The Electrodynamic Screen: Closed-Form Solutions for the Electric Field and Dielectrophoretic Forces

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Abstract*— The Electrodynamic Screen (EDS) has shown promising results in removing dust particles from solar collectors, acting as an alternative for the water-based cleaning systems used widely in practice. The analysis of the electric field is a crucial step in detailed modeling of the EDS operation in dust removal. In this paper, the analytical solutions for the electric potential and electric field inside the transparent dielectric coating and above the EDS surface are presented. The role of transparent dielectric layer is considered explicitly and the effect of its thickness in the behavior of the electric field on the EDS is highlighted. Unlike the preceding studies, we have adopted the two-wire model from transmission lines theory to model the voltage profile between adjacent electrodes. It is shown that the adopted model significantly reduces the computational errors introduced by the linear approximation of voltage profile. Furthermore, the EDS model has been developed in the COMSOL Multiphysics finite element analysis (FEA) software and the simulation results are in good agreement with the analytical solutions. Our hypothesis is that the dielectrophoretic (DEP) force and electro-rotational torque may play a major role in charging the initially uncharged dust particles that deposit on the solar collectors. Specifically, in initial moments of the EDS operation, the DEP forces are predominant over the Coulomb force. Once the dust particles are charged sufficiently through the triboelectrification process, the Coulomb force is able to levitate and convey the particle. As the particles becomes highly charged, the DEP forces become negligible in comparison to the Coulomb force. The FEA results for different particle size are discussed based on the analysis of DEP force formulations. Our objective is to investigate the roles of DEP forces for charging particles located on the surface of EDS with no initial net charge. An outline of the theoretical model and experimental data would be presented.