

# Experimental Investigation of Heat Transfer Analysis through Fins of Different Materials and Geometries

Dr.Umakant V. Kongre<sup>1</sup>, Mayur P.Lukka<sup>2</sup>, Shubham V. Daryapurkar<sup>3</sup>

Associate Professor, Department of Mechanical Engineering, Jawaharlal Darda Institute of Engg. &Tech, Yavatmal, Maharashtra, India<sup>1</sup>

U.G. Student, Department of Mechanical Engineering, Jawaharlal Darda Institute of Engg. &Tech, Yavatmal, Maharashtra, India<sup>2</sup>

U.G. Student, Department of Mechanical Engineering, Jawaharlal Darda Institute of Engg. &Tech, Yavatmal, Maharashtra, India<sup>3</sup>

**ABSTRACT:** An experimental analysis is carried out for knowing the optimum heat transfer from the fin. In this work the rectangular duct with heated fins placed inside it is used to understand the heat transfer by natural and forced convection which enable to provide respective pattern of flow carries heat through convection. Also the rate of heat transfer depends on the flow velocity, area of exposure and other parameters. Different profiled objects may give different rate of heat transfer. Hence the objects like pin fin with enhanced surface areas placed inside the duct to find the heat transfer rate. In this experimental paper, design and methodology are summarized and explained. Also, different characteristics like rate of heat transfer, mass flow rate, inside velocity, pressure and other associated parameters are studied and explained.

**KEYWORDS:** Fluid Flow, Heat Transfer Rate, Pin Fin, Mass flow rate.

## I. INTRODUCTION

In view to enhance optimum heat transfer rate certain measures required to understand the characteristics of material and type of mode of heat transfer. Heating of components in different engineering applications is a challenge to increase the efficiency and life cycle. Also, optimum heat transfer from heated surfaces, reducing cost and material weight has turned into major challenge for heat transfer. Pin fins are broadly utilized as a part of heat exchanging body which result in enhancing the heat exchange between the surface of the body and ambient fluid by doing thermal analysis on the fins, it is helpful to know the heat dissipation. A fin is a surface that extends from an object to increase the rate of heat transfer to or from the environment by increasing convection. It is well known fact that by increasing the surface area of pin configuration we can increase the heat dissipation rate of this process. By knowing the mode of heat transfer and its influence through principle of conduction, convection, radiation which determines the amount of heat transfer increasing the temperature difference between the fin configurations. Therefore the effectiveness of fin is very essential characteristic for design and optimum heat transfer in a component. Pin fin is majorly used for heat transfer results in the heat exchange between the surface of the body and the fluid flow through it. There are various types of fins for a heat transfer. In this work we manufactured pin fin of various geometry and materials like, copper fin of circular slotted shape, aluminium fin of rectangular bar shape, composite fin of aluminium and copper. In this work the stress is given on free and forced convection.

## II. EXPERIMENTAL SETUP



Fig 1: Pin Fin Apparatus

### A. APPARATUS

A fin of different cross sections is fitted across a long rectangular duct the other end of duct is connected to the suction side of blower and the air flow pass the fin perpendicular to the axis. One end of the fin projects outside the duct and is heated by the heater. Temperature measuring thermocouples are attached equidistance at five points along the length of fins. The air flow rate is measured by an orifice meter fitted on the delivery side of blower.

### B. SPECIFICATIONS

- Fins: 20 mm diameter with 150 mm length and 6 thermocouples along the length.
- Rectangular Duct: 150 mm\*100 mm cross-section area with 1000 mm length one side of which is connected to blower.
- Centrifugal blower is used to supply forced air.
- Multichannel digital indicator 0-300 C
- Dimmer-stat 2 Amp, 240 Volt, for heater input control.
- Voltmeter 0-250 Volts.
- Ammeter 0-2 Amp.
- Orifice-meter with water manometer.

## III. EXPERIMENTAL PROCEDURE

### A. NATURAL CONVECTION

- Start heating the fin by switching ON the heater element and adjust the voltage on dimmer-stat from 0 to 100 V.
- See that this input remains constant throughout the experiment.
- When steady state is reached, record the final readings (1) to (5) and also record the ambient temperature reading.
- Note down readings in the observation table.

### B. FORCED CONVECTION

- Start heating the fin by switching ON the heater element and adjust the voltage on dimmer-stat from 0 to 100 V.
- See that this input remains constant throughout the experiment.
- Start the blower and adjust the difference of level in the manometer with the help of gate valve.



- When steady state is reached, record the final readings (1) to (5) and also record the ambient temperature reading.
- Note down readings in the observation table

IV. CALCULATIONS

A. ALUMINIUM

Observation:

- Voltmeter reading(V) = 100 volts
- Ammeter reading(I) = 0.5Amp
- Heater input(VI) = 50 watts
- Manometer reading( $h_2-h_1$ ) =  $1.6 \times 10^{-2}$ m  
{Where,  $h_2= 7.0$ cm,  $h_1=5.6$ cm}

Tabular column:

- For natural convection,

Thermocouple No.	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>
emp. °C	121	119	118	118	118	36

- For forced convection

Thermocouple No.	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>
Temp. °C	111	107	106	106	102	36

B. COPPER

Observation:

- Voltmeter reading(V) = 100 volts
- Ammeter reading(I) = 0.5Amp
- Heater input(VI) = 50 watts
- Manometer reading( $h_2-h_1$ ) =  $1.8 \times 10^{-2}$ m  
{Where,  $h_2= 7.1$ cm,  $h_1=5.3$ cm}

Tabular column:

For natural convection,

Thermocouple No.	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>
Temp. °C	116	115	114	114	109	36

For forced convection

Thermocouple No.	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>
Temp. °C	108	100	95	89	83	36



**C. COMPOSITE FIN**

**Observation:**

- Voltmeter reading(V) = 100 volts
- Ammeter reading(I) = 0.5Amp
- Heater input(VI) = 50 watts
- Manometer reading( $h_2-h_1$ ) =  $1.5 \times 10^{-2}$  m  
 {Where,  $h_2= 6.8$ cm,  $h_1=5.3$ cm}

**Tabular column:**

For natural convection,

Thermocouple No.	<b>T<sub>1</sub></b>	<b>T<sub>2</sub></b>	<b>T<sub>3</sub></b>	<b>T<sub>4</sub></b>	<b>T<sub>5</sub></b>	<b>T<sub>6</sub></b>
Temp. °C	113	110	109	109	102	36

For forced convection,

Thermocouple No.	<b>T<sub>1</sub></b>	<b>T<sub>2</sub></b>	<b>T<sub>3</sub></b>	<b>T<sub>4</sub></b>	<b>T<sub>5</sub></b>	<b>T<sub>6</sub></b>
Temp. °C	111	109	100	97	80	36

**V. RESULTS COMPARIISON**

**FOR NATURAL CONVECTION**

Sr.no.	Parameters	Aluminium	Copper	Composite
1.	Average fin temp.in K ( $T_m$ )	391.8 K	386.6 K	381.6 K
2.	Mean fin temp.in K ( $T_{mf}$ )	350.4 K	347.8 K	345.3 K
3.	Duct temp.in K ( $T_f$ )	309 K	309 K	309 K
4.	Temp. diff.in ( $\Delta T$ )	82.8 K	77.6 K	72.6 K
5.	Coefficient of thermal exp.( $\beta$ )	$2.853 \times 10^{-3}$	$2.853 \times 10^{-3}$	$2.896 \times 10^{-3}$
6.	Grashof no.( $G_r$ )	18502.42	41420.21	39034
7.	Prandtl no. ( $P_r$ )	0.696	0.696	0.696
8.	Actual discharge in $m^3/s$ (Q)	$1.588 \times 10^{-3}$	$1.685 \times 10^{-3}$	$1.53 \times 10^{-3}$
9.	Velocity of air $m/s$ (V)	0.105	0.112	0.102
10	Reynolds no( $R_e$ )	92.46	131.5	119.76
11	Nussle's no. ( $N_u$ )	5.325	6.091	6.031
12	Coefficient of heat transfer in $w/m^2K$ (h)	$7.99 \times 10^{-3}$	$8.31 \times 10^{-3}$	$8.25 \times 10^{-3}$
13	Heat transfer rate in W (Q)	272.79	279.20	276.35
14	Fin parameter (m)	0.0903	0.0207	0.074
15	Effectiveness of fin,( $\epsilon$ )	0.9999575329	0.9999647683	0.9999614801

## FOR FORCED CONVECTION

Sr.no.	Parameters	Aluminium	Copper	Composite
1.	Average fin temp.in K ( $T_m$ )	379.4 K	367.6 K	372.4 K
2.	Mean fin temp.in K ( $T_{mf}$ )	344.2 K	338.3 K	340.7 K
3.	Duct temp.in K ( $T_f$ )	309 K	309 K	309 K
4.	Temp. diff.in ( $\Delta T$ )	70.4 K	58.6 K	63.4 K
5.	Coefficient of thermal exp.( $\beta$ )	$2.905 \times 10^{-3}$	$2.995 \times 10^{-3}$	$2.935 \times 10^{-3}$
6.	Grashof no.( $G_r$ )	17012.79	38315.7	40623.72
7.	Prandtl no. ( $P_r$ )	0.717	0.720	0.720
8.	Actual discharge in $m^3/s$ (Q)	$1.588 \times 10^{-3}$	$1.685 \times 10^{-3}$	$1.53 \times 10^{-3}$
9.	Velocity of air $m/s$ (V)	0.105	0.112	0.102
10	Reynolds no( $R_e$ )	95.28	142.59	129.86
11	Nussle's no. ( $N_u$ )	5.141	6.204	5.939
12	Coefficient of heat transfer in $w/m^2K$ (h)	$9.874 \times 10^{-3}$	$9.933 \times 10^{-3}$	$9089 \times 10^{-3}$
13	Heat transfer rate in W (Q)	291.94	304.32	300.34
14	Fin parameter (m)	0.10	0.0718	0.0818
15	Effectiveness of fin,( $\epsilon$ )	0.9999679199	0.9999737456	0.9999691512

## VI. CONCLUSION

In this study, the overall heat transfer, friction factor and the effect of the various design parameters on the heat transfer and friction factor for the heat experiment equipped with cylindrical cross-sectional perforated pin fins were investigated experimentally. The effects of the flow and geometrical parameters on the heat transfer and friction characteristics were determined and the enhancement efficiency correlations have been obtained.

Three case studies were performed, the temperature profile of different fins as a function of length for different materials, and the effect of thickness on the proper length of the fin and the heat transfer rate for copper and aluminium. The best working material was copper with the highest thermal conductivity (395W/mo.). Low thickness involves low temperature in the extreme of the fin resulting in a low heat transfer in that zone. Between copper and aluminium, the best material for the same thickness is aluminium because it has the shortest proper length. Though, it is necessary to see the amount of heat removed. Aluminium removes less heat than copper. The composite fin gives result in between two.

- Heat Transfer rate is directly proportional to the surface fin area, flow velocity and room temperature.
- Heat Dissipation accurse along the flow through duct.

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