Energy, exergy and economic analysis of liquid flat-plate solar collector using green covalent functionalized graphene nanoplatelets

By: Kumar, LH (Kumar, L. Harish) [1]; Kazi, SN (Kazi, S. N.) [1]; Masjuki, HH (Masjuki, H. H.) [1, 2]; Zubir, MNM (Zubir, M. N. M.) [1]; Jahan, A (Jahan, Afrin) [3]; Bhinitha, C (Bhinitha, C.) [1]

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Abstract

The conventional method of synthesizing carbon-based nanofluids produces harmful products that are highly toxic and hazardous. The present investigation deals with the effects of using eco-friendly, non-corrosive, covalent functionalized Graphene Nanoplatelets with gallic acid (GGNPs) as heat transfer fluid on energetic and exergetic performance of a Liquid flat-plate solar collector (LFPSC). Long-term dispersible stable GGNP nanofluids with base fluid distilled water are prepared with different weight concentrations of 0.025%, 0.05% & 0.1%. For varying concentrations, fluid flow rates of 0.8, 1.2, and 1.5 L/min, heat flux intensities of 600, 800, and 1000 W/m(2), and inlet temperature ranging from 303 to 323 K are considered for the conduction of experiments. Improvement in energy and exergetic efficiency was achieved using GGNP nanofluids. Thermal efficiency surges with increment in flow rate and heat flux intensities, meanwhile it decreases for increment in inlet temperature. The maximum enhancement in LFPSC efficiency is 24.09% for 0.1 wt% GGNPs and flow rate of 1.5 L/min than distilled water. Analysis of exergetic performance revealed that exergy efficiency reduces with a rise in mass flow rate meanwhile enhanced with an increase in nanofluid concentration. Exergy efficiency was maximum for 0.1% GGNP concentration and flow rate of 0.8 L/min. The maximum increase in friction factor values is approximately 1.5, 2.6 and 7.9% for 0.025, 0.05 and 0.1% GGNP nanofluids than distilled water. Relative pumping power slightly increases with the increment of GGNP concentration but is quite close to that of the base fluid. Performance index greater than one is obtained with higher values achieved at an increase in GGNP weight concentration. Economic consideration of GGNP nanofluids in LFPSC showcased a maximum reduction of 26.41% in the size of collector area using 0.1% GGNP nanofluid instead of distilled water. The payback period for LFPSC using GGNPs was 5.615% lesser than that of using water.

Keywords

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Author Information

Corresponding Address: Kumar, L. Harish (corresponding author)
Univ Malaya, Fac Engn, Dept Mech Engn, Kuala Lumpur, Malaysia
Addresses:
[1] Univ Malaya, Fac Engn, Dept Mech Engn, Kuala Lumpur, Malaysia
[2] Int Islamic Univ Malaysia, Fac Engn, Dept Mech Engn, Kuala Lumpur, Malaysia
Affiliation
International Islamic University Malaysia
[3] Univ Malaya, NANOCAT, Kuala Lumpur, Malaysia

E-mail Addresses: harishsanjeetha@gmail.com; salimnewaz@um.edu.my; nashrul@um.edu.my

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