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Capital cost and economic viability of thermosyphonic solar water heaters manufactured from alternate materials in India

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Abstract

Many companies in India manufacture solar water heaters but these are not becoming popular in the domestic sector because of their high cost. The Ministry of Non-Conventional Energy Sources (MNES), New Delhi is recommending flat-plate collectors with copper (Cu) risers, headers and plate. Therefore, their cost is high. Long term studies have been carried out at the Central Arid Zone Research Institute, Jodhpur, to reduce the cost by replacing copper tubes with galvanised steel (G.S.) tube and copper plate with aluminium (Al) plate. The aluminium plate is wrapped over the G.S. tube by a special wire wound technique so that good contact of plate with risers and headers has been maintained. In this paper performance and testing of solar water heaters having G.S.–Al fin, Cu–Al fin and Cu–Cu fin in flat-plate collectors have been compared. It has been found that performance of all the three heaters is almost similar. The heater can provide 100 litres of hot water at an average temperature 62.0°C at 4 pm that can be retained to 50.4°C when average tap water temperature was 23.9°C. The efficiency of the heater is 51.9%. The cost of the heater with G.S.–Al collector is only Rs. 8,000.00 while it is Rs. 10,250.00 for solar water heaters with Cu–Cu collectors. The payback period of a solar water heater with G.S.–Al collector has been worked out by considering 10% compound annual interest, 5% maintenance cost, 5%, inflation in fuel prices and maintenance cost. The payback period varies between 2.92 years to 4.53 years depending upon which fuel it replaces. The payback periods are in increasing order with respect to fuels: electricity, firewood, LPG, charcoal, and kerosene.

Keywords: Solar water heater; Natural circulation; Energy conservation; Solar energy

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Nomenclature

a	Compound interest rate per annum
A	Absorber area, m^2
b	Inflation rate in energy and maintenance per annum
C	Cost of the heater, Rs.
E	Energy savings per year, Rs.
H_T	Solar radiation on collector plane, J m^{-2} h^{-1}
M	Maintenance cost per annum, Rs.
N	Payback periods yr
q_u	Useful heat collected by the solar water heater, J
θ	Period of test, h
η	Efficiency of the solar water heater
λ	Latitude of the place

1. Introduction

Hot water is an essential requirement in industries as well as in the domestic sector. It is required for taking baths and for washing clothes, utensils and other domestic purposes both in urban as well as in rural areas. Hot water is required in large quantities in hostels, hotels, hospitals, and industries such as textile, paper, food processing, dairy, edible oil, etc. Water is generally heated by burning non-commercial fuels, namely firewood and cow dung cake in rural areas and by commercial fuels such as kerosene, liquid petroleum gas (LPG), coal, furnace oil and electricity in urban areas and in industries. It has been predicted that there will be a great shortage in the supply of conventional fuels if a suitable alternative is not found. Fortunately India is blessed with abundant solar radiation [1]. Solar radiation is available almost the whole year throughout India. The maximum daily average solar radiation of 20.97 MJ m^{-2} day^{-1} is received at Jodhpur which is known as the Sun City of India, while the minimum of 15.90 MJ m^{-2} day^{-1} is received at Shillong. The most arid parts of the country receive maximum radiation, i.e. 7200 to 7600 MJ m^{-2} per annum, semi arid areas receive 7200 to 7600 MJ m^{-2} per annum and the amount received in mountainous regions is also appreciable at 6000 MJ m^{-2} per annum. Solar water heaters, therefore, seem to be a viable alternative to conventional fuels for water heating.

The most commonly used solar water heater for domestic needs is the natural circulation type. This type of solar water heater has been designed, developed and investigated in detail by Close [2], Yellot and Sobotaka [3], Gupta and Garg [4], Ong [5], Nahar [6], Morrison and Tran [7], Morrison and Braun [8], Vaxman and Sokolov [9], Nahar and Gupta [10], Norton et al. [11], Nahar [12], Nahar [13], Joudi [14], and Kalogivou et al. [15]. The basic unit in this system is a flat-plate solar