Penetration of Moisture in a Solar Panel Edge Seal

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Abstract

The search for lower cost photovoltaic panels for the conversion of solar to electrical energy has lead to some types with sensitivity to degradation by moisture. The addition of an edge-seal containing a desiccant can reduce the amount of water reaching the photovoltaic panel. This report discusses the modeling of the water transport into the solar cell system to determine the amount of edge seal and desiccant required to guarantee performance over the standard 20 year lifetime.
The roots of the problem lie in Josef Stefan's work on freezing sea ice. The transport of heat in the Stefan problem is analogous to the transfer of moisture in the present problem. The latent heat of freezing in the Stefan problem is analogous to the adsorption of moisture by the desiccant in the edge seal. The same differential equation describes both problems. The moving freezing front of the original Stefan problem becomes a moving moisture front representing the border where the desiccant is combining with the water; as the desiccant is saturated, the front moves in further. The Stefan problem has been treated in other COMSOL models [1,2], and this provides a starting point for verifying that the COMSOL model matches the known solution of the Stefan problem in the case of constant boundary conditions. The COMSOL Deformed Geometry physics can easily be used to satisfy the Stefan conditions for the advancing moisture front. Actual photovoltaic panel use conditions have varying temperature and humidity. The time dependent solution can calculate the advance of the moisture front with varying conditions. Climate data for temperature and humidity can be added via the COMSOL interpolation functions and used to adjust boundary conditions and the temperature dependant water solubility and diffusivity in the edge seal material. For example, the Typical Metrological Year data from the National Renewable Energy Laboratory [3] can be used for temperature and humidity data. The data must be adjusted for the actual temperatures experienced by the photovoltaic panel, which differ from ambient. Moisture diffusion is modeled by the COMSOL Transport of Diluted Species physics. The diffusion problem is relatively simple. Execution time is determined by the need to match the time varying temperature and humidity conditions; short time steps are required to match the hourly variation over years of simulated time. Figure 1 shows a run for one specific climate and desiccant level. This paper compares model results with experimental measurements of moisture front movement [4]. Predictions from the climate model can be used to verify the amount of edge seal required to meet the 20 year reliability requirement.

Reference

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2. Carin, M.; "Numerical Simulation of Moving Boundary Problems with an ALE Method. Validation in the Case of a Free Surface or a Moving Solidification Front", COMSOL Conference 2006 Paris [COMSOL model 1691].
3. http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/
4. Kempe, M.D. et al; "Evaluation and modeling of edge-seal materials for photovoltaic applications", 35th IEEE Photovoltaic Specialists Conference (PVSC), pp 256-261 (June 2010).

Figures used in the abstract

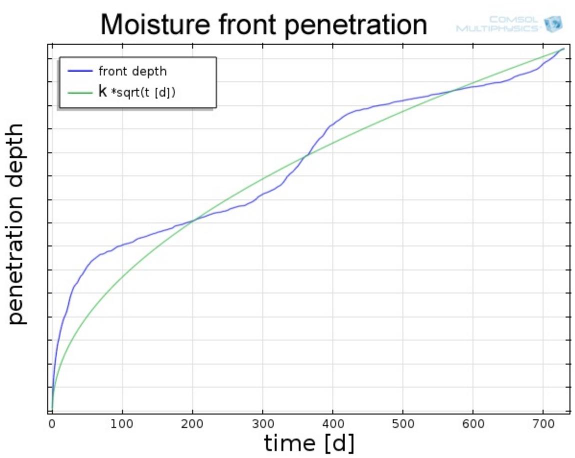

Figure 1: Moisture front penetration.