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Experimental Investigations of Pulsating Heat Exchanger

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Abstract: This Experimental investigation was conducted to understand heat transfer characteristic of the pulsating heat exchanger, and the pulsating heat pipe is made of the copper tube, the copper tube internal diameter is the mm 5 mm and the outer diameter is 6.15 mm and the total turn of copper tube is the 5 turn. And this experiment performing at different filling ratio like 50% ,30%.and also change the working substance like methanol and acetone at the same heat input. The experimental result indicate that the total heat resistance of PHP is increased with the filling ratio and heat transfer rate achieves optimum in the working substance acetone at the 30% filling ratio. in the working substance methanol and acetone are used because of the both working fluid the boiling temperature less then the water, methanol boiling temperature was 64 ˚C and the acetone boiling temperature was 56 ˚C. By performing the our experiment we can say that the acetone as the working fluid is more efficient then the methanol at the 50% and 30% filling Ratio. In the acetone the 30% filling Ratio is more efficient.
Keywords: Pulsating heat exchanger, condenser, evaporator, thermal heat transfer co-officient

I. INTRODUCTION

A heat exchanger is a system used to transfer heat between two or more fluids Heat exchangers are used in both cooling and heating processes. The fluids may be separated by a solid wall to prevent mixing or they may be in direct Contact.

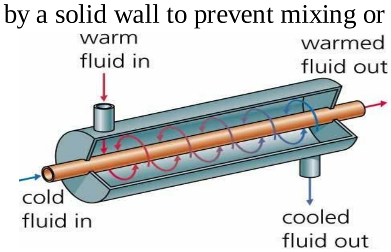

Fig (1) Heat Exchanger

They are widely used in space heating, refrigeration air conditioning, power stations, chemical plants, petrochemical plants, petroleum refineries, natural-gas processing, and sewage treatment. The classic example of a heat exchanger is found in an internal combustion engine in which a circulating fluid known as engine coolant flows through radiator coils and air flows past the coils, which cools the coolant and heats the incoming air. Another example is the heat sink, which is a passive heat exchanger that transfers the heat generated by an electronic or a mechanical device to a fluid medium, often air or a liquid coolant.

1) *Pulsating Heat Exchanger:* Heat exchangers are needed to hamess transport from various process industry operations.The available thermal energy may often be low-grade and distributed in addition, high heat flux removal at controlled temperature is needed for power electronics thermal management and transport requirements. The range of Pulsating Heat Pipe (PHP) two-phase systems introduced in the later part of the last century are quite attractive from many aspects Passive operation.high heat flux handling, ease of manufacture and interesting thermo-fluidic two-phase transport from an academic viewpoint, are some of the striking features of this class of heat pipes.

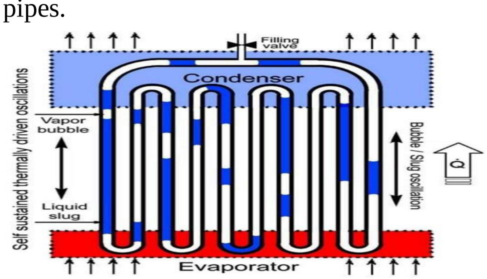

Fig (2) Pulsating Heat Exchanger

The fundamental transport processes that occur inside the PHP can be understood by looking at Figure 1-c which suggests the various forces, including heat and mass transfer processes acting on a typical liquid-slug vapor-bubble (unit cell) system, as formed inside the PHP. The primary unit-cell processes are The flow pattern in the PHP tubes may be broadly categorized as capillary slug flow. This type of flow is characterized by: (a) the flow pattern is 'generally' axi symmetric, at least in vertical flows (in horizontal flows, there will be some asymmetry depending on the Bo, (b) the velocity of large vapour bubbles relative to the liquid slug is somewhat faster.Due to the capillary dimensions of the PHP tube, a of liquid slugs and vapour bubbles having menisci on its edges are formed due to surface tension forces. Usually a liquid thin film exists surrounding the vapour bubbles. The angle of contact of the menisci, the liquid thin film stability and its thickness depend on the fluidsolid combination and the selected operating parameters.Liquid slugs and vapor bubbles move against the gravity vector, in its direction or at an angle to it, depending on the global PHP orientation and the location of slugs/ bubbles in the up-header or down-header tubes.The liquid slugs and vapour bubbles are subjected to pressure force 1 FG and 2 FGfrom the adjoining slugs/bubbles. These are not only caused due to phase-change mass transfer but also due to capillary forces.The liquid slugs and vapor bubbles experience internal viscous dissipation as well as wall shear stress as they move in the PHP tube. Their relative magnitude decides the predominant force to be considered.The liquid slugs and vapor bubbles may receive heat, reject heat, or move without any external heat transfer, depending on their location in the evaporator, condenser or the adiabatic section, respectively. Most thermal transport occurs through the thin film and its dynamics plays a crucial role in the overall thermal transport.

II. LITERATURE REVIEW

A. Experimental research on pulsating heat pipe
B. Performance Of closed loop pulsating heat pipe
C. Review on closed loop oscillating pipe.
D. Study on a hydrogen Closed loop pulsating Heat pipe With different lengths.

III. NUMERICAL DESIGN PROCEDURE

In the present work, at first a TCTHE is designed by LMTD method by considering a known set of input values as given in table 1.Then by finding the length, drawing the TCTHE setup by using Illustartor as shown in figure 1.

TABLE I
Input parameters for calculation of TPCHE

Input parameters	Symbols	Values
Average evaporator temperature ˚C	Te	60
Average condenser temperature ˚C	Tc	48
Heat input (Watt) W	Q	27
Thermal heat resistance ˚C/W	R	27
Diameter of copper pipe, mm	D	12
Thickness of each pipe, mm	T	1

NOTATION

˚C	celsius
W	watt
MM	millimeter
L	length
H	height
B	width
R1,R2	radius
R	Thermal heat resistance
Q	Heat input
V	voltage
I	current
v	volume
A	area

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A. Working Substances ratio Calculation

1) Copper tube diameter d= 6 mm
2) Height h= 27 feet = 8229.6 mm
3) Volume of copper tube (v)=πr^2h

$$=3.14*3^2*8229.6$$

$$=232568.5\ mm^3$$

$$v=0.0002325 m^3 \qquad (1\ m^3 = 1000L)$$

$$V=232.5ml$$

At 30% filling ratio
v=70ml

At 50% filling ratio
v=116 ml

B. Thermal Resistance Calculation

1) Average evaporator temperature Calculated by equation.
  - Te = (T1+T2+T3+T4+T5+T6)/6

2) Average compressor temperature calculated by equation
  - Tc = (T7+T8+T9+T10+T11+T12)/6

3) Q = Heat input
4) Q = Voltage × current
5) Thermal resistance
6) R thermal = Te-Tc/Q

C. 3 D Model Of Pulsating Heat Exchanger

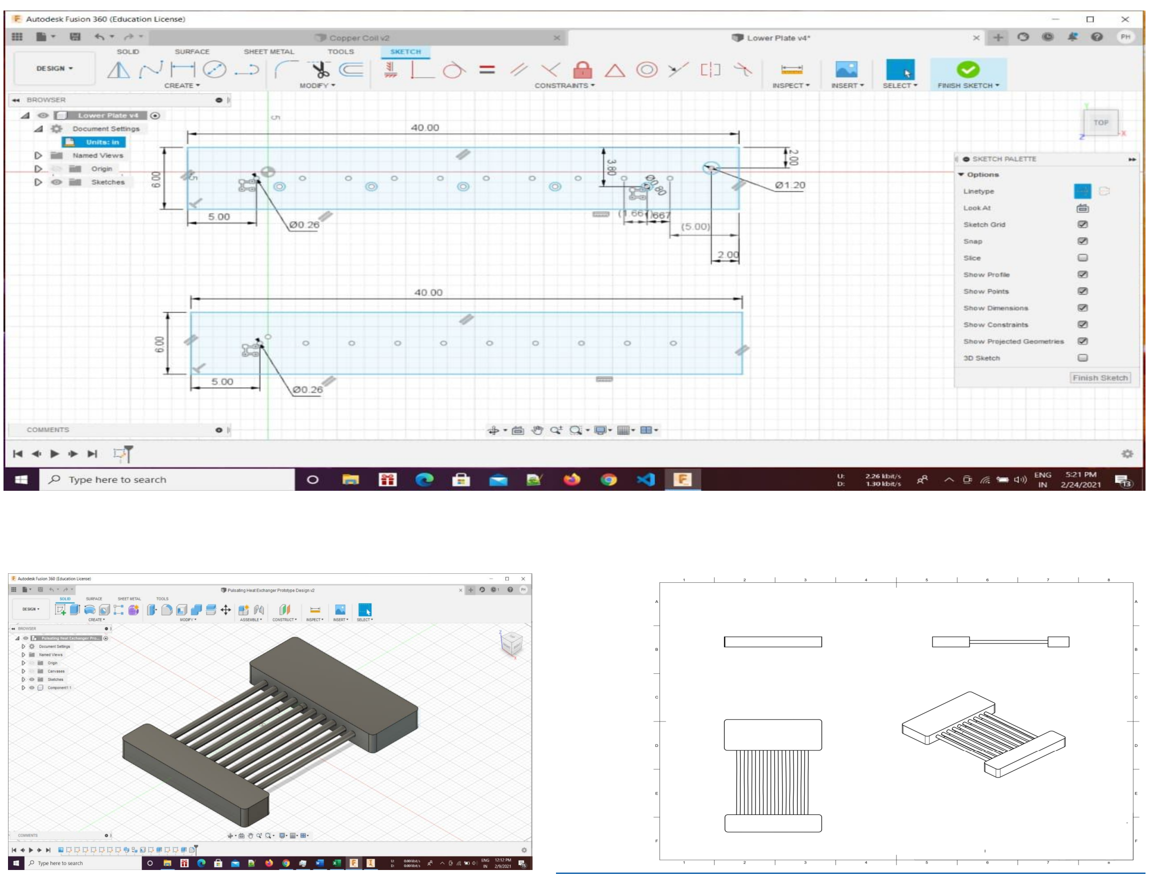

Fig (3) 3D model

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D. Actual Model Of Pulsating Heat Exchanger

Fig(4) Actual model

Fig(5)reading by Digital thermometer

IV. METHANOL AND ACETONE READING AT THE 50% FILLING RATIO

A. Observation Table

Sr.no	V(v)	I(a)	Q(w)	Working substance ratio (%)	Evaporator temp of methanol(C)		Avg. Evaporator temp(C)
					T1	T2	
1	230	1.08	250	50	52	43.2	47.6
2	230	1.08	250	50	52.1	44.3	48.2
3	230	1.08	250	50	52.9	45	48.95
4	230	1.08	250	50	53.4	45.7	49.55
5	230	1.08	250	50	54.2	46.4	50.3

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B. Observation Table

Sr.no	V(v)	I(a)	Q(w)	Working substance ratio (%)	condenser temp of methanol(C)		Avg. Condenser temp(C)
					T3	T4	
1	230	1.08	250	50	39.1	39.2	39.15
2	230	1.08	250	50	39.3	39.3	39.3
3	230	1.08	250	50	39.9	39.7	39.8
4	230	1.08	250	50	40.2	40.0	40.1
5	230	1.08	250	50	40.5	40.3	40.4

C. Observation Table

Sr.no	V(v)	I(a)	Q(w)	Working substance ratio (%)	Evaporator temp of acetone(C)		Avg. Evaporator temp(C)
					T1	T2	
1	230	1.08	250	50	41.4	37.1	39.25
2	230	1.08	250	50	41.9	37.7	39.8
3	230	1.08	250	50	42.9	38.6	40.75
4	230	1.08	250	50	43.7	39.7	41.7
5	230	1.08	250	50	44.5	40.4	42.5

E. Observation Table

Sr.no	V(v)	I(a)	Q(w)	Working substance ratio (%)	condenser temp of acetone (C)		Avg. Condenser temp(C)
					T3	T4	
1	230	1.08	250	50	35.4	35.3	35.35
2	230	1.08	250	50	35.4	35.2	34.3
3	230	1.08	250	50	34.9	35.0	34.95
4	230	1.08	250	50	35.5	35.6	35.55
5	230	1.08	250	50	36.1	36.2	36.15

V. METHANOL AND ACETONE READING AT THE 30% FILLING RATIO

A. Observation Table

Sr.no	V(v)	I(a)	Q(w)	Working substance ratio (%)	Evaporator temp of methanol(C)		Avg. Evaporator temp(C)
					T1	T2	
1	230	1.08	250	30	44.2	45.6	44.9
2	230	1.08	250	30	44.6	45.9	45.25
3	230	1.08	250	30	45.2	46.3	45.75
4	230	1.08	250	30	45.9	46.8	46.35
5	230	1.08	250	30	46.5	47.2	46.85

B. Observation Table

Sr.no	V(v)	I(a)	Q(w)	Working substance ratio (%)	condenser temp of methanol(C)		Avg. condenser temp(C)
					T3	T4	
1	230	1.08	250	30	37.6	37.2	37.4
2	230	1.08	250	30	37.6	37.5	37.55
3	230	1.08	250	30	37.7	37.7	37.8
4	230	1.08	250	30	38.3	38.0	38.15
5	230	1.08	250	30	38.5	38.2	38.35

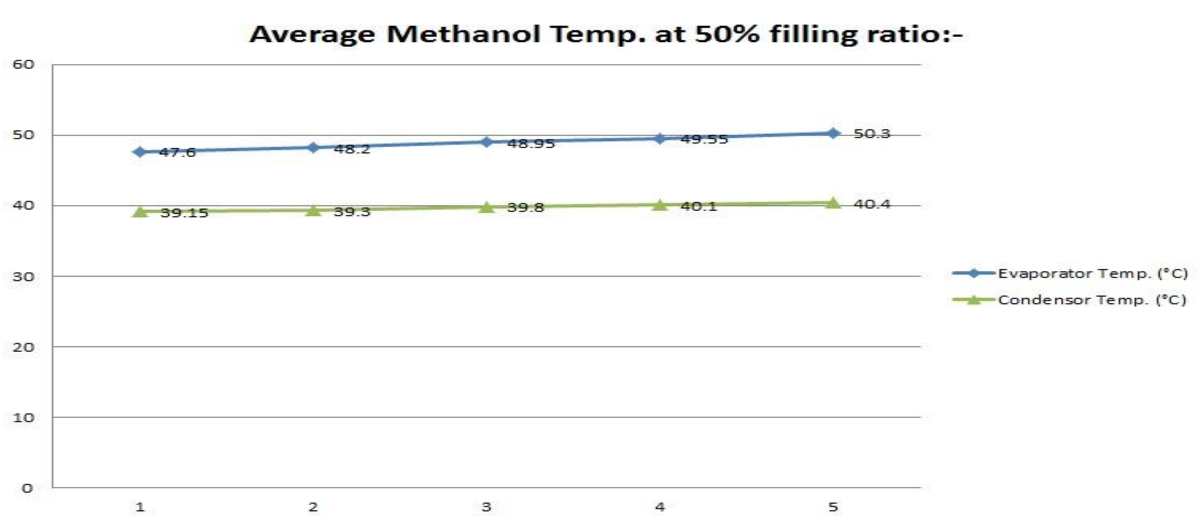
C. Observation Table

Sr.no	V(v)	I(a)	Q(w)	Working substance ratio (%)	Evaporator temp of acetone(C)		Avg. Evaporator temp(C)
					T1	T2	
1	230	1.08	250	30	40.4	38.2	39.3
2	230	1.08	250	30	40.9	38.8	39.85
3	230	1.08	250	30	41.6	39.5	40.55
4	230	1.08	250	30	42.5	40.7	41.6
5	230	1.08	250	30	43.4	41.5	42.45

F. Observation Table

Sr.no	V(v)	I(a)	Q(w)	Working substance ratio (%)	condenser temp of acetone(C)		Avg. condenser temp(C)
					T3	T4	
1	230	1.08	250	30	35.4	35.5	35.5
2	230	1.08	250	30	35.7	35.8	35.8
3	230	1.08	250	30	35.4	35.7	35.45
4	230	1.08	250	30	35.9	36	35.95
5	230	1.08	250	30	36.3	36.2	36.35

VI. GRAPHICAL REPRESENTATION OF AVERAGE TEMPRATURE OF METHANOL AND ACETONE



Fig(6) Graph of Methanol Temp. At 50% Filling Ratio

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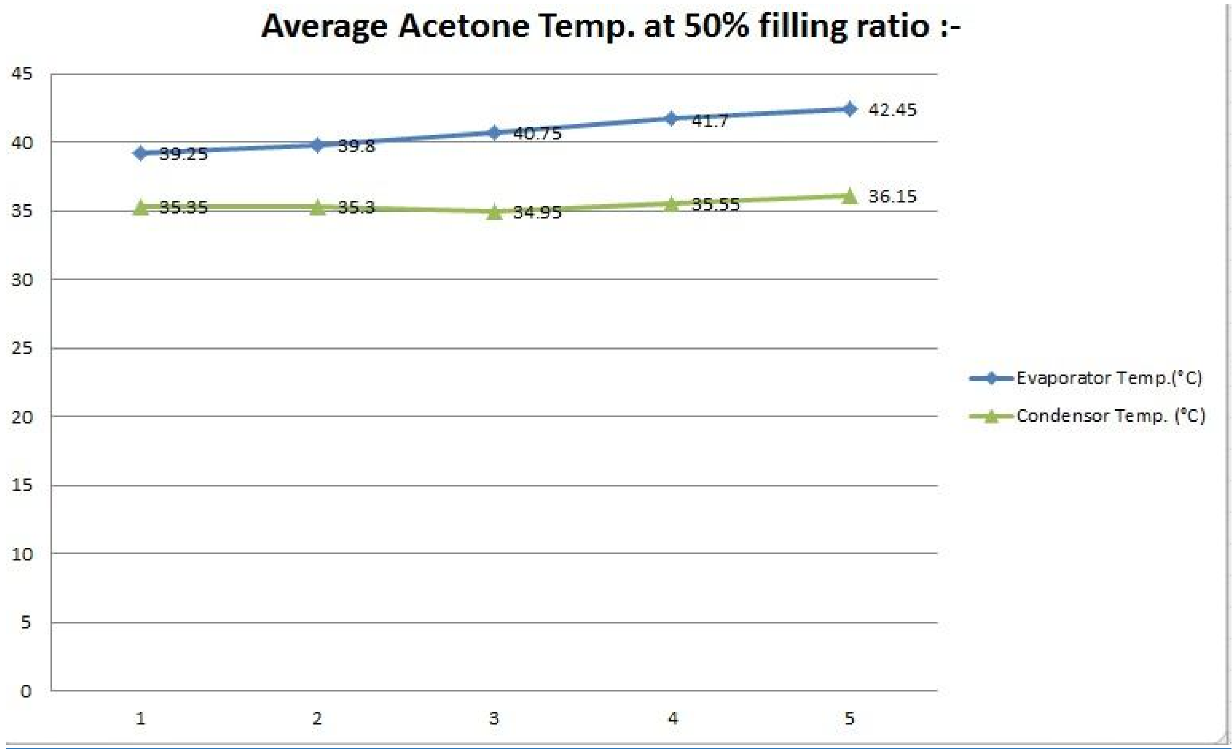
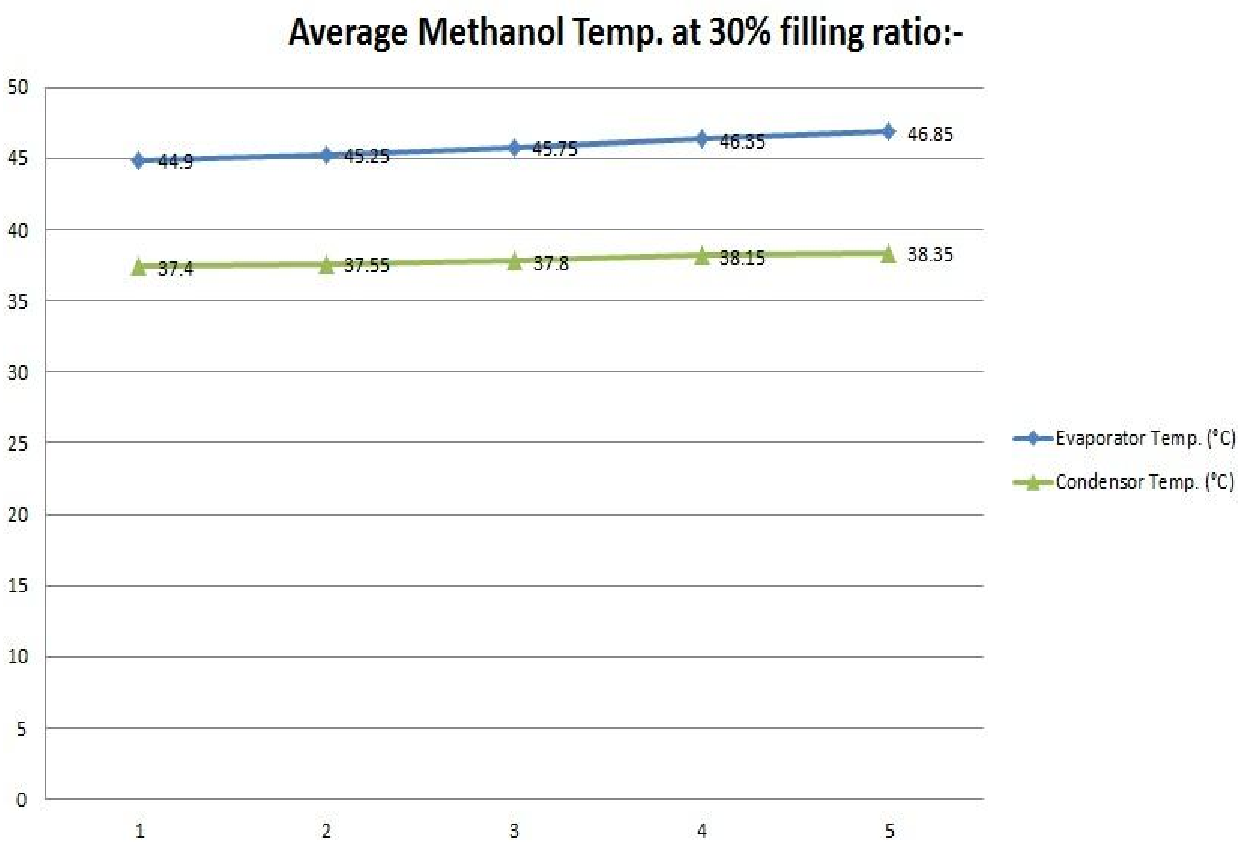


Fig(7) Graph of acetone Temp. At 50% Filling Ratio



Fig(8) Graph of Acetone Temp. At 30% Filling Ratio

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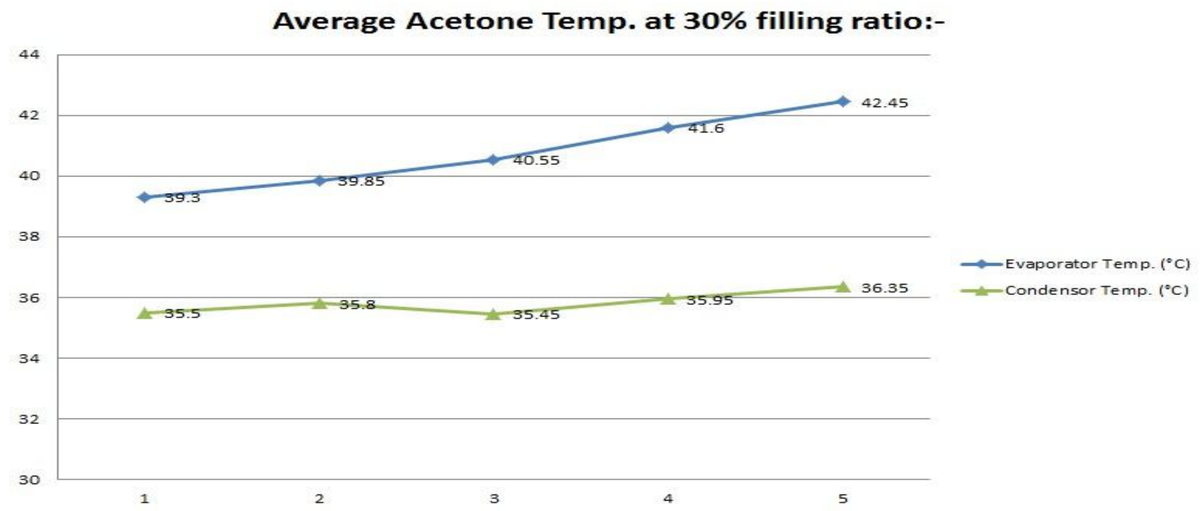

Fig(9) Graph of Acetone Temp. At 30% Filling Ratio

VII.COMPARISON OF THERMAL RESISTANCE

A. Comparison at 50 %

Sr. N0.	Heat input(watt)	Working substances ratio in(%)	Thermal Resistance of Acetone(c/w)	Thermal Resistance of Methanol(c/w)
1	250	50	0.0156	0.0338
2	250	50	0.018	0.0356
3	250	50	0.0232	0.0366
4	250	50	0.0246	0.0378
5	250	50	0.0252	0.0396

B. Comparison at 30%

Sr.no	Heat input(watt)	Working substances ration in(%)	Thermal Resistance of Acetone(c/w)	Thermal Resistance of Methanol(c/w)
1	250	30	0.0152	0.03
2	250	30	0.0162	0.0308
3	250	30	0.0204	0.0318
4	250	30	0.0226	0.0328
5	250	30	0.0244	0.034

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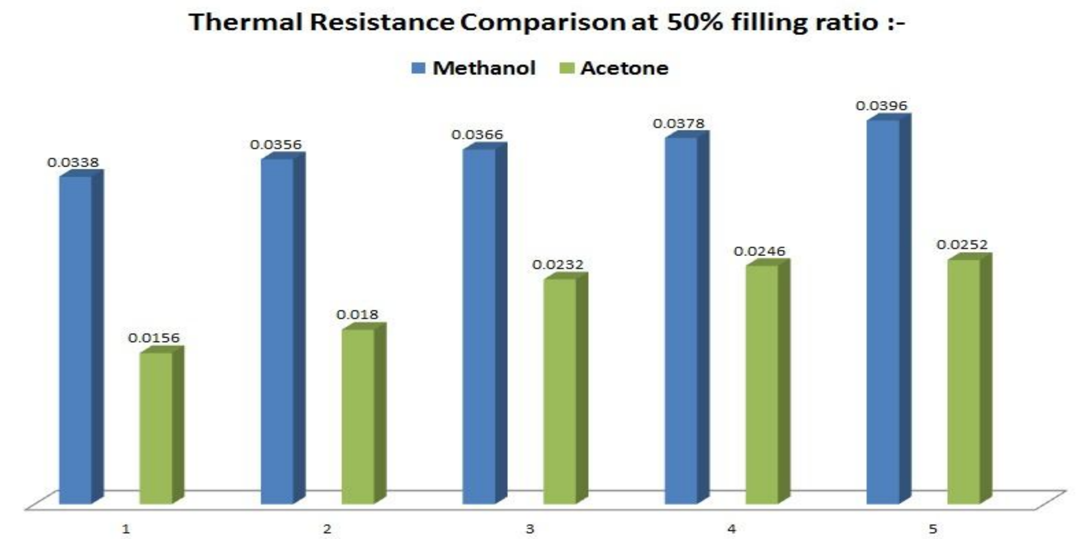
VIII. GRAPHICAL REPRESANTION OF THERMAL HEAT RESISTANT



Fig(10) Graph of thermal heat resistance at 50%

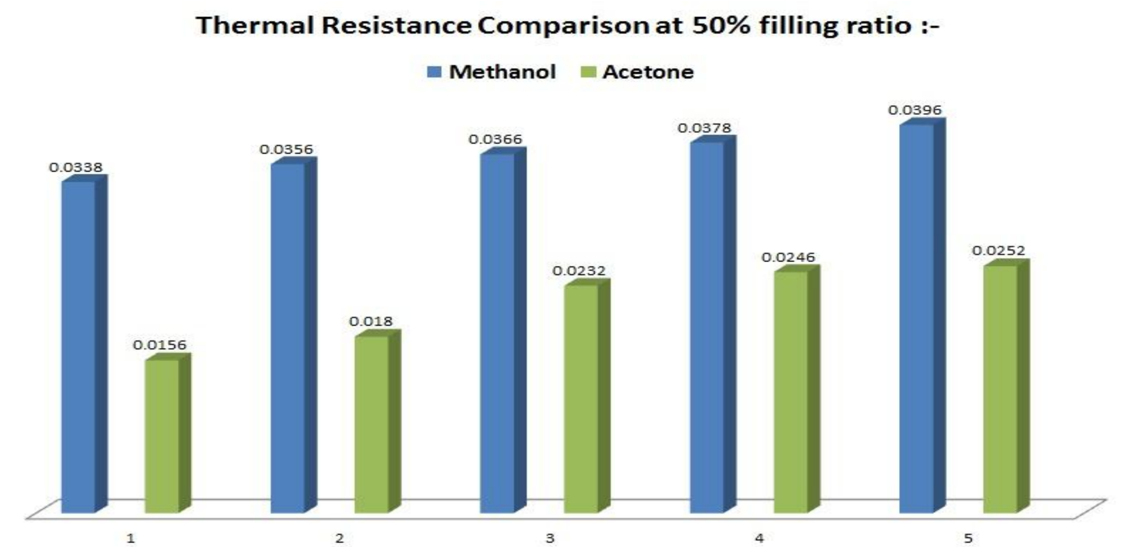


Fig (11) Graph of thermal heat resistance at 30%

IX. CONCLUSION

We were observed during the experimentation that as the water bath temperature increases there is increase in evaporator and condenser temperature of CLPHP. With Same heat input For Methanol Thermal Resistance Increases Than Acetone at 30% & 50% Filling Ratio of Working Substance. For Acetone it was observed that the thermal resistance decreases Than Methanol At Both 30% & 50% Filling Ratio Of Working Substance.In Acetone And Methanol We Were observed The Thermal Resistance At 50% Filling Ratio Of Working Substance is Higher Than 30% Filling Ratio of Working Substance.

It was observed that at the same heat input and the filling ratio of 30% & 50% Acetone has lesser thermal resistance than Methanol. PHP with Acetone as working fluid gives higher thermal performance.

The thermal resistance of PHP with Acetone as working fluid is less as compared to thermal resistance of Methanol at same heat inputs and filling ratio of 30% & 50%

Hence from the experimentation, it can be concluded that out of the two hydrocarbon working fluids, the thermal performance of Acetone is higher Than Methanol.

X. ACKNOWLEDGMENT

We would like to take this opportunity to bestow our acknowledgements to all the persons who have directly or indirectly been Involved into our work and help us to complete the project. It is the result of many hands, and countless hours from many people. Our thanks go to all those who helped, whether through their comments, feedback, edits or suggestions. We express a deep sense of gratitude for providing a suitable environment, where we can implement our work. Moreover, we would like to thank our guide Prof. Vishal Tailor who has helped us throughout our project development.

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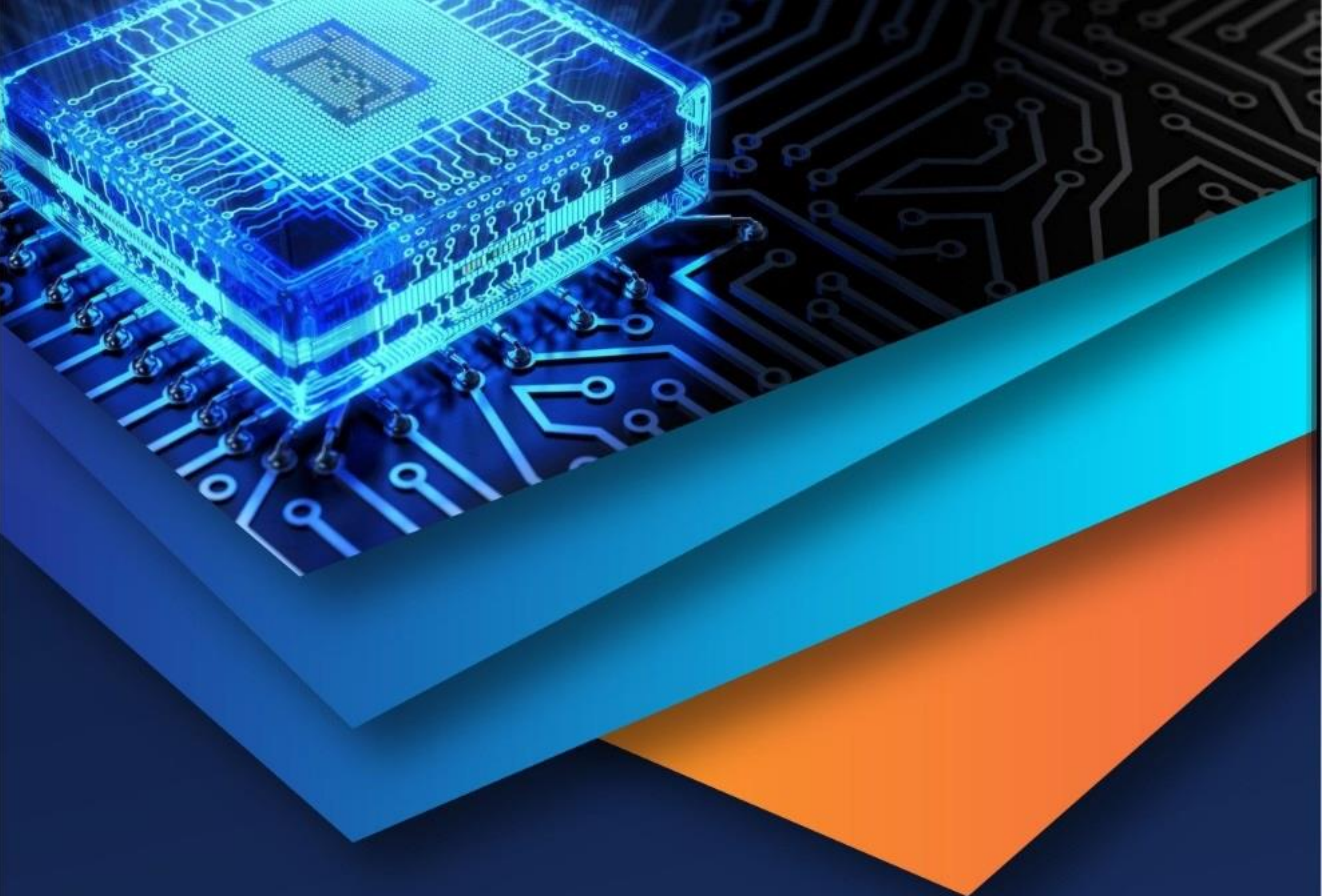

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