Study and Analysis of the Influencing Factors in Optical Performance of Horizontal Single Solar Photovoltaic Arrays.

Dr. O.P. Upadhyay
Department of Mechanical Engineering,
Faculty of Engineering & Technology
MJP Rohilkhand University, Bareilly (U.P)

ABSTRACT

The use of non-renewable fuels for meeting rising demands of power generation is the main challenge that the world will face in next few years. Keeping this in mind among all the renewable sources of energy wind, hydro and solar, solar energy is the best and most beneficial. In order to harvest the energy of sun coming from sun to earth many different types of solar panels are used. Harvesting this energy efficiently throughout the day is a major challenge so in order to maximize the efficiency of solar panels systems for sun rays tracking are required. In this study various types of systems for sun rays tracking are discussed and the best among them is studied.

In this study a thorough study has been done on the various types of devices for sun rays tracking throughout the day developed all over the world. It has been find out that these tracking devices can be classified into single axis and dual axis tracking systems based on the process by which they work in order to track sun most effectively and efficiently.

1. INTRODUCTION

For the development of a nation energy is the prime factor. A very large amount of energy is tracked and gets changed and used globally on a daily basis. About 85% of production of power is relying on non-renewable fuels. Non-renewable fuels are in limited quantity and the use of non-renewable fuels causes the green house effect which in turn causes global warming through the emission of greenhouse gases. In order to make the world cleaner and healthier for future coming a more solar power dependency needed. In past years world has seen a rise in demand for power from renewable power sources like wind, ocean tidal, geothermal and solar energy. Solar energy plays a main role in the overall power demand and for meeting this demand solar is the main renewable power source. To convert solar energy into electric energy solar photovoltaic panels are used. These panels are generally made up of semiconductor materials like Si. Si is the most efficient among all the semiconductor materials used for making these panels and is 24.5 % efficient. This is the most efficient panels power output so more than that power output is not recorded by changing the material of panels. So secondly this efficiency can be increased by increasing the effective area in contact with sun rays throughout the day.

Solar rays tracking throughout the day by using tracking devices is most used and efficient way in order to increase the power output and efficiency of the solar photovoltaic cells. In this process the panels are facing mostly towards the sun rays to get most rays falling on them.

2. WHAT ARE SOLAR TRACKING DEVICES?

A solar tracking apparatus is a device which consist of automatically alligned solar photovoltaic panels which follows the solar rays to give maximum solar energy output. With the help of these tracking devices solar power can be collected throughout the day with maximum efficiency as sun position changes or shift with the seasons. Solar trackers are of different types classified according to their axis and drive types. Tracking devices with Dual axis is one of the type of tracker based on axis. These tracking devices have two different rotational axis which are usually at 90 degree to each and rotate in both north to south and east to west (zenithally).

Solar tracking device is considered as most useful technology to increase the output of electricity through a P.V device. Many different approaches have been used in order to achieve high degree of freedom.

1. NEED OF SOLAR TRACKING SYSTEM

Θs	**Power Loss= 1 - cos(θs)**
0°	0%
1°	0.015%
8°	1%
23.4°	8.3%
30°	13.4%
45°	30%
60°	>50%
75°	>75%

We know that the solar energy has two main parts which is “direct falling beam” and “diffused sunlight”.The direct beam have 90% of the solar energy and remaining 10% is diffused sunlight which is responsible for blue sky. So, it is clear that maximum amount of sunlight is carried by direct beam and by maximizing the collection of direct beam we can increase the power output and for it the panel should be perpendicular to the sun throughout the day.

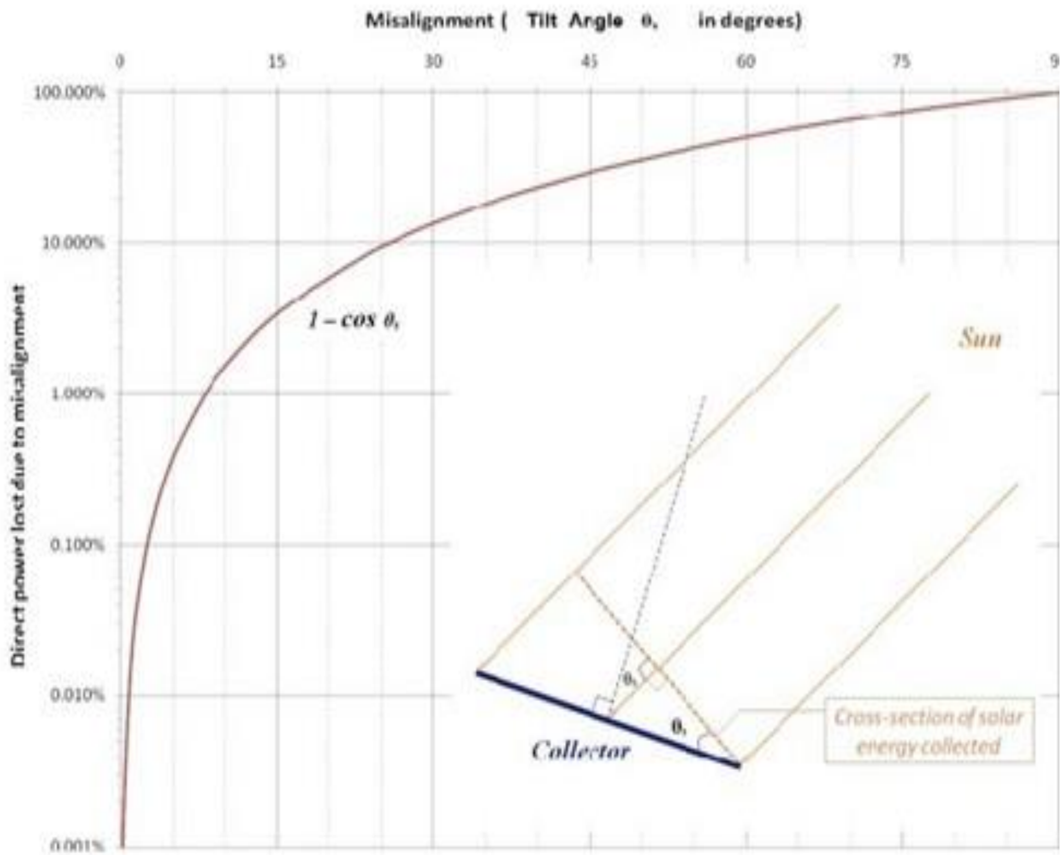

Fig 1 Percentage power lost due to misalignment

Contribution of direct beams among all the energy decreased with the cosine of the tilt angle. Solar tilt angle is the angle which is calculated from overhead to the geometric centre of the sun. It is also known as solar zenith angle. The angle between the horizontal axis and the sun centre is called the solar elevation angle.

If solar zenith angle is ‘θs’ the solar elevation angle is $\alpha s = 9- \theta s$.

Tracking devices having accuracy of ± 5° can cause efficiency greater than 99.6% of energy given by the direct beam added to 100% of energy delivered by the diffused beam. Thus the need for solar tracking system is needed.

4. SOLAR TRACKERS TYPES BASED ON DRIVES

4.1. PASSIVE TRACKERS

These types of trackers works on basic type of thermal hydraulic systems. It has two tanks with tubes which are fixed on one side of the photovoltaic solar panel. When pressure changes between two points it causes change in pressure on this principle this works. This change in pressure is caused by the solar heat generated by the sun that causes increase in pressure of gas this pressurised gas rotates the structure. This method doesn’t rely on sensors so it uses very less power to work on.

4.2. ACTIVE TRACKERS

Active trackers consist of gear and motor and gets moved by controller which changes with the sun position. So due to the presence of motors and other moving parts, regular maintenance is required. But it has much better use of solar energy as compared to passive trackers.

5. SOLAR TRACKERS TYPES BASED ON AXIS OF ROTATION

5.1. TRACKERS WITH SINGLE AXIS

The sun travels east to west through 360° per day. Taking it from the perspective of a fixed point, it travels through 180° during one half of the day. Local horizon effect will decrease it to 150°. Let us consider a fixed solar panel, it will face 75° between dawn to dusk. From Table 2 we can see that it will lose 75% of energy for a misalignment of 75°, in the evening and morning.

These losses can be reduced by suing Rotating panels to the east and west. Tracker rotating towards east-west direction is called a Single Axis Solar Tracker. It is done based on Solar Azimuth angle.

5.1. SINGLE AXIS TRACKER TYPES.

Fig 2 single axis tracker

5.1.1. Horizontal Single-Axis Solar Tracker (HSAT)

Fig 3 Horizontal Single-Axis Solar Tracker (HSAT)

The rotational axis of single axis tracking system is in horizontal position with the earth. These solar tracking systems move from east to west during the whole solar day. Guihua et al. calculated the optical performance of horizontal single axis tracking solar panels. He found that the in east-west direction placed HSAT is worst to boost and to increased the efficiency drastically around 36% energy while the north-south placed HSAT.

5.1.2. Vertical Single Axis Tracker (VSAT)

The axis of rotation for this type of solar tracking device is kept vertical with respect to the earth. These solar tracking systems move from east to west during the whole solar day. Lorenzo et al. designed the tracking device for photovoltaic systems having single vertical axis. The vertical single axis tracking device also called as azimuth tracking system is mainly used for the energy gain which can be 40% more compared to tilted static panels.

Fig 4

Vertical Single Axis Tracker (VSAT)

5.2. DUAL AXIS TRACKERS

This type of tracking device has two degrees of rotation i.e azimuth rotation (which allows the PVC panel to rotate in a circular path parallel to the panel surface) and horizontally rotating, also called elevation angle of rotation (causing panel move up and down directions).

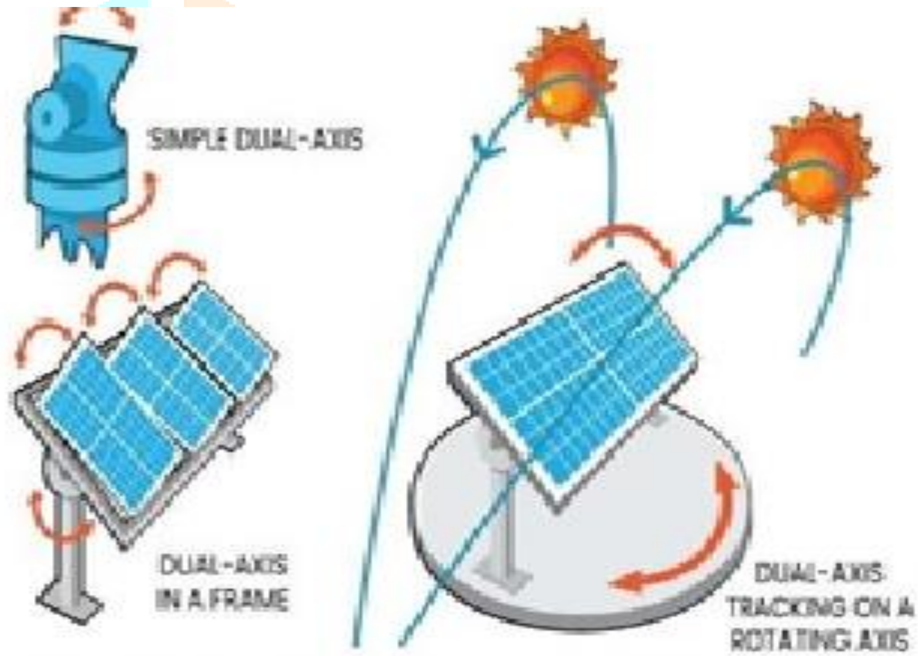

Fig 5 DUAL AXIS TRACKERS

6. ADVANTAGES

1. Solar tracking devices are very cost effective, efficient devices. They have very less after installation cost.
2. As solar tracking devices are directly exposed to falling solar rays, power generation is more as compared to conventional one.
3. solar tracking devices make the panels face towards the sun all the time causing more efficient and more power output.
4. solar tracking devices in comparison to tilt devices produces more power output as compared to their counterparts.
5. In low horizon areas and hilly areas solar tracking devices are most efficient as they are free from shade and light all the day.
6. there are many types of solar tracking devices available deping upon the installation size, local weather, degree of latitude and electrical requirements such as single axis, dual axis trackers which fits in required environment easily.

7. THE FUTURE SCOPE OF SYSTEMS FOR SUN RAYS TRACKING

Solar tracking devices, whether single-axis or dual-axis. It can generate the maximum level of solar energy. so, it is important to decide which type of tracker is most appropriate for factors consideration, including the terrain, climate, and the type of solar panels that are being used. If you are a solar installer, depending on the budgetary constraints of your client, the terrain and climate, and the lifespan of the system, you need to consider the key factors to make the right decision. Now, when it comes to the future of the solar tracker industry, it seems pretty bright.

8. CONCLUSIONS

The development of sun tracking system is possible through innovative design of many solar thermal and photovoltaic system. Solar tracking devices which follow the motion of the sun over the whole day collected a large amount of sun rays giving a large power output. In this study a thorough study has been done on the various types of devices for sun rays tracking throughout the day developed all over the world. It has been found out that these tracking devices can be classified into single axis and dual axis tracking systems based on the process by which they work in order to track sun most effectively and efficiently.

9. REFRENCES

1. Guihua. Li., Runsheng Tang., and Hao Zhang. 2012. "Optical Performance Of Horizontal Single Axis tracked Solar Panels:2012." International Conference on Future Energy, Environment and materials 16:1744-1752. 20. Lorenzo. E., Perez. M.,.Ezpeleta.A., and Acedo. J. 2002. "Design of Tracking Photovoltaic Systems with a Single Vertical Axis." Progress in photovoltaic: research and applications 10:533-543.
2. Mehleri. E., Zervas. P., Sarimveis. H., Palyvos. J., and Markatos. N. 2010. "Determination of the optimal tilt angle and orientation for solar photovoltaic arrays." Renewable Energy 2; 24-69.
3. Al Mohamad.A. 2004. "Efficiency improvements of photo-voltaic panels using a Sun-tracking system." Applied Energy 79:345–54.
4. Batayneh. W., Owais. A. and Nairoukh. M. 2013. "An intelligent fuzzy based tracking controller for a dual-axis solar PV system." Automatic in Construction 29: 100-106.
5. Alata. M., Al-Nimr .M. A. and Qaroush.Y. 2005. "Developing a multipurpose sun tracking system using fuzzy control." Energy Conversion & Management 46:1229-1245.
6. Al-Naima.F.M., Yaghobian,N.A. 1990. "Design and construction of a solar tracking system." Solar Wind Technol 7: 611-617.
7. Liqun Liu., Han Xiaoqing., Chunxia Liu and Jing Wang. 2013. "The influence factors analysis of the best orientation relative to the sun for dual-axis sun tracking system." Journal of Vibration and Control: 1-7.
8. Arbab.H., Jazi. B., and Rezagholizadeh. M. 2009. "A computer tracking system of solar dish with two- axis degree freedoms based on picture processing of bar shadow." Renewable Energy 34: 1114–1118.