



EXPERIMENTAL DETERMINATION OF CONDENSER LENGTH EFFECT ON THE THERMOSYPHON PERFORMAN

Talib, Z. Farge

Sahar, R. Al-Sakini

Aseel, A. Ismael

drtalebf@yahoo.com

drsaharalsakini@yahoo.com

aseelahmed8423@yahoo.com

Electromechanical Engineering Department University of Technology- IRAQ, Baghdad

ABSTRACT

In the current work, a thermosyphon was used to investigate the effect of condenser length on its performance. Experimentally by using a pipe of copper having same evaporator length of 120 mm and three different condenser lengths which were 400 mm , 500 mm and 600 mm. The internal and external diameters of the thermosyphon were 26 mm and 28 mm respectively. The evaporator part of the thermosyphon was immersed in the electrical transformer oil, which heated by external heater from ambient temperature to approximately 80 oC, while the condenser part was left to cool naturally by air. Five thermocouples were located on the thermosyphon wall to read the temperature distribution at different positions. The working fluid was water with filling ratio of 50%.

The results have obviously shown that temperature gradient was decreased when the condenser length increased and giving a better performance for heat dissipation. The percentage of temperature gradient was positively correlated to the condenser length and it was found that condenser length of (400 , 500 , 600) mm gave percentage of decreasing temperature gradient are 67.94 % , 72.94 % , and 77.06 % respectively with respect to that without using thermosyphon .

Key Words: Thermosyphon, condenser length, evaporator, temperature gradient, performance. Thermosyphon resistance.

LIST OF SYMBOLS

C_p	Specific heat	(J/Kg K)
$c1,c2,c3,c4$	Condenser wall temperatures	K
e	Evaporator temperature	K
L_c	Condenser length	mm
m	Mass of oil	kg
Q_{oil}	Heat absorbs by the oil	W
ΔT	Temperature difference	K
∇T	Temperature gradient	K /min.
T	Temperature in any time	K
T_{max}	Maximum temperature	K
T_{amb}	Ambient temperature	K
Δt	Time difference	min.
R	Thermal resistance	K/W

INTRODUCTION

A thermosyphon is a device of heat-transfer instrument (passive devices) which combine the principles of both phase transition and thermal conductivity to efficiently handle the heat of transfer between two mediator. The material of the thermosyphon is made from a material with higher thermal conductivity and compatible with working fluid, for example water for copper thermosyphon and ammonia for aluminum thermosyphon. The thermosyphon always contains two phases liquid and vapor over the operating temperature range, Vanyasree [2017] and Piyush [2007]. The thermosyphon is composed of two parts which are evaporator section and the condenser section as shown in Figure(1), Stéphane [2009]. Figure (1) shows the working mechanism of the thermosyphon. When a heat is applied to evaporator section the working fluid will be evaporated and flow up wards to the condenser section. In the condenser section the vapor will be condensation on the internal wall due low temperature. The condensation liquid flows downwards on the internal wall to the evaporator section as a thin film due to the gravity effect, Kannan [2014]. The effect of condenser lengths of a vertical thermosyphon with different flow rates to condenser and different inputted heat to evaporator had been investigated experimentally, Anjankar [2012]. It has been found that higher performance of thermosyphon would be achieved with condenser of longer length. The effect of inclination and filling ratio on the evaporator section of a thermosyphon have been investigated by previous studies Khazaei [2010] and Ong [2011]. The results presented that the boiling period was decreased as the heat load increased, while increased as the filling ratio increased. An experiment of a numerical model was developed by other works Toshiaki [2014] and Hamidreza [2014] to simulate the operation of thermosyphon by using various working fluids and filling ratios. It was found that the flux of heat at the beginning fluctuation of the temperature was increased as connecting pipe size increased. The objective of the present study is to investigate the effect of the various condenser lengths on the performance of a water filled thermosyphon to determine a better condenser length.

EXPERIMENTAL PROCEDURE

Figure (2) shows the experimental apparatus of the testing used in this work. The thermosyphon was made from copper tube having an internal diameter of 26 mm and external diameter of 28 mm. The experiments were carried out with different lengths of condenser section with a constant evaporator length of 120 mm for different thermosyphon as shown in Figure (3). The working fluid of distilled water with 50% filling ratio The heat was applied to the evaporator section via heating electrical transformer oil while the condenser section was subjected to the ambient temperature that surrounding the thermosyphon. Temperatures were measured with five Type-K thermocouples, as shown in Figure 1b. The thermosyphon was first charged with water and then fully evacuated to -760 mm Hg. Temperatures were logged every minute using temperature recorder. The electrical transformer oil heated by external heater with power of 700 W. The oil was heated from ambient temperature to approximately 80 °C and then the heater power has been switched off once the system cooled naturally while the condenser part was cooled naturally by air.

CALCULATIONS

The thermal performance tests of thermosyphon were performed and the rate of heat transfer (Q_{oil}) for the oil was calculated by the following equation, Ahmet [2018].

$$Q_{oil} = mc_p \Delta T \quad (1)$$

Where : m , c_p are the mass and specific heat of oil and ΔT temperature difference.

Oil specific heat can be calculated by following equation, Alejandro [2018].

$$c_p = 807.163 + 3.58 * T \quad (2)$$

T: Is the oil temperature (K)

Where the dimensionless temperature was equal to:

$$\text{Dimensionless temperature} = \frac{T - T_{amb}}{T_{max} - T_{amb}} \quad (3)$$

$$\text{Temperature gradient } (\nabla T) = \frac{\Delta T}{\Delta t} \quad (4)$$

Percentage decrease in the temperature gradient equal to :

$$\nabla T \% = \frac{\nabla T_{without\ thermosyphon} - \nabla T_{with\ thermosyphon}}{\nabla T_{without\ thermosyphon}} * 100\% \quad (5)$$

The thermosyphon thermal resistance is given by the following equation, Vanyasree [2017]:

$$R = \frac{T_g - T_c}{Q} \quad (6)$$

RESULT AND DISCUSSION

Figures (4), (5) and (6) show the relation between the temperatures distribution along the thermosyphon wall and the time of different condenser lengths which were 400 mm, 500 mm and 600 mm respectively. These figures show that the curves were wobbling at condenser section, which increasing from the bottom to the top of the condenser section firstly, and secondly increasing when the length of the condenser section increased. This is due to forming a thin film of the condensation liquid on the internal wall of the thermosyphon. Also this thin film of the condensation liquid become thicker toward the bottom of the condenser section as shown in Figure(1). These results are backed by those of previous study, Fadas (2015). Figure(7) shows the dimensionless temperature of the heating transformer oil temperature gradient for the different thermosyphon and that without using thermosyphon. This figure shows that the temperature gradient was decreased towards increasing condenser lengths of the thermosyphon due to increasing the surface area of the thermosyphon which increases the heat transfer to the surrounding. Also, the figure shows that the heat dissipation was more in the case of using thermosyphon rather than being without using thermosyphon. Figure 8 shows the percentage of decreasing in the temperature gradient for the different thermosyphon; it had indicated that the highest percentage decreased in the temperature gradient for different thermosyphon was for the longest condenser length than the others due to highest heat dissipation. Figure (9) shows oil heat rate without and with three different condenser lengths thermosyphon. From this figure, it can be showed that the maximum oil heat was without thermosyphon but when thermosyphon was added, the heat rate was decreased and gave minimum value at condenser length of 600 mm due to higher heat dissipation. Figure (10) shows relationship between thermosyphon resistances with condenser length. From this figure, it has been noticed that, the resistance is decreased with increasing condenser length because the heat dissipation by condenser it maximum at condenser length equal to 600 mm, which lead to a higher heat transfer to the surrounding.

CONCLUSIONS

The importance of heat transfer capability was limited by length of thermosyphon, especially condenser section. So in this study, the effects of length of condenser section on performance of thermosyphon have been investigated. It has been found that:

- The heat distribution along the thermosyphon wall was decreased towards the tip of thermosyphon.
- It was observed that the temperature curves were wobbling at low temperature on the thermosyphon.
- The heat dissipation was increased as the condenser length increased.
- The decreasing of temperature gradient was equal to 67.94 %, 72.94 % and 77.06 % of the thermosyphon condenser length were 400 mm ,500 mm and 600 mm respectively.

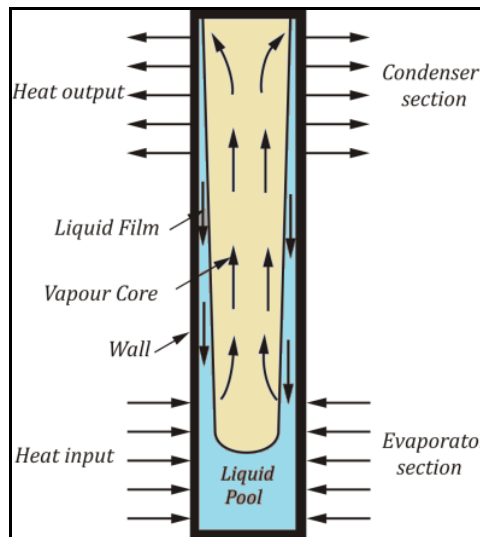
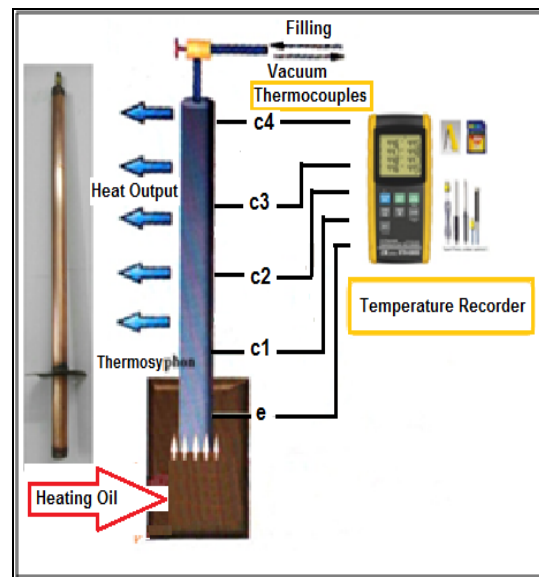


Fig. 1. Thermosyphon schematic



(a): Experimental test rig



(b): Sketch of thermosyphon

Fig. 2 Experimental test

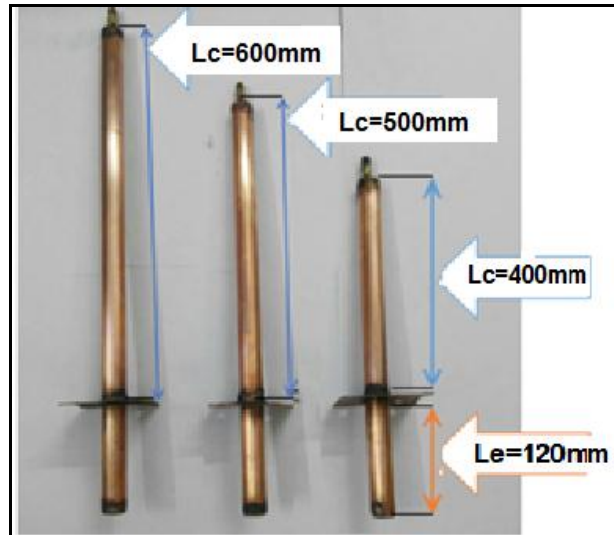


Fig. 3 Thermosyphon with three different lengths of condenser section and the same evaporator section

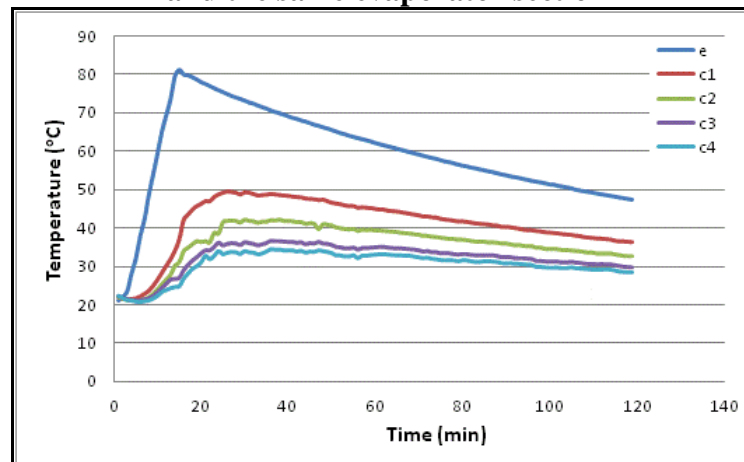


Fig.4 Temperatures distributions along the thermosyphon wall with respect to time for the condenser length of 400 mm.

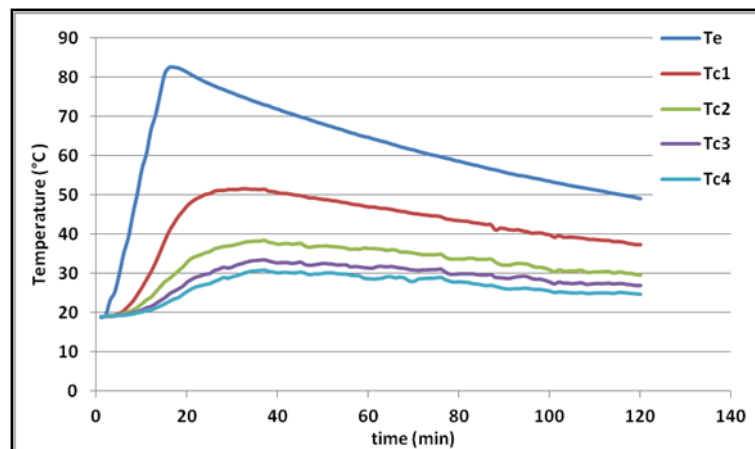


Fig.5 Temperatures distributions along the thermosyphon wall with respect to time for the condenser length of 500 mm.

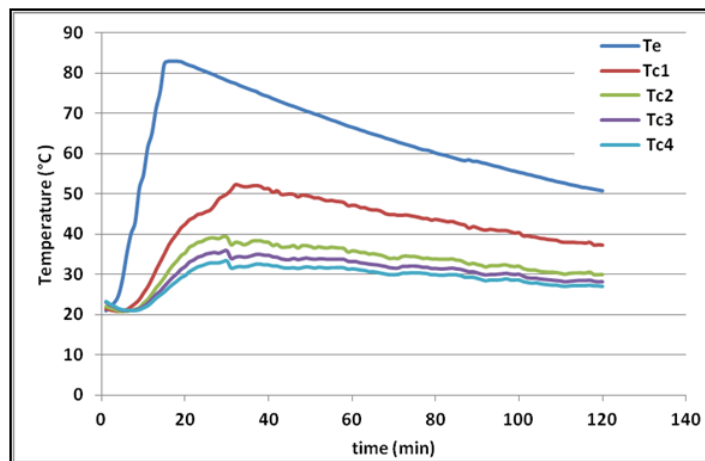


Fig.6 Temperatures distributions along the thermosyphon wall with respect to time for the condenser length of 600 mm.

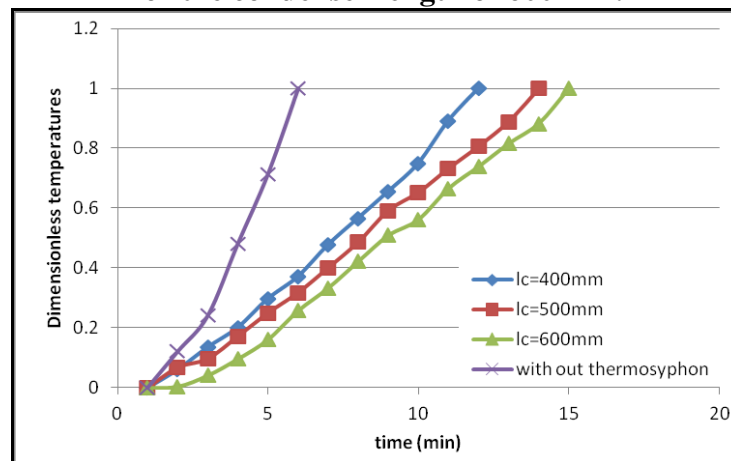


Fig.7 Dimensionless temperatures comparison for the three different thermosyphon.

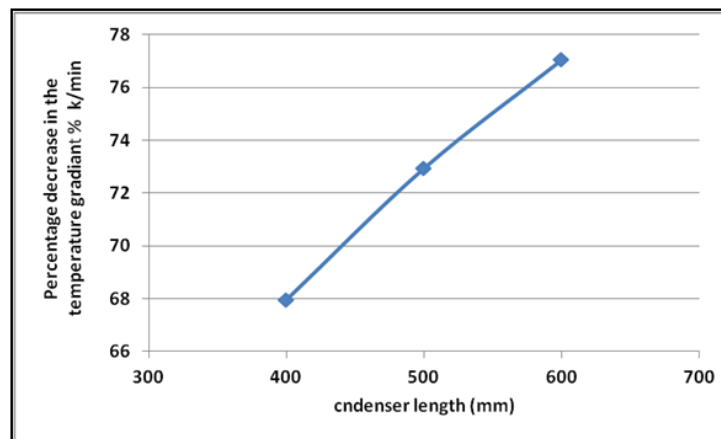


Fig. 8 Percentage decreased in the temperature gradient for different thermosyphon.

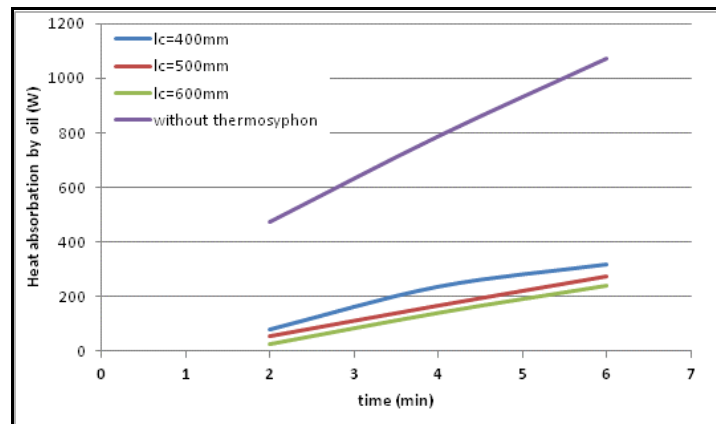


Fig.9 The oil heat with and without for the three different thermosyphon.

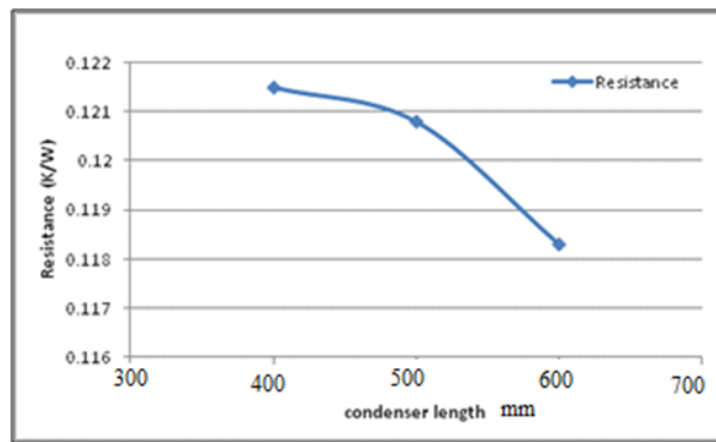


Fig. 10 Relationship between thermosyphon resistances with condenser lengths

REERENCES

Ahmet Ozsoy and Vahit Corumlu, " Thermal performance of a thermosyphon thermosyphon evacuated tube solar collector using silver-water nanofluid for commercial applications", Renewable Energy 122 , 26-34, 2018.

Alejandro Roberto T.C., "Simulation of a distribution transformer", 2018.

Anjankar.P.G , Dr. Yarasu.R.B, " Experimental Analysis of Condenser Length Effect on the Performance of Thermosyphon", International Journal of Emerging Technology and Advanced Engineering, ISSN 2250-2459, Volume 2, Issue 3, March 2012.

Hamidreza Shabgard, Bin Xiao, Amir Faghri, Ramesh Gupta, Walter Weissman, " Thermal characteristics of a closed thermosyphon under various filling Conditions", International Journal of Heat and Mass Transfer 70, 91–102, 2014.

Fadas N. A. and Mali, " Thermal Performance of Thermosyphon Thermosyphon Charged with Binary Mixture", Inernational jornal of science, engineering and technology research, 2015.

Kannan.M, Senthir.R, Baskaran .Rand Deepanraj.B, "An Experimental Study on Heat Transport Capability of A Two Phase Thermosyphon Charged With Different Working Fluids", American Journal of Applied Sciences 11 (4): 584-591, 2014.

Khazaei, I., Hosseini, R., Noei, S.H., "Experimental investigation of effective parameters and correlation of geysers boiling in a two-phase closed thermosyphon" *Applied Thermal Engineering* 30, 406–412, 2010.

Ong, K.S. and Tong, W.L., "Inclination and Fill Ratio Effects on Water Filled Two-Phase Closed Thermosyphon", 10th IHPS, Taipei, Taiwan, Nov. 6-9, 2011.

Piyush Sabharwal, Fred Gunnerson, Akira Tokuhira, Vivek Utgiker, Kevan Weaver and Steven Sherman, "Theoretical Design of a Thermosyphon for Efficient Process Heat Removal from Next Generation Nuclear Plant (NGNP) for Production of Hydrogen", October 2007.

Stéphane Lips, Frédéric Lefèvre and Jocelyn Bonjour, "Nucleate boiling in a flat grooved thermosyphon", *International Journal of Thermal Sciences* 48, 1273–1278, 2009.

Toshiaki Inoue, Masanori Monde, "Operating limit of heat transport in two-phase thermosyphon with connecting pipe (heated surface temperature fluctuation and flow pattern)", *International Journal of Heat and Mass Transfer* 52, 4519–4524, 2014.

Vanyasree, G. and Ramana, P.V., "Experimental Analysis on Thermosyphon Thermosyphon to Find Heat Transfer Coefficient", *International Research Journal of Engineering and Technology*, Volume: 04 Issue: 08, August -2017.