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Paper ID : 108 Design and Mechanical Analysis of a Modular Heliostat with Screw-Driven Dual-Axis Tracking for Solar Tower CSP Systems

Abstract: The widespread deployment of Concentrated Solar Power (CSP) plants is strongly influenced by the manufacturing cost and structural complexity of heliostat systems. Conventional heliostat designs often require location-specific mirror geometries and customized structural components, increasing production cost and limiting scalability. This study presents the design and structural assessment of a low-cost modular heliostat for solar tower CSP applications. The proposed heliostat integrates a screw-driven dual-axis tracking mechanism with stepper motor azimuth control, servo-driven elevation motion, and encoder-based position feedback. A modular mirror architecture employing standardized structural components enables position-independent manufacturing, reducing fabrication complexity and production cost. The structural performance of the heliostat was evaluated using finite element analysis under self-weight and wind loading conditions. The results show that the maximum stress remained below the allowable material limits, while the predicted deformation was sufficiently small to maintain the structural stiffness required for accurate solar tracking. Euler buckling analysis confirmed the stability of the screw-driven actuator, and the estimated manufacturing cost was approximately 93 USD/m², demonstrating the economic feasibility of the proposed design. Overall, the proposed modular heliostat provides a structurally reliable, scalable, and cost-effective solution for future solar tower CSP systems.

CV:

She has been involved in the topics of vibration and wave propagation in her graduate studies. While working as a Research Assistant in Applied Mechanics at Faculty of Engineering at Middle East Technical University, she completed his Master's degree and also completed his doctoral thesis at the same university with his work on fracture mechanics in 1998. Dr. M. Evren Toygar has been working at the Department of Mechanical Engineering, Faculty of Engineering, Dokuz Eylül University since 2000 and has been a full-time professor at the same department since 2017. Her research focuses on the fracture and damage mechanics of composite and metallic materials and the mechanical design of the renewable energy systems. She has published numerous scientific articles in these fields and contributed extensively to academic journals and book chapters on topics related to experimental mechanics and design methodologies. She has taught various undergraduate and graduate-level courses, including Fracture Mechanics, Failure and Fracture Mechanics of Composite Materials, Computational Mathematics, Elastic Stability, and Fundamentals of Solid Mechanics.