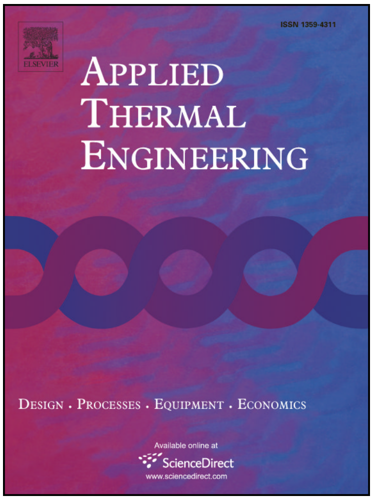

Experimental and analytical study of thermohydraulic performance of a novel loop heat pipe with an innovative active temperature control method

M. Khalili, A. Mostafazade Abolmaali, M.B. Shafii

PII: S1359-4311(18)30541-6
DOI: https://doi.org/10.1016/j.applthermaleng.2018.08.008
Reference: ATE 12511

To appear in: *Applied Thermal Engineering*

Received Date: 24 January 2018
Revised Date: 19 July 2018
Accepted Date: 3 August 2018

Please cite this article as: M. Khalili, A. Mostafazade Abolmaali, M.B. Shafii, Experimental and analytical study of thermohydraulic performance of a novel loop heat pipe with an innovative active temperature control method, *Applied Thermal Engineering* (2018), doi: https://doi.org/10.1016/j.applthermaleng.2018.08.008

Experimental and analytical study of thermohydraulic performance of a novel loop heat pipe with an innovative active temperature control method

M. Khalili[a], A. Mostafazade Abolmaali [b], M.B. Shafii [b,] *

[a] *Department of Mechanical Engineering, Faculty of Engineering, Arak University, Arak 38156-8-8349, Iran.*
[a] *School of Mechanical Engineering, Sharif University of Technology, P.O. Box 11155-9567, Tehran, Iran.*
* Corresponding author. Tel.: +98 21 6616 5675; fax: +98 21 6600 0021.
E-mail address: behshad@sharif.edu (M.B. Shafii).

Abstract

In this study, a novel type of LHP is innovated, fabricated, and its performance is assessed by numerous experiments. Compared to conventional LHPs, this novel design has some modifications in its evaporator and reservoir configuration. This particular type has a simpler and less costly fabrication procedure compared to other LHPs and it yields acceptable performance. Additionally, a novel method is introduced to control the temperature distribution in the system. A steel ball is placed in the evaporator to actively control the operating temperature. The ball is moved by two magnets installed outside of the evaporator. Moreover, a steady-state one-dimensional mathematical model of the fabricated LHP is developed and compared with experiments. This model is derived based on the energy balance equations in the horizontally installed setup. The average difference between modeling and experiment in calculation of evaporator casing temperature at different positions of the steel ball, from position No. 1 to position No. 5, is 2.2%, 3.7%, 2.5%, 3.8%, and 4.3%, respectively. Therefore, the modeling results are in good agreement with experimental data. In addition, the model can predict the effect of steel ball displacement on the variation of energy and fluid flow. Finally, the effects of heat sink temperature, ambient temperature and porosity of wick on the performance of LHP are studied by the validated model.

Keywords: Loop heat pipe, Active temperature control, Analytical modeling, Magnetic force.

1. Introduction

Loop heat pipes (LHPs) are two phase heat transfer devices consisting evaporator, condenser, reservoir, wick, and vapor and liquid lines as main components. The performance of a LHP is expressed in terms of “equivalent thermal conductivity” which can be several hundred times greater than that of metals such as copper[1]. The LHPs are more effective and flexible compared to traditional heat pipes due to their capability of heat transfer in long distances. The LHPs are vastly used in spacecraft [2], aircraft anti-icing applications [3], electronic cooling systems [4–7], and thermal management [8,9].

Many experimental researches have been conducted on development of HPs. Bai et al. [10] have modeled steady-state operation of a LHP and compared it with experiment. They have investigated the impacts of two layer wick on the evaporator and considered surface tension and interaction between liquid and vapor phases in the condenser. Zhao et al. [11] have experimentally investigated the thermal characteristics of a LHP with liquid guiding holes and water as working fluid at heat loads ranging from 70 W to 220 W and tilt angles between the evaporator and compensation chamber from 0º to 10º. Zhu et al. [12,13] have studied a novel LHP experimentally and analytically. To use the pressure head generated by evaporation, they have separated the wick from the heating surface using a chamber. They have compared pressure and capillary heads by means of validated model and concluded that the pressure head play a major role in the recirculation of working fluid. A 21 meter-long LHP made of stainless steel is developed and tested by Maydanik et al. [14]. The thermal performance of a pulsating heat pipe (PHP) utilizing graphene oxide nanofluid as working fluid is experimentally studied and it is concluded that adding