Mechanical Engineering Thesis Defense

Optimizing Design Parameters of a Compact Linear Fresnel Reflector Solar Energy System with Machine Learning

School for Engineering of Matter, Transport and Energy

Shyam Lunagariya

Advisor: Dr. Patrick Phelan

Abstract

Compact Linear Fresnel Reflector (CLFR) is a simple, cost effective and scalable option for generating solar power by concentrating the sun rays. To make a most feasible application, design parameters of the CLFR such as solar concentrator design parameters, receiver design parameters, heat transfer and power block parameters, etc. should be optimized to achieve optimum efficiency. Many researchers have carried out modeling and optimization of CLFR with various numerical or analytical methods. However, often computational time and cost are significant in these existing approaches. This research attempts to address this issue by proposing a novel computational approach with the help of increased computational efficiency and machine learning. The approach consists of two parts: the algorithm and machine learning model. The algorithm has been created to fulfill the requirement of the Monte Carlo Ray tracing method for CLFR collector simulation which is a simplified version of the conventional ray tracing method. For various configurations of the CLFR system, optical losses and optical efficiency are calculated by employing these design parameters, such as number of mirrors, mirror length, mirror width, space between adjacent mirrors and orientation angle of the CLFR system. Further, to reduce the computational time, a machine learning method is used to predict the optical efficiency for the various configurations of the CLFR system. This entire method is validated using an existing approach (SolTrace) for the optical losses and optical efficiency of a CLFR system. In the case study example presented here, it is observed that in the existing approach, 6.63 CPU-hours of computational time are required by the program to calculate efficiency, whereas the novel machine learning approach took only seconds to predict the optical efficiency with great accuracy (R2 of 0.99). Therefore, this method can be used to optimize a CLFR system based on the location and land configuration with reduced computational time. This will be beneficial for CLFR to be a potential candidate for concentrating solar power option.

November 4, 2021; 10 AM;

Zoom Link: https://asu.zoom.us/j/87545633929