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Evaluation of Effectiveness and Efficiency of Cylindrical Fin for Different Material

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Abstract-Fin is an extended surface used to transfer of heat by increasing heat transfer area. The experimental investigation has been carried out for the thermal performance of pin fin. The main aim of this paper is to choose the most effective fin from a number of available fins of different materials and geometries. Here available materials are Copper, Aluminum, Brass, Mild Steel and selected geometrical shape of fin is solid cylindrical, our system follows forced convection .Taken different trial for varying Reynolds number and results has been found for each fin. Due to varying Reynolds number the Nusselt number and convective heat transfer co-efficient also varying. The evaluation and comparative analysis has been done experimentally and theoretically using force convection for each fin of different materials. Heat transfer rate, effectiveness, efficiency and weight of fin compared under equal volume condition for all fins. Fin effectiveness is useful in order to achieve high rate of heat transfer of fin material.

Keywords —Efficiency, Effectiveness, Reynold's number,Nusselt's number, prandtl's number, Force cunvecton.

I. INTRODUCTION

An expose surface (also known as a combined conduction-convection system or a fin) is a solid within which heat transfer by conduction is assumed to be one dimensional, while heat is also transferred by convection from the surface in a direction transverse to that of conduction. Fins are used where heat transfer coefficient is low and to increase the heat transfer rate by increasing surface area. To the best knowledge of the fin, fins as passive elements for enhancing heat transfer rates surface to the surrounding fluid.The use of fin are seen at different places such as in electronic industries, thermal storage heat exchanger. It is also attached with engine body, with transformer body, with condenser. The use of fin are depending their size, shape and materials.

Fins are classified according to the following criteria:

1Geometrical shape of the fin.

2 Fin arrangement.

3 Location of fin base with respect to the solid boundary.

4 Composition of the fin

5 Fin interacted with a number of heat source

Different modes of heat transfer

(i).Conduction

(ii).Convection

(iii).Radiation

Conduction:

Conduction is the mode of heat transfer in which heat is transferred within solid body due to direct collision caused by lattice vibration. These solid body must have physical contact. The conduction heat transfer rate is given by Fourier's law.

According to this law,

Qconduction= -KAcs$\frac{T_h - T_c}{d}$

Convection:

When a solid surface is surrounded by fluid at different temperature, then the heat transfer between surface and fluid is by convection. In convection heat transfer fluid particle is heated and then travels carries with thermal energy. There are two type of convection heat transfer, force convection and free convection The equation for convection rate is

Qconvection =hA(Ts-Tf)

Radiation:

Radiation is a mode of heat transfer for which there is no need of medium for transfer heat from one place to another place. It is generally neglected in fin problem. According to Stefan- Boltzmann law

Qradiation = σ A ($T_1^4 - T_2^4$)

Fin efficiency : It is defined as the ratio of rate of actual heat transfer from the fin to the rate of maximum heat transfer from fin which is entire fin was at base temperature.

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$\eta_{fin} = \frac{Q_{fin}}{Q_{fin.max}} = \frac{actual\ heat\ transfer\ rate\ from\ fin}{ideal\ heat\ transfer\ rate\ from\ fin}$

Fin effectiveness : It is the ratio of heat transfer rate with fin to the heat transfer rate without fin means where fin is not attached with structure.

$\varepsilon_{fin} = \frac{Q_{with\ fin}}{Q_{without\ fin}}$

II. FABRICATION OF EXPERIMENTAL SETUP

Specification

Duct size	200mmX150mm
Length of duct	900mm
Blower	0.32HP
Number of thermocouple	4-5
Temperature indicator	Digital 0-300°C
Dimmerstat input	3.7A, 32V
Heater	300W Band type
Voltameter	0-200V
Ammeter	0-20A

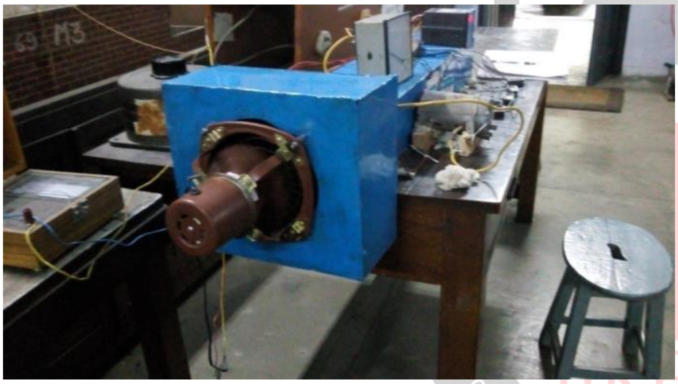


Fig01:Force convection Experimental setup

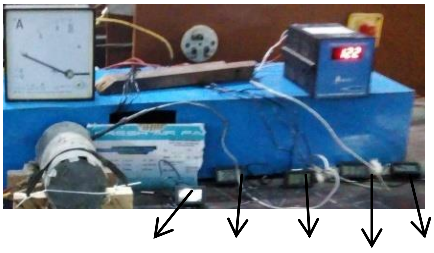
The experimental setup is used for analyzed the effectiveness and efficiency of fin of different materials. The component of experimental setup are duct, blower, ammeter voltameter, dimmerstat,band, heater ,thermocouples, anemometer, and fin of different materials etc.

A. Setting of fin

Fig02: Setting of fin with band heater

This fig shown thathow the fin is attached with band heater, there are four places on fin at which there are fuor thermocouple are attached .There is a small hole shown in duct, the fin is enter through this small hole.

B.Temperature distribution on fin profile



T_a T_1 T_2 T_3 T_4

Fig03Temperature distribution on fin.

There are four different places are taken along the length of fin.Fig 03 shown the variation of temperature along the length,this fig also shows that the supply current and voltage, here the supply input for each fin is 3.7A and 32V, which is adjusted by dimmerstat

III. MATH

Formula used for calculation

Heat input (Q) = V.I

Thermocouple temperature =T_a, T_1, T_2, T_3,T_4.

Average surface temperature (T_s) = $\frac{T_1+T_2+T_3+T_4}{4}$, °C

Ambient temperature = T_a

Mean film temperature (T_f) =$\frac{T_f+T_a}{2}$, °C

Kinematic viscosity = v, $\frac{m^2}{s}$

Prandtl' snumber(P_r) = $\frac{mC_P}{K}$

Reynold' snumber(R_e) = $\frac{VD}{v}$

Nusseltnumber(N_u) = $\frac{hD}{K}$

Nu = .023 $Re^{0.8}$ $Pr^{0.3}$ …………..For 2300<Re<100000 and 0.6<Pr<160 (Dittus-Boelter Equation)

$$Q_{Fin} = \sqrt{hpkA_{cs}}(T_0 - T_a) \left(\frac{\tanh(mL)+\frac{h}{km}}{1+\frac{h}{km}\tanh(mL)}\right)$$

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IV. RESULTS AND DISCUSSION

Results:

Fin material	Velocity	h	Q_{fin}	η	ε
Brass	3.2	20.172	2.161	61.645	23.299
	4.2	25.076	1.918	58.770	22.213
Mild steel	3.2	20.168	2.052	58.229	22.010
	4.2	25.075	1.879	52.915	20.001
Aluminum	3.2	20.175	2.145	81.658	30.829
	4.2	25.080	2.112	71.347	26.965
Copper	3.2	20.178	2.213	84.541	33.028
	4.2	25.095	2.169	74.456	28.137

This is the table of results which is obtained after calculation. The observation is taken at velocity 3.2m/s and 4.2m/s for each fin,at different velocity, found different convective heat transfer co-efficient and use these value for calculating of efficiency and effectiveness.

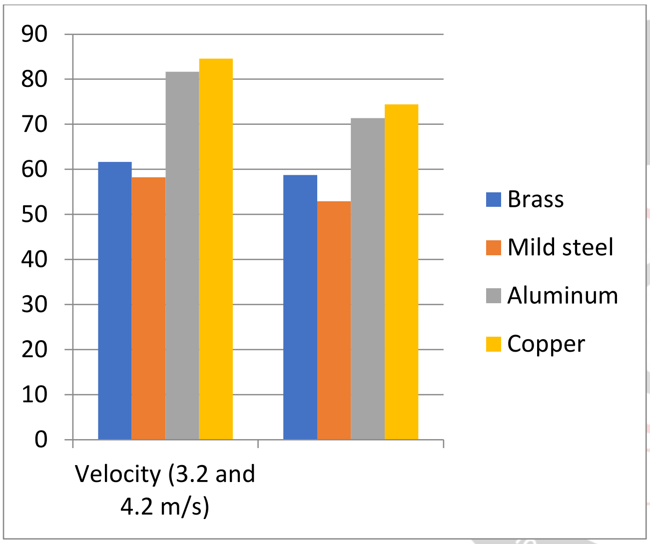

Fig.04:Graph between efficiency and different material at velocity 3.2m/s and at4.2m/s

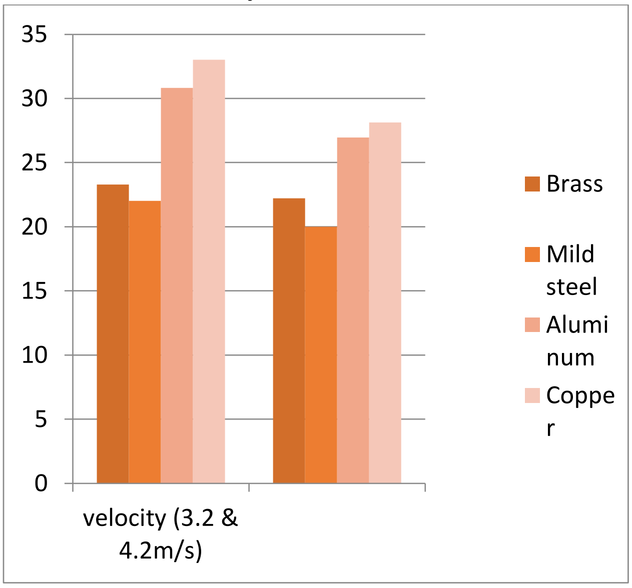

Fig 05: Graph between effectiveness and different material at velocity 3.2m/s and at 4.2m/s

Discussion

When Aluminum fin compare with brass, mild steel and copper fin at air flow velocity 4.2 m/s

- Aluminum fin is17.6% better effective and 18.4% better efficient than brass fin.
- Aluminum fin is 25.7% better effective and 25.8% better efficient than mild steel fin.
- Copper fin is only 4% better effective and 4.17% better efficient than aluminum fin.

When Aluminum fin compare with brass, mild steel and copper fin at air flow velocity 3.2 m/s

- Aluminum fin is24.4% better effective and 24.5% better efficient than brass fin
- Aluminum fin is 28.6% better effective and 28.7% better efficient than mild steel fin.
- Copper fin is only 6.65% better effective and 3.4% better efficient than aluminum fin

V. CONCLUSION

From above results we conclude that:-

- As the Reynold's number increases the efficiency and effectiveness of fin decreases
- The decrease in efficiency for brass and for mild steel is minimum as compare to aluminum and copper, hence aluminum and copper fin is more sensitive with heat.
- Obviously copper better material for heat transfer but, if we consider other factor such that cost, reliability and density, aluminum is most effective material.

VI. FUTURE SCOPE

In this project work that we conclude that effectiveness and efficiency of Brass fin, Mild steel fin, Aluminum fin, and Copper fin for same dimension and for same volume by experimental data.

- Different profile of fin are used and compare the different fin parameters in same volume
- Different type of fin materials can be used for increases fin properties.
- Use optimization technique to optimize best shape and best materials of fin which gives maximum effectiveness and efficiency.

APPENDIX

T Temperaturer (^oC)

Q Rate of heat transfer through fin (J/s)

v Kinematic viscosity ($\frac{m^2}{s}$)

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P_r Prandtl's number ($\frac{mC_P}{K}$)

R_e Reynold'snumber ($\frac{VD}{v}$)

N_u Nusseltnumber($\frac{hD}{K}$)

ƐEffectiveness

ɳEfficiency

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