Available online www.ejaet.com

European Journal of Advances in Engineering and Technology, 2024, 11(6):11-14

Research Article ISSN: 2394 - 658X

Estimating the Efficiency of a Pin Fin: An Experimental Study

Shreyas Kotian

Graduate Student, Department of Mechanical and Aerospace Engineering, University of California San Diego, San Diego, CA, 92093, USA

ABSTRACT
The following study reports the results of an experimental study conducted on a pin fin. Fins are extended surfaces which are used to increase the heat transfer rate between a solid surface and the surrounding fluid which may be liquid or gas by increasing the surface area available for heat exchange. They are used in various industrial applications such as heat exchangers, radiators, and cooling systems to enhance the efficiency of heat dissipation. There are various types such as straight fins, pin fins, annular fins, rectangular fins, and perforated fins. In this study temperature of the pin fin is plotted as a function of distance.

Keywords: Fins, extended surfaces, heat transfer coefficient

INTRODUCTION
Whenever the available surface is found inadequate to transfer the required quantity of heat with the available temperature drop and convective heat transfer coefficient, extended surfaces or fins are used. This practice invariably is found necessary in heat transfer between a surface and gas as the convective heat transfer coefficient is rather low in these situations.

The finned surfaces are widely used in
- Economizers for stem power plant
- Convectors for steam and hot water heating system
- Radiators of automobile vehicles
- Air cooled engine cylinder heads
- Cooling coils and condenser coils in refrigerator and air conditioners
- Electric motor bodies
- Transformers and electronic equipment's

In practice, all kinds of shape and sizes of fins are employed. Some common types of fins are uniform straight fins of rectangular, square, or circular shape, tapered straight fins, and splines.

It is obvious that a fin surface sticks out from the primary heat transfer surface. The temperature difference with surrounding fluid will steadily diminish as one moves out along the fin. This experimental set up is designed to find the efficiency and to study the temperature distribution in a simple fin.

EXPERIMENTAL SETUP
A brass fin of circular cross section is fitted in a long rectangular duct. The other end of the duct is connected to the suction side of a blower and the air flow past the fin perpendicular to its axis. One end of the fin projects the duct and is heated by the heater. Temperatures are six points along the length of the fin is measured by Cr/Al thermocouples. Air flow rate is measured by an orifice meter fitted on the delivery side of the blower. The schematic of the experimental set up is shown in the figure below.

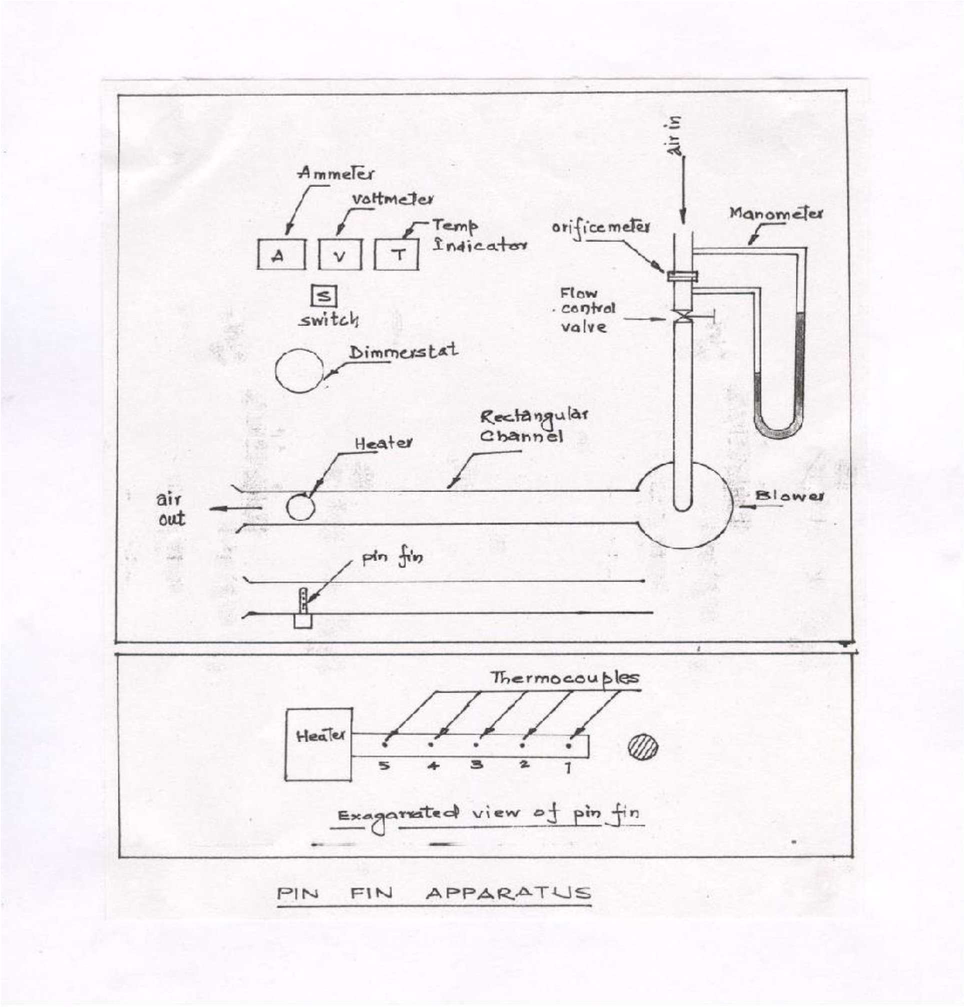


Figure 1: Schematic of the experimental set up

Specifications

- Duct size = 150 X 100 X 1100 mm
- Diameter of the fin = 12.7mm
- Length of the fin = 150 mm
- Diameter of the orifice = 35 mm
- Diameter of the delivery pipe = 55 mm
- Coefficient of discharge of the orifice = 0.64
- Centrifugal blower (1 HP) having a single-phase motor
- Thermocouples on the fin = 6
- Thermocouple # 7 reads the ambient temperature on the inside of the duct
- Fin material = Brass
- Nichrome wire heater (Band type) placed over a pipe having a capacity of 500 W
- Dimerstat: Heater control unit: 0-230 V, 0-2 A, Single phase auto transformer
- Voltmeter, 0-200 V
- Ammeter, 0-2 A
- Temperature indicator (Digital type), 0-200°C

Procedure:

- Switch “ON” the supply
- Start heating the fin by switching on the heater and adjust the Dimerstat voltage between 100-110 V.
- Start the blower and adjust the difference of level in the manometer with the help of valve provided on the duct.
- Note down the thermocouple readings at a time interval of 15 min.

- When a steady state is reached, record the final readings and also record the ambient temperature reading which is on thermocouple #7
- Note down the readings in the observation table.

Observation Table

Sr. No.	Time Min	Volt ageV	Cur rentI	Heat Input V × I	Temperature (°C)							
					T1	T2	T3	T4	T5	T6	Tamb	Head (hw) cm
1.	0	100	0.39	39	44	40	37	36	35	34	32	166-102
2.	15				60	53	48	44	42	41	32	165-102
3.	30				63	55	50	46	44	42	32	165-102
4.	45				63	55	50	46	44	42	32	165-102

Theoretical Calculations

- Average temperature of the fin, $T_a = \frac{T_1 + T_2 + T_3 + T_4 + T_5 + T_6}{6}$
- Mean fin temperature, $T_m = \frac{T_a + T_{amb}}{2}$
- Air volume flow rate, $Q = \frac{C_d \times a_1 \times a_2 \times \sqrt{2gh_w(\rho_w/\rho_a)}}{\sqrt{a_1{}^2 - a_2{}^2}}$

  Where C_d is the coefficient of discharge for the orifice, a_1 is the area of the pipe, a_2 is the are of the orifice, g is the acceleration due to gravity, h_w is the difference of height of water column in the manometer, ρ_w is the density of water, and ρ_a is the density of air at ambient temperature
- Velocity of air at ambient temperature, $V = \frac{Q}{A}$

  Where A is the area of the duct.
- Velocity of the air at mean fin temperature, $V_m = V \times \left[\frac{T_a+273}{T_m+273}\right]$
- Reynolds number, $Re = \frac{V_m \times d}{\vartheta_a}$

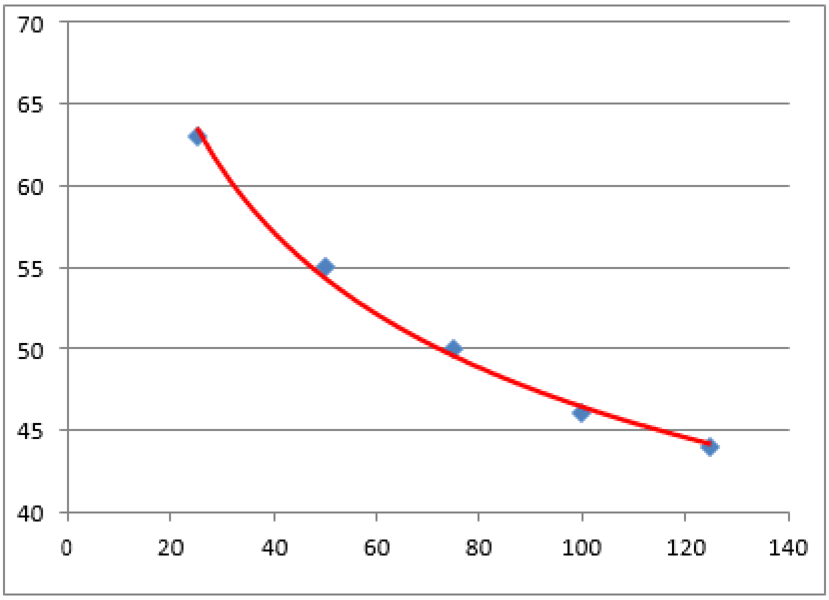
  Where, d is the diameter of the fin, and ϑ_a is the kinematic viscosity of air at T_m.
- Nusselt number, $Nu = 0.165 \times Re^{0.466} \times Pr^{\frac{1}{3}} \ldots\ldots 40 < Re < 4000$

  $$Nu = 0.174 \times Re^{0.618} \times Pr^{\frac{1}{3}} \ldots\ldots 4000 < Re < 40000$$
- Heat transfer coefficient, $h = \frac{Nu \times k_w}{d}$
- Mass flow rate of air, $m = \sqrt{\frac{hP}{kA}}$

  P is the perimeter of the fin, k is the thermal conductivity of the fin material, and A is the area of cross section of the pin.
- Efficiency of the pin, $= \frac{\tanh(mL)}{mL}$

RESULTS

We plot temperature of the pin fin as a function of the distance of points of thermocouple along the length of the pin fin from the heating end.



Conclusion

Thus, through this experiment we have successfully determined the efficiency of the fin used in this set up. We have also found out the effectiveness of the fin and its value which is found out to be greater than 5 indicates that it can be used for practical purposes.

References

[1]. F.P. Incropera and D.P. Dewitt, Introduction to Heat Transfer, Wiley, 1996.
[2]. Y.A. Cengel and A.J. Ghajar, Heat and Mass Transfer: Fundamentals and Applications, Fifth Edition, McGraw-Hill Education, 2015.
[3]. S. Kakac, H. Liu and A. Pramuanjaroenkij, Heat Exchangers Selection, Rating and Thermal Design, Third Edition, CRC Press, 2012.