AN EXPERIMENTAL INVESTIGATION OF ANNULAR FINS UNDER FORCED CONVECTION

Ranjan Kumar Baidya[1], V.V.Rama Krishna[2]

[1,2]*Kakinada Institute of Technology & Science*

Abstract

Heat transfer characteristics under forced convection are investigated experimentally by varying parameters like surface area, base-to-ambient temperature difference and Reynolds number. To investigate the performance of fins experimentally, fins made of aluminium (high thermal conductivity) are taken. For varying the surface area fin with 11 mm diameter without circumferential fins, fin with 31 mm diameter and annular fins of 31 mm diameter are taken as specimens. Base to ambient temperature difference is varied with the aid of dimmerstat ranging from 25W to 45W. Reynolds number is also varied by varying the velocities of air. Velocities are varied by the aid of fan. Then these fins are tested under different load conditions, different Reynolds number by varying the surface area of fins increase the rate of heat transfer. With the variation of relevant parameters under forced convection heat transfer rates are analyzed experimentally. Experiments are conducted by using the annular fins, fin with diameter 11mm without circumferential fins and fin with diameter 31mm at different Reynolds number and loads under forced convection and comparison is made between fins. Experimental results shows that forced convection heat transfer rate from fins depend on surface areas, base ambient temperature difference and Reynolds number. The base temperature for annular fins is reduced by 30% when compared to fin with diameter 11mm due to increase in surface area about 40%. The base temperature for annular fins is reduced by 10% when compared to fin with diameter of 31mm due to decrease in surface area about 41%. It is also observed that at higher heat load i.e., 45W, the overall fin efficiency of annular fins is increased by 44% and 8% compared to fin with diameter of 11mm and 31mm respectively. At higher Reynolds number range 800-2000, heat transfer rate increases in annular fins due to more number of air molecules get in contact with the heated surface.

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INTRODUCTION

Heat generation is the result of many engineering system. But due to unwanted heat overheating and failure of the system occure so the heat generated with in the system should be dissipated to surrounding in order to maintain the system working effectively and reliably. To overcome from this problem, thermal systems with effective emitters as fins is considerable, to achive the desired rate of heat dissipation. The heat dissipation from system to atmosphere can be obtain by using of convection and radiation heat transfer. As we know that the heat transfer rate can be increased by increasing the surface area or heat transfer coefficient.

Heat Transfer:

Heat is transferred from one system to another system or surrounding due to temperture difference. Heat is transferred in three modes Conduction ,Convection & Radiation.

CONVECTION:

Heat transfer through fluid is known as convection. Convection heat transfer is very complicated because it depends on fluid motion and heat conduction. And it also depends on the fluid properties like dynamic viscosity, thermal conductivity, density, specific heat and also geometry and roughness of the solid surface. As we know that the heat transfer by convection is expressed as

$Q = h A_s (T_s - T_a)$

CLASSIFICATION OF CONVECTION PROCESS:

The convection heat transfer is two types:

a) Natural convection b) Forced convection

(a). Natural convection:

If heat transfer from one fluid to another due to temperature difference without any external agency is said to be free convection.

(b). Forced convection:

If any the fluid motion is artificially created by means of an external agency like blower or fan, the heat transfer is termed as forced convection. It considered as one of the main method of useful heat transfer as significant amounts of heat energy can be transposed very efficiently.

TYPES OF FINS:

1.Straight fins 2. Annular fins 3.Pin fins

CIRCUMFERENTIAL FINS OR ANNULAR FINS:

An annular fin is a fin attached circumferentially attached to a cylinder and its cross section varies with radius from the centre line of the cylinder. Fins are used on electric transformers and motors, cooling of electronic components, cylinders and cylinder heads of air cooled IC engines and on a large variety of heat exchangers. Commonly used configurations are annular fins with rectangular, triangular and hyperbolic profile.

INVESTIGATIONS ON HEAT TRANSFER DISTRIBUTION WITH FORCED CONVECTION USING FINS

By increasing the temperature difference between the system and the environment, increasing the convection heat transfer co-efficient, or increasing the surface area of the object increases the heat transfer. Heat transfer rate can be increased by using forced convection, due to more number of air molecules get in contact with the surface area.

Experimental set up:

In this experiment, heat transfer distribution is analyzed by using annular fins under forced convection. Experiments are carried out by heating the specimen i.e. annular fins by using band heater at different loads. Loads are varied by the aid of dimmerstat. Specified load is adjusted by varying inputs such as current and voltage. At different loads the velocity of air is varied with induced draft fan with the help of regulator. Thermocouples were equidistantly placed on the rod and they were connected to the digital temperature indicator to indicate the temperature. The experimental investigation involves the study of heat transfer rate of rod with fins and without fins under forced convection. To analyze the heat distribution, circumferential fins of 31mm diameter, rod of 31mm diameter and rod of 11mm diameter of 150mm long are taken as specimens. A rod of 150mm long of diameter 31mm is taken and it is machined to form circumferential or annular fins of 31mm diameter on base diameter 11mm.

Circumferential Fin of Rectangular Profile:

Annular fin or circumferential fin is one, which is attached circumferentially to a cylindrical surface. An Aluminium rod of 31mm diameter of 150mm long is taken and it is machined to form annular fins on it. Annular fins are used to increase the surface area so that the heat transfer rate would be maximised.

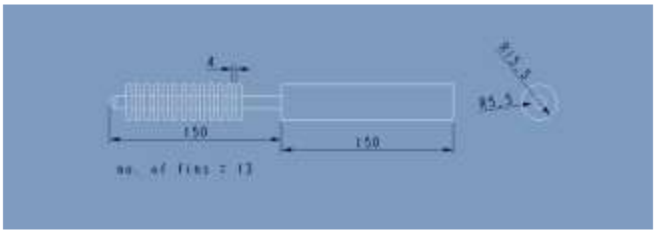


Figure -Annular fins of 31mm diameter

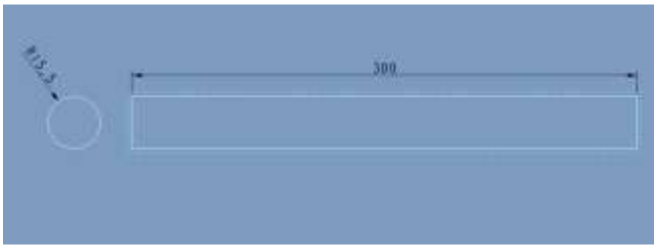


Figure -Fin of 31mm diameter

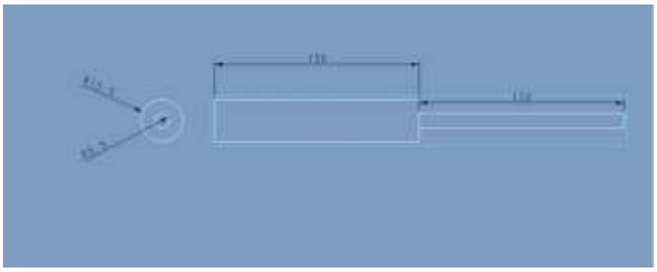


Figure - Fin of 11mm diameter

SPECIFICATIONS:

Material used – Aluminium 6063, Thermal conductivity of metal – 220W/m^{2}K
Number of circumferential fins – 13, Thickness of each fin – 4mm
Gap between two fins – 4 mm, Effective length – 150mm

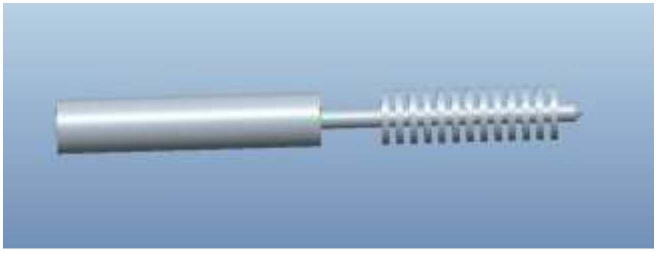


Figure -Annular fins with 31mm diameter

Band heater:

Band heaters are used to heat the specimen i.e. they provides to raise the temperature of the specimen. These band heaters are available in different heights and different widths. Specified band heater is selected according to the cylindrical diameter which is to be heated. To provide close contact with the cylindrical surface, tighten clamping bands. After heat – up occasionally re-tighten the clamping band.

Figure -Band heater

Induced draft fan:

This fan is used to cool the heated specimen. The required amount of air is supplied to the system, which used for forced convection of the heated element. This device is fixed at one end of the duct to provide forced convection.

Speed – 2650rmp, Velocity – 4 m/s, Size – 12cm×12cm

Thermocouples and Digital temperature indicator:

"A thermocouple is a sensor to measure the temperature. It consists of two dissimilar metals, joined together at one end. When the junction of the two metals is heated or cooled a voltage is produced that can be correlated back to the temperature. The thermocouple alloys are commonly available as wire". J type thermocouple is used to sense for sensing lower temperatures.Thermocouples are attached to the digital temperature indicator where the sensed temperature is displayed.

Ammeter, Voltmeter and Dimmerstat:

An ammeter measures the electric current in a circuit. In order for an ammeter to measure a device current, it must be connected in series to that device. This is necessary because objects in series experience the same current.

A voltmeter is an instrument that measures the difference in electrical potential between two points in an electric circuit. To measure voltage, voltmeter must be connected in parallel to that device. This is necessary because objects in parallel experience the same potential difference. A digital voltmeter provides a numerical display.

Specifications:

Component	Specifications
Fin	Aluminium Al-6063
Band heater	550 W
Dimmerstat	10 A
Ammeter	0.1A Resolution, ±0.5% Accuracy
Voltmeter	1V Resolution, ±0.5% Accuracy
Digital Temperature Indicator	Digital, 1/0.1^0 Resolution, ±0.25% Accuracy
I.D.Fan	12×12 mm, 4.5 m/s velocity
J – Type thermocouples	Range -40 to 750^{0}C

Circuit diagram of experimental set up:

An air sealed duct made from Australian wood was taken for conducting experiments, one end of duct is connected to induced draft fan and the other end is made to set free. Fan is connected to regulator to control the flow of the velocity. Annular fins rod of 31mm diameter of length 300 mm long is inserted into the duct. The rod is heated with the aid of band heater to provide insulation asbestos rope is wounded to band heater. Thermocouples were placed on the rod to know the temperature distribution; these thermocouples are connected to the digital temperature indicator.

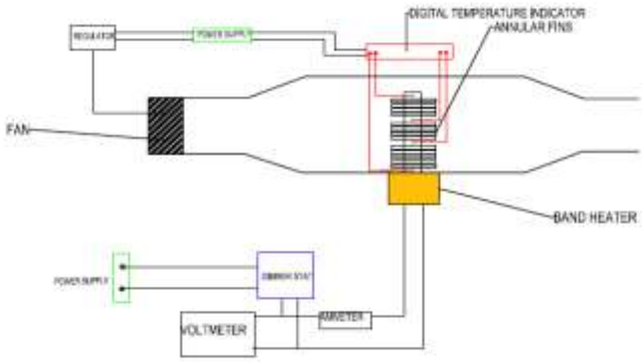


Figure -Circuit diagram of experimental setup

RESULT AND DISCUSSION

The experiment has been conducted for various power inputs such as:

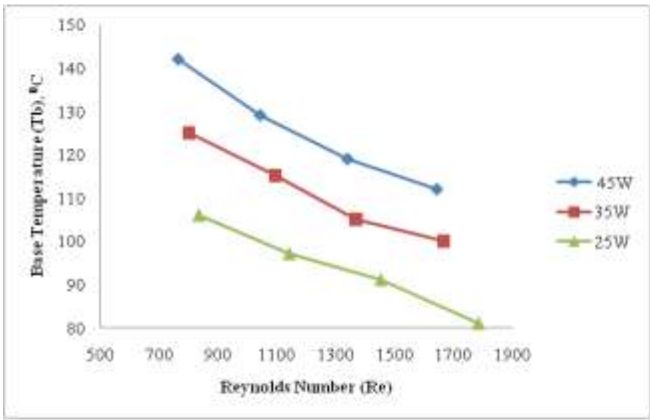
1.25 W 2. 35 W 3. 45 W

For these power inputs the experiment is conducted for various velocities of air to vary the Reynolds number and heat transfer coefficient on different geometries of the pipe to study the heat transfer rates, they were,

- Fin of 11 mm diameter without circumferential fins
- Fin of 31 mm diameter and
- Annular fins

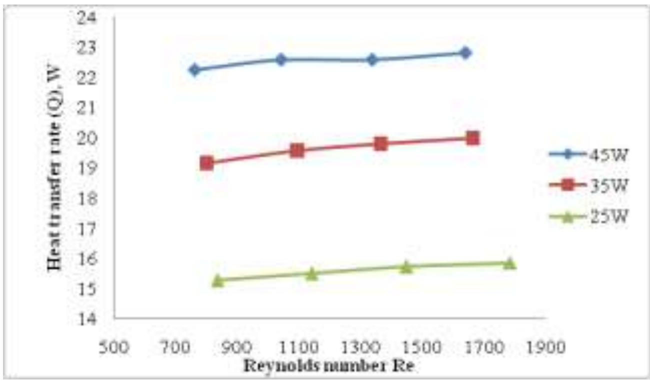
Fin of 11 mm diameter without circumferential fins:

The following graph is plotted for Reynolds number and base temperature at different loads i.e., 25 W, 35 W and 45 W. From the graph it is observed that, with an increase in Reynolds number there is a decrease in base temperature due to more number of molecules of air get in contact with the heated surface. So, the heated surface gets cooled and base temperature decreases.



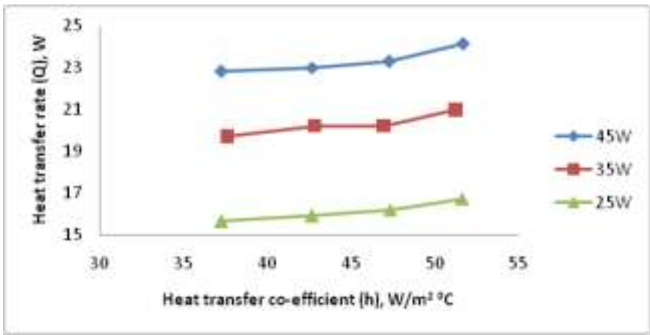
Graph Base temperature (Vs) Reynolds number (Re) for fins of 11mm diameter

The following graph is plotted for Reynolds number and heat transfer rate at different loads i.e., 25 W, 35 W and 45 W. From the graph it is observed that, increase in Reynolds number with increase in heat transfer rate due to more number of molecules of air get in contact with the heated surface.



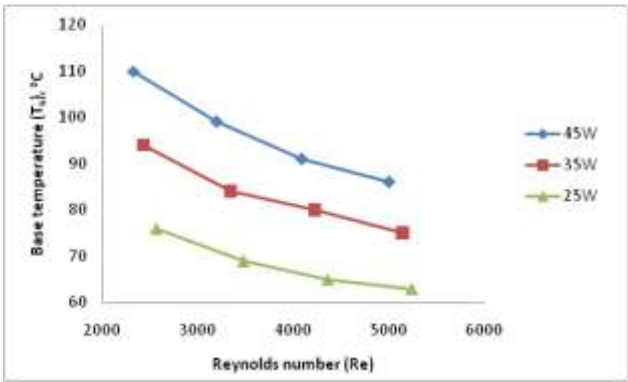
Graph Heat transfer rate Q (Vs) Reynolds number (Re) for fins of 11mm diameter

The following graph is plotted for heat transfer co-efficient (h) and heat transfer rate (Q). From the graph it is observed that, heat transfer rate increases with increase in heat transfer coefficient. From Newton's law of cooling heat transfer rate is directly proportional to the heat transfer coefficient.

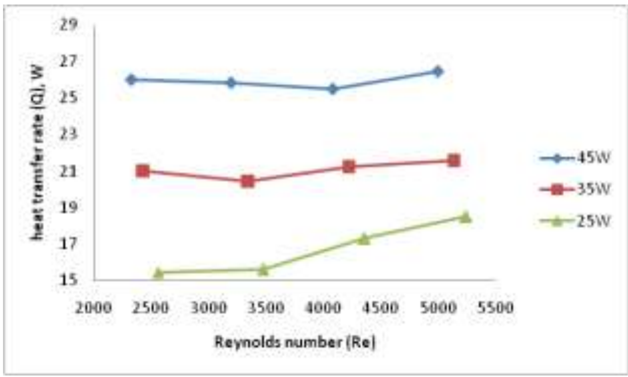


Heat transfer rate Q (Vs) heat transfer co-efficient (h) for fins of 11mm diameter

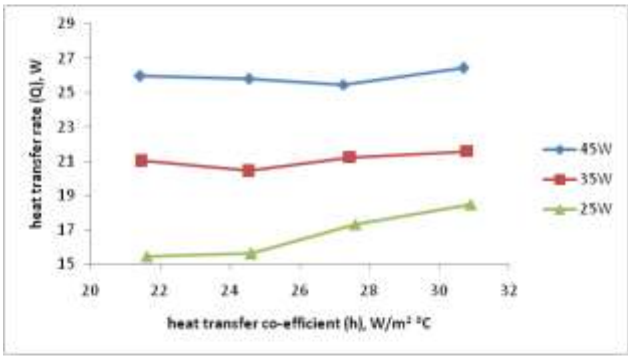
4.2 Results for fin of 31mm diameter



Graph Reynolds number (Re) (Vs) Base temperature for fins of 31mm diameter

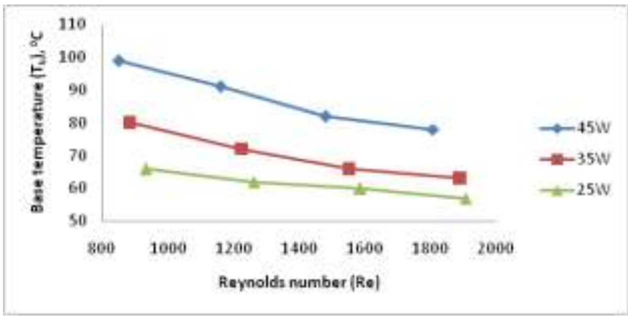


Graph Reynolds number (Re) (Vs) Heat transfer rate Q for fins of 31mm diameter

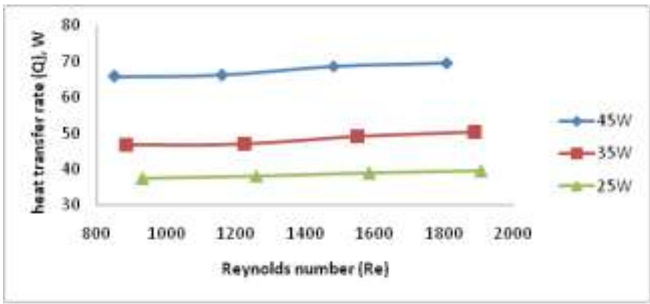


Graph Heat transfer co-efficient (h) (Vs) Heat transfer rate Q for fins of 31mm diameter

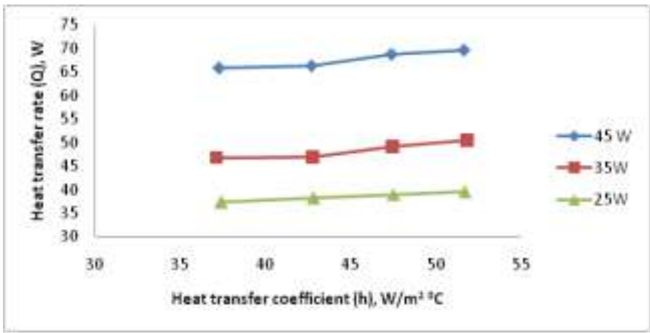
4.3 Annular Fins



Graph Reynolds number (Re) (Vs) Base temperature for annular fins



Graph Reynolds number (Re) (Vs) Heat transfer rate Q for annular fins



Graph Heat transfer co-efficient (h) (Vs) Heat transfer rate Q for annular fins

CONCLUSION

The experimental investigation is carried out to study the heat transfer characteristics of fin with 11mm diameter without circumferential fins, fin with 31mm diameter and annular fins with 31 mm diameter under forced convection at different power inputs and Reynolds number.

The variation of relevant parameters in convective heat transfer with fins has been analyzed in the present experimental investigation under forced convection. During this experimental investigation, variations of Reynolds number and surface areas greatly affect the heat transfer rates.

- The base temperature for annular fins is reduced by 30% when compared to fin with diameter 11mm due to increase in surface area about 40%.
- The base temperature for annular fins is reduced by 10% when compared to fin with diameter of 31mm due to decrease in surface area about 41%.
- Heat transfer rates increase predominantly with the provision of annular fins due to increase in the surface area. It is also observed that at higher heat load i.e. at 45W,
- The overall fin efficiency of annular fins is increased by 44 % and 8% when compared to fin with diameter 11mm and 31mm respectively. At higher Reynolds number range 800-2000, heat transfer rate increases in annular fins due to more number of molecules of air get in contact with the heated surface.

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