Journal of Cleaner Production 133 (2016) 518–530

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Energy and exergy analysis of a flat plate solar collector using different sizes of aluminium oxide based nanofluid

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ARTICLE INFO

Article history:
Received 21 November 2015
Received in revised form
28 May 2016
Accepted 28 May 2016
Available online 2 June 2016

Keywords:
Nanofluid
Size
Energy
Exergy
Thermal conductivity
Al_2O_3

ABSTRACT

Growing dependence of industry and technology on fossil energy and increasing population encounters all countries with challenge of energy for future. Therefore, investigation about renewable energies, particularly solar energy is considered. The use of nanofluids in solar collectors offers better performance, as they are very efficient in transporting heat even under small temperature difference. The effect of Aluminium oxide (Al_2O_3)–water nanofluid, as working fluid, is used to evaluate the thermal efficiency of a flat plate solar collector, experimentally. A volume fraction of 0.1% for size of (13 nm and 20 nm) nanoparticles, respectively was used for this study. The mass flow rates of the nanofluid varied from 0.5 to 1.5 kg/min. Experiments were carried out using a stable nanofluid. The stability of nanofluid was obtained by controlling the pH of the solution. An ASHRAE Standard 93-2010 (R2014) was used to analyze efficiency of the solar collector. The results reflect the contribution and significance of each of these parameters to the collector overall energetic and exergetic efficiencies. Two different sizes of Al_2O_3 –water nanofluid 13 nm and 20 nm are examined, and results show that 13 nm Al_2O_3 nanofluid shows higher thermal conductivity enhancement and efficiency, compared to that of 20 nm Al_2O_3 nanofluid and water. Al_2O_3–H_2O (13 nm) nanofluid with 0.1% volume fraction and at a flow rate of 1.5 kg/min showed the highest energy efficiency of about 73.7%, compared to Al_2O_3–H_2O (20 nm) nanofluid, which showed an energy efficiency of 70.7%. Critical point of Al_2O_3–water nanofluid is also presented, which has not be reported in literature according to author's knowledge, which also shows the novelty of this work.

1. Introduction

Energy is an important entity for the economic development of any country. By the end of the 21st century, oil will be past its dominance as the major source of energy. With the ongoing rise in the world's population and the growth of modernization, the global need for energy will be increased in the next 20 years. Unfortunately, the assets of fossil fuels are not huge or renewable; the sources are constrained. Technologies that can be used to harvest energy from direct and indirect effects on the Earth from the sun's energy (e.g., solar energy, wind, and hydropower), gravitational effects (ebb and flow), and the high temperature of the Earth's core (geothermal) are known as renewable energy technologies. Solar energy is sustainable, free, clean and infinite. Grounded on the necessary environmental and safety features of solar energy, it is usually recognized that it can be used to a larger extent with the smallest environmental effects than other sources of renewable energy.

The paper focuses on the detailed energy analysis of flat plate solar collector for evaluating the thermal performance and finding the optimum values of the mass flow rate, effect of different size of Al_2O_3 nanoparticle and the maximum energy efficiency and exergy efficiency under given operating conditions. Considerable research has been accomplished in this area. Man is currently in a position where population increase, the main world problems of global warming and the coming energy crisis (Goodstein and Intriligator, 2013) are leading to global security worries and pushing us to transform, the use and harvest energy. Wind, biomass, geothermal and solar are the common substitute energy technologies presently

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http://dx.doi.org/10.1016/j.jclepro.2016.05.178
0959-6526/