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Artificial Neural Network and Genetic Algorithm-based prediction of photovoltaic panel performance with porous foam gradient and nano-enhanced phase change material

Somayeh Davoodabadi Farahani [a], Mehdi Khademi Zare [a], As'ad Alizadeh [b]

[a] School of Mechanical Engineering, Arak University of Technology, 38181-41167 Arak, Iran
[b] Department of Civil Engineering, College of Engineering, Cihan University-Erbil, Erbil, Iraq

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Abstract

Photovoltaic panels (PV) become less efficient as the temperature rises. The use of porous foam gradient, phase change materials (PCMs), and nanoparticle-PCM (nePCM) can effectively lower the temperature of PV panels. This study employed numerical analysis using the finite volume method to investigate the effects of different types of PCMs (n-octadecane, decanoic acid natural, lauric acid, paraffin wax, and RT-42), mono and hybrid nanoparticles/PCM, and the position of PCM in the design system. The results indicate that the highest electrical efficiency of 9% is achieved when the PCM is placed under the PV panel and the thickness of the PCM layer is 0.6 times the height of the microchannel. Furthermore, the use of a porous medium with a variable porosity coefficient that increases along the y-direction can significantly improve thermal and electrical efficiency (approximately 5–42% and 5–48% respectively). Additionally, incorporating PCM and hybrid nanoparticles-PCM enhances PV performance compared to the absence of nanoparticles. For TiO2, Ag, Al2O3, GO, and MWCNT nanoparticles, the thermal efficiency, electrical efficiency, and exergetic efficiency increase by approximately 24.18%, 26.15%, 26.28%, 26.30%, and 26.33% respectively. Similarly, for hybrid nanoparticles such as GO-Al2O3, GO-Al2O3-MWCNT, MWCNT-GO, and MWCNT-Al2O3, these values increase by approximately 26.32%, 26.3419%, 26.3432%, and 26.335% respectively for thermal efficiency, and 5.16%, 5.1702%, 5.1704%, and 5.1689% respectively for electrical efficiency. Moreover, n-octadecane exhibits the highest melting fraction, while paraffin wax has the lowest melting fraction. Lastly, the genetic algorithm-neural network method was employed to estimate the PV electrical efficiency.