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Comparative Analysis of Rectangular and Triangular Fin in Free and Forced Convection

Saurav kumar[1], Prof. M.K. Singh[2]

[1]M.Tech, Research Scholar, [2]Associate Professor

Department of Mechanical Engineering, BIT Sindri, Dhanbad (India)

ABSTRACT

Extended surfaces commonly known as fins offer an economical and trouble free solutions in many situations demanding heat transfer. Rectangular and Triangular fin have been investigated experimentally and theoretically in free and forced convection to find out temperature and heat transfer coefficient of both fins. Fin effectiveness is useful in order to achieve the high rate of heat transfer of fin material. Heat transfer rate, effectiveness, efficiency and mass of fin are compared under same dimension and equal volume conditions for both fins (Rectangular and triangular fin). Analysis of both fins have been made for heat transfer rate, efficiency and effectiveness. The equation of temperature distribution of Triangular fin is solved using Laplace transformation.

I. INTRODUCTION

Extended surface is known as fin, which is used to enhance rate of heat transfer from a surface or structures. The fin is used where heat transfer coefficient is low. In fin, heat transfer takes place by means of conduction and convection. The major heat transfer to the surface of fin takes place by conduction and by convection heat transfer from the surface of the fin to the surrounding. In current

era heat transfer is very important for any industry; we required better fins, which dissipate more and more heat from the primary surface. Now a day's fins are mostly used in the electronic industry to avoid the damaging effects of burning or overheating like normal computer or laptop used everything can be placed in small space. The design and selection of any particular type of fin is very important in engineering application, we choose those fins which give maximum heat transfer rate and it depends on the shape or geometry of fin and it is less difficult in manufacturing. The fin should be low cost and light weight and volume .Some example of fins is given below which is commonly used Straight fin (Rectangular fin) is a common type of fin which is used in many places because it can be easily manufactured and it is simple in design. The rate of heat transfer from a fin base decreases along the tip of the fin. But on the other hand triangular fin is attractive for an equal heat transfer it takes less volume (fin material) compared to rectangular fin. In parabolic fins heat transfer rate per unit volume slightly greater than triangular fin.

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

II. MATERIALS USED FOR FIN

The materials used for fins should be of high thermal conductivity, light weight and cheap. Silver, Copper and Aluminum have thermal conductivity of 410W/mK, 385W/mK and 225W/mK respectively.Aluminumis selected for fin material because it is of low density, light weight, cheap price and non corrosive type.

III. LITERATURE REVIEW

Kushwaha, A. and Kirar,R.[1] have suggested now a day's we want everything will be compact you cannot install a big heat sink for your device because it increases cost and size of your device.

Bilirgen,H.and Dunbar,S.[2] investigated temperature distribution and heat transfer and The effects of fin spacing, fin height, fin thickness, and fin material for a single row of finned tubes in Cross flow.

Guo,S.and Zhang,J.and Li,G.and Zhou,F.[3] have analyzed for a non linear equation Laplace transformation technique is easy to solving problem than other method.

Mirapalli,S.and Kishore,P.S.[4] Have analyzed for an equal heat transfer triangular fin requires much less volume than rectangular fin.

Jacob,A. and Chandrashekhara,G. and George,J.and George,J.[5] have suggested that triangular fin it requires much less volume (fin material) than a rectangular profile. And for a parabolic profile, heat transfer rate per unit volume

is only slightly greater than that for the triangular profile.

Lee,K.H. and Son,J.W. and Kim,H.I. and In,B.D. [6] have experimentally used rectangular and triangular heat sink attach with thermoelectric generator for generating electricity from exhaust gas of diesel engine and its use in another place where it required.

Pise,T. and Awasarmol,U.A. [7] have used Rectangular fin array compare the natural convection heat transfer at different angles of inclination and its effect on fin performance like heat transfer rate, effectiveness and efficiency.

Kumar,G. and Kamal,R.S.and Dwivedi,A.and Yadav,A.S.and Patel,H .[10] in their article provided experimental investigation to predict the performance of heated triangular fin array within a vertically direction and its effects in brief.

Cuse,E.and Cuse,P.M..[8] investigated in porous fin efficiency reduces and fin effectiveness exponentially decrease compare to Rectangular fin.

Kumar,D.S.(2011), [9] in their book straight triangular fin is of great importance because it yields the maximum heat flow per unit weight of fin.

Rajput,R.[10] In their book fin mostly used when effectiveness of fin must be greater than or equal to 2.

Mahesh,M.M.[11] in their book gave practical applications of rectangular and triangular fins in many places in industry.

Balpande,A.and Bute,j.and Andsable,V.[12] suggest that compact heat sink with less weight, cost and space are required in food processing , chemical industries and refrigeration units. From space restriction on one side and enough space in particular direction triangular fins will be best choice.

Li,B.and Byon,C.[13] investigated in radial heat sink, fin number and fins length on the orientation effect are important, while the fin height and base height are slightly not significant.

IJARSE
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Aziz,A.and Fang,T.[14] Investigated temperature distribution in the fins are provided for rectangular, trapezoidal, and concave parabolic. Results illustrate the relationship between the dimensionless heat flux, the fin parameter, and dimensionless tip temperatures are provided for all three geometries. The results of this paper not only complement the classical results but are more convenient for design purposes under certain cooling circumstances.

Daund,V.S.and Palande,D.D.[15] Investigated in Rectangular fin the effect of fin spacing, fin height, fin length on the performance of heat dissipation from the fin arrays. It is found that convection heat transfer rate depends on fin height and fin length. For a given fin spacing, the convection heat transfer rate from fins increases with fin height and length.

Hossain,Md.and Raiyan,Md.and Sayeed, J.and Ahamed,U.[16] Suggested that Fin performance can be varied under various circumstances like, length of fin profile, coefficient of thermal conductivity, ambient temperature. Different fin

profile needs to be chosen for different purpose.

Raju,G.andPanitapu D.Band Naidu,S.C.V.R.M.[17] have used genetic algorithm for optimal design of I.C engine cylindrical fin arrrays. The fin arrays of

rectangular and triangular fin. The result is shown in terms of aspect ratio, space between fins and maximum heat transfer rate.

III. OBJECTIVES

- To conduct experimental Investigation and analysis of Rectangular and Triangular fin in free convection and forced convection.
- To find the value of heat transfer coefficient of both fins in free and forced convection.
- To compare the heat transfer, mass, efficiency and effectiveness of both fins (Rectangular and Triangular) in same dimension.
- To compare the heat transfer rate, efficiency and effectiveness of both fins (Rectangular and Triangular) for equal volume.

IV. METHODOLOGY

4.1 Specification of Material

ALUMINUM:-

[1] Density = 2.70

[2] Melting Point = 660.32 °C

[3] Non corrosive, Light weight and cheap.

Billet Size:-90mm×90mm×12m

IJARSE
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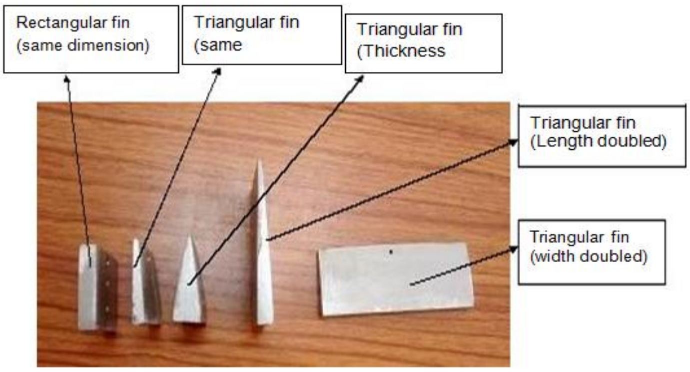


Dimension of fin

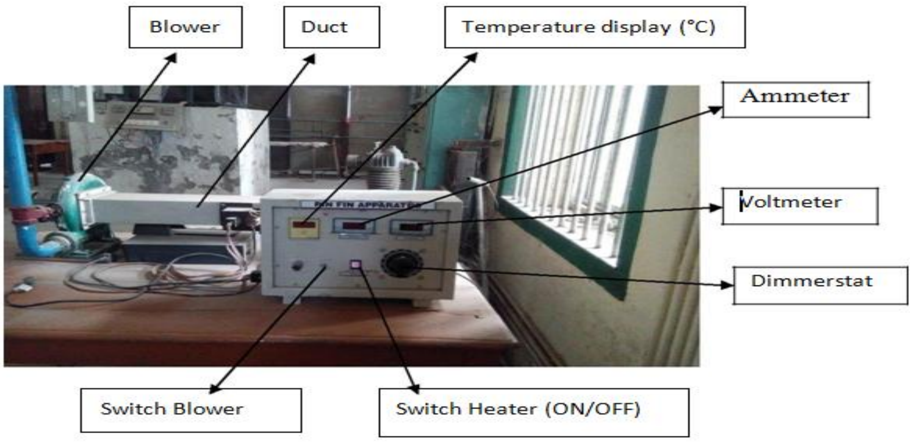
Length of fin (L) = 25mm

Width of fin (w) = 40mm.

Thickness of fin (2δ) = 6mm

- In same dimension take the same values of the dimension of the fin.
- In same or equal volume double one parameter thickness, width and length of Triangular fin. Which was in the same dimension? Then becomes Rectangular and triangular fin in the same volume.

V. APPARATUS DISCRIPTION



VI. EXPERIMENTAL PROCEDURE

To read the variation of temperature along the axial direction at a particular distance to the straight fin (Rectangular and Triangular fin) in both free (natural) and forced convection. At first we have found temperatures at the points on the Rectangular, Triangular fin with the help of thermocouple. We are using copper constraint Thermocouple for measuring temperature. The primary aim of this experimental setup is to analyze the temperature distribution in Rectangular and Triangular fin.

VII. PROCESS

To study the temperature distribution along the length of both fins (Rectangular and Triangular fin) in natural and forced convention.

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

1. Switch on the heater for the heating heater and heater heated aluminium bar. Fin is attached in aluminium bar. Slowly increase values of current and voltage by the dimmerstat and fix a value which needed.

2. Switch off the blower.

3. Measure the temperature at different point with the help of thermocouple and mark down at every 5 minute time interval.

4. When the temperature of fin reached in steady state, record the final reading of 1 to 3 thermocouple, and also measure the reading of fourth thermocouple which shows the ambient temperature reading.

VIII. FORCED CONVECTION

1. Switch on heater for heating purpose and adjust the power by the help of dimmerstat.

2. Switch on of the blower and adjusts the manometer difference with the help of gate valve.

3. Mark down the thermocouple reading 1 to 3 at the five minute of time interval.

4. When fin reached in steady state, then records the final reading of 1 to 3 thermocouple and measure the ambient temperature by the fourth thermocouple.

5. Repeat the same experiment procedure for different profile of fin.

6. Before switch on heater, dimmerstat must be at zero position.

Fig.3.10:-Experiment on Triangular fin (Width is doubled)

Fig.3.11:-Experiment on Triangular fin (Length is doubled)

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

Fig.3.12:-Experiment on Triangular fin (Thickness is doubled)

IX. ASSUMPTIONS

1. Homogeneous and isotropic fin material.
2. Heat transfer coefficient (h) is uniform over the entire fin surface.
3. No heat generation within the fin.
4. Steady state heat dissipation.
5. One dimensional heat conduction exists.
6. Negligible Radiation effect.

X. EXPERIMENTAL OBSERVATION DATA

- Observation table for Rectangular fin Free convection heat supplied at 60 V and 0.212 A.

Time	T_1 (°C)	T_2 (°C)	T_3 (°C)	T_0 (°C)
0	30.4	30.4	30.4	30.4
5	45.9	44.6	43.2	30.6
10	53.2	51.7	50.4	30.7
15	62.1	60.6	58.9	30.8
20	68.1	66.1	65.2	31
25	74.2	72.4	71.5	31.2
30	78.7	76.6	75	31.4
35	82.7	80.2	79.3	31.5
40	85.1	82.6	81.5	31.7
45	86.5	84.1	83.2	31.8
50	87.8	85	83.9	31.8
55	89.4	86.7	85.1	31.9
60	90.1	87.8	86.8	32
65	90.6	88.1	87	32.2
70	91.1	88.4	87.2	32.3

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

75	91.7	88.9	87.4	32.5
80	92.4	91.2	90.5	32.4
85	92.8	91.7	90.9	32.6
90	93.3	92.1	91.3	33.1

- Forced convection heat supplied at 60 V and 0.212 A. Vm = 1.8 m/s (measured by anemometer)

Time	T_1 (°C)	T_2 (°C)	T_3 (°C)	T_0 (°C)
0	30.9	30.9	30.9	30.9
5	35.3	34.1	33.4	31.1
10	39.6	38.9	37.6	31.4
15	42.9	41.7	40.1	31.6
20	45.7	44.6	43	31.7
25	48.5	47.8	46.6	32
30	49.7	48.6	47.7	32.2
35	51.1	50.5	49.8	32.4
40	51.5	50.9	50.1	32.5
45	52.1	51.4	50.6	32.7
50	52.5	51.8	51	32.9
55	52.8	52.1	51.4	33.1
60	53.1	52.3	51.8	33.4
65	53.5	52.5	52.1	33.5
70	53.8	52.8	52.5	33.6
75	54.1	53.1	52.8	33.8
80	54.5	53.6	53.3	34
85	54.9	54.2	53.8	34.1
90	55.4	54.9	54.4	34.3

- Observation table for Triangular fins. Free Convection heat supplied at 60 V and 0.212 A.

Time	T_1 (°C)	T_2 (°C)	T_3 (°C)	T_0 (°C)
0	29.2	29.2	29.2	29.2
5	40.4	39.7	39.1	29.4
10	48.1	47	45.8	29.5
15	61.4	60	58.8	29.6
20	66.6	65.4	63.9	29.7
25	71.8	70.2	69.1	29.9

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

30	77.1	75.3	74.8	30.1
35	80.8	79.3	78	30.2
40	83	81.8	80.6	30.3
45	85.3	83.4	82.1	30.2
50	87.5	86.2	85	30.3
60	89.6	87.8	86.8	30.4
65	90.7	89.6	88.4	30.6
70	91.8	90.3	89.6	30.7
75	92	91.2	90.1	30.9
80	92.8	91.9	90.8	31
85	93.8	92.6	91.7	31.3
90	94.2	93.5	92.4	31.5

- Forced convection heat supplied at 60 V and 0.212 A. Vm = 1.8 m/s (measured by anemometer)

Time	T_1 (°C)	T_2 (°C)	T_3 (°C)	T_0 (°C)
0	31.6	31.6	31.6	31.6
5	35.4	34.6	33.5	31.7
10	39.6	38.3	37.5	31.9
15	42.5	41.3	40.6	32
20	45.8	44.5	43.8	32.2
25	47.3	46.7	45.8	32.4
30	49.4	48.6	47.5	32.5
35	50.6	49.8	48.8	32.6
40	51.4	50.6	49.6	32.8
45	51.8	50.7	50.2	32.8
50	52	51.4	50.7	32.9
55	52.4	51.7	51	33.1
60	52.9	51.9	51.3	33.5
65	53.2	52.2	51.5	33.6
70	53.6	52.6	52.1	33.8
75	54.4	53.4	52.6	34.1
80	55	54.5	53.7	34
85	55.7	55	54.1	34.2
90	56.4	55.8	54.9	

- free convection heat supplied at 60 V and 0.212 A. When thickness is doubled.

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

Time (minutes)	T_1 (°C)	T_2 (°C)	T_3 (°C)	T_0 (°C)
0	31.2	31.2	31.2	31.2
5	44.6	39.8	39.1	31.3
10	50.6	49.8	49	31.5
15	61.5	61.1	60.1	31.9
20	68.1	67.7	66.6	32
25	70.8	69.9	69.1	32.1
30	75.5	75.3	73.8	32.1
35	78.1	77.5	76.1	32.4
40	80.1	79.3	78.6	32.5
45	82.8	82.6	81.2	32.8
50	83.6	83.2	82.5	33
55	84.8	84	83.6	33.3
60	86.6	86.1	85.8	33.5
65	87.5	87.2	86	33.7
70	88.1	87.5	87.3	33.8
75	88.8	89.1	88.1	34
80	89.4	89.1	88.8	34.1
85	90.1	89.7	88.5	34.4
90	90.7	90.5	89.2	34.6

- Forced convection heat supplied at 60 V and 0.212 A. When thickness is doubled Vm = 1.8 m/s (measured by anemometer)

Time (minutes)	T_1 (°C)	T_2 (°C)	T_3 (°C)	T_0 (°C)
0	32.8	32.8	32.8	32.8
5	35.6	35.5	34	32.9
10	40.5	40.3	37.5	33.1
15	44.9	44.6	33.4	33.4
20	48.7	48.4	33.5	33.5
25	50.4	50.1	33.6	33.6
30	52.4	52	33.7	33.7
35	53.7	53.4	33.9	33.9
40	55.3	54.9	34	34
45	54.9	54.5	34.2	34.2
50	55.8	55.4	34.3	34.3

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

55	56.6	56.2	34.4	34.4
60	56.9	56.7	34.6	34.6
65	57.6	57.2	34.7	34.7
70	57.8	57.4	34.9	34.9
75	58.4	58	35	35
80	58.4	58.1	35.1	35.1
85	58.9	58.3	35.3	35.3
90	59	58.5	35.5	35.5

- free convection heat supplied at 60 V and 0.212 A. when width is doubled

Time (minutes)	T_1 (°C)	T_2 (°C)	T_3 (°C)	T_0 (°C)
0	29.4	29.4	29.4	29.4
5	37.7	37.5	37.4	29.5
10	47.5	47.1	47	29.5
15	56.5	56.3	56.2	29.6
20	62.5	62.4	62.2	29.7
25	67.8	67.7	67.6	29.7
30	71.6	71.5	71.3	29.8
35	74.5	74.4	74.1	29.9
40	77.8	77.5	77.4	30
45	79.4	79	78.9	30.2
50	81.8	81.4	81.2	30.3
55	82.6	82.3	82.1	30.3
60	84.2	83.7	83.6	30.4
65	85.1	84.5	84.4	30.5
70	85.6	85.2	84.9	30.6
75	86.2	85.7	85.5	30.8
80	86.7	86.3	86.2	30.9
85	87.1	86.8	86.4	30.9
90	87.3	86.6	86.5	31

- Forced convection heat supplied at 60 V and 0.212 A. When width is doubled

  Vm = 1.8 m/s (measured by anemometer)

Time (minutes)	T_1 (°C)	T_2 (°C)	T_3 (°C)	T_0 (°C)
0	33.4	33.4	33.4	33.4
5	36.4	36.2	36.1	33.6

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

10	41.7	41.6	41.4	33.7
15	45.4	45.2	44.9	33.9
20	48.3	48.2	47.7	34
25	50.2	50	49.7	34.1
30	51.4	51.3	51.1	34.4
35	52.8	52.4	52.2	34.4
40	53.3	53.1	52.7	34.6
45	54.1	53.8	53.4	34.8
50	54.6	54.2	54	34.9
55	54.9	54.6	54.2	35
60	55.4	55.2	54.7	35.2
65	55.7	55.4	55.1	35.4
70	55.9	55.8	55.5	35.5
75	56.3	56	55.9	35.7
80	56.5	56.2	56.1	35.8
85	56.8	56.4	56.3	35.9
90	57.1	56.9	56.7	36.1

- free convection heat supplied at 60 V and 0.212 A. when length is doubled

Time (minutes)	T_1 (°C)	T_2 (°C)	T_3 (°C)	T_0 (°C)
0	27.6	27.6	27.6	27.6
5	39.2	38.9	38.6	27.7
10	49.8	49.6	49.4	27.7
15	57.7	57.6	57.5	27.9
20	64.7	64.5	64.3	28.1
25	69.6	69.4	69.3	28.2
30	74.1	73.9	73.8	28.5
35	76.7	76.6	76.4	29.7
40	79.4	79.1	79	28.9
45	81	80.8	80.7	29
50	82.9	82.8	82.7	29.2
55	83.6	83.5	83.4	29.3
60	84.8	84.7	84.7	29.4
65	85.7	85.5	85.4	29.6
70	86.4	86.3	83.1	29.7
75	86.9	86.8	86.6	29.8
80	87.5	87.4	87.2	30

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

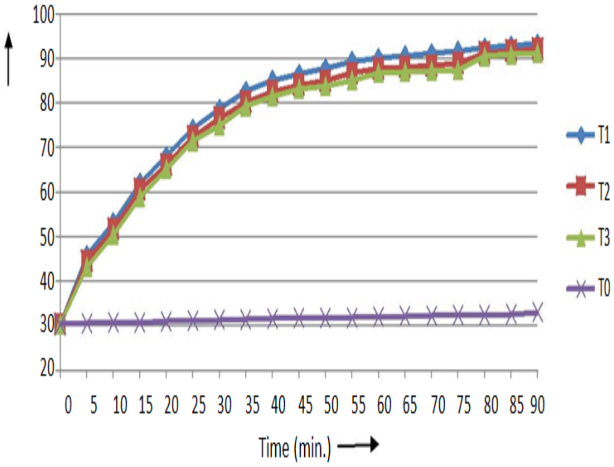
85	87.9	87.8	87.5	30.1
90	88.1	87.9	87.8	30.1

- Forced convection heat supplied at 60 V and 0.212 A. When length is doubled

  Vm = 1.8 m/s (measured by anemometer)

Time (minutes)	T_1 (°C)	T_2 (°C)	T_3 (°C)	T_0 (°C)
0	29.5	29.5	29.5	29.5
5	35	34.8	34.7	29.7
10	39.1	38.8	36.6	29.8
15	42.1	41.7	41.6	30
20	43.9	43.6	43.5	30.3
25	45.5	45.3	45.1	30.3
30	46.6	46.2	42.1	30.5
35	47.7	47.4	47.1	30.6
40	48.5	47.8	47.7	30.7
45	48.4	47.9	47.5	30.8
50	48.7	48.1	48	30.9
55	49	48.4	48.3	31.0
60	49.2	48.7	48.6	31.2
65	49.5	49	48.9	31.3
70	49.6	49.2	49	31.5
75	49.8	49.5	49.3	31.6
80	49.7	49.3	49.1	31.8
85	50.2	49.7	49.6	31.8
90	50.4	49.8	49.7	32

- Temperature Variation with time of Rectangular fin at 60V and 0.212A for Free Convection.



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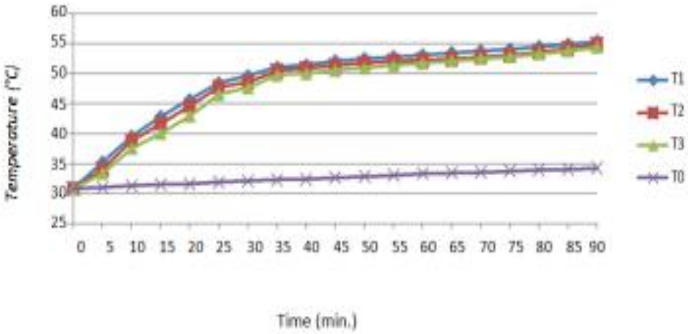
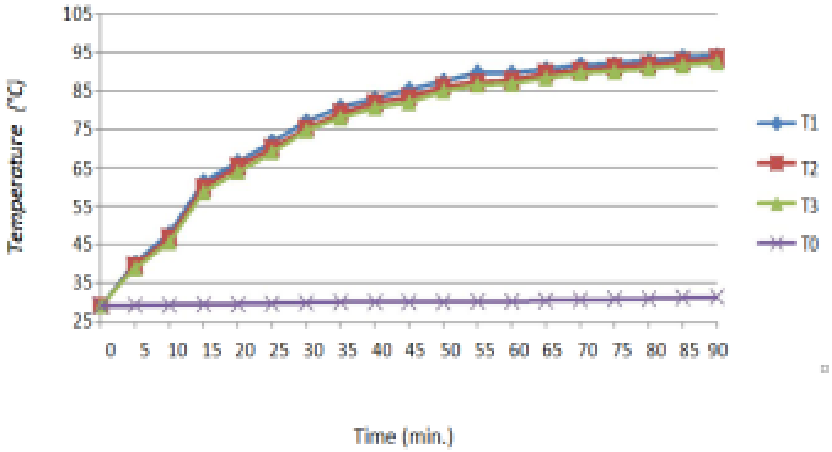
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

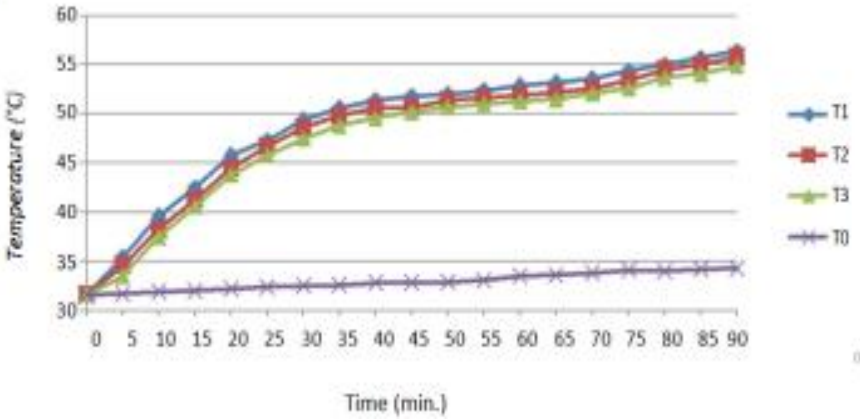
- Temperature Variation with time of Rectangular fin at 60V and 0.212A for Forced Convection



- Temperature Variation with time of Triangular fin at 60V and 0.212A for Free Convection.

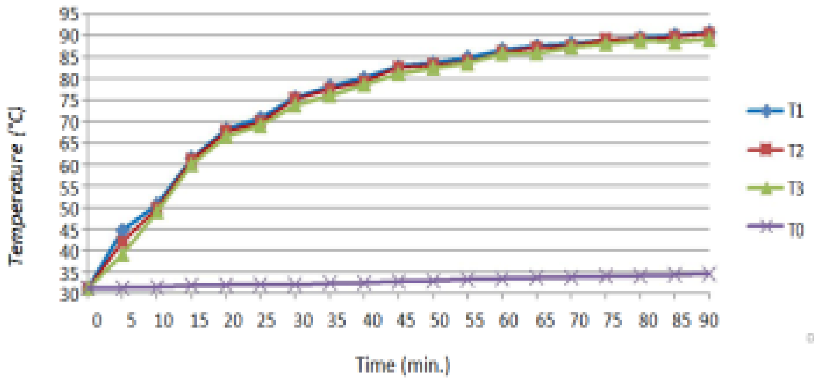


- Temperature Variation with time of Triangular fin at 60V and 0.212A for Forced Convection.

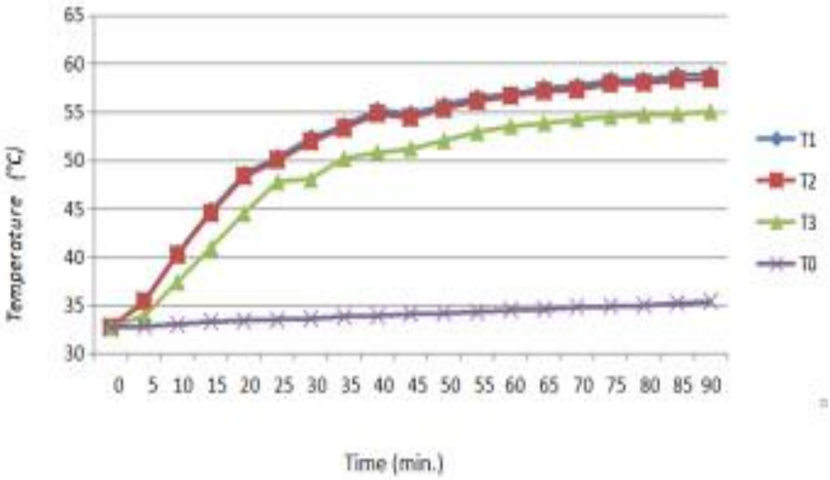


- Temperature Variation with time of Triangular fin (Thickness is doubled) at 60V and 0.212A for Free Convection.

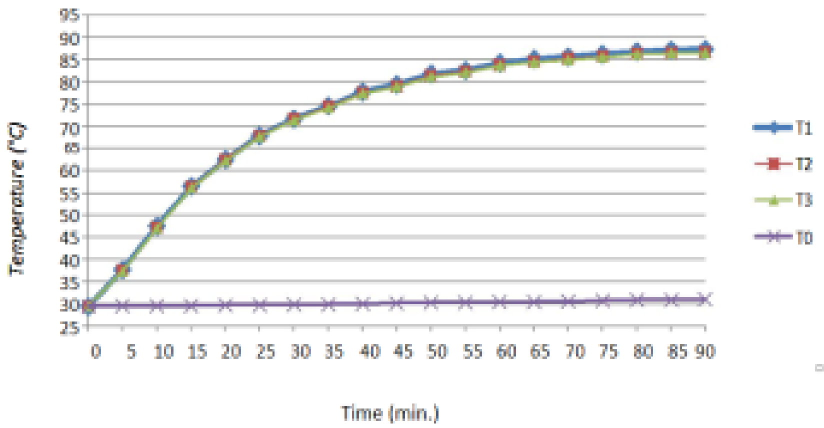
IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346



➢ Temperature Variation with time of Triangular fin (Thickness is doubled) at 60V and 0.212A for Forced Convection.



➢ Temperature Variation with time of Triangular fin (width is doubled) at 60V and 0.212A for Free Convection.



➢ Temperature Variation with time of Triangular fin (width is doubled) at 60V and 0.212A for Forced Convection.

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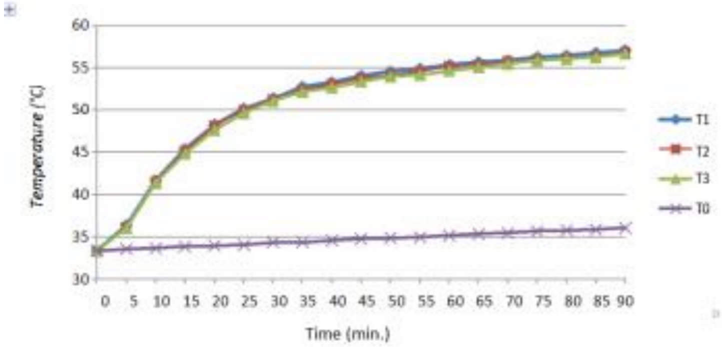
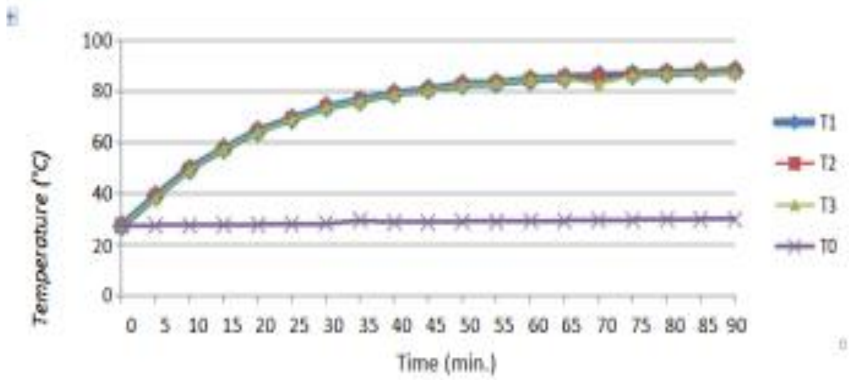
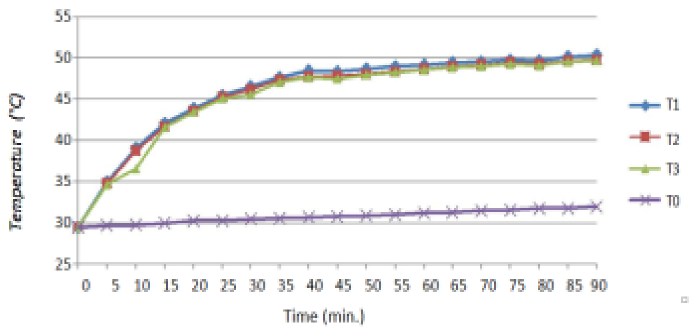


➢ Temperature Variation with time of Triangular fin (Length is doubled) at 60V and 0.212A for Free Convection.



➢ Temperature Variation with time of Triangular fin (Length is doubled) at 60V and 0.212A for Forced Convection.



XI. RESULT

Free convection experimental result

Profile	h (w/m^2k)	Q(w)	ε	η (%)	Mass(gm)	w/gm
Rectangular Fin	10.22	1.50	10.38	98.09	16.2	0.092
Triangular Fin	10.08	1.23	8.28	92.09	8.1	0.148
Triangular Fin(Thickness Doubled)	10.05	1.11	4.14	86.47	16.2	0.068

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Triangular Fin(Width Doubled)	10.07	2.22	8.24	95.7	16.2	0.137
Triangular Fin(Length Doubled)	8.5	1.92	16.3	90.8	16.2	0.118

Forced convection experimental result

Profile	h w) m^2k	Q(w)	ε	η (%)	Mass(gm)	w/gm
Rectangular Fin	26.04	1.29	10.37	98	16.2	0.079
Triangular Fin	26.12	1.12	8.37	93.43	8.1	0.138
Triangular Fin(Thickness Doubled)	25.78	1.10	4.08	85.20	16.2	0.067
Triangular Fin(Width Doubled)	18.47	1.51	8.19	94.7	16.2	0.093
Triangular Fin(Length Doubled)	26.08	1.95	17.37	97	16.2	0.120

XII. CONCLUSION

Free convection

- After experiment we see in free convection heat transfer coefficient is nearly same as Triangular fin but Heat transfer rate, Effectiveness and efficiency as 18%, 20.23% and 6.1% less as respectively to Rectangular fin for in same basic dimensions.
- Mass of rectangular fin is 50% greater used than triangular fin for same basic dimensions.
- For equal volume, triangular fin has got 48% and 28% more heat transfer rate than rectangular fin when width & length of triangular fin respectively are doubled. Similarly for equal volume when the thickness of triangular fin is doubled, the heat transfer rate is decreased by 26%.
- Efficiency is less as compared to Rectangular fin in all dimensions by 11.84%, 2.77% and7.3% when thickness, width and length of triangular fin is doubled.
- Most importantly, effectiveness of triangular is increased by 59.24% only when Length of fin is doubled and decreased by 60.11% and 20.61% when thickness and width are doubled of triangular fin.

Forced convection

- After experiment we see in forced convection heat transfer coefficient is nearly same as Triangular fin but Heat transfer rate, Effectiveness and efficiency are 13.17%, 19.28% and 4.66% less as respectively to Rectangular fin for in same dimensions.
- Mass of rectangular fin is 50% greater used than triangular fin for same basic dimensions.
- For equal volume, triangular fin has got 17.05% and 51.06% more heat transfer rate than rectangular fin when width & length of triangular fin respectively are doubled. Similarly for equal volume when the thickness of triangular fin is doubled, the heat transfer rate is decreased by 14.17%.
- Efficiency is less as compared to Rectangular fin in all dimensions by 13.06%, 3.36% and 1.05 % when thickness, width and length of triangular fin are doubled.
- Most importantly, effectiveness of triangular is increased by 67.50% only when Length of fin is doubled and decreased by 60.65% and 21.02% when thickness and width are doubled of triangular fin.

XIII. SCOPE FOR FUTURE WORK

In this project work we calculated the values of heat transfer rate, effectiveness and efficiency of rectangular and triangular fin in same dimension and same volume by experimental data.

1. Different profiles of fins are used and compare the different fin parameters in same volume.
2. Different type of fin materials can be used for increase fin properties.
3. Use optimization technique to optimize best shape of fin which gives maximum heat transfer rate, effectiveness and efficiency.

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