International Journal of Thermal Sciences 50 (2011) 1954–1962

Contents lists available at ScienceDirect

International Journal of Thermal Sciences

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

Thermal performance comparison of oscillating heat pipes with SiO_2/water and Al_2O_3/water nanofluids

Jian Qu, Huiying Wu*

Key Laboratory for Power Machinery and Engineering of Ministry of Education, School of Mechanical Engineering, Shanghai Jiaotong University, Shanghai 200240, PR China

ARTICLE INFO

Article history:
Received 6 January 2010
Received in revised form
7 April 2011
Accepted 13 April 2011
Available online 11 May 2011

Keywords:
Oscillating heat pipe
Nanofluid
Thermal performance
Nanoparticle deposition
Improvement/deterioration in heat transfer

ABSTRACT

Thermal performances of two same oscillating heat pipes (OHPs) charged with SiO_2/water and Al_2O_3/water nanofluids, respectively, were investigated experimentally. Both the average evaporator wall temperature and the overall thermal resistance of the OHPs at different nanoparticle mass concentrations (0–0.6 wt% for silica nanofluids and 0–1.2 wt% for alumina nanofluids) and at the volume filling ratio of 50% were tested and compared. Experimental results showed that different nanofluids caused different thermal performances of OHPs. Within the experimental range, using the alumina nanofluid instead of pure water enhanced the heat transfer of the OHP (reductions in the evaporator wall temperature and thermal resistance of the OHP of about 5.6 °C (or 8.7%) and 0.057 °C/W (or 25.7%), respectively, were obtained), while using the silica nanofluid instead of pure water deteriorated the thermal performance of the OHPs (with the evaporator wall temperature and the thermal resistance of the OHP being increased by 3.5 °C (or 5.5%) and 0.075 °C/W (or 23.7%), respectively). A preliminary analysis was conducted for the different effects induced by the addition of different nanoparticles to pure water, and it was found that the change of surface condition at the evaporator and condenser due to different nanoparticle deposition behaviors was the main reason for the thermal performance improvement or deterioration of the OHPs charged with different nanofluids.

1. Introduction

With the great demand for dissipating increasingly higher heat fluxes from devices including, but not limited to, electronics, computer and laser, many efforts have been devoted to develop heat transfer enhancement technologies. Among them, nanofluids, engineered by dispersing metallic/nonmetallic nanometer-sized particles in conventional fluids such as water, have attracted much attention for the past decade due to their excellent thermal properties [1,2]. Experimental investigations on the convective heat transfer [3,4] and pool boiling [5] of nanofluids have demonstrated their great heat transport capability in the open thermal systems. Inspired by this, some studies on the use of nanofluids in the closed thermal systems such as heat pipes have also been performed recently [6–14].

In 2004, Tsai et al. [6] introduced water-based gold particle nanofluids into a circular meshed heat pipe. They examined the effect of structural characteristics of nanoparticles on heat pipe thermal performance and found that the thermal resistance of the heat pipe with nanofluids was lower than that with distilled water. Subsequently, Ma et al. [7,8] conducted an experimental investigation to study the nanofluid effect on the heat transport capability in an oscillating heat pipe. Their results demonstrated that the thermal performance of the OHP was significantly improved when charged with water-based diamond nanofluid, with the thermal resistance decreased to 0.03 °C/W at a power input of 336 W. A similar experiment was performed by Lin et al. [9] in an OHP charged with aqueous silver nanofluid. It was found that the average temperature difference between the evaporator and condenser, and the thermal resistance of the OHP charged with nanofluids could be decreased by 7.79 °C and 0.092 °C/W, respectively. Kang et al. [10] investigated the thermal performance of a micro-grooved circular heat pipe charged with the silver nanofluid, and significant reductions in the thermal resistance and the evaporator temperature of the heat pipe were detected when using the silver nanofluid instead of distilled water. In addition, the thermal efficiency of a heat pipe could also be improved after using nanofluids. Naphon et al. [11] used TiO_2/R11 as working fluid in a copper tube heat pipe. They found that the heat pipe charged with the TiO_2/R11 nanofluid of 0.1% nanoparticle concentration operated with the efficiency 1.4 times higher than the heat pipe charged with pure refrigerant (R11). Noie et al. [12] also

* Corresponding author. Tel.: +86 21 34205299; fax: +86 21 34206337.
E-mail address: whysrj@sjtu.edu.cn (H. Wu).

1290-0729/$ – see front matter © 2011 Elsevier Masson SAS. All rights reserved.
doi:10.1016/j.ijthermalsci.2011.04.004