Optimization of Electrode Geometry for Designing Electrodynamic Screens Integrated on Solar Mirrors with Maximum Electrostatic Forces for Dust Removal with Minimal Specular Reflection Losses

John Hudelson, Jeremy Stark, and Vicente Colmenares
Electrical and Computer Engineering Department
Boston University
e-mail: mazumder@bu.edu

***Abstract*— High levels of direct normal irradiance and the availability low-cost land make areas with arid environments attractive for large-scale MW photovoltaic and solar thermal power plants. Environmental dust deposition on the optical surface of both photovoltaic panels and solar mirrors can lower collector efficiency by obscuring and scattering incident light. Solar collectors in these environments require frequent cleaning with water and detergents. Such cleaning is labor intensive and can deplete local water resources. Integrating electro dynamic screens (EDS) into the front surface of the solar mirrors may significantly lower the frequency of these washings and maintain high reflection efficiency of sunlight. EDS, which contains parallel transparent electrodes deposited on the surface of solar collectors and embedded within a transparent dielectric film, create a traveling electrostatic wave when three-phase high voltage pulses activate the electrodes. The width and spacing of these electrodes are of critical importance for optimizing the dust removal capabilities of the EDS as well for minimizing reflection loss caused by the presence of the electrodes on the mirror surface. Previously, electrode geometries have been determined by trial and error or by manufacturing constraints. This paper reports on the electrode design based on an electrostatic force model calculation on the relationship between electrode geometry and dust clearance. Prediction on the electric field values necessary to remove particles of a given diameter was made based on the ratio of particle adhesion to the removal forces. Next the minimum electric field strengths for different electrode geometries were computed using finite element analysis software, COMSOL. Considering the variation of electric field strengths on the EDS surface, predictions of electrostatic removal force acting on particles of different sizes were made. Ten different electrode geometries were implemented on EDS using photolithography and were tested with JSC-1A simulant dust. Comparisons of particle size distributions before and after cleaning were performed to evaluate the model predictions. Results of modeling and experiments are presented.**