IIETA International Information and Engineering Technology Association

International Journal of Heat and Technology
Vol. 40, No. 2, April, 2022, pp. 535-542
Journal homepage: http://iieta.org/journals/ijht

Effect of Heat Input and Filling Ratio on Raise in Temperature of the Oscillating Heat Pipe with Different Working Fluids Using ANN Model

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https://doi.org/10.18280/ijht.400221

Received: 16 March 2022
Accepted: 6 April 2022

Keywords:
Oscillating Heat Pipe (OHP), acetone, ethanol, methanol, filling ratio, heat input, Artificial Neural Network (ANN)

ABSTRACT

In the present article, feed forward multilayer perceptron neural network (FFMLPNN) model has been used to predict the rise in temperature in closed loop oscillating heat pipe filled with three different fluid i.e., Acetone, methanol and ethanol respectively. Experimental test was carried out for the inner diameter of 1.7mm copper tube for all the combinations of filling ratio, heat input and time taken to evaluate the performance of the OHP. Totally 2000 data sets have been used for Acetone and Methanol, 1500 data sets is used for ethanol in the present NN model. ANN model with FFMLPNN using three input parameter (Filling ratio, heat input and time taken) and rise in temperature has output parameter respectively. Levenberg-Marquardt algorithm with a 4-10 neurons has been used for the determination of optimal model. The 3-8-1 combinations predict the rise in temperature for ethanol and acetone whereas for methanol 3-7-1 is the optimal combinations was achieved. For all the combinations RMSE values are 0.3414, 0.1285 and 0.1237 (Training-70%), 0.3526, 0.1375, 0.1234 (testing-15%) and 0.3010, 0.1515, 0.1425 (validation-15%). The values for coefficient of determinations are 0.9941, 0.9975 and 0.9971 for methanol, acetone and ethanol was achieved. The results clearly indicated that the proposed MLPANN model can successfully predict the rise in temperature.

1. INTRODUCTION

In heat pipes, pulsating heat pipe was the promising device for the heat transportation in heat transfer unit. Therefore micro-grooved oscillating heat pipe (OHP) is one of the effective modes to evaluate the performance heat transfer of the system. This device would enhance the allowable input heat flux by condensate the backflow to the evaporator when the filling ratio ranging from 30% to 60% [1]. Due to increase in filling ratio, heat added to the evaporator section leads to increase in temperature and pressure during the flow process. Therefore filling ratio was the major part to increase the heat input for the oscillation motion of the working fluid [2]. To heat the oscillating pipe many methods was applied in the evaporator section. There was a pulsed supply with regulated current method was used to heat the system. This method generates a large amplitude oscillation to heat up for a short period of time [3]. Temperature distribution for the thermal management of the oscillating heat pipe with copper particles in the evaporator was investigated. At low filling ratio of 30% temperature distribution was good uniformity by neglecting the gravity action was achieved in this study [4]. In anti-gravity OHP system high temperature was exist in the exhaust to preheat. For this current 35 turns OHP with a filling ratio of 70% gave a better bond number from 0.814 to 0.986 for the same geometry it exhibits a better heat transfer [5].

The performance of the OHP using Al_2O_3 nano-particles with a particle size of 56nm by considering the filling ratio, mass fraction of the nano-particles and power inputs to determine the thermal resistance was carried out. For the mass fraction of 0.9% there was a decrease by 0.14°C/W was achieved compare to water filled OHP [6]. Different mathematical models were used to determine the internal motion of working fluid mechanism in the closed loop OHP. The simulation study shows that the heating period and heating interval factors are major concerned for the evaluation of the heat transfer enhancement in OHP [7]. Temperature distribution and heat transfer rate using iron oxide and kerosene as a nano fluid in copper OHP was studied. Addition of iron oxide gives a better performance with an increase in in heat transfer coefficient and difference temperature between the surface and the vapor was 3.1°C and 2°C respectively [8]. To increase the heat transfer mechanisms of oscillating pipe a mathematical model was developed by considering spring mass system to for an annular flow with a slug causing of penetrate liquid. This flow trains the liquid by disappearing the vapour bubbles by creating the pulsating effect of the liquid [9]. For the performance improvement of oscillating pipe mixing of self-rewetting fluids and nanofluids was developed. To determine the high performance of the OHP optimum concentration of the nanoparticles (16%) and self-rewetting (12%) was used [10].

In case of hybrid flexile oscillating heat pipe at the adiabatic section at the heating and cooling side, a micro grooved copper tube was designed and fabricated. This structural design creates a deformation of adiabatic section and exhibits a spatial