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

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

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%, 0.2%, 0.5%, and 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/m², and inlet temperature ranging from 303 to 323 K are conducted for the experiment. Improvements in energy and exergetic efficiency was achieved using GGNP nanofluids. Thermal efficiency surges with increment in flow rate and heat flux intensities; meanwhile, exergy efficiency slightly decreases 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 energetic 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 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. The maximum increase in friction factor values was achieved using GGNP nanofluids. Exergonic performance revealed that exergy efficiency reduces with an increase in 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 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 the base fluid.

Keywords
- Graphene nanoplatelets; Green functionalization; Liquid flat-plate solar collector; Thermal performance; Economic analysis

Author Keywords
- Graphene nanoplatelets; Green functionalization; Liquid flat-plate solar collector; Thermal performance; Economic analysis

Author Information
- Kumar, L. Harish (corresponding author)
- Univ Malaya, Fac Engn, Dept Mech Engn, Kuala Lumpur, Malaysia
- Int Islamic Univ Malaysia, Fac Engn, Dept Mech Engn, Kuala Lumpur, Malaysia
- International Islamic University Malaysia
- Univ Malaya, NANOCAT, Kuala Lumpur, Malaysia
- harishsanjeetha@gmail.com; salinmewaz@um.edu.my; nashrul@um.edu.my

Categories/Classification
- Research Areas: Thermodynamics; Energy & Fuels; Engineering; Mechanics

Funding
- Funding agency
- Grant number

Citation Network
In Web of Science Core Collection
1 Citation
- Create citation alert
- All Citations
1 In All Databases
- More citations

Cited References
87
- View Related Records
- You may also like...
  - Bellos, E; Tzivanidis, C; Parametric investigation of supercritical carbon dioxide utilization in parabolic trough collectors
  - Matheswaran, MM; Arjunan, TV; Somasundaram, D; Energetic, exergetic and enviro-economic analysis of parallel pass jet plate solar air heater with artificial roughness
- Journal of Thermal Analysis and Calorimetry
  - Arora, S; Fekadu, G; Subudhi, S; Energy and Exergy Analysis of Marquise Shaped Channel Flat Plate Solar Collector Using Al2O3-Water Nanofluid and Water
- Journal of Solar Energy Engineering-Transactions of the ASME
  - Ardeh, EAA; Loni, R; Wen, D; et al. Exergy and economic assessments of solar organic Rankine cycle system with linear V-Shape cavity
  - Energy Conversion and Management
  - Aatæe, S; Ameri, M; Energy and exergy analysis of all-glass evacuated solar collector tubes with coaxial fluid conduit
  - Solar Energy

Most Recently Cited
- Alawi, OA; Kamar, HM; Yaseen, ZM; et al. Experimental and Theoretical Analysis of Energy Efficiency in a Flat Plate Solar Collector
The authors gratefully acknowledge the FRGS grant FP143-2019A and research grant GPF019A-2019, IIRG006B-19I1SS, University of Malaya, Kuala Lumpur, Malaysia for the support to conduct this research work.