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Sun-Tracking System in Solar Energy Application

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One of the wide applications for automation in the area of solar energy is sun-tracking system in which control theory is employed to drive the solar collector or concentrator towards the sun in all times. Sun-tracking system can allow the solar collector to harness maximum solar irradiance due to the nature of apparent motion of the sun relative to the earth during the day. The critical issue of installing sun-tracker to any solar collector is more towards investment and return. How much improvement in energy gain in term of kilowatt hour versus the cost of tracker is the main consideration in this issue?

Generally, all the sun trackers can be categorized as one-axis and two-axis tracking devices. For one-axis sun-tracker, the tracking system only drives the collector about a single axis of rotation until the sun central ray and the aperture normal are coplanar. Generally, there are three types of one-axis sun tracker: horizontal-axis tracker (the tracking axis is parallel to the surface of the earth with the orientation to be aligned along either east-west or north-south direction), tilted-axis tracker (the tracking axis is tilted from the horizon by an angle oriented along north-south direction, e.g. latitude-tilted-axis sun tracker), and vertical-axis tracker (the tracking axis is collinear with the zenith axis and it is known as azimuth sun tracker). On the other hand, the two-axis sun trackers, which are azimuth-elevation and tilt-roll sun trackers, track the sun in two axes such that the sun vector is always normal to the aperture in order to obtain 100% collective efficiency. Azimuth-elevation tracker has advantage in the mechanical structure that is easier to be constructed, whilst tilt-roll tracker has advantage in the design of control system because one of the tracking axes that aligned with polar-axis tracks the sun at constant velocity of 15 degrees per hour. Despite many available options, a right design of sun-tracking system to be adapted to a right solar collector or concentrator is very significant to make the whole system cost effective. Gandhidasn and Satcunanathan [1], have performed a theoretical comparative study between two-axis and one-axis tracking flat plate collectors in which one-axis tracking system was able to capture 92% of energy collected by the two-axis tracking system. Mousazadeh et al. [2], has calculated 57% more energy to be received by the tracking collector (two-axis sun-tracker) compared to the fixed collector. For concentrating system, two-axis sun-tracker with high tracking accuracy is highly required. For flat plate collector, one-axis or two-axis sun-tracker with less demanding on the accuracy is normally sufficient. If the aim of flat plat collector is off by 10°, the output is still 98.5% of that of the full-tracking. Therefore, a careful consideration is necessary so that the cost of the solar power system can be more competitive compared with other renewable energy sources.

A well-performed sun-tracking system must be reliable, accurate and able keep track to the sun even in the periods of cloud cover. Over the past two decades, various sun-tracking approaches have been proposed to enhance the performance of solar collectors in harnessing solar energy. Although the degree of accuracy required depends on the specific characteristics of the concentrating solar power system being analyzed, generally the higher the system concentration the higher the tracking accuracy will be needed. In the architectural design of control and automation, there are three possible sun-tracking algorithms: open-loop, closed-loop, and hybrid of both. Among the three algorithms, the hybrid of open and closed loop can achieve the highest tracking accuracy but it is also the most expensive design. According to Carnot efficiency, concentrating solar power that capable of achieving high temperature (more than 1000°C) definitely can obtain higher the energy conversion efficiency compared to that of same collective area of flat plate collector. However, the cost of concentrating device is always more expensive, which is not only caused by the optical design but also the requirement of accurate sun-tracking system.

In recent years, concentrator photovoltaic (CPV) system with the cell conversion efficiency of more than 40 % with the use of relatively inexpensive optics such as mirrors or lenses to focus the sunlight on multi-junction solar cells has gained more attention. CPV has several advantages compared to flat plate photovoltaic (PV) including more than double conversion efficiency and replacing the expensive semiconductor material by lower cost of mirror or lens. Nonetheless, a high-precision of sun-tracking system is a must for CPV system not only to maintain high and stable output power but also to avoid the damage to the solar cells due to the highly concentrated sunlight off to one side of the solar cells. In order to reduce the cost of sun-tracking system, the collective area of the CPV system is increased to as large as possible so that the cost of sun-tracking system per kilo-Watt peak can be minimized. The appropriate design of sun-tracker for the CPV system is key factor to make the whole CPV system successful and competitive.

Various innovative and creative ideas to minimize the cost of sun-tracking system are very important to guarantee a good future of solar energy application especially high concentration system. We welcome more researchers or industrial players to propose or submit their innovative or creative ideas in reducing the cost of sun-tracking system to the journal of Advances in Robotic and Automation.

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