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Research Article

Experimental Investigation on the Effect of 6063Aluminium Alloy Elliptical Thermosyphon using Graphene Nanofluid

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The need for energy savings is growing rapidly as the global economy grows. Without them, developing a more efficient and less expensive heat transfer device such as a heat pipe system becomes more important due to industrial development. Conventional heat pipes play an important role in heat loss and heat management systems. A thermosyphon as a condensing and evaporation machine can transfer the latent heat of evaporation flowing from the vapor component to the condenser phase over long distances by the loss of unnecessary heat. This study evaluates the effect of 6063 Aluminum Alloy Elliptical Thermosyphon using Graphene Nanofluid. The container material and the cross section of the thermosyphon play an important role in heat transfer. The temperature load varies between 60 to 100 w, the piping position is maintained at 30 deg to 90 deg and the water flow rate in the condenser section ranges from 60 ml / min to 120 ml / min. In this work the effect of the elliptical thermosyphone is analyzed with graphene nano fluid. Significant reductions in temperature resistance and improved efficiency have been achieved.

Keywords: 6063 AA Elliptical thermosyphon, graphene nanofluid, thermal resistance, overall heat transfer co-efficient, RSM.

1. Introduction

Thermosyphons transmit heat, using a two-way method and the gravitational impact of the active fluid, from one source to another. The active fluid, which is filled in the evaporator, evaporates due to the heat dissipated and enters the adiabatic phase and converts into a condenser state. evaporator. Thermosyphons, in general, are used in many fields [1,2] to dissipate heat generated in many engineering machines. Such as computers, laptops, notepads and other solar-based systems, air conditioning, and air-conditioning systems. Numerous studies, conducted on the use of thermosyphon to control thermal plants, have found the thermosyphon to be suitable for heat transfer, except that it is effective, reliable and inexpensive. Gloria A Adewumi et al. [3] tested the viscosity of Ethylene glycol (EG) at 60:40%, following experimental measurements with water nanofluids and nanoparticles found in coconutfibre. The combined nanoparticles and the related viscosity of the nanofluid due to the effect of temperature and Mass collision were studied. F.M. Nair et al. [4] studied the EV system for lithiumion batteries to detect restrictions on the use of copper sintered copper heat pipes used in temperature control. In order to achieve improvement, the High Response Response System (RSM) with Best Design was used. This study includes three independent variables, namely battery temperature generation, condenser length of heat pipes and flow rate of cooling water. In order to achieve each aspect and the important interaction that takes place, ANOVA was used. Model of high temperature (Tmax) and temperature differences, T was found to be significant with P at

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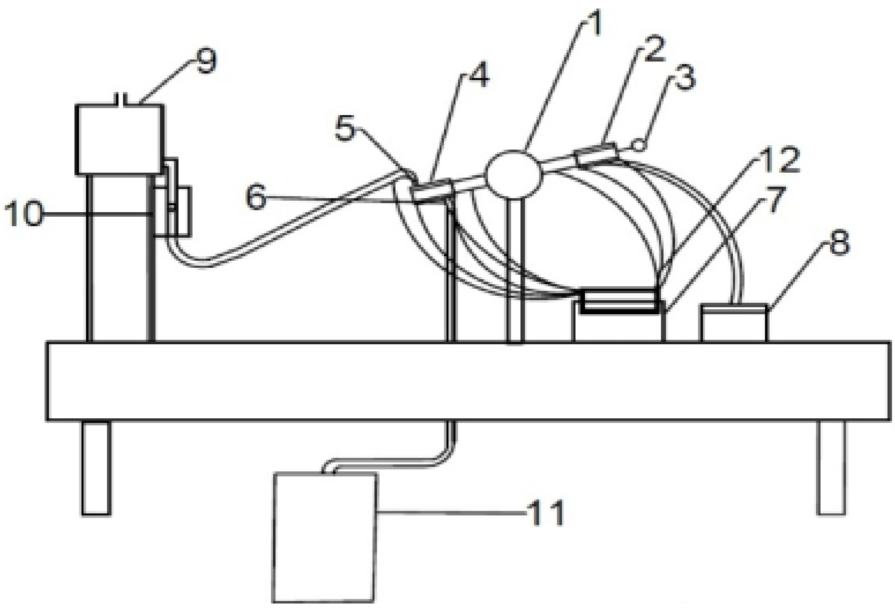
<0.0001 and found very well adjusted with a value of R^2 of 0.9945 and 0.9981 respectively. By keeping the temperature above the battery and the temperature difference in the battery itself lower than the desired limit with the maximum heat production rate, the results obtained are improved, while the Response Method is found to be an important process.

Park et al. [6] investigate the use of heat pipes, in order to maintain the temperature in ion thelithium batteries, while improving operating conditions. The authors have followed RSM as one of the procedures for developing loop heat pipe (LHP) to cool batteries, fitted with airbone electriclasers, to aircraft used in military equipment. Although a few literature reviews have identified RSM as the most popular method in the process of developing heat pipe parameters (7-11), most of them prefer the use of Box-Behnken. Heat input, cooling rate, and angle of inclination of the heat pipe include performance parameters learned in this study. In order to improve thermal efficiency, in addition to reducing heat resistance and increasing the heat transfer coefficient, it was necessary to make improvements.

Independent variables have been added as additional parameters to include the use of nanofluid as an active liquid in independent variable temperature pipes including nanoparticle concentrations and filling fillatio. The study conducted found that 5% of the difference was found between the value obtained from the actual test and the efficiency of the operating conditions. Ghanbarpour et al. [12] conduct experimental studies to show how the thermal performance of heat pipes depends on the impact generated by the nanofluid and the moving angle. By using SiC / nanofluid water based heat pipe with nanoparticle mass concentrations of 0.35%, 0.7% and 1%, the authors obtained 30% heat resistance in the heat pipe. Sarafraz et al. [13] copper warmth pipe made up of 10.7mm inner diameter, 12mm outer diameter 280mm and an ecofriendly nanofluid heat pipe.



1	Angle protector
2	Evaporate section
3	Vacuum gauge
4	condenser section
5	Inlet water
6	outlet water
7	Data logger
8	Autotransfer
9	Water tank
10	Rotameter
11	collecting water
12	Thermocouple wires

Fig.1. Layout of experimental setup

Then, the authors used an electric cartridge in the evaporator section to provide the same temperature and, using the coat method, condenser section was cooled. Finally, the authors found the values of the operating conditions i.e., the filling rate, the angle of inclination, and the concentration of nanoparticles and their impact on the operation of the heat pipe. Research has determined the fact that the use of nanofluid in a heat pipe causes an increasing impact improvement of temperature and resistance, that is, the distribution of pipe temperature. Huminic [14] performed experiments using water and Fe2O3 to test thermosyphon thermal performance with water and nanofluid. Water and Fe2O3 have a concentration of 0 to 5.3% concentration and a temperature of 60 ° C to 90 ° C. The authors conclude on the note that the temperature difference decreases with the concentration of the nanoparticles which play an important role in the process occurring in the evaporator and condenser components. A study by Chen et al. [15] attempted to determine the effect exerted by performance indicators such as active fluid, active temperature and pressure using a copper wire tied to a flat water pipe, ethanol and nanofluids.

Sarafraz et al. [16] The predicted thermosyphon is embedded in a screen mesh thread in the negative formation of water based on TiO2 nanofluids. Such a formulation increases nanofluid concentration and is effective in maintaining the thermosyphon operating time. The literature [17 - 26] contains details about heat transfer characteristics, the use of nanofluids of different types with different concentrations and concentrations.

Using the Elliptical 6063 AA TPCT and a functional group with a unique environment, a two-phase thermosyphon (TPCT) thermal performance analysis was performed as given in the Figure 1. The model has the following features and resources. Elliptical 6063AAt TPs. The installation of an inclinometer (Bevel Protector) is performed on a test machine to rotate the TPCT over an angle between 0˚ - 180˚.

TPCT is marketed, in whole, in K-type thermocouples in eight independent locations, coupled to a logging system to develop perfect temperature measurements. The required heat is to provide as an input by is wrapping the evaporator portion in a capacity of 200 watts power supply and the same is monitored by three different phases that can control the power supply required for testing. The power supply supplied to the evaporator phase heater is maintained by a wattmeter and the 3phase variac holds a range of 0-250 watts and 230 volts. The variac used, here, is capable of holding 1800 watts and 230 volts and 20 amps. The controlled load is found on the watt meter digital indicator. Water passing through a condenser jacket is a convenient mode for measuring TPCT power output.

Plan 6063 AA elliptical TPCT and jacket 6063 AA with outer diameter 30mm and length 250mm with the provision of entry and exit and stop, diagonal, opposite, to facilitate the flow of swirl to the proposed. Similarly, the semi-circular 6063 Al TPCT jacket made up of alloy is also used and a rotometer is affixed to a 220V monitor. Part of the condenser is cooled by tap water. The maximum flow rate of the condensed phase is controlled by a rotometer and the flow rate of cooling water discharged from the water tank is measured. The adiabatic part is covered with glass wool to avoid heat and ambiance interactions. Before charging the working liquid, the TPCT enclosure is extracted and stored in a space of 99kPa to 100kPa. Then a sufficient amount of active fluid was added.

The container is approved with a 50 percent rate of filling. The condition of the wall material in the TPCT vessels is measured by eight K-type thermocouples. Two thermocouples are placed in the adiabatic section and two in the evaporator section, and four in the condenser section. The thermocouple detection is illustrated in Fig 1. All K-Type thermocouples are linked and examined using an 8-channel data logging system. A flat-type heater connected to the evaporator is linked to a three-phase variac with a 20 amps power supply. Temperature input varies by using a variac. Thermal power response can be obtained from a wattmeter.

2. Fixation of nanofluids

Therefore, the work used a two-step formula for preparing nanofluids. Graphene nano particles (20 nm), a purchased USA form, are dispersed precisely in DI at a concentration of 0.09% by volume (up to 10 hours) is shown in Figure 2.

It is necessary to accept the possible type of process, in the construction of the test and the analysis of the collected data. To improve the input parameters you want, RSM is used in Experimental Design. Box - The Behnken model has three distinct variables they are input temperature (A), angle of inclination (B), and rate of flow (C) which helps us to acquire thermal-resistant (R^{th}) retaliation and efficiency (%).

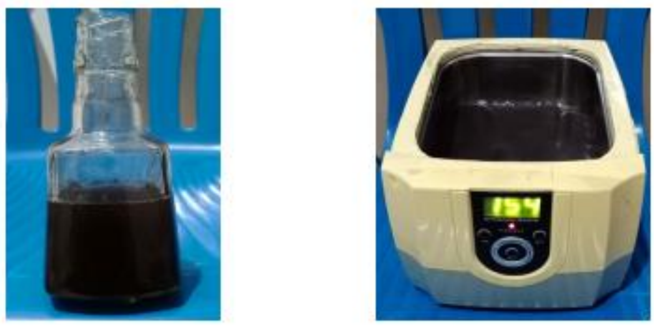


Fig 2. a) Graphene nanofluid b) Ultrasonic Homogenizer

3. Result and Discussion

- Experimental data obtained from this study were analyzed by RSM using the Designer software.
- From ANOVA survey of a small amount of Elliptical surface thermal resistance, it was established that the solution could be acceptably defined as a decreased quadratic model.

Table 1. ANOVA Analysis of Response Surface Quadratic Model for a separate table [Total fraction square - Type III] – (Response 1 R^{TH})

Source	Sum of Squares	Mean df	F Square	p-value	Prob > F
Model	2.430E-003	9	2.700E-004	4.69	0.0269
A-HEAT INPUT	5.556E-004	1	5.556E-004	9.65	0.0172
B-ANGLE	1.221E-004	1	1.221E-004	2.12	0.1886
C-FLOW RATE	1.825E-005	1	1.825E-005	0.32	0.5909
AB	0.000	1	0.000	0.000	1.0000
AC	1.778E-004	1	1.778E-004	3.09	0.1222
BC	9.766E-006	1	9.766E-006	0.17	0.6927
A2	9.940E-004	1	9.940E-004	17.27	0.0043
B2	9.252E-007	1	9.252E-007	0.016	0.9027
C2	4.615E-004	1	4.615E-004	8.02	0.0253
Residual	4.028E-004	7	5.755E-005		
Lack of Fit	4.028E-004	3	1.343E-004		
Pure Error	0.000	4	0.000		
Cor Total	2.833E-003	16			

Table 1 shows the output from the analysis. Displays a Model F value of 4.69 to indicate value as a value. Model F-Value occurring due to noise has a probability of 2.69%. The prob> F value of 0.0500 indicates the model as important. Here, A, A2 and C2 are considered as important model terms. If values greater than 0.1000 model terms are considered in significant. If the number of model names is not significant (except those that determine the category), it is possible that the model reduction will improve the model.

Std. Dev.	7.586E-003	R-Squared	0.8578
Mean	0.17	Adj R-Squared	0.6749
C.V. %	4.34	Pr. R-Squared	-1.2754
PRESS	6.445E-003	Adeq Precision	6.759

The opposing "Pr. R-Squared" suggests that the total is a better predictor of your response than the current model. A rating greater than 4 is attractive. Your ratio of 6.759 indicates a sufficient signal. This model can be used to navigate the design area.

Final Equation in Terms of Coded Factors:

R^{TH} = +0.16 -8.333E-003* A-3.906E-003* B-1.510E-003* C+0.000* A * B-6.667E-003* A * C +1.562E-003* B * C+0.015* A^2+4.688E-004* B^2+0.010* C^2

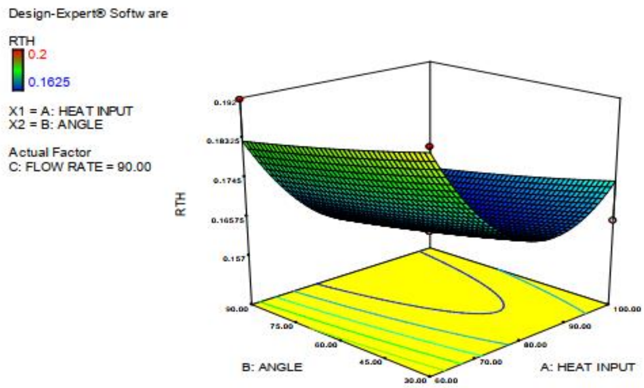


Fig 3. Wire mesh plot - R^{th} wrt Angle & Heat input

Fig. 3. Shows the structure of the wire mesh, in which the interaction effect of the heat input and the angle of inclination to heat resistance are observed. Increased heat input greatly reduces heat resistance at first and then rises slightly. Temperature resistance starts low and then increases with an angle of inclination The Elliptical thermosyphon. The interaction effect of these two factors is found to be similar to each thermal input effect. This is because the elliptical profile increases the surface area which opens the way to absorb high temperatures and creates the effect of boiling the film in the evaporator phase which affects the thermal conductivity of the heat pipe.

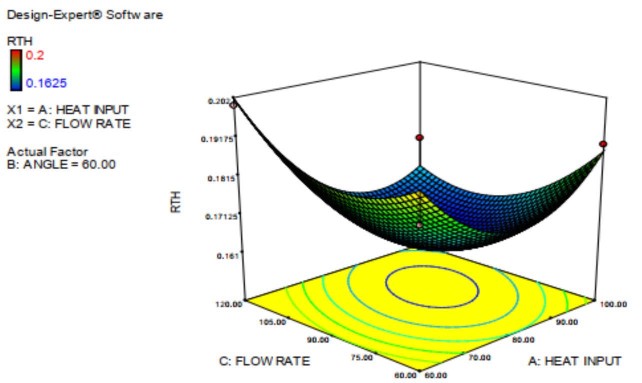


Fig 4. Wire mesh plot - R^{th} wrt Flow rate & Heat input

Fig. 4. It shows the structure of the wire mesh, the interaction effect of heat dissipation, and the flow rate against heat resistance. Increased thermal insulation increases heat resistance when the water flow rate is high in the condensed phase. Temperature resistance first increases with decreasing flow rate and gradually decreases with increasing flow. The interactive effect of heat dissipation and flow rate is found to have a significant increase in temperature resistance at the beginning and then decrease. However, an increase in temperature with an increase in flow rate leads to a decrease in the temperature difference at the inlet and outlet of the condenser. It is therefore obtained by reducing heat resistance.

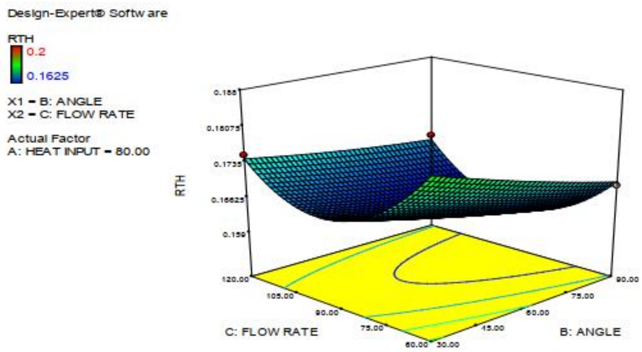


Fig 5. Wire mesh plot - R^{th} wrt Flow rate &Angle

Fig. 5. It shows the interactive effect of the factor inclination angle and the Elliptical TPCT flow rate in temperature resistance. When the inclination angle of the ETCTT is the rise, the heat resistance increases first and then decreases. It is noteworthy that the interactive effect of the angle of selection and rate of flow indicates a tiny drop in temperature reluctance to the initial temperature and an increase in the angle of inclination. In ETCTT the graphene nanofluid system is used, the temperature resistance is low in the slope area, where at a high slope angle, the formation of a liquid film inside the condenser phase is high leading to an increase in the temperature resistance of the vapor. of active fluid and circulating water on the part of the condenser. Here heat reluctant is correlated with water flow in the condenser section.

Table 2. ANOVA Quadratic Model Response Model Variance Table [Total Square - Type III] – (Response 2 EFFICIENCY)

Source	Sum of Squares	Mean df	F Square	p-value	Prob > F
Model	0.14	9	0.015	50.21	< 0.0001
A-HEAT INPUT	0.000	1	0.000	0.000	1.0000
B-ANGLE	3.956E-003	1	3.956E-003	13.21	0.0083
C-FLOW RATE	0.080	1	0.080	266.39	< 0.0001
AB	3.943E-003	1	3.943E-003	13.17	0.0084
AC	5.890E-003	1	5.890E-003	19.67	0.0030
BC	6.845E-004	1	6.845E-004	2.29	0.1743
A2	1.801E-004	1	1.801E-004	0.60	0.4634
B2	3.811E-003	1	3.811E-003	12.73	0.0091
C2	0.038	1	0.038	128.23	< 0.0001
Residual	2.096E-003	7	2.994E-004		
Lack of Fit	2.096E-003	3	6.987E-004		
Pure Error	0.000	4	0.000		
Cor Total	0.14	16			

The rate of 50.21 obtained from model F defines the model as significant. Due to noise the F value model of this large one appears at probability of 0.01%. If Prob is greater than F data a minimum value of 0.0500 then model terms are considered important. Here, B, C, AB, AC, B2 and C2 are considered the most important models.

Model terms will be considered insignificant when the values are greater than 0.1000. If an excess of the names of the model models are not significant (except for those that determine the sequence), it is possible that the reduction of the model will improve the model.

Std. Dev.	0.017	R-Squared	0.9847
Mean	0.68	Adj R-Squared	0.9651
C.V. %	2.55	Pr. R-Squared	0.7560
PRESS	0.034	Adeq Precision	23.919

The "Pr. R-Squared" of 0.7560 is not close to the "Adj R-Squared" of 0.9651 which is generally expected. This may indicate a significant blocking effect or potential problem between the model or the data, therefore it is necessary to check the model reduction, response, conversion, outliers, etc. "Adeq Precision" measures the signal at amplitude. As required a greater than 4 ratio. A rating of 23,919 is taken to address adequate signals, ranging from the model that will normally roam in the visual field.

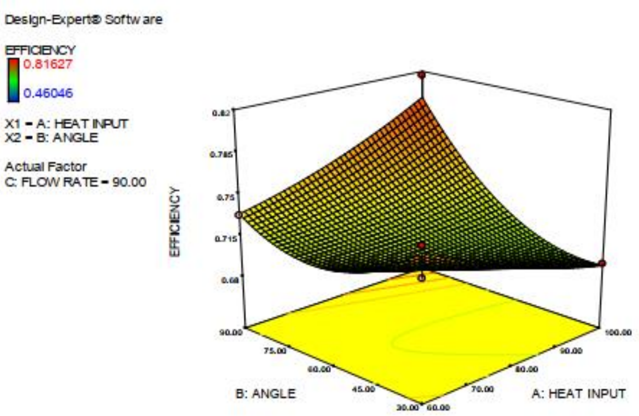


Fig 6. Efficiency wrt Angle & Heat input

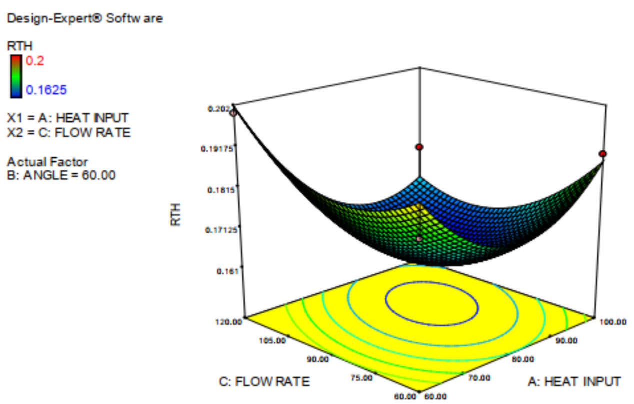


Fig 7. Efficiency wrt Flow rate & Heat input

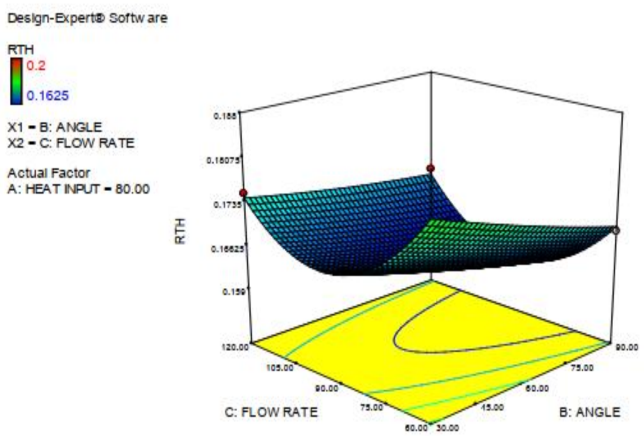


Fig 8. Efficiency wrt Flow rate &Angle

Final Equation in Terms of Coded Factors:

EFFICIENCY =+0.71+0.000 * A+0.022 * B+0.100 * C+0.031* A * B+0.038* A * C-0.013* B * C +6.541E-003 * A^2+0.030* B^2-0.095* C^2

Here, A represents the input temperature (watts), B represents the choice angle (°) and C represents the rate (ml / min). Further curves for efficient heat response are shown in Fig. 6 to 8. Thermosyphon thermal efficiency is calculated because the temperature limit rejected in condenser section which incorporates heat within the evaporator phase Naphon, (2009). The sites show the thermal efficiency of the warmth pipe because it gains the linear pressure by increasing the intensity of the evaporator phase therefore the efficiency increases to a rate of 120 ml / min and increases the rate of flow. Although when the inclination angle increases, the efficiency increases up to 73% .Thus, the input power parameter between the three input impeller angle of inclination Richter and Gottschlich, (1994) and flow.

When the gradient temperature rises between the impeller and the diaphragm, there is an increase within the efficiency of the heating tube and a rise within the rate of flow Amit Faghri, (2016). Evaporator section obtains a warmth temperature input and evaporates from the active fluid into condenser section at high speed.

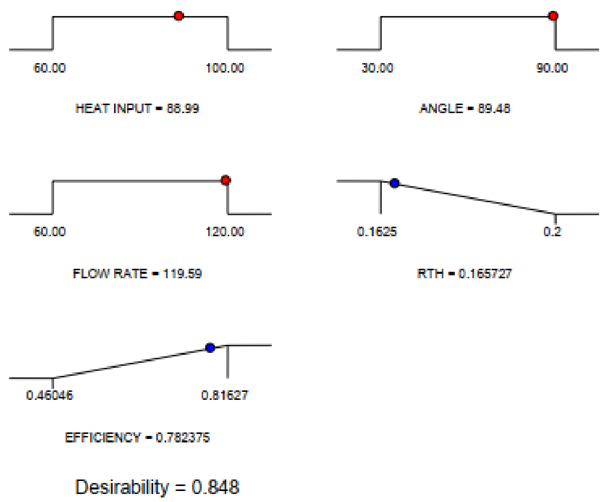


Fig 9. Heat input vs Angle vs Flow rate

The ETPCT cross section provides a bent to maneuver over the vapor barrier during the formation of graphene temporarily stops the nano fluid. Therefore, it is expected that the nucleus of the volcanic nucleus will be smaller in the liquid containing nano particles suspended than in the liquid. However, the cross-section of ETPCT equally raises the temperature from the Evaporator to the Condenser phase. The development in thermal efficiency of 6063 ETPCT with graphene nano fluid is 78.23% achieved at 90 watts, 90° and flow rate of 120 ml / min

4. Conclusion

1) The utilization of 6063 AA ETPCT ends up in a discount in temperature near TPCT.
2) Graphene nanofluid significantly improves heat efficiency to 78.23%
3) Temperature resistance was reduced to 0.1657° C / W by the utilization of graphene nanofluid under ambient temperatures of 90 watts, 90° and 120 ml / min.
4) During this study it shows that the alternative a part of the pipe and also the graphene nanofluid ends up in the event of high temperatures.

REFERENCES

[1] Ivanova, M., Avenas, Y., Schaeffer, C., Dezord, J. B., and Harder, J. S., 2006, "Heat Pipe Integrated in Direct Bonded Copper (DBC) Technology for Cooling of Power Electronics Packaging," IEEE Trans. Power Electron., 21(6), pp. 1541–1547.

[2] Leong, K. Y., Saidur, R., Mahlia, T. M. I., and Yau, Y. H., 2012, "Performance Investigation of Nanofluids as Working Fluid in a Thermosyphon Air Preheater," Int. Commun. Heat Mass Transfer, 39(4), pp. 523–529.

[3] Gloria A Adewuni, Freddie Iaamboo, Mohsen sharifpur and Josua P Mayer "Investigation of the viscosity and stability of green nanofluids from coconut fibre carbon nano particles, Effect of temperature and mass fraction", IJAER,ISSN 0973-4562, Volume 13, no 10 (2018) pp.8336-8342.

[4] F.M.Nasir,M.Z.Abdullah, and M.A.Ismail, "Optimization of operating conditions of heat pipes BTMS using response surface method, Advances in civil Engineering and Science Technology",

[5]. P. Gunnasegaran, M. Z. Abdullah, M. Z. Yusoff, and S. F. Abdullah, Case Stud. Therm. Eng. 6, 238 (2015).

[6]. Y. Park, S. Jun, S. Kim, and D.-H. Lee, J. Mech. Sci. Technol. 24, 609 (2010).

[7]. M. H. A. Elnaggar, M. Z. Abdullah, and M. A. Mujeebu, Exp. Tech. 37, 34 (2013).

[8]. M. Saravanan and N. Karunakaran, Adv. Nat. Appl. Sci. 10, 61 (2016).

[9]. R. Hariprasanth and R. Hariharan, Int. J. Pure Appl. Math. 116, 379 (2017).

[10]. B. C. Nookaraju, P. S. V. Kurmarao, S. Nagasarada, R. Karthikeyan, and A. Vinay, Mater. Today Proc. 5, 5262 (2018).

[11]. G. Sudhakar and P. L. Reddy, Int. J. Eng. Res. Sci. Technol. 4, 240 (2015).

[12] M. Ghanbarpour, N. Nikkam, R. Khodabandeh, and M. S. Toprak, "Improvement of heat transfer characteristics of cylindrical heat pipe by using SiC Nanofluids," Appl. Thermal Eng., vol. 90, pp. 127- 135.

[13] M. M. Sarafraz, F. Hormozi, and S. M. Peyghambarzadeh, "Thermal performance and efficiency of a thermosyphon heat pipe working with a biologically ecofriendly nanofluid," Inter. Comm. Heat Mass. Transfer, vol. 57, pp. 297–303, 2014.

[14] G. Huminic and A. Huminic, "Numerical study on heat transfer characteristics of thermosyphon heat pipes using nanofluids," Energy Conv. And Manage, vol. 76, pp. 393–399, 2013.

[15] Y.-J. Chen, P.-Y. Wang, Z.-H. Liu, and -Y.-Y. Li, "Heat transfer characteristics of a new type of copper wirebonded flat heat pipe using nanofluids, inter," J. Heat Mass. Transfer, vol. 67, pp. 548–559. 2013.

[16] M. M. Sarafraz, F. Hormozi, and S. M. Peyghambarzadeh, "Role of nanofluid fouling on thermal performance of a thermosyphon: are nanofluids reliable working fluid?" Appl. Thermal Eng., vol. 82, pp.212–224, 2015.

[17] M. Khoshvaght-Aliabadi, F. Rahimpour, O. Sartipzadeh, and S. Pazdar, "Heat transfer enhancement by combination of serpentine curves and nanofluid flow in microtube," Exp. Heat Transfer, vol. 30, pp. 235–252, 2017.

[18] A. Sözen, et al., "Utilization of fly ash nanofluids in two-phase closed thermosyphon for enhancing heat transfer," Exp. Heat Transfer, vol. 29, pp. 337–354, 2016.

[19] S. Z. Miry, M. Roshani, P. Hanafizadeh, M. Ashjaee, and F. Amini, "Heat transfer and hydrodynamic performance analysis of a miniature tangential heat sink using Al2O3–H2O and TiO2– H2O Nanofluids," Exp. Heat Transfer, vol. 29, pp. 536–560, 2016.

[20] A. Sözen, H. İ. Variyenli, M. B. Özdemir, and M. Gürü, “Improving the thermal performance of parallel and cross-flow concentric tube heat exchangers using fly-ash nanofluid,” Heat Transfer Eng., vol. 37, pp. 805–813, 2016.

[21] A. Sözen, H. İ. Variyenli, and M. B. Özdemir, Metin Gürü, and Ipek Aytaç, “Heat transfer enhancement using alumina and fly ash nanofluids in parallel and cross-flow concentric tube heat exchangers,” J. Energy Inst., vol. 89, pp. 414–424, 2016.

[22] M. Khoshvaght-Aliabadi and F. Hormozi, “Investigation on heat transfer and pressure drop of copper–water nanofluid flow in plain and perforated channels,” Exp. Heat Transfer, vol. 29, pp. 427–444, 2016.

[23] A. Sözen, M. Gürü, T. Menlik, and M. Aktaş, “Utilization of blast furnace slag nanofluids in two phase closed thermos-syphon heat pipes for enhancing heat transfer,” Exp. Heat Transfer, vol. 30, pp. 112–125, 2017.

[24] S. Abbasi, S. M. Zebarjad, S. H. N. Baghban, and A. Youssefi, “Comparison between experimental and theoretical thermal conductivity of nanofluids containing multi-walled carbon nanotubes decorated with TiO2 nanoparticles,” Exp. Heat Transfer, vol. 29, pp. 781–795, 2016.

[25] M. M. Sarafraz, A. Arya, F. Hormozi, and V. Nikkhah, “On the convective thermal performance of a cpu cooler working with liquid gallium and CuO/water nanofluid: A comparative study,” Appl. Thermal Eng., vol. 112, pp. 1373–1381, 2017.

[26] Z. Aparna, S. Ghosh, and S. K. Pabi, “Influence of container material on the heat transfer characteristics of nanofluids,” Exp. Heat Transfer, vol. 30, pp. 302–315, 2017.