Numerical simulation of passive cooling of a photovoltaic panel using environmentally friendly recycled materials: comparison between aluminum fins and polyurethane foam

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Abstract : This study introduces a numerical model of two passive cooling techniques that incorporate recycled materials: the first uses aluminum fins salvaged from carpentry waste, and the second employs polyurethane foam (PU) sourced from tapestry residues. The proposed approach is fully consistent with the principles of environmental responsibility and supports sustainable development goals. The evaluated configurations aim to minimize the harmful thermal effects associated with high operating temperatures beyond standard test conditions (STC), with the goal of improving the performance and energy efficiency of PV systems. Simulations were conducted using COMSOL Multiphysics software. In the first approach, aluminum fins are arranged horizontally on the rear side of the solar panel to facilitate convective heat transfer driven by natural air circulation. Additionally, the cooling technique utilizes a polyurethane foam saturated with water to enhance heat dissipation to exploit the latent heat of vaporization, thereby reducing the temperature of the photovoltaic panel. Analysis includes both fluid dynamics and heat transfer in solid and porous media. Numerical simulations demonstrated that the integration of passive cooling systems based on aluminum fins and polyurethane (PU) foam reduced the average temperature of the photovoltaic panel by approximately 9.8°C and 16.4°C, respectively. The observed temperature reductions led to efficiency improvements of 8.4% and 16.4%, demonstrating the effectiveness of the cooling methods introduced.

3D modeling of the main cooling system with COMSOL

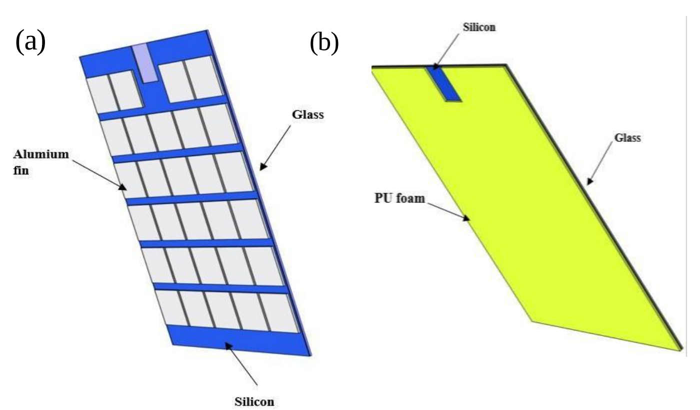

Fig.1: Cooling systems (a)Aluminum fins, (b) PU foam

Results

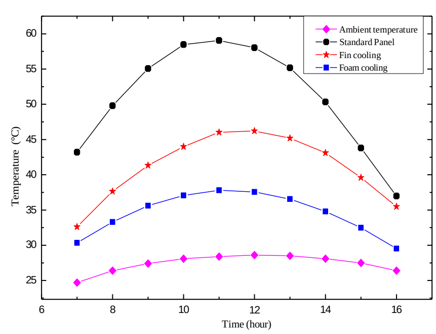

Fig.2 : PV temperatures with and without coolings

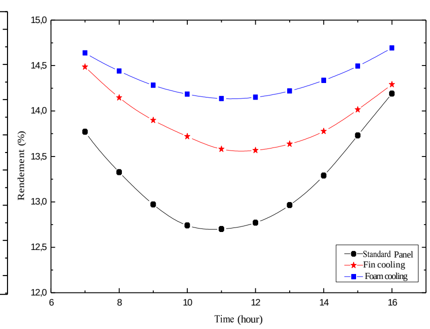

Fig.3 : PV rendement with and without coolings

In the final version, I will provide additional details along with the relevant bibliography.