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Performance Analysis of Half Aged PV Panel under Fixed & Tracking Mode

Rahul Mishra[1], Rajeev Ranjan Tiwari[2], Anil Kumar[3]

[1] Department of Electronics and Instrumentation, Lakshmi Narain College of Technology, Bhopal, Madhya Pradesh, India

[2] Department of Electrical, Maulana Azad National Institute of Technology, Bhopal, Madhya Pradesh, India

[3] Department of Energy, Maulana Azad National Institute of Technology, Bhopal, Madhya Pradesh, India

Abstract
An experimental study is performed to investigate the performance of 10 year old PV panel under tilted fixed mount and tilted single axis tracking mode. Manufacturer estimated the life of PV panel between 15 & 20 year. Study gives an idea about the performance of half aged PV panel in fixed mode and also suggests the utility of sun tracking system to enhance the performance of half aged PV panel. The experiment was conducted at MANIT, Bhopal (23 ^{o} 16' N, 77 ^{o} 36' E) in 23 ^{o} tilted fixed mount on 24 April, 15 May & 04 June 2013 and in tracking mode 25 April, 16 May and 05 June 2013 during 9:00 hrs to 17:00 hrs. It is observed that the average electrical efficiency of the PV panel decreased and remains 2.08 % due to ageing effect .But it is found that the electrical efficiency during 9:00-11:00 hrs and 13:00- 17:00 hrs increased in tracking mode and becomes 2.38 %.

Keywords: *Fixed mount, tracking mode, electrical efficiency, temperature, ageing effect.*

1. Introduction

Life of the PV panel estimated by the manufacturer is 20-25 years with 80% power still available at the end of that time period. Tests show that 90% of existing solar panels last for 30 years, instead of the predicted 20 years. Panels had been expected to last for 20 years [1].

Solar panels convert 22% of their available energy into electrical power. This may not sound very good, but it is much better than most solar panels. As technology has evolved, the conversion efficiency of the PV panels has increased steadily, but still it does not exceed 13% for the common ones. The PV panels exhibits a strongly non-linear I-V (current - voltage) characteristic and a power output that is also non-linearly dependant on the surface insolation [2]. It reaches the value of 10.34% and 15% in the summer and winter season, respectively. However, the yearly gain relative to a fixed panel installed with the yearly optimal tilt angle is 5.76 % [2]. It has been expected that the power from solar panels can be increased by 30 to 50% by utilizing a tracking system instead of a fixed tilt [3]. The panel efficiency is usually 1 to 3% lower than the solar cell efficiency due to glass reflection, frame shadowing, higher temperatures etc.

It is well known that the PV cell temperature has an important effect on the PV output power. This temperature can be same as the ambient temperature during the night but it can go over the ambient temperature by 30^{o}c or more in full sun. Hence, it is necessary to calculate the PV cell temperature in order to account for this meaning effect [2].

On sunny days the direct sunshine accounts for up to 90% of the total solar energy, with the other 10% from diffuse (scattered) solar energy. During cloudy periods we show that a fixed horizontal module orientation increases the solar energy capture by nearly 50% compared to 2-axis solar tracking during the same period [3].

Light gathering is dependent on the angle of incidence of the light source given that power (i.e. the sun) to the solar cell's surface, and the nearer to perpendicular which increases the power [4]. If a flat solar panel is mounted on level ground, it is obvious that over the course of the day the sunlight will have an angle of incidence close to 90° in the morning and the evening. At such an angle, the light gathering ability of the cell is essentially zero, resulting in no output. At noon time, the angle of incidence approaches 0°, causing a steady increase in power until at the point where the light incident on the panel is completely perpendicular, and maximum power is achieved. As the day continues toward twilight, again increasing the incidence angle causes the power to decrease again toward minimum again. From this background, we see the need to maintain the maximum power output from the panel by maintaining an angle of incidence as close to 0° as possible [4].

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2. Performance analysis

Performance of the half aged PV panels analyses in two operating modes. Fig. 1, Six Photovoltaic panels used together in a parallel operation rated as 18 volt 12 amp gives a rated output power 216 watt mounted on a tilted single axis tracking system whereas each panel of 36 watt (18 volt and 2 amps).

Various parameters like diffuse solar radiation, global solar radiation, ambient temperature, PV panel temperature and wind speed are measured during analysis. The maximum and minimum values of global radiation (I_g) were found to be 1128 and 390 W/m^2. The maximum values of ambient temperature (T_a) were found to be 40.3 °C and diffuse radiation found between 201- 86 W/m^2. Wind velocity (U) found between 1.5 and 2.6 m/s. Analysis exhibits the influence of various parameters over system variables.

2.1 Electrical efficiency of PV panels under fixed mount and tracking mode

From hourly data analysis it is cleared that the I_{sc} and V_{oc} of PV system during 9:00-11:00 hrs and 13:00- 17:00 hrs has large value in tracking mode as compare to fixed mount mode. Average electrical efficiency (η_{el}) of the panel under fixed mount is lesser than the tracking mode and is calculated by the equation 1. The minimum and maximum value of electrical efficiency calculated under fixed mount mode is 1.5 % in morning and evening hours and 2.6 % during noon. Under tracking mode minimum value of electrical efficiency increases and it is between 2.1 and 2.4 %

2.2 Temperature affects the performance of PV panels

Fig.3 and Fig.4 shows the variation of PV system parameters with respect to time under fixed mount mode and tracking mode. Fig 2, it is observe that during 9:00-11:00 hrs and 13:00- 17:00 hrs output power (P_o) of PV system is more in tracking mode as compare to fixed mount mode. Throughout the experiment, wind velocity found below 2.6 m/s. A lower wind is responsible for the large PV panel temperature and as a result the electrical efficiency of PV panel gets reduce.

3. Tables, Figures and Equations

3.1 Tables and Figures

Table1: Observations under fixed mount mode (24 / 04/ 13)

Hr	I_{sc}	V_{oc}	I_g	T_p	U	η_{el}
9:00	3.1	17.6	883	30.8	2.4	1.7
10:00	4.2	17.8	934	46.4	2.1	2.3
11:00	5.1	17.9	1032	57.7	2.2	2.6
12:00	5.6	18.0	1117	59.2	1.7	2.6
13:00	5.5	18.0	1099	59.7	2.8	2.5
14:00	4.5	17.9	1019	59.6	2.2	2.1
15:00	3.9	17.7	861	58.2	1.3	2.0
16:00	3.0	17.5	554	54.3	1.7	2.0
17:00	1.9	17.3	389	51.1	3.2	1.9

Table 2: Observations under fixed mount mode (15/05/13)

Hr	I_{sc}	V_{oc}	I_g	T_p	U	η_{el}
9:00	3.0	17.5	879	32.5	1.8	1.6
10:00	3.9	17.6	932	48.6	1.9	2.1
11:00	5.2	17.9	1037	59.1	1.5	2.6
12:00	5.6	18.1	1121	61.8	0.7	2.6
13:00	5.4	18.0	1097	62.5	0.8	2.4
14:00	4.7	17.9	1020	62.3	1.2	2.2
15:00	3.8	17.6	865	61.7	1.3	2.0
16:00	2.8	17.5	560	59.8	0.7	1.9
17:00	1.8	17.3	393	55.5	0.4	1.8

Table 3: Observations under fixed mount mode (04/06/13)

Hr	I_{sc}	V_{oc}	I_g	T_p	U	η_{el}
9:00	2.7	17.5	884	43.2	0.3	1.5
10:00	3.3	17.6	936	52.8	0.3	1.8
11:00	4.9	17.9	1050	59.4	0.3	2.5
12:00	5.2	18.0	1128	62.7	0.3	2.4
13:00	5.0	18.0	1089	64.8	0.4	2.2
14:00	4.3	17.9	1009	63.9	0.2	2.0
15:00	3.2	17.6	955	63.3	0.2	1.6
16:00	2.8	17.4	580	61.6	0.2	1.7
17:00	1.6	17.4	398	60.2	0.3	1.5

Tracking mode

Table 4: Observations under tracking mode (25/04/13)

Hr	I_{sc}	V_{oc}	I_g	T_p	U	η_{el}
9:00	4.1	17.8	908	30.2	2.1	2.2
10:00	4.9	18.0	986	45.8	2.3	2.6
11:00	5.2	18.0	1034	56.4	2.8	2.6
12:00	5.7	18.1	1121	58.3	1.4	2.6
13:00	5.5	18.1	1101	58.8	2.1	2.5
14:00	5.1	18.0	1023	58.6	2.2	2.4
15:00	4.8	17.9	926	58.1	1.8	2.5
16:00	4.4	17.7	867	54.1	1.7	2.4
17:00	3.5	17.5	534	51.2	2.7	2.4

Table 5: Observations under tracking mode (16/05/13)

Hr	I_{sc}	V_{oc}	I_g	T_p	U	η_{el}
9:00	4.1	17.8	904	31.6	1.3	2.2
10:00	4.7	17.9	978	48.6	2.1	2.5
11:00	5.1	18.0	1025	59.1	1.1	2.5
12:00	5.6	18.1	1112	62.6	1.7	2.6
13:00	5.4	18.0	1109	62.9	0.4	2.4
14:00	5.0	17.9	1043	62.7	1.2	2.3
15:00	4.7	17.8	918	62.3	2.3	2.4
16:00	4.2	17.7	859	60.1	0.9	2.3
17:00	3.3	17.4	529	54.3	0.7	2.3

Table 6: Observations under tracking mode (05/06/13)

Hr	I_{sc}	V_{oc}	I_g	T_p	U	η_{el}
9:00	3.9	17.7	890	43.3	0.2	2.1
10:00	4.3	17.8	968	52.9	0.4	2.3
11:00	4.9	17.9	1022	59.6	0.2	2.5
12:00	5.3	18.0	1110	62.9	0.1	2.5
13:00	5.1	18.0	1104	64.8	0.1	2.3
14:00	4.9	17.9	1038	63.8	0.1	2.3
15:00	4.4	17.7	926	63.3	0.2	2.2
16:00	4.1	17.6	858	61.4	1.2	2.2
17:00	3.1	17.3	539	60.1	1.1	2.2

Fig. 1 Six PV panel of each 36 watt connected parallel

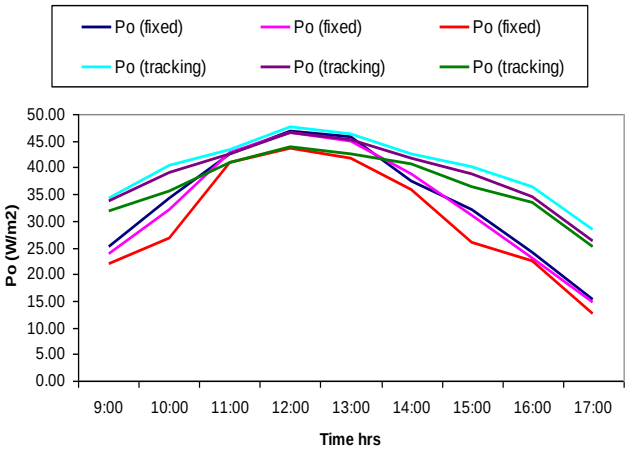

Fig. 2 Output power curve

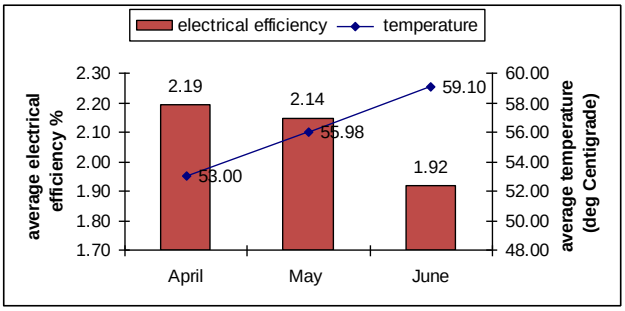

Fig. 3 Average electrical efficiency Vs Temperature under fixed mount

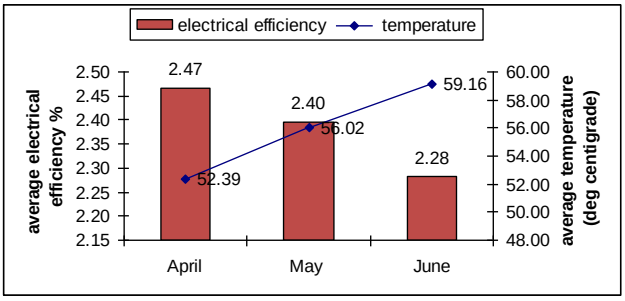

Fig. 4 Average electrical efficiency Vs Temperature under tracking mode

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3.2 Equations

Electrical efficiency of the PV panel is calculated by the given equation

$$\eta_{el} = (FF \times V_{oc} \times I_{sc}) / (I_g \times A) \quad (1)$$

FF = Fill factor of the PV module = 0.693
A = Area of the PV system = 2.5 m^2
Ig = Global Solar radiation
Voc = open circuit voltage of PV system
Isc = short circuit current of PV system

4. Conclusions

An experiment has performed to analyses the performance of 10 year old PV panel under fixed mount and tracking mode. Fig 2, it is found that the I_{sc} reduce to less than half of the rated value. Resultant performance of PV panel very much differs from the expected result. PV panel performance very much degraded due to ageing effect. But the single axis tracking system helps to increase the magnitude of I_{sc}. Fig. 3 & 4, the effect of temperature on PV panel is also an important aspect shown in study. Wind velocity has prominently affected the PV panel performance because it work as a natural cooling system for the PV panel The increase in PV panel temperature causes to decrease in the magnitude of output power.

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First Author: B.E. (Instrumentation and control) in 2006, M.Tech (Energy) in 2012; from (July 2006 – Sep 2009) SUZLON as an Operation and Maintenance engineer; from (Sep 2009 – June 2010) Swami Vivekanand College of Engineering, Bhopal as a lecturer; from (July 2012- June 2013) in MANIT, Bhopal as an Asst. Professor in Energy dept. on contract basis; from (July 2013- till date) in LNCT, Bhopal as an Asst. Professor; current research interests in renewable energy.

Second Author: B.E. (Electrical and Electronics) in 2010, M.Tech (Energy) in 2012; from (July 2012 – Jan 2014) in VNSIT,Bhopal as an Asst. Professor; from (Jan 2014- till date) in MANIT, Bhopal as an Asst. Professor on contract basis; current research interests in renewable energy.

Third Author: B.Tech. (Mechanical) in 2000, M.Tech (Energy Technology) in 2001; Phd (Solar Energy) in 2007 from IIT Delhi; from (Aug 2005 – May 2010) lecturer in RGPV Bhopal in Dept.of Mechanical Engg; from (2010 – till date) MANIT, Bhopal as an Asst. Professor in Dept. of Energy; current research interests in renewable energy.