EFFECT OF WATER BATH TEMPERATURE ON EVAPORATOR AND CONDENSER TEMPERATURE OF CLOSED LOOP PULSATING HEAT PIPE WITH ACETONE AS WORKING FLUID

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Abstract

The objective of this paper is to study the effect of water bath temperature on evaporator and condenser temperature of closed loop pulsating heat pipe with acetone as working fluid. Heat pipe is a heat exchanger with high heat dissipation capacity and used for cooling the electronic equipments. Here in this paper copper has been selected as material for heat pipe due to compatibility of copper with acetone as working fluid. Filling ratio of the working fluid significantly influence on the performance closed loop pulsating heat pipe. Here in this paper 60 % filling ratio has been selected for this filing ratio the effect of increasing water bath temperature on acetone closed loop pulsating heat pipe is investigated.

Keywords: *closed loop pulsating heat pipe, condenser, evaporator, working fluid, filling ratio.*

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1. INTRODUCTION

The closed-loop pulsating heat pipe is a type of small heat transfer device with a very high thermal conductivity. It was invented to meet the requirement for smaller heat transfer devices. It can transfer sufficient heat for heat dissipation applications in modern electronic devices. The Closed loop pulsating heat pipe is made of a long copper capillary tube, bent into an undulating tube and connected at the ends to form a closed-loop with no internal wick structure [1]. Working fluid is partially filled in the tube. The closed loop pulsating heat pipe has a condenser, evaporator section and adiabatic section. As any other two-phase passive thermal control device, heat is acquired from the source through the evaporator section transferring it to the working fluid where the slug/plug pumping action will be generated. The fluid then flows by the adiabatic section towards the condenser section. On a closed loop configuration, the fluid is allowed to circulate and after being condensed, the fluid returns to the evaporator section to complete the loop. The tube is evacuated and consequently partially filled with working fluid. Since an inner diameter of the tube is very small and then meets a capillary scale, the inside working fluid forms into liquid slugs alternating with vapour plugs along the entire length of the tube [2].

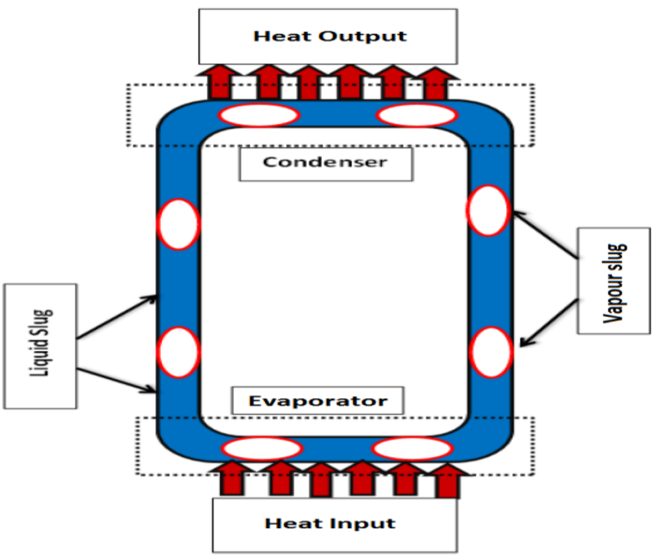


Fig 1: Closed loop pulsating heat pipe

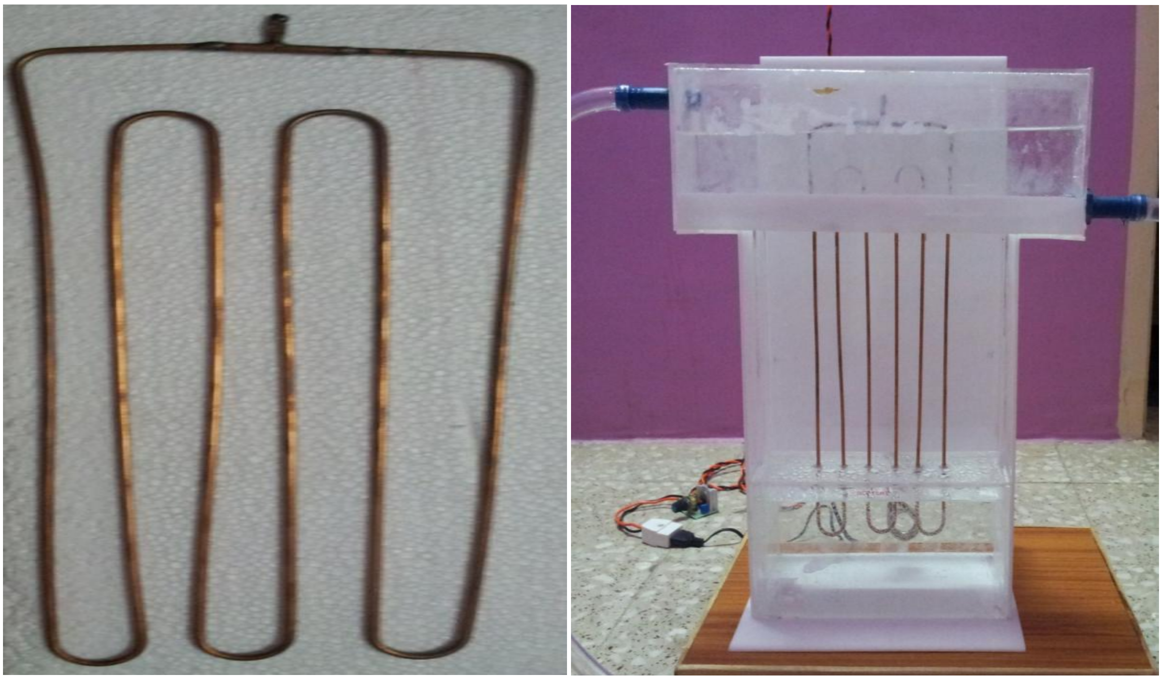
When one end of the closed-loop pulsating heat pipe, called ‘evaporator section’, is subjected to heat or high temperature, the working fluid, which is in liquid slug form, will evaporate, expand, and move through the no heat transferring zone, or ‘adiabatic section’, toward a cooler Section, ‘condenser section’ . Then, the vapour plugs will condense, collapse, and release the heat into the environment. Therefore, the vapour plug evaporating in the evaporator section will consequently flow to replace the vapour plug collapsing in the condenser section. Due to this mechanism, the working fluid can circulate and continuously transfer heat in a cycle. The structure of the closed loop pulsating heat pipe is as shown in Figure 1.

Table 1: Compatibility of closed loop pulsating heat pipe material with the working fluid [2]

Working fluid	Compatible Material
Methanol	Stainless Steel, Iron, Copper, Brass, Silica, Nickel
Acetone	Stainless Steel, Copper, Brass, Silica

Table 2: Boiling point and operating ranges of working fluid [2]

Working fluid	Boiling point At 1 atm in K	Temperature ranges in K
Acetone	329.4	273-393
Methanol	337.8	283-403
Ethanol	351.5	273-403



(a) **(b)**

Fig 2: (a) Closed loop heat pipe with acetone as working fluid having inner diameter of 2mm. (b) Experimental setup of closed loop pulsating heat pipe with acetone as working fluid

2. EXPERIMENTATION AND TESTING CLOSED LOOP PULSATING HEAT PIPE WITH ACETONE AS WORKING FLUID

Table 3: Evaporator temperature of closed loop pulsating heat pipe with acetone as working fluid at variable water bath temperature

Water bath temperature $in\ ^0C$	Evaporator Temperature $in\ ^0C$						
	T_1	T_2	T_3	T_4	T_5	T_6	$T_{average}$
38	**31.2**	**31.5**	**31.1**	**31.1**	**31.3**	**31.5**	**31.28**
40	**33.1**	**33.2**	**33.9**	**34.0**	**33.9**	**33.9**	**33.66**
42	**33.7**	**34.4**	**34.7**	**34.8**	**34.6**	**34.7**	**34.48**
44	**34.8**	**34.7**	**34.7**	**34.8**	**34.7**	**34.5**	**34.7**
48	**36.7**	**36.8**	**36.7**	**36.4**	**36.5**	**36.4**	**36.58**
50	**36.5**	**37.1**	**37.0**	**37.1**	**36.9**	**37.0**	**36.93**

52	39	38.9	38.7	38.6	38.7	38.8	38.83
54	38.9	38.9	39.1	39.1	39.3	39.5	39.13
56	40.6	40.5	40.1	40.2	40.3	40.2	40.31
58	41.8	41.4	43.5	42.9	42.1	42.3	42.33
60	46.8	44.3	44.6	45.3	45.5	46.2	45.45
62	47.7	44.6	44.8	49	45.5	45.3	45.46
64	47.5	48.4	48.2	46.8	49	48.5	48.06
65	49.8	50.2	48.8	49.8	50	50.1	49.74
66	51.9	52	50.5	51.2	50.8	50.6	51.16
67	52.9	52.5	52.1	51.6	51.3	51.1	51.91
69	51.1	52	52.0	51.7	51.7	51.9	51.73
70	54	54	54.1	53.6	53.0	52.4	53.51
71	54.2	54.3	54.0	53.7	53.7	53.5	53.9
72	54.9	54.9	54.5	54.0	53.7	53.2	54.2

Table 4: Condenser temperature of closed loop pulsating heat with acetone as working fluid at variable water bath temperature

Water bath temperature $in\,^{0}C$	Condenser Temperature $in\,^{0}C$					
	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	$T_{average}$
38	27.5	27.3	27.5	27.3	27.0	26.9	27.25
40	27.8	27.1	27.6	27.3	27.0	26.7	27.25
42	27.7	27.5	27.5	27.6	27.0	26.9	27.36
44	27.6	27.7	27.7	27.4	27.0	27.0	27.4
48	27.8	27.7	27.8	27.8	27.6	27.3	27.66
50	28.0	27.9	27.9	27.8	27.7	27.5	27.86
52	28.3	28.1	27.9	27.9	27.8	27.7	27.98
54	28.2	28.3	28.5	28.3	28.1	27.4	28.13
56	28.3	28.3	28.3	28.3	28.2	27.9	28.21
58	28.3	28.4	28.5	28.5	28.0	27.5	28.21
60	28.3	28.4	28.5	28.5	28.2	27.9	28.3
62	28.7	28.7	28.6	28.6	28.2	27.5	28.38
64	28.7	28.7	28.8	28.8	28.5	28.2	28.61
65	28.9	28.8	28.9	28.9	28.9	28.7	28.85
66	28.7	28.7	29.0	29.2	29.2	29.2	29.0
67	29.2	29.4	29.5	29.4	29.3	29.0	29.3
69	29.7	29.7	29.7	29.6	29.3	29.0	29.5
70	29.7	29.7	29.9	29.9	29.6	29.6	29.73
71	30.1	30.1	30.1	30.0	30.0	29.6	29.98
72	30.1	30.1	30.3	30.3	30.0	29.6	30.06

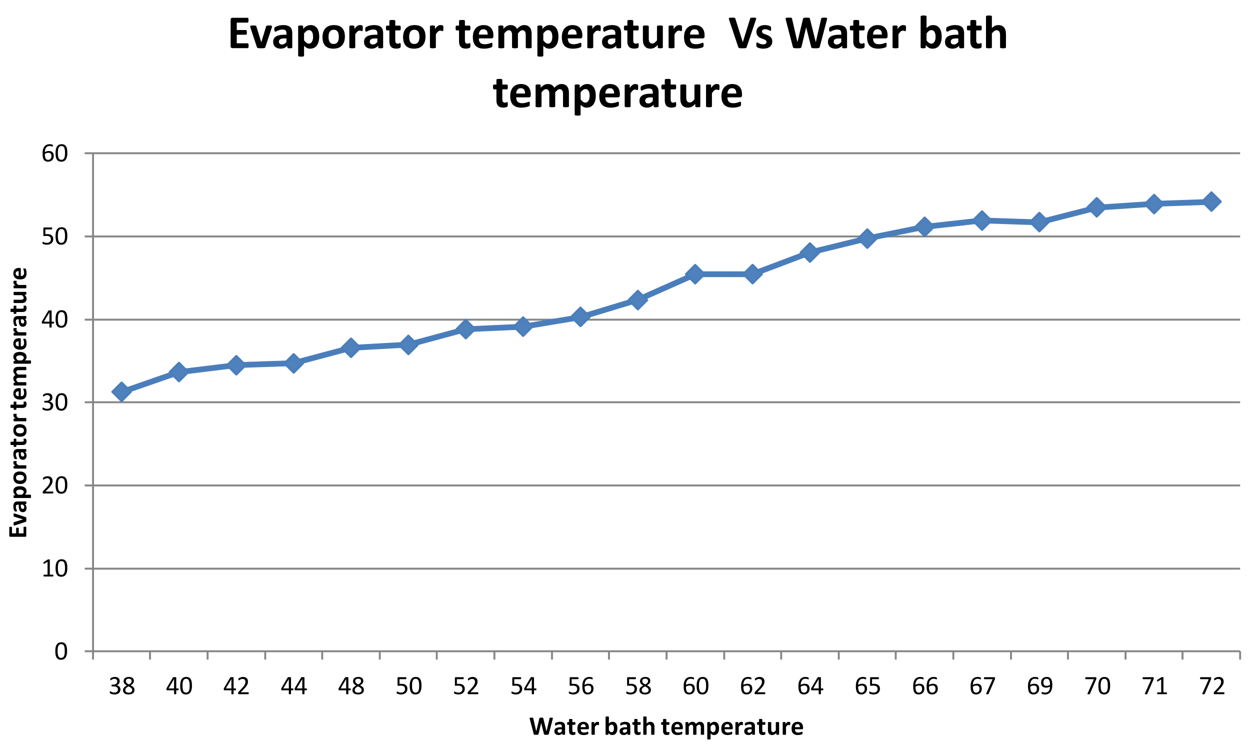


Fig 3: Evaporator temperature of closed loop pulsating heat pipe with acetone as working fluid at variable water bath temperature

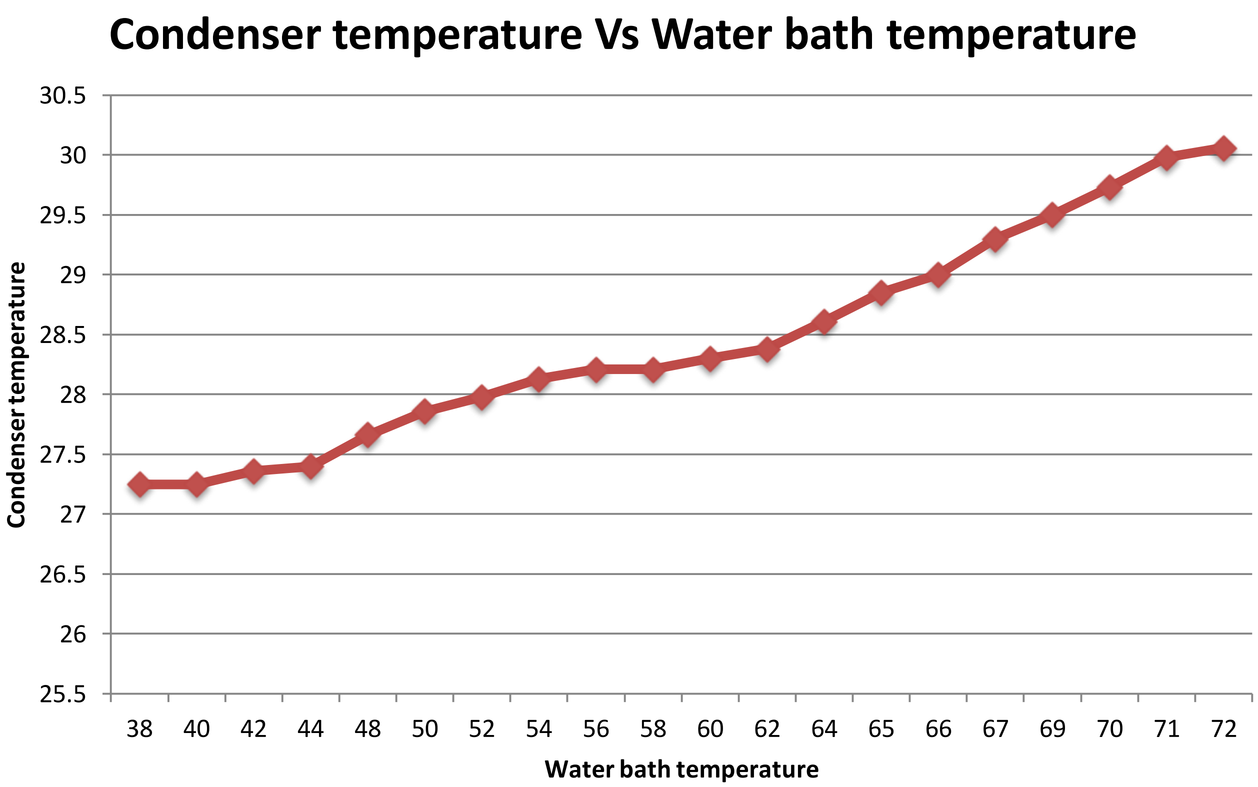


Fig 4: Condenser temperature of closed loop pulsating heat pipe with acetone as working fluid at variable water bath temperature.

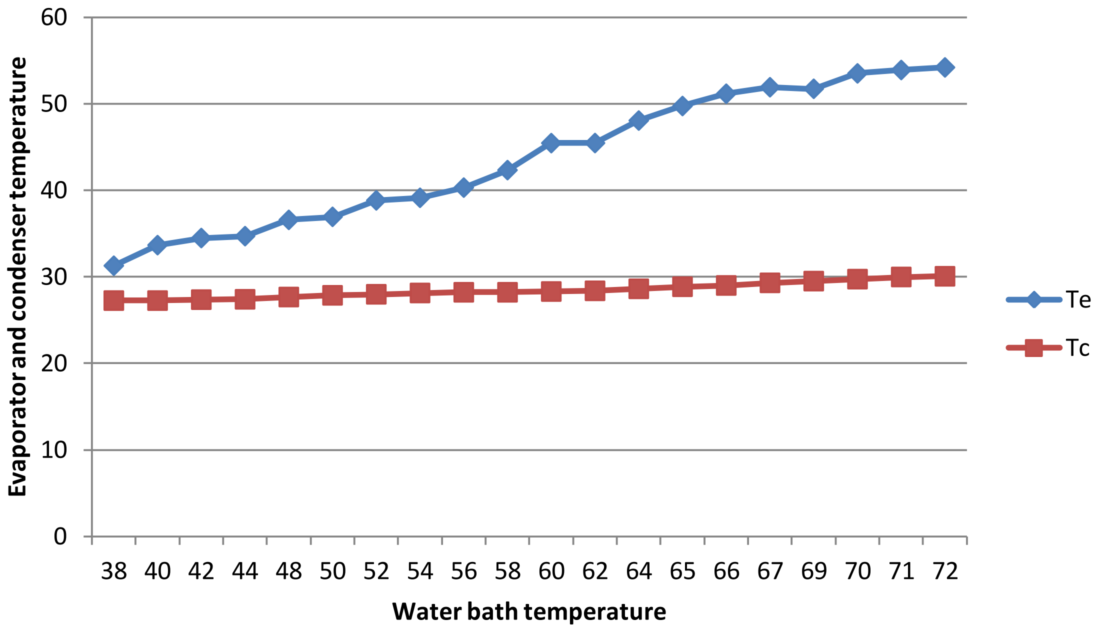


Fig 5: Evaporator and condenser temperature of closed loop pulsating heat pipe with acetone as working fluid at variable water bath temperature

3. CONCLUSION

When the temperature of the water bath increases there is increase in the evaporator and condenser temperature of closed loop pulsating heat pipe with acetone as working fluid the temperature of condenser increases more rapidly when the temperature of water bath increases when the water bath temperature reaches to the boiling point of acetone. As the temperature of water bath increases the thermal resistance of closed loop pulsating heat piped decreases. Saturation temperature of working fluids affect on the temperature difference between evaporator and condenser section and therefore lower saturation temperature working fluids gives better performance.

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