Simulating Specular Reflectance in Solar Cleaning Films Using the Particle Tracing Module of the COMSOL Multiphysics® Software and LiveLink™ for MATLAB®

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Abstract

One of the obstacles preventing photovoltaic and concentrated solar power technologies from scaling up to meet increasing electricity demands is the inevitable dust accumulation on the optical surfaces of solar collectors. The ideal location for solar power is arid environments due to their high annual solar irradiance. However, these environments also have high rates of natural soiling. Many current methods of cleaning these devices are water-based cleaning methods, which are expensive and not environmentally sustainable, as there is an obvious lack of fresh water in these regions. The electrodynamic screen (EDS) is a dust removal technology which cleans solar collector devices through the electrostatic charging of dust particles without the use of water and with no moving parts. The EDS is comprised of electrodes printed on a film, which is then laminated on a glass substrate. Three-phased high voltage pulses are then applied to these electrodes, causing a sweeping electric field which lifts the charged dust particles off of the surface. A model was developed with COMSOL® which computes the electric field of the EDS with the Electrostatics module and then tracks dust particles during EDS activation with the Particle Tracing for Fluid Flow module. There are multiple ways to empirically test EDS efficiency using optical measurements. With LiveLink™ for MATLAB®, ray tracing operations were performed on the model to simulate these optical measurements. These simulated tests will enable us to evaluate the efficiency of different EDS designs before the manufacturing stage, leading to quicker and more cost-efficient design optimization. Improving the EDS optical properties and dust removal will allow for a water free method of cleaning, thereby improving the sustainability of solar collection technologies.

Figures used in the abstract

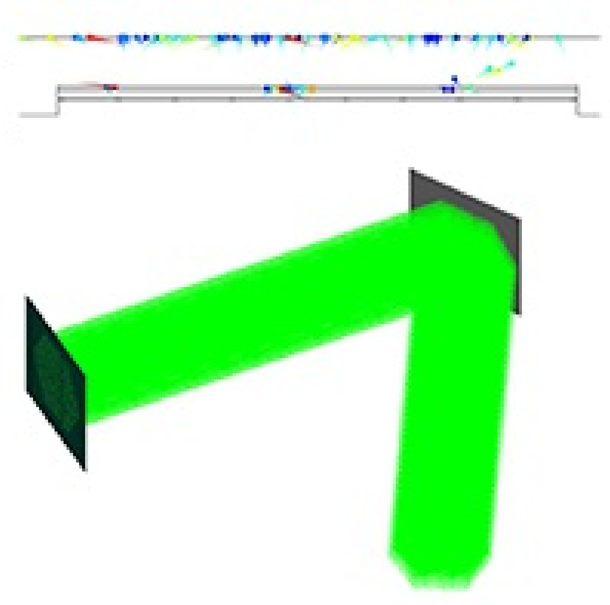

Figure 1: Plot of particle trajectories (above) at an intermediate time step with a visual demonstration of ray tracing (below) through a clean EDS.