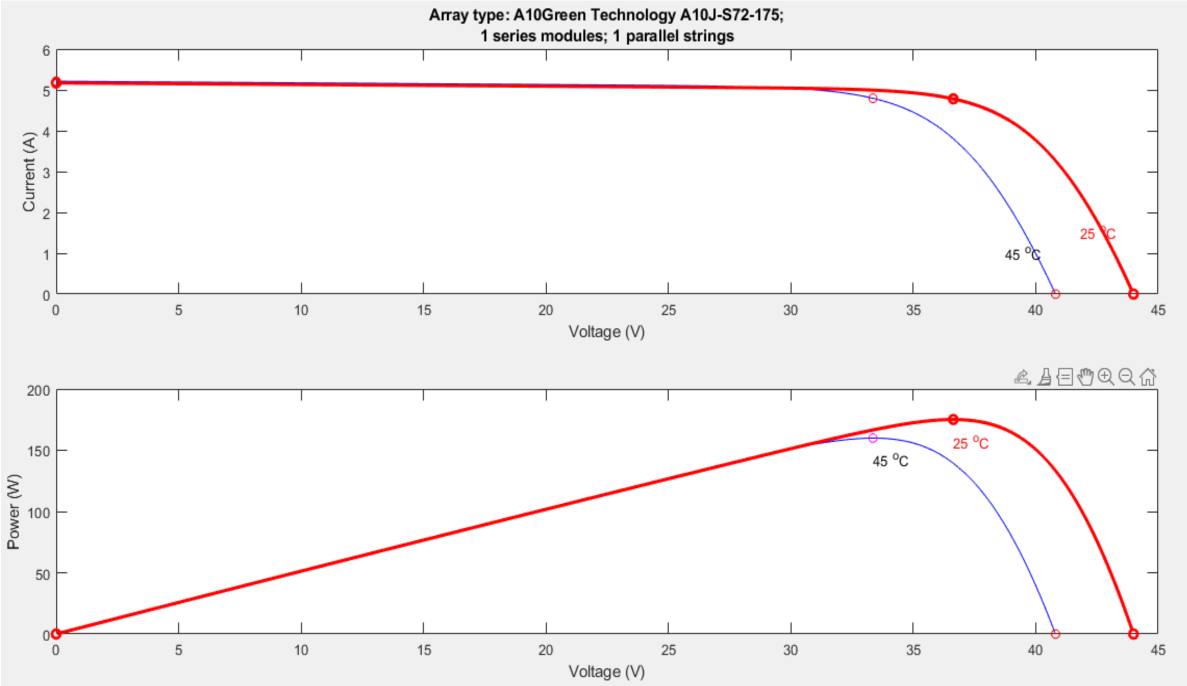

Fig. 14 Temperature and Power Variation of MATLAB Model

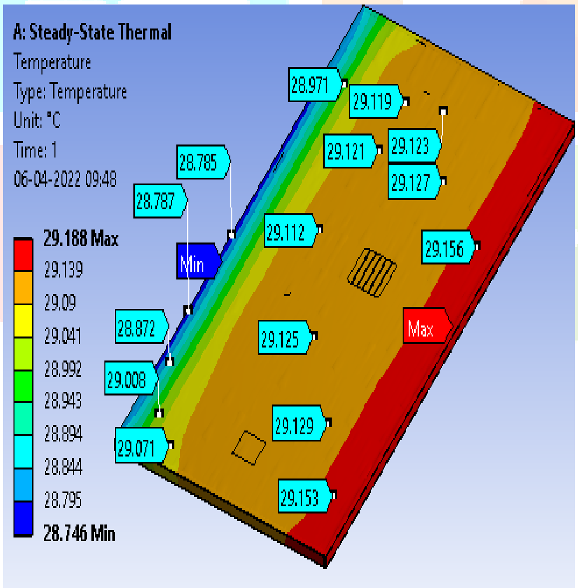

Fig. 15 Temperature Distribution on Silicon Solar Cell

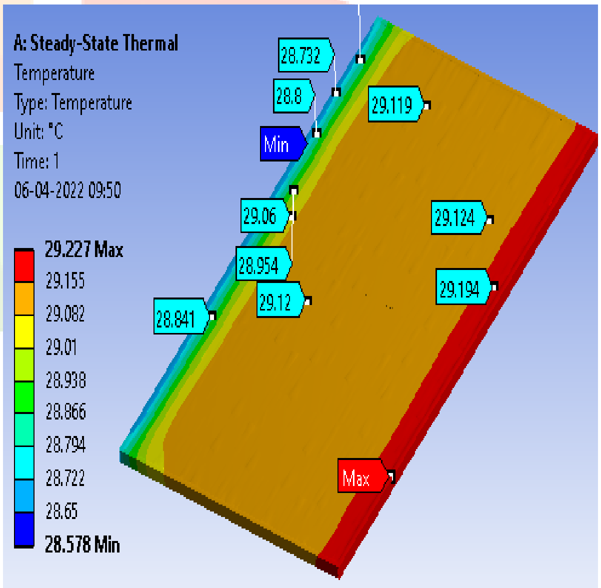

Fig. 16 Temperature Distribution on Gallium Arsenide Solar Cell

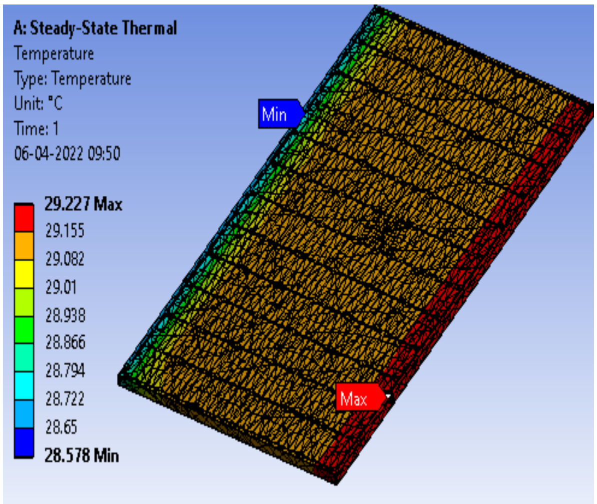

Fig. 17 Temperature of Gallium Arsenide Solar CelL

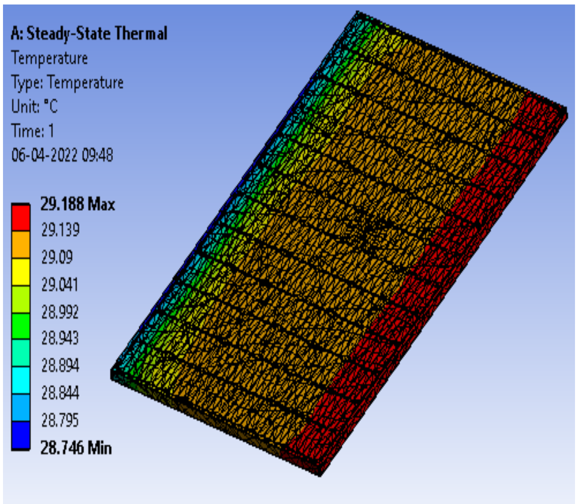

Fig.18 Temperature of Silicon Solar Cell

Table No-2 Temperature Variation

MATERIAL	TEMPERATURE
Silicon	29.188 C
Gallium Arsenide	29.227C

VI. CONCLUSION AND FUTURE SCOPE

The present research was carried out to check the performance in terms of maximum power of the Solar PV cell model on different temperature and the result reveals that the maximum power was achieved at minimum temperature. The proposed work also examined the best alternative materials which can replace the existing material for better thermal properties. Hence, a check for the thermal properties was done on two materials namely Silicon and Gallium Arsenide were investigated. However the result disclose that there are no major difference on the changes of properties but the Gallium Arsenide has slightly better thermal properties than Silicon. Further this work move to the next extent of thermal analysis with new alternative materials available in order to meet the current challenges such as cost, weight and thermal efficiency. The other scope which can be considered for the future work could the check for maximum power with temperature variation such as what would be the maximum power at minimum temperature and vice versa.

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