Influence of Material Models on the Numerical Predictions of Thermomechanical Behavior of Silicon Photovoltaic Modules

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Throughout their lifetimes operating outdoors, silicon photovoltaic (PV) modules experience a variety of environmental factors. These environmental factors can lead to the degradation of PV modules' materials and the subsequent appearance of failure modes that affect their performance. PV modules are made of different layers of materials, mainly glass, EVA, silicon, and a backsheet material such as PET. Since the materials have different coefficients of thermal expansion (CTE), temperature changes result in internal stresses, which can drive some of the failure modes. To gain a better understanding of the internal stresses that arise during operation, it is necessary to accurately model the thermomechanical behavior of PV modules. To achieve this, different material models must be analyzed. In this study, a 2D thermomechanical, finite-element (FE) model of PV modules was created, and the influence of the material models on the numerical simulation were compared. Attention was given to the material models of EVA and silicon. Firstly, different material models of EVA were considered and compared. Secondly, as the CTE plays a major role in the thermomechanical behavior, the influence of its temperature dependence on the predictions was compared. The numerical results show that it is necessary to use a viscoelastic EVA model to reproduce the experimental data of cells gap. It was also found that the temperature dependence of the CTE of EVA and silicon has significant influence on the deflection, hence it should be taken into consideration in future studies.