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Effect of Colour Spectrum and Plastic on the Performance of PV Solar System

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Abstract*: Solar irradiation is the primary input for the solar PV module. Different types of PV module are used to get high efficiency such as polycrystalline, monocrystalline and amorphous PV module . Among all module polycrystalline PV cell is the most reliable one. Two valuable inputs of a solar PV cell are solar irradiation and temperature. For temperature, solar PV material is very sensitive. However, solar irradiation has many types of wavelengths, and each wavelength has a different effect on solar cell because each wavelength has different energy frequency. Energy frequency is the primary term which affects the output of PV panel.so in this paper two types of experimental analysis has done to know the effect of the colour spectrum, and another experiment has done to know the effect of different types of plastic on PV panel. The experimental data used to verify the efficiency and output power of the system. The results show how the output power and efficiency of PV affected by these two factors.

Keywords* : Colour spectrum, Solar PV panel, Thickness of plastic, Temperature, Wavelength

I. INTRODUCTION

India is a country where 21.9% proportion of the population living below the poverty line and 84.5%proportion of the population have access to electricity, whereas 34.0% have the renewable energy share in the total final energy consumption[1]. India is prone to be affected by cyclonic storms disrupting electricity supply which takes a pretty long time to restore. The consumption of conventional energy sources as evident has a severe effect on the environment, causing a rise in temperature[2]. It is also predicted that some of the costal prosperous cities may be submerged owing to global warming and the increase of carbon dioxide and monoxide proportion will result in the extinction of a variety of animals and plants. From the above, it can be observed that solar energy is the only solution to the above problem which not only increase the standard of living of the people of the country but also have a high impact on correcting the environment [3,4]. Nowadays, the demand for solar system especially solar photovoltaic system is of prime importance owing to its cost-effective nature and effortlessness installation [5]. The basic principle of a solar PV cell is to convert the solar irradiation into electricity .semiconductor of cell absorb solar irradiation. Spectral irradiance is the power radiation obtained from each wavelength by unit area [5]. These spectral irradiances influence the atmosphere by its path length and optical transmittance properties, whereas the attenuation of the spectral irradiance is the exponential function of the distance that the radiation travels. The Air Mass (AM) is the ratio of the actual distance travelled to that of the path of shortest distance [6].

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II. EXPERIMENTAL ANALYSIS

The experimental work is divided into two sections in which the first section includes the effect of the colour spectrum and the second section includes the thickness of plastic on solar PV performance. To verify this two experiment, a polycrystalline PV module was taken. The specification of this PV module is given in Table I.

Table- I: Solar PV panel specification

Max power	10watt
dimension	30cm×20cm
Open circuit voltage	18.7 volt
Short circuit current	0.8 amp
Maximum voltage	16volt
Maximum current	0.5 amp

III. EFFECT OF COLOUR SPECTRUM ON SOLAR PV PERFORMANCE.

The solar radiation absorbs by the ground is divided from different energy content which is called wavelength. There are three types of wavelength such as ultraviolet which is less than 400nm with an energy content 5 to 10% from the total energy level. The second one is visible light which is 400 to 700nm, and it covers 40% total energy, and the last one is infra-red, which is above 700nm, and it contains 50% of total energy content. As we know that ultraviolet ray can't enter to the earth atmosphere due to the presence of the ozone layer. So 90% of solar irradiation which includes visible and infra-red ray only absorbed by the earth surface[7,8].

Visible ray has different ranges of the colour spectrum, which starts from violet to red. As per the energy equation E=hf, where E is defined as the energy of the photon, h is the Plank's constant and f is the frequency of light.

So the colour spectrum has a significant effect on the photovoltaic cell. In this experimental work, some colour filters were taken to verify the effect of these wavelengths on solar PV module.

The wavelength of various colour spectrums which are used in this experiment given in table II.

Table-II: Different colour spectrum with a respective wavelength

Colour	Wavelength(nm)
Red	622-780
Yellow	577-597
Green	492-577
Blue	455-492
white	400-750

A.Experimental Set-up

The experiment was conducted at KIIT, BBSR, INDIA in April 2019. To get accuracy, the same experiments have done repeatedly for three days. The results are discussed in the result and discussion part of the paper.

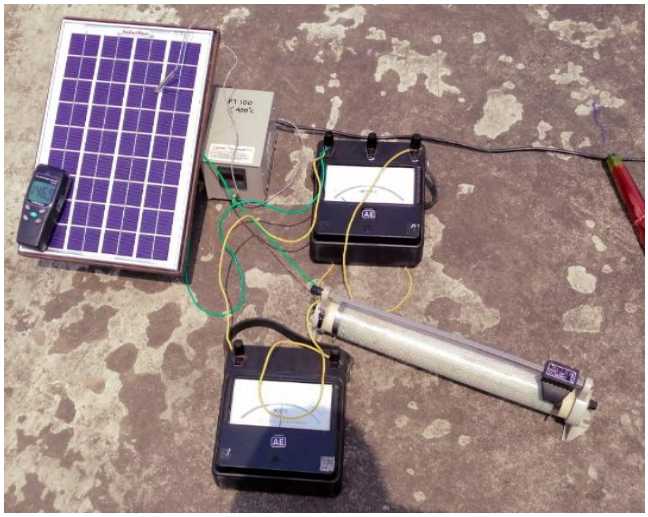

Fig. 1. Experimental set-up of Solar panel at the clean condition

First the experiment has done in clean panel with out putting any type of material to it ,so that we can compare other results with this experiment .and every experiment include colour spectrum and thickness of plastic has done with irradiation 1000 to 1050 w/m^2 and solar module has set with 22 ^{0} tilt angle to absorb maximum solar irradiation. The required instruments for the experimental purpose has given in Table-III.

Table- III: required instruments for experimental work

Instruments required	Range
solar panel	10W
Ammeter	0-1 a(dc)
Voltmeter(multi meter)	0-100v(dc)
Rheostat	0-145ohm
Solari meter	Measuring irradiation
solar PV stand	tilt angle-22deg
R.T.D	0- 500^{0}cel

The experimental set-up is given in Fig-2 .in which effect of five colours has done individually .and obtain the value of voltage, current and open circuit voltage and short circuit current .after taking those reading the power and efficiency of each case has calculated.

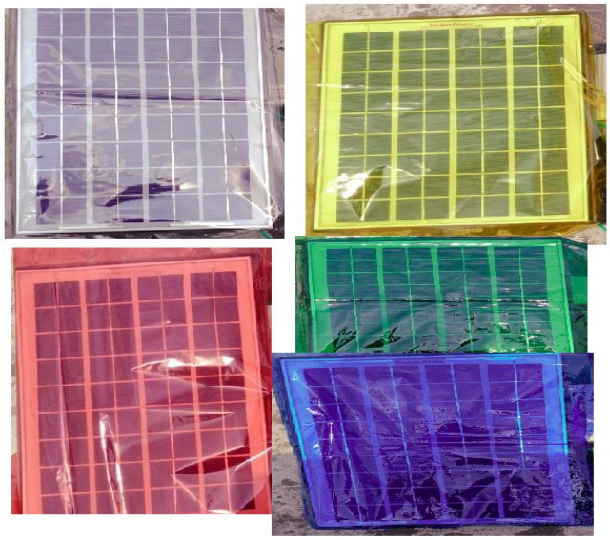

Fig. 2. Experimental set-up with different colour spectrum

IV. EFFECT OF THICKNESS OF PLASTIC ON SOLAR PV PERFORMANCE

Today researches are doing various experiments to increase the efficiency of solar PV module [9]. As per the effect of different environmental condition, the efficiency of the PV module is vary because the output of PV system depends on PV materials also [10,11]. To know the different thickness of plastic effect to the PV performance, Here slide calipers was taken to measure the thickness of plastics and three different thickness of plastic (0.002cm, 0.005cm and 0.008cm) was kept on solar PV module. The temperature is measured both above and below the plastic. This experiment was conducted at the same place in May 2019. The results of this experiment has shown in result and discussion part of this paper.

Fig. 3. Experimental set-up with different thickness of plastic.

Every conditions of this experiment are compared with the clean panel, which absorbs the direct solar irradiation.

V. RESULT AND DISCUSSION.

A. Results of the different colour spectrum.

The output power and efficiency of the above experimental analysis was compared with clean panel and with different colour filter .whish is shown in Table-1V and Table –V.

Table- IV: Average outcomes of PV panel with colour spectrum

Different colour spectrum	Current Isc (amp)	Voltage Voc (volt)	Power Pm (watt)	Efficiency
Clean	0.36	18.4	2.997	4.88
White	0.35	18.3	2.668	4.44
Red	0.36	18.2	2.619	4.365
Yellow	0.33	18.1	2.484	4.14
Green	0.32	17.8	1.892	3.15
Blue	0.32	17.8	1.856	3.1

from above reading it shows that the efficiency of the clean panel gives better efficiency then other filters.as per result the short circuit current of red is higher as compare to other colour filters due to its longer wavelength . From five colour spectrum it shows that the white colour gives more output in compare with other colour filter. After white colour filter. red colour filter gives more output then other three and blue colour gives minimum output as compare to other due to shorter wavelength.so from above result shorter the wavelength the output power and efficiency is decreasing accordingly.

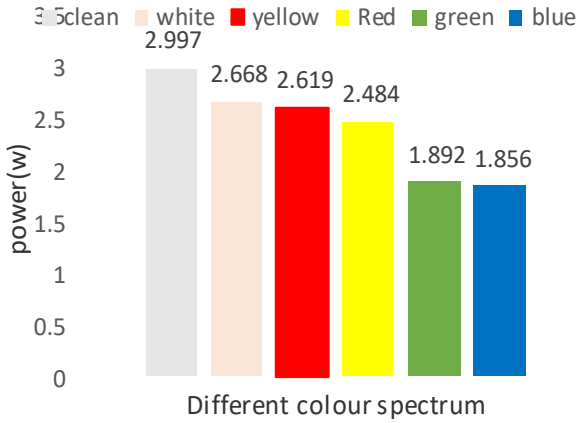

Fig. 3. Effect of power on the different colour spectrum

The above graph shows the output power of different colour spectrum after clean panel, the white colour give the maximum power than other colour spectrum.

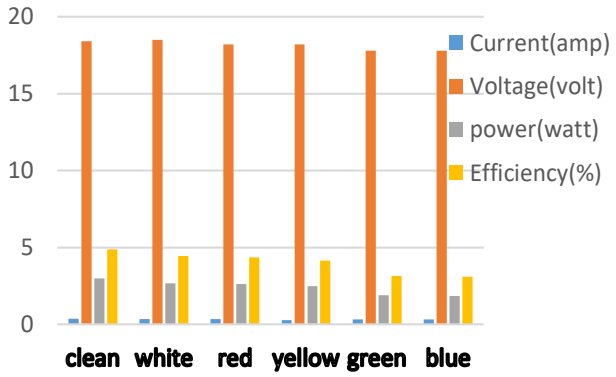

Fig-4 Current ,voltage, power and efficiency of the solar module at Different colour spectrums.

B. Results of different types of plastic

Table- V: Average outcomes of Pv panel with different plastic

Thickness of plastic (cm)	Voltage Voc (volt)	Current Isc (amp)	Temp(av)/ Temp(un) (^{0}cel)	Power (watt)	Efficiency
w.o.p	18.4	0.36	50.2	2.997	4.88
0.002	18.1	0.36	50.8/52.4	2.716	4.52
0.005	18	0.37	51.4/53.6	2.632	4.37
0.008	17.3	0.375	51.4/54.2	2.52	4.2

From the above reading (Table-V) shows that clean panel gives more output power than other plastic .the effect of temperature is the leading region of this experimental analysis. With increase of temperature the output power of the module is decreasing .so, it is essential to maintain the less temperature to get maximum output power.

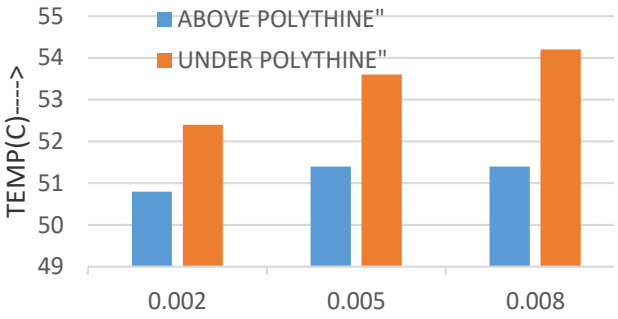

Fig-5 Above and below the temperature of various plastic

From the above graph shows that more thickness of plastic give less output due to an increase in temperature and vice versa. With increase in temperature the output power and efficiency is decreased. For every solar module, there is a standard temperature which is called standard test condition temperature (STC). And on this standard test condition PV module gives maximum output.so to maintain the standard temperature it is necessary to clean the module as a various procedure like water spray, wind spray or auto cleaning mechanisms.

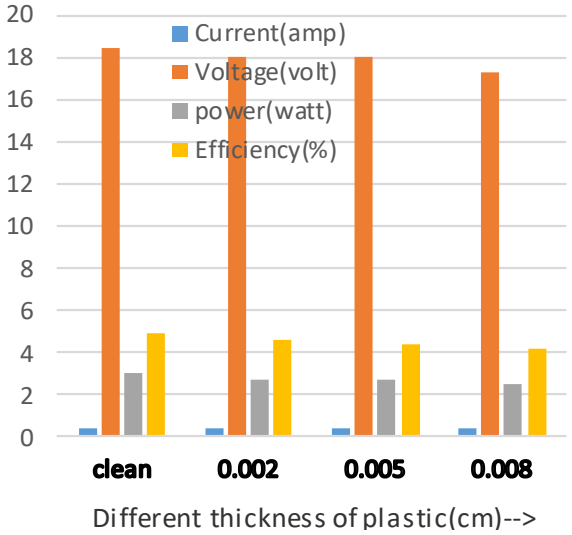

Fig. 5. Current, voltage, power and efficiency of the solar module at various plastic and clean panel.

Above figure shows the graphical representation of voltage, current, power and efficiency of the above experiment.

VI. CONCLUSION

Experimental analysis has given a brief idea about the effect of a various factors on solar PV output. Till date the efficiency of solar PV panel is 15 to 20% but the demand of PV energy is increasing day by day.so it is the time to give more concentration on PV system that can give more efficiency for coming decades .coming to above experimental analysis it conclude that longer wavelength spectrums are more efficient with photovoltaic cells than shorter. In general, to get more efficiency, the high solar radiation intensity is needed without colored filters. From the effect of plastic analysis shows that solar PV is very sensitive to temperature .very less increase of temperature also effect more to solar PV output.so to ensure better efficiency it is essential to keep the module temperature less.

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Bhabani Patnaik obtained her B.Tech in Electrical Engineering, 2010 from Synergy Institute Of Engineering and Technology, Dhenkanal and M.Tech. in Power System, 2012 from CVRCE, Bhubaneswar, BPUT. She is currently pursuing her PhD in Electrical Engineering from KIIT Deemed to be University, Bhubaneswar. Her areas of interest are Power System, Renewable Energy source and published good conference papers and journal

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