Passive Solar Tracking for Energy and Lighting Applications

N.S. Sigurdarson

DTU Mechanical Engineering, Technical University of Denmark

INTRODUCTION

Solar tracking systems – that allow solar energy systems to adjust their position in accordance with the movement of the sun across the sky - are used to optimize the energy output from solar energy systems, increasing the energy yield by up to 80 %. Yet, tracking systems are more or less only used in large scale energy parks, due to the high cost, complex installation, and the long time it takes to achieve a return of investment. This project - conducted in collaboration with Velux A/S and DTU MEK - entails the development of a simple, inexpensive, passive solar tracking concept that does not require an external power source, for use in photovoltaic-, solar thermal-, and daylighting systems, in an effort to improve their performance.

THEORY AND METHODS

To ensure simplicity allowing for low potential manufacturing costs, the focus of the project was concentrated on finding a way of creating passive sun-following movement. This was done through actuation that is entirely powered and controlled by the angle of incidence and intensity of sunlight. As such, the aim was to utilize the relative temperature difference, between sunlight and shade that occurs due to the continuously changing intensity-, and angle of incidence of sunlight, both daily and seasonally. In order to create actuation as a reaction to relative changes in temperature, a solid thermal expansion principle as seen in thermal expansion systems such as thermometers and linear thermal microactuators was used as a basis.

Through a biomimetic engineering design approach, a functioning passive tracking principle was developed, based on bimetallic actuators and sensory surfaces inspired by self-organizing plants. Biomimetics were a key source of inspiration for the mechanical design, as there are several examples of solar tracking in biological systems, such as flowers and plants. This is a characteristic known as heliotropism.

Finally, the system was dimensioned through the use of:

- A numerical mathematical model estimating the optimum patterns of movement
- Static mechanics based on *Finite Element Analysis* to ensure continuous movement and reliability
- Thermodynamic models to simulate the thermal expansion (and therefore movement) of the system under different weather conditions.

Results and perspectives

The final (fully dimensioned) tracking system allows for biaxial tracking movement through rotation around two axes of movement, making full, year round solar tracking possible. Numerical simulations over annual solar movement and the expected tracking lag and imprecision, have shown that the passive tracking system could run on a relative temperature difference (between sunlight and shade) of between 10-15°C, which is achievable even during the winter. The simulations also showed a possible gain in energy output of between 43-87 % in solar energy systems, depending on the system type, and the conditions in the surroundings.