



# Experimental study of thermodynamic assessment of a small scale solar thermal system



H.U. Helvaci\*, Z.A. Khan

Bournemouth University, Faculty of Science and Technology, Bournemouth, Nano Corr., Energy and Modelling Research Group, BH12 5BB, UK

## ARTICLE INFO

### Article history:

Received 7 January 2016  
Received in revised form 17 March 2016  
Accepted 19 March 2016

### Keywords:

Solar energy  
ORC  
HFE 7000  
Flat plate collector  
Exergy

## ABSTRACT

In this study, a scaled solar thermal system, which utilises HFE 7000, an environmentally friendly organic fluid has been designed, commissioned and tested to investigate the system performance. The proposed system comprises a flat-plate solar energy collector, a rotary vane expander, a brazed type water-cooled condenser, a pump and a heat recovery unit. In the experimental system, the flat-plate collector is employed to convert HFE-7000 into high temperature superheated vapour, which is then used to drive the rotary vane expander, as well as to generate mechanical work.

Furthermore, a heat recovery unit is employed to utilise the condensation heat. This heat recovery unit consists of a domestic hot water tank which is connected to the condenser. Energy and exergy analysis have been conducted to assess the thermodynamic performance of the system. It has been found that the collector can transfer 3564.2 W heat to the working fluid (HFE 7000) which accounts for the 57.53% of the total energy on the collector surface. The rotary vane expander generates 146.74 W mechanical work with an isentropic efficiency of 58.66%. In the heat recovery unit, 23.2% of the total rejected heat (3406.48 W) from the condenser is recovered in the hot water tank and it is harnessed to heat the water temperature in the domestic hot water tank up to 22.41 °C which subsequently will be utilised for secondary applications. The net work output and the first law efficiency of the solar ORC is found to be 135.96 W and 3.81% respectively. Exergy analysis demonstrates that the most exergy destruction rate takes place in the flat plate collector (431 W), which is the thermal source of the system. Post collector, it is followed by the expander (95 W), the condenser (32.3 W) and the pump (3.8 W) respectively. Exergy analysis results also show that the second law efficiency of the solar ORC is 17.8% at reference temperature of 15 °C. Parametric study analysis reveals that both increase in the expander inlet pressure and the degree of superheat enhances the thermodynamic performance of the solar ORC.

© 2016 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

## 1. Introduction

Large scale energy utilisation has become a vital concern due to the increase in the demand of energy use in the last decades. At the same time, use of conventional energy sources such as fossil fuels has brought many environmental problems. Climate change and global warming, which is the main issues resulted from the release of harmful substances into the atmosphere have been forcing us to explore alternative energy sources [1,2].

Solar energy is a free, clean and abundant alternative energy source and it can be utilised by means of solar photovoltaic (PV) and solar thermal systems [3]. Although solar PVs have become one of the most representative ways of electricity generation in

rural areas, high costs of PV panels, limited efficiency and requirement of expensive batteries are the main disadvantages of such systems [4].

Medium and high temperature solar thermal systems where concentrated solar collectors such as parabolic through [5,6], linear Fresnel [7] and parabolic dish [8] are used have been suggested and developed over the last decades. However, these systems need high initial cost and complex tracking devices [9].

An organic Rankine cycle, which has the same system configuration as conventional Rankine cycle uses organic substances (refrigerants or hydrocarbons) instead of water as a working fluid [10]. Using organic fluids with a lower boiling temperature than water allows these systems to utilise low temperature heat from various renewable energy sources [11]. As a result, non-concentrated low temperature flat plate collectors can be employed in organic Rankine cycles to generate power and heat simultaneously [12].

\* Corresponding author at: Faculty of Science and Technology, Fern Barrow, Talbot Campus, Bournemouth University, Poole, Dorset BH12 5BB, UK.

E-mail address: [hhelvaci@bournemouth.ac.uk](mailto:hhelvaci@bournemouth.ac.uk) (H.U. Helvaci).



Download English Version:

<https://daneshyari.com/en/article/7160855>

Download Persian Version:

<https://daneshyari.com/article/7160855>

[Daneshyari.com](https://daneshyari.com)