A study on 6063aa elliptical and semi-circular cross-section tpct with $\text{Fe}_3\text{O}_4$ nano fluid

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Abstract: Thermosyphon is the most preferred device to transfer heat for it costs low, requires comparatively low maintenance, besides being adaptable to any size. The ship transfer characteristics in this cooling system get enhanced by the use of the working fluid this paper deals with the elliptical and semicircular Two-Phase Closed Thermosyphon (TPCT) range of efficiency when it is added with $\text{Fe}_3\text{O}_4$ nanofluid. A number of tests are conducted with elliptical and semicircular TPCT with $\text{Fe}_3\text{O}_4$ with the inevitable input parameters such as heat input, inclination and pure water flow rate to obtain the output result of efficiency. The results of the experiments with thermosyphons proved the fact that the thermal performance has improved with the incorporation of elliptical TPCT combined with $\text{Fe}_3\text{O}_4$ Nano. 

Key words: Al 6063 elliptical cross-section, Al 6063 semi-circular cross-section, $\text{Fe}_3\text{O}_4$ Nano fluid, efficiency.

Introduction

The world in its move towards prosperity with the support of ever developing technologies needs energy and the quantum of energy consumption and their need increases every day. The BP Company estimated the energy consumption is increasing by 2.9% in 2018, a double fold increase of the average consumption recorded with last 10 years. The energy information administration (EIA) projected the energy consumption, for the year 2050, as 50% increase from today's Annul consumption level (international energy Outlook 2019). Energy consumption although indicates countries march towards progress, it does have its own negative aspects such as carbon emissions and other pollutants which naturally lead to environment related problems [1]. Unless attention is not paid on the control of pollutants the life on the earth would become only a dream. In order to count the ever-increasing energy resources man has been trying to tap energy from various renewable resources, but optimum use of the fossil fuels to generate energy remains the prioritized and viable one. However, the use of fossil fuels not only fulfils our energy requirement, but causes air pollution and a short lived one. So, to save our environment and to find newer energy resources we need to identify the energy efficient methods [2].

Energy consumption happens at a higher level in the industrial sector from the various energy sources available in the world both natural and manmade. Thermal energy is an important one as it converts the excessive heat energy into electric energy involving the heat recovery system equipped with heat exchangers, heat pipes and so on. The heat transfer applications become the most preferred as they employ heat pipes which cost less and the process of installation maintenance and operation are easy [3, 4]. The charged liquid undergoing a continuous process of evaporation and condensation two phase flow in the heat pipe is a process on which the heat pipe works [5].

Evaporation, the chief mechanism, allows the heat in the plain heat pipe in the process of heat transfer, but, sometimes nucleate boiling occurs when the input rate of heat is too high. Using the pressure in the sub atmospheric state the system is able to provide faster and potential heat transfer in low temperature too. Working fluids and their particles hamper the efficiency of the heat pipes. Nanofluids, containing particles such as base fluid, Nano particles and a surfactant, have long been used as working fluid although distilled water is quite popular as a working fluid. However, the Nano
particles enhance the heat transfer characteristics and thus promote the thermal conductivity which improves the thermal efficiency. The properties of Nano fluid depend on the factors like concentration, size and morphology of the Nano particles [6]. Investigators have employed a few Nano particles such as copper, silver, etc. (metals), oxides of zinc, Silicon, etc. (Metal oxides), Graphene, carbon nanotube, diamond (carbon based), boron nitride, aluminum nitrite (metal nitrites) and silicon carbides (metal carbides), for preparing the nanofluid suspensions [7].

The investigators have found the efficiency of nanofluid in the process of heat transfer the traditional fluids with solid particles mixed as colloids enhance the thermal conductivity of the base liquid owing to the fact that the solid particle has greater thermal conductivity power than the base liquids. The metallic nanoparticles suspended in the traditional fluid improve the specific heat capacity of the liquid and broaden the surface area, while the effective heat capacity decreasing due to pressure of suspended particles, the contact surface between the flow passage and the fluid gets improvement in its quantity owing to the interactions and collisions occur between the nanoparticles [8]. A number of studies analyzed the utilization of fluids containing nanoparticles and the improved level of heat pipe thermal efficiency; a few of such studies are summarized. Peyghambarzadeh et al. [9] analysed the thermal performance caused by three working fluids in a 40cm heat pipe. Using low heat flux (2500Wm⁻²) experiments were conducted with water, ethanol and methanol. Of the three liquids water showed the best results and suited well for such studies. At lower condenser temperatures, the authors found the heat transfer coefficient and increments as declining. Employing heating power, tilt angle and cooling water mass flow rate with the working fluid such as water, ethanol and ethylene glycol, Gedik attempted to study the performance of tpct. The distribution of temperature or at surface level temperature Measured both entry and exit points of cooling water in the thermosyphon were quantified and adopted in order to calculate the thermal resistance and efficiency the experiments underlined the print that the thermal efficiency of the TPCT was found varying between 30% and 95% of the three liquids utilized water yielded result of under 200W and 10 l/hr condition, Whereas ethanol gave under 600W and 10 litre/hour and ethylene glycol recorded under 200W and 30 litre per hour conditions[10].

Jafari, et.al. [11] used distilled water to investigate the heat transfer realized with evaporation-condensation in the heat pipe fabricator on the tpct model. While comparing the results with those of the experimental studies in the literature, the authors found the length of the pipe as 50 mm the evaporator as 150 mm the condenser as 150 mm and the adiabatic as 200mm along with the feeling ratio as 16%, 35%, 50% and 100% at the evaporation region. The obtained results were incongruent with the equation found in the literature by ± 30% [11]. Xu et.al., did experiments on TPCT using both single and hybrid nanofluids the nanoparticle induced by Author include Al₂O₃, TiO₂ along with the three mixtures of two particles namely alumina 75% + titanium oxide 25%, Alumina 50% + titanium dioxide 50% and alumina 25% + titanium dioxide 75%. The power input for heating had a range of 200 to 400 watts with the increasing increment of 50W. Three different flow rates of cooling water and same number of filling ratios were the other conditions observed in the experiments. The results of the experiments, conducted with the mixture of alumina 25% and titanium dioxide 75% - water and titanium dioxide - water nanofluids was proved to be yielding the best performance results. The heating power of 400W loading rate of 50% and the flow of cooling water at 0.4 l/m, determine the thermal resistance which decreases by 26.8% for the mixture of water nanofluids alumina 25% + titanium dioxide 75% under similar conditions, there was 22.8 decrease in the thermal resistance of titanium dioxide - water nanofluid. The 25% alumina + 75% titanium dioxide - water nanofluid recorded 25.78% upgraded heat transfer coefficient with 10.6% increment ratio in the thermal efficiency.

Similarly, an upgraded heat transfer coefficient of 21.62% was noticed with the increment of 9.2% thermal efficiency of titanium - water nanofluid [12]. Despite the Iron (III) oxide and alumina the metal oxide nanoparticles - providing considerable chemical stability and diffusion, these metal oxides are not apparent choice in enhancing the thermal characteristics, particularly, thermal conductivity. The base fluid gets its thermal conductivity enhanced when the metal nanoparticles, such as iron, copper and others, are employed, but a stable nanofluid suspension is not guaranteed with these metal nanoparticles. Therefore, a combination of metal oxide nanoparticles and metal
nanoparticles is the only method of making Nanofluid solution which could bear chemically stable as well as enhanced thermal properties [13].

**Materials and Methods**

In order to narrow down on the choice of material to be used in this study, the chemical composition test is performed and it is presented in the Table 1. From the chemical composition, it is identified that the selected container material is alloyed with magnesium and silicon in a high quantity by weight percentage (wt%). Therefore the grade of the material chosen for the study is Elliptical 6063AA TPCT and Semi-Circular 6063AA TPCT. Some of the important properties used for the study are listed in the Table 2.

| Table. 1: Chemical composition (wt%) of Aluminium (6063 AA) as container metal |
|-------------------|---|---|---|---|---|---|---|
| Mg               | Si  | Fe  | Cu  | Mn  | Zn  | Cr  | Al  |
| 0.7              | 0.532 | 0.35 | 0.1 | 0.7 | 0.02 | 0.1 | Remainder |

| Table. 2: Key properties of 6063 AA |
|-----------------------------|
| Density                     | 2.7 g/cm³ |
| Thermal conductivity K      | 200 W/mK  |
| Thermal expansion coefficient| 23 µm/m°C |

1. Experimental Set Up

An experimental setup was built to carry out the thermal performance analysis of Two-Phase Closed Thermosyphon (TPCT) with Elliptical 6063AA TPCT and Semi-Circular 6063 AA TPCT. The schematic layout of the experimental setup is shown in Fig 1. The setup consists of the following equipment and facilities. The inclinometer (Bevel Protector) provision is made on the test rig to rotate the TPCT through 0˚ - 180˚ angle.

To supply heat as output to the evaporator an electrical heater with 200 watts capacity is wrapped around the evaporator based on the requirement a regulated power supply with three phase variac 1800 watts 230 volts and 20 amps is provided. The wattmeter attached measures the wattage of the power supply provided to the heater in the evaporator, using the various having three phases with 0 - 250 watts and 230-volt range. The load value is shown on the digital display of the wattmeter on 8 points that k-type Thermocouple are Soldered on the TPCT and connected to the data logger in order to yield better results while measuring the temperature Condenser jacket, through which water passes, is employed to measure the power output of TPCT. This experiment
uses the elliptical and semicircular 6063 AA TPCT with a 6063 AA jacket having 30 mm and 250 mm diameter and length respectively along with diagonally positioned inlet and outlet. So that the swirl flow gets induced, besides a rotometer controls the flow rate of the coolant water.

The evaporator section of the TPCT is connected with heat source of plate type heater with a maximum power output of 200W at 220V and the condenser section is cooled by tap water. The mass flow rate of condenser section is controlled by rotometer. The adiabatic section is insulated by glass wool to avoid heat energy interaction with the ambience. The working fluid is charged after evacuating the tpct enclosure by maintaining 99kPa to 100 kPa vacuum.

The container material was tested with at filling ratio of 50 percent. The wall temperature on the TPCT container materials is measured by eight thermocouples of K-type. Two thermocouples were mounted on the evaporator section, two on the adiabatic section and four on the condenser section. The location of thermocouples is shown in Fig 4.2. All the thermocouples (K-Type) are connected and monitored using 8-channel data logger system. The flat plate type heater of the evaporator section is connected to the three phase variac of 20 amps. The heat input is varied by using a variac. The heating power input can be observed from watt mater.

Preparation of nanofluids

This study employs the two step method in order to prepare the nanofluids. The Fe3O4 nano particles (30mm) bought from the USA mixed with DI water at 0.09% of concentration. Then, the dispersed nano particle is allowed to undergo the sonication process for 12 hours with Ultrasonic homogenizer (Oleco Pvt Ltd, 42KHz).

Similarly, Fe3O4 nano fluid prepared in the concentration of 0.09% by volume and sonicated for 15 hours is shown in fig2. Prepared Fe3O4 nano fluid shown in fig3.

Test Procedure

The Design of Experiments (DOE) is an effective process that helps us in conducting experiments as well as in analyzing the collected data easily. In order to optimize the input parameters for the desired performance, the RSM is employed for the Design of Experiments. Box – Behnken Design is used with three varying input parameters were used, namely heat input (A), angle of inclination (B) and flow rate of water in the condenser section (C) to obtain the output responses of thermal resistance (Rth), and overall heat transfer coefficient (Uoverall). Table. 3 shows the process parameters and their levels. Table. 4 shows the design of matrix.

| Parameters                  | Level |
|-----------------------------|-------|
| Heat Input, W               | -1    | 0 | 1    |
| Angle of inclination, °     | 30    | 60 | 90   |
| Flow Rate, ml/min           | 60    | 90 | 120  |
Table 4: Shows the Design of Matrix

| Std | Run | Factor 1: Heat Input | Factor 2: Angle of Inclination | Factor 3: Flow Rate |
|-----|-----|----------------------|-------------------------------|-------------------|
| 2   | 1   | 80                   | 60                            | 90                |
| 1   | 2   | 80                   | 90                            | 120               |
| 7   | 3   | 60                   | 90                            | 90                |
| 5   | 4   | 100                  | 60                            | 120               |
| 16  | 5   | 100                  | 90                            | 90                |
| 9   | 6   | 100                  | 30                            | 90                |
| 10  | 7   | 80                   | 60                            | 90                |
| 4   | 8   | 60                   | 60                            | 60                |
| 14  | 9   | 80                   | 30                            | 60                |
| 13  | 10  | 80                   | 30                            | 120               |
| 8   | 11  | 80                   | 60                            | 90                |
| 11  | 12  | 60                   | 30                            | 90                |
| 12  | 13  | 60                   | 60                            | 120               |
| 17  | 14  | 80                   | 60                            | 90                |
| 3   | 15  | 100                  | 60                            | 60                |
| 15  | 16  | 80                   | 60                            | 90                |
| 6   | 17  | 80                   | 90                            | 60                |

The BBD resulted in 17 runs of simulation arranged by three factors as listed in Table 4. The 17 runs were conducted as per the resulting design matrix by varying, the mass flow rate of pure water flowing through the condenser section using rotometer, the inclination angle of TCPT and heat input. Approximately it took 15 minutes for Fe₃O₄ nanofluid to attain the steady state. The temperature at each trial is recorded after the attainment of steady state condition using data logger system.

Data reduction

Data reduction is a process in which the information collected, in numerical and alphabetical forms, usually derived from empirical or experimental analysis, gets corrected, ordered and entered in a simplified manner. Reducing a huge amount of data into small units of meaningful information is concept behind data reduction.

The thermal efficiency of the thermosyphon (η%), is evaluated by,

\[
\eta \% = \frac{Q_{\text{out}}}{Q_{\text{in}}} \times 100
\]

\[
Q_{\text{out}} = m_c C_p (T_{\text{out}} - T_{\text{in}})
\]

where,

- \( m_c \) = Mass flow rate of pure water in condenser section, kg/sec.
- \( C_p \) = Specific heat of water, J/kg°C
- \( T_{\text{out}} \) = Temperature at outlet of the water condenser section, °C
- \( T_{\text{in}} \) = Temperature at inlet of the water condenser section °C
- \( Q_{\text{in}} \) = Heat input in watts

Uncertainty for \( \eta \% \) is evaluated by,
\[ e = \frac{\partial \eta}{\partial \eta} = \left[ \sum_{i=1}^{N} \left( \frac{1}{\eta} \times \frac{\partial R}{\partial x_i} \right)^2 \right]^{1/2} \]

\[ = \left[ \left( \frac{\partial m}{m} \right)^2 + \left( \frac{\partial Q_\text{out}}{Q_\text{out}} \right)^2 + \left( \frac{\partial Q_\text{in}}{Q_\text{in}} \right)^2 \right]^{1/2} \]

By calculating \( \eta \) over the entire experimental range, the maximum uncertainty is associated with the resulting \( \eta \) values that found to be around 1.97 percent.

**Result and Discussions**

**Response 1 EFFICIENCY (elliptical) Fe\textsubscript{3}O\textsubscript{4}**

ANOVA for Response Surface Quadratic Model

| Source     | Sum of Squares | df | Mean Square | F Value | p-value | Prob > F |
|------------|----------------|----|-------------|---------|---------|----------|
| Model      | 0.25           | 9  | 0.028       | 243.13  | < 0.0001 | significant |
| A-HEAT INPUT | 4.770E-003    | 1  | 4.770E-003  | 41.26   | 0.0004  |           |
| B-ANGLE    | 0.018          | 1  | 0.018       | 153.47  | < 0.0001 |           |
| C-FLOW RATE | 0.15           | 1  | 0.15        | 1330.58 | < 0.0001 |           |
| AB         | 4.381E-004     | 1  | 4.381E-004  | 3.79    | 0.0926  |           |
| AC         | 7.009E-003     | 1  | 7.009E-003  | 60.63   | 0.0001  |           |
| BC         | 0.000          | 1  | 0.000       | 0.000   | 1.0000  |           |
| A\(^2\)    | 0.014          | 1  | 0.014       | 124.35  | < 0.0001 |           |
| B\(^2\)    | 2.693E-003     | 1  | 2.693E-003  | 23.30   | 0.0019  |           |
| C\(^2\)    | 0.047          | 1  | 0.047       | 405.57  | < 0.0001 |           |
| Residual   | 8.092E-004     | 7  | 1.156E-004  |         |         |          |
| Lack of Fit| 8.092E-004     | 3  | 2.697E-004  |         |         |          |
| Pure Error | 0.000          | 4  | 0.000       |         |         |          |
| Cor Total  | 0.25           | 16 |             |         |         |          |

The model “F-value” being 243.13 it is considered as significant the model of value of this magnitude occurs, owing to the noise, since there is 0.01 % probability. If the prob>F records 0.0500 values, it will indicate the models terms as significant.

Here, A, B, C, AC, A\(^2\), B\(^2\) and C\(^2\) are found as significant model terms. If the values are found greater than 0.1000 then the model terms are not considered as significant. Increase the significant model terms (except those considered for maintaining hierarchy), there will be improvement in the production model.

Std. Dev. 0.011 R-Squared 0.9968
Mean0.70 Adj R-Squared 0.9927
C.V. % 1.55 Pred R-Squared 0.9490
PRESS 0.013 Adeq Precision 45.475

The "Pred R-Squared" of 0.9490 is in reasonable agreement with the "Adj R-Squared" of 0.9927. "Adeq Precision" measures the signal to noise ratio. A ratio greater than 4 is desirable. Your ratio of 45.475 indicates an adequate signal. This model can be used to navigate the design space.
| Factor       | Coefficient Estimate | df | Standard Error | 95% CI Low | 95% CI High | VIF |
|--------------|----------------------|----|----------------|------------|-------------|-----|
| Intercept    | 0.78                 | 1  | 4.808E-003     | 0.77       | 0.80        |     |
| A-HEAT INPUT | 0.024                | 1  | 3.801E-003     | 0.015      | 0.033       | 1.00|
| B-ANGLE      | 0.047                | 1  | 3.801E-003     | 0.038      | 0.056       | 1.00|
| C-FLOW RATE  | 0.14                 | 1  | 3.801E-003     | 0.13       | 0.15        | 1.00|
| AB           | -0.010               | 1  | 5.376E-003     | -0.023     | 2.247E-003  | 1.00|
| AC           | 0.042                | 1  | 5.376E-003     | 0.029      | 0.055       | 1.00|
| BC           | 0.000                | 1  | 5.376E-003     | -0.013     | 0.013       | 1.00|
| A^2          | -0.058               | 1  | 5.240E-003     | -0.071     | -0.046      | 1.01|
| B^2          | -0.025               | 1  | 5.240E-003     | -0.038     | -0.013      | 1.01|
| C^2          | -0.11                | 1  | 5.240E-003     | -0.12      | -0.093      | 1.01|

Final Equation in Terms of Coded Factors:

EFFICIENCY =
+0.78 +0.024 * A +0.047 * B +0.14 * C -0.010 * A * B +0.042 * A * C +0.000 * B * C -0.058 * A^2 -0.025 * B^2 -0.11 * C^2

Final Equation in Terms of Actual Factors:

EFFICIENCY =
-1.39010 +0.019360 * HEAT INPUT +6.33714E-003 * ANGLE +0.020145 * FLOW RATE -1.74417E-005 * HEAT INPUT * ANGLE +6.97667E-005 * HEAT INPUT * FLOW RATE +0.000000 * ANGLE * FLOW RATE -1.46074E-004 * HEAT INPUT^2 -2.81005E-005 * ANGLE^2 -1.17247E-004 * FLOW RATE^2
The plots show the interactive effect of heat input and inclination angle of the elliptical with thermal efficiency.

From the figure it is seen that the interactive effect of heat input and inclination angle of the elliptical 6063 TPCT along with Fe$_3$O$_4$ nanofluid increase in heat input gradually increases the thermal efficiency upto 80 W and thereafter decrease. Whereas increase of inclination angle the thermal efficiency increases with from 30° to 90°. Similarly the efficiency is increases with the flow rate. Therefore the thermal efficiency of the elliptical TPCT 6063 with Fe$_3$O$_4$ nanofluid is affable after 80W of heat input. Hence, the influential parameter is heat input. Nanofluid utilization increases the efficiency 85% under 90W and 120 lit/min cooling water mass flow rate condition.

**Response 1 EFFICIENCY Semi Circular (Fe$_3$O$_4$)**

ANOVA for Response Surface Quadratic Model

Analysis of variance table [Partial sum of squares - Type III]

| Source         | Sum of Squares | df | Mean Square | F Value | p-value Prob > F |
|----------------|----------------|----|-------------|---------|-----------------|
| Model          | 0.14           | 9  | 0.016       | 54.56   | <0.0001 significant |
| A-HEAT INPUT   | 0.016          | 1  | 0.016       | 57.27   | 0.0001          |
| B-ANGLE        | 6.037E-003     | 1  | 6.037E-003  | 21.02   | 0.0025          |
| C-FLOW RATE    | 0.040          | 1  | 0.040       | 140.68  | <0.0001         |
| AB             | 4.381E-004     | 1  | 4.381E-004  | 1.52    | 0.2567          |
| AC             | 1.947E-004     | 1  | 1.947E-004  | 0.68    | 0.4375          |
| BC             | 6.845E-004     | 1  | 6.845E-004  | 2.38    | 0.1666          |
| A$^2$          | 0.014          | 1  | 0.014       | 47.83   | 0.0002          |
| B$^2$          | 4.266E-003     | 1  | 4.266E-003  | 14.85   | 0.0063          |
| C$^2$          | 0.053          | 1  | 0.053       | 184.07  | <0.0001         |
| Residual       | 2.011E-003     | 7  | 2.873E-004  |         |                 |
| Lack of Fit    | 2.011E-003     | 3  | 6.703E-004  |         |                 |
| Pure Error     | 0.000          | 4  | 0.000       |         |                 |
| Cor Total      | 0.14           | 16 |             |         |                 |

The model “F-value” being 54.56 it is considered as significant the model of value of this magnitude occurs, owing to the noise, since there is 0.01 % probability. If the prob>F records 0.0500 values, it will indicate the models terms as significant. Here, A, B, C, AC, A$^2$, B$^2$ and C$^2$ are found as significant model terms. If the values are found greater than 0.1000 then the model terms are not considered as significant. Increase the significant model terms (except those considered for maintaining hierarchy), there will be improvement in the production model.
The "Pred R-Squared" of 0.7751 is in reasonable agreement with the "Adj R-Squared" of 0.9679.

"Adeq Precision" measures the signal to noise ratio. A ratio greater than 4 is desirable. Your ratio of 21.435 indicates an adequate signal. This model can be used to navigate the design space.

Final Equation in Terms of Coded Factors

\[
\text{EFFICIENCY} = +0.71 + 0.045 A + 0.027 B + 0.071 C - 0.010 AB - 0.013 AC - 0.057 A^2 - 0.032 B^2 - 0.11 C^2
\]

Final Equation in Terms of Actual Factors:

\[
\text{EFFICIENCY} = -1.87149 + 0.025116 \text{HEAT INPUT} + 7.86328 \text{ANGLE} + 0.024724 \text{FLOW RATE} - 1.74417 \text{HEAT INPUT * ANGLE} + 1.16278 \text{HEAT INPUT * FLOW RATE} - 1.45347 \text{ANGLE * FLOW RATE} - 1.42804 \text{HEAT INPUT}^2 - 3.53678 \text{ANGLE}^2 - 1.24514 \text{FLOW RATE}^2
\]
The thermal efficiency of the TPCT is calculated as the ratio of heat rejected at the condenser section to heat input at evaporator section. From Fig. 5 shows the effect of heat input and inclination angle on thermal efficiency. From the figure, it is observed that an increase in heat input results in a gradual increase of the thermal efficiency initially and then slightly decreases whereas an increase in the flow rate causes a steep increase in the thermal efficiency. The interactive effect of flow rate and angle increase the thermal efficiency. The thermal efficiency of the heat pipe increases with the increase in heat flux, due to the fact that temperature gradient between the evaporator and condenser section increases. For higher values of heat input in evaporator section, the heat generated in the surface is more and working fluid which is in form of vapor moves vigorously into the condenser section. The circulating water in condenser section absorbs this excessive heat and as a result, the efficiency of heat pipe increases. Hence, the influential input parameters are the heat input at evaporator inclination angle and flow rate. The thermal efficiency is maximum up to 90° inclination angle and then decreases.

**Fig 5: Wire-mesh plot for Semi-Circular 6063 TPCT along with Fe₃O₄ Nanofluid**

**Fig 6: Optimization Plot**

Elliptical Cross Section

Semi Circular Cross Section
Fig 6 shows the optimization plot, For elliptical cross-section the optimized values
Heat Input : 99W
Flow rate : 120 l/m
Angle : 35°
Efficiency : 77.63%
For Semi-Circular cross-section the optimized values
Heat Input : 100W
Flow rate : 120 l/m
Angle : 40°
Efficiency : 65%

For the above optimized values, the experimental reading has also taken the Efficiency Elliptical 79% and for the Semi-Circular 67%.

CONCLUSION

With the aim of improving the heat transfer aptitude of the 6063 alloy TPCT with cross section as elliptical and semi circular with the working fluid as Fe₃O₄ has been investigated in a test rig. Experiments were accomplished under changing cross-section and then experimental results were compared to each other. The findings acquired from this study on the assessment of TPCT performance of a give rise to the consequent remarks:

1) Distribution of the wall temperature was uniform to a elliptical pipe with Fe₃O₄ nanofluid, when compare to semi circular cross-section. The difference between the wall temperature of the evaporator and the condenser sections was smaller when employing the elliptical cross section.
2) The maximum enhancement in efficiency 77.63% was obtained under 99W heating power and 120 l/m cooling water mass flow rate conditions.
3) Surface area of the pipe plays a major role with the addition of nanoparticles inside it.
4) From the experiment elliptical cross-section gives the best result.

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