International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-05, Issue-06, Sep 2019

Thermal Analysis of Aluminum Alloys Stepped Rectangular Fins using Force convection

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Abstract- **In this paper thermal analysis of aluminum alloys (Al-93%, Cu-4% and rest, Mn & impurities) has been carried out and is compared with uniform rectangular fins for forced and natural convection. The dimension of the fins are taken as 120mm X 40mm X 18mm.The experimental results show the maximum value of stepped rectangular fin efficiencyas98% and 99.75% respectively in forced and natural convection at a constant voltage of 60 volts whereas for uniform rectangular fins these values are found to be 92% and 98% respectively in forced and natural convection at a constant voltage of 60 volts.**

Keywords-Stepped rectangular fin, Uniform rectangular fin, Heat transfer coefficient, Efficiency, Aluminum alloy.

I. INTRODUCTION

Fin is attached an extruded surface to the hot body for increasing heat transfer rate to the environment. The value of heat transfer from a body may be determined by the value of conduction, convection or radiation from the body. As we know that the heat transfer can be increased by increasing the temperature difference between the base of hot source and environment, by increasing the surface area and the heat transfer coefficient of the body. Generally, fin is used where heat transfer is low, in recent era heat transfer is very important for any industry; Fins are mostly used to improve the rate of heat transfer from a hot surface. Generally, uses in thermal engineering applications where cooling is required to protect the damage of equipment. Besides the conventional applications, like as internal combustion engines, compressors and heat exchangers, fins also prove that effective in heat-rejection systems in space vehicles and in the cooling of electronic equipment. Generally, fins are used in the electronics industry to avoid the damaging effects of burning or overheating like computer or laptop used everything can be placed in small space. Extruded surfaces (fins) are mostly used in major engineering applications such as refrigeration, air conditioning, automobile and chemical developing equipment. Objective of using extruded surface is to increases heat transfer between the hot surface where fin is attached and its convective, irradiative or convective radiative environment. Natural convection cooling with the help of extruded surface usually offers a low cost. Fins on horizontal and vertical surfaces, used in different engineering application, release heat to the environment. Because it requires a very high skill operator and its high manufacturing cost, their use is consequently restricted to applications where the cost of the fins must absolutely be kept at a minimum. [Kobus et al 2006]. It is observed that a parabolic fin requires a lower volume of fin material to achieve the same heat transfer rate. The concave parabolic profile has been shown to be the ideal choice because it uses the least quality of fin materials for a specified heat transfer duty, but its curved surface makes it more difficult and expensive to manufacture.

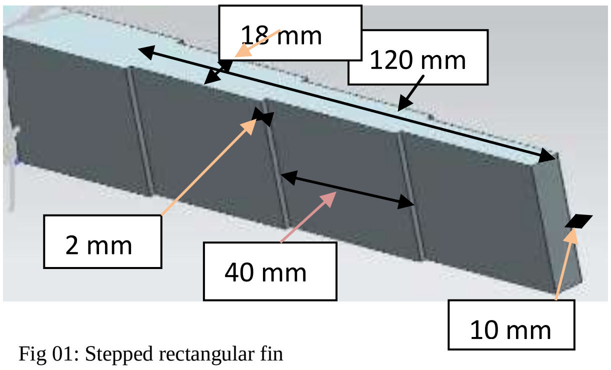


Fig 01: Stepped rectangular fin

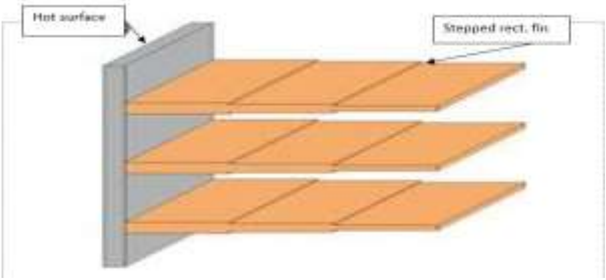


Fig 02: Arrangement of stepped rectangular fin on hot surface

II. FABRICATION OF EXPERIMENTAL SETUP

Experimental set-up has been prepared for measurement of required data of fins. Setup is prepared in Heat Transfer Lab, Department of Mechanical Engineering, BIT sindri. The experimental setup is used to determine temperature at different point on fin. There is three point of 40 mm distance where temperature indicators are attached to measure temperature. In our experimental setup a duct of 225X125 mm^2 with fan is required for forced convection analysis. Four heating elements of 65 watt each are required to heat the base temperature of fins which is control by Dimmer stat at different power supply such as 60V, 80V& 100V.

At steady state of note down the temperature shown by temperature Indicator at all points corresponding to supply voltage of 60V, 80V& 100V respectively.

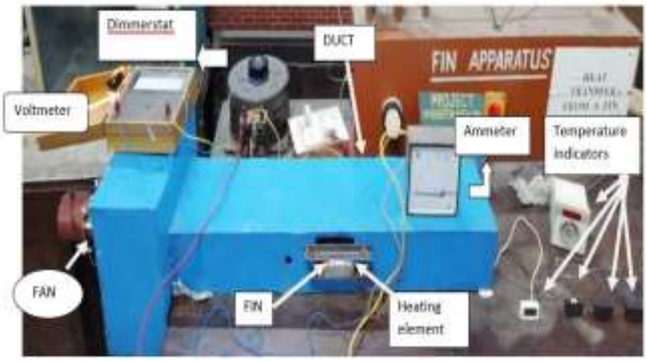


Fig 03: Experimental setup of fins in natural and forced convection analysis.

III. EXPERIMENTAL SET-UP DETAILS

1. **Dimmer stat: -**It is a manual operating device which is used for giving variable heat input on heater.

2. **Voltmeter: -**A voltmeter is an instrument used for measuring electrical potential difference between two points in an electric circuit. This is based on seeback effect in which a temperature difference between two dissimilar electrical conductors or semiconductor produces a voltage difference between the two substances. Analog voltmeters move a pointer across a scale in proportion to the voltage of the circuit. Digital voltmeters give a numerical display of voltage by use of an analog to digital converter.

3. **Ammeter:** - It is a measuring instrument which is used to measure electric current in a circuit. Electric currents are measured in amperes (A) hence the name of instrument is ammeter. This Instrument is used to measure smaller currents in the milliampere or microampere range is designated as milli-ammeters or micro-ammeters.

4. **Heating Element:** - It is an element which is used to increase the temperature of base metal (base temperature of fin). There are four heating elements required in our experimental work of 65 watt and volts of 220v-230v each. So, 4*65=260 watt is the power required in project. It is connected with dimmer stat to regulate power supply. And also connected with voltmeter and ammeter to take reading of voltage and current respectively.

5. **Temperature indicator (TI): -**It is a temperature measuring device which is based on working principle of thermocouple. Digital temperature indicator gives a numerical display of temperature due to voltage difference of two dissimilar conductive materials. There are five temperature indicators are required in our project work at different sections. And one is required for environment temperature.

6. **Duct with fan: -** A duct of 225mm X 125mm with 0.3 hp (horse power) is required for forced convection analysis in our project work. The velocity of air in duct is measured by hot wire anemometer.

7. **Anemometer: -**It is an instrument which is used to measuring velocity of air in duct. For determining Reynolds number to get the value of heat transfer coefficient (h).

Table 01: Specification of fins

Material	Aluminum Alloy
Length	120 mm
Width	40 mm
Thickness	18mm, 14mm, 10mm
Thermal conductivity	198 w/mK
Density	2.70 g/cm^2
Melting Point	660 ^{0}c
Billet size	160X90X20 mm^3

IV. RESULTS AND DISCUSSION

In order to describe the experimental outcomes, graphs are plotted between different parameters obtained from number of observations.

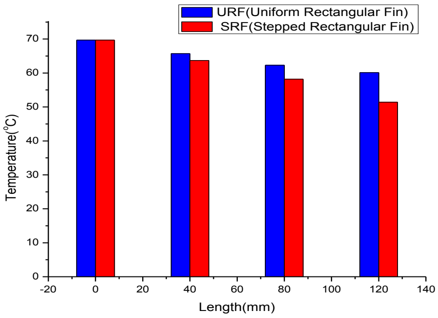


Fig.4.1. Graph between length vs temperature for uniform uniform rectangular fin and stepped rectangular fin at 60V in natural convection.

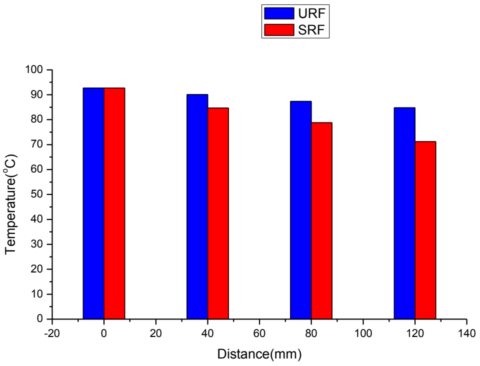


Fig.4.2. Graph between length vs temperature for rectangular fin and stepped rectangular fin at 80V in natural convection.

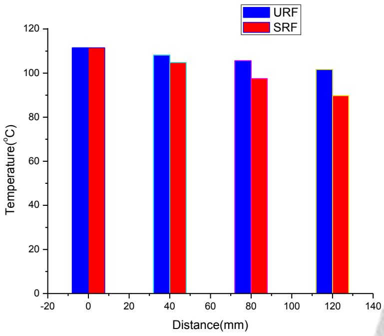


Fig.4.3. Graph between length vs temperature for uniform uniform rectangular fin and stepped rectangular fin at 100V in natural convection.

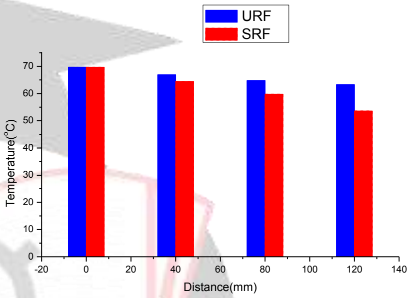
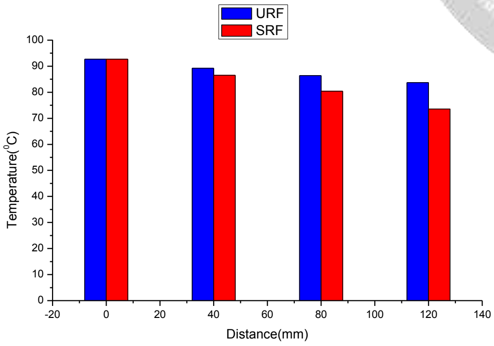


Fig.4.4. Graph between length vs temperature for rectangular fin and stepped rectangular fin at 60V in forced convection.



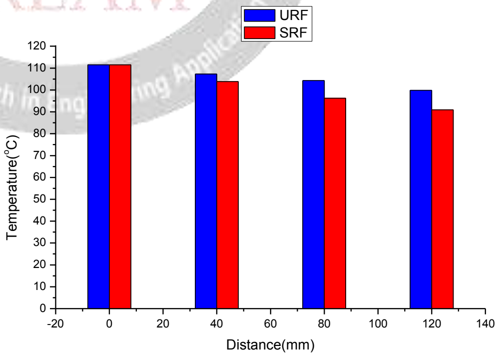


Fig.4.5. Graph between length vs temperature for uniform uniform rectangular fin and stepped rectangular fin at 80V in forced convection.

Fig.4.6. Graph between length vs temperature for rectangular fin and stepped rectangular fin at 100V in forced convection.

DOI : 10.35291/2454-9150.2019.0425

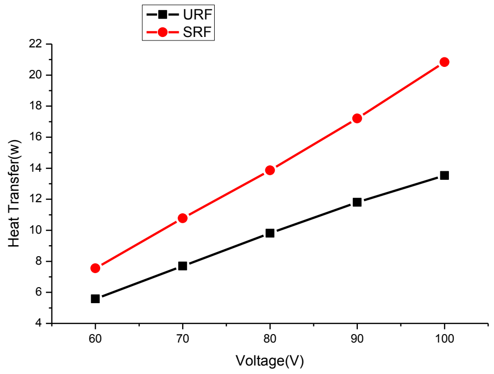


Fig.4.7. Graph of Voltage vs Heat transfer in natural convection

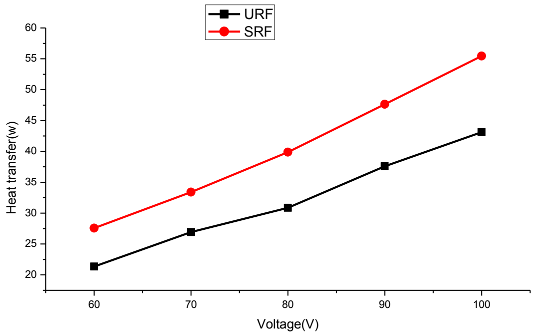


Fig.4.8. Graph of Voltage vs Heat transfer in forced convection.

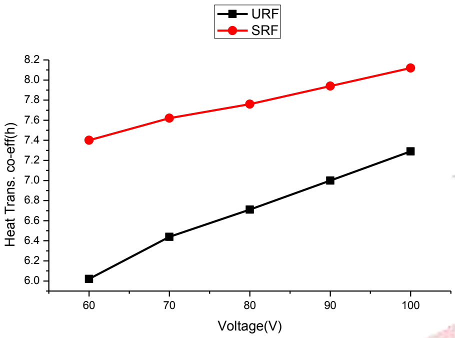


Fig.4.9. Graph of Voltage vs Heat transfer co-efficient in efficient in natural convection

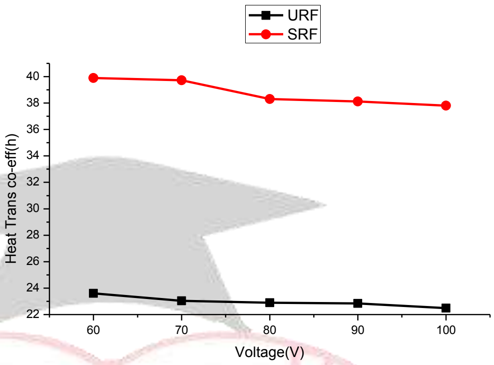


Fig.4.10. Graph of Voltage vs Heat transfer co- forced convection.

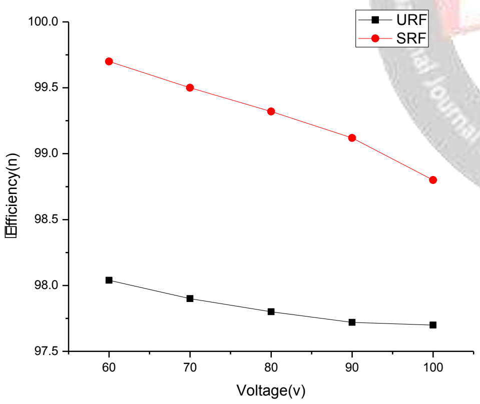


Fig.4.11. Graph of Voltage vs Efficiency in natural convection.

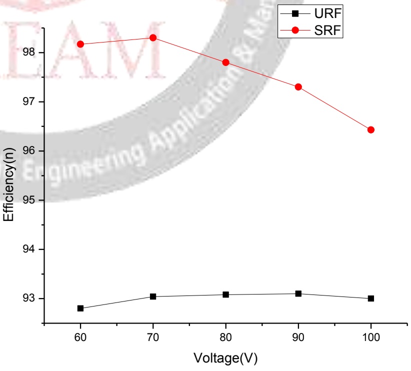


Fig.4.12. Graph of Voltage vs Efficiency in forced convection.

- ❖ Figure 4.1, 4.2 & 4.3 show the variation of length with temperature of both fins Stepped rectangular fin and Uniform rectangular fin with change in Power supply (Voltage) i.e. at 60V, 80V & 100V respectively in natural convection. It is observed that temperature drop of stepped rectangular fin is more than uniform rectangular fin.
- ❖ Figure 4.4, 4.5 & 4.6 show the variation of length with temperature of both fins Stepped rectangular fin and Uniform rectangular fin with change in Power supply (Voltage) i.e. at 60V, 80V & 100V respectively in forced convection. It is observed that temperature drop of stepped rectangular fin is more than uniform rectangular fin.
- ❖ Again figure 4.7 shows the variation of voltage with heat transfer of both fins Stepped rectangular fin and Uniform rectangular fin in natural convection. It is observed that Heat transfer in stepped rectangular fin is better than uniform rectangular fin.

DOI : 10.35291/2454-9150.2019.0425

- Figure 4.8 shows the variation of voltage with heat transfer of both fins Stepped rectangular fin and Uniform rectangular fin in forced convection. It is observed that Heat transfer in stepped rectangular fin is better than uniform rectangular fin.
- Again figure 4.9 shows the variation of voltage with heat transfer coefficient of both fins Stepped rectangular fin and Uniform rectangular fin in natural convection. It is observed that Heat transfer coefficient in stepped rectangular fin is better than uniform rectangular fin.
- Figure 4.10 shows the variation of voltage with heat transfer coefficient of both fins Stepped rectangular fin and Uniform rectangular fin in forced convection. It is observed that Heat transfer coefficient in stepped rectangular fin is better than uniform rectangular fin.
- Again figure 4.11 shows the variation of voltage with efficiency of both fins Stepped rectangular fin and Uniform rectangular fin in natural convection. It is observed that efficiency in stepped rectangular fin is more than uniform rectangular fin.
- Figure 4.12 shows the variation of voltage with efficiency of both fins Stepped rectangular fin and Uniform rectangular fin in forced convection. It is observed that efficiency in stepped rectangular fin is more than uniform rectangular fin.

V. CONCLUSION

The present work is about the comparative experimental study and performance analysis of uniform rectangular and stepped rectangular fin in both natural and forced convection analysis. The following conclusions are straight out through the experimental analysis: -

- Temperature drop in stepped rectangular fin is more than uniform rectangular fin by 15.32%in natural and 14.47% in forced convection analysis.
- Heat transfer of stepped rectangular fin is 35.30% more than uniform rectangular fin in natural whereas it is 29.13% more in forced convection analysis and is increasing as the supplied voltage increases..
- Heat transfer coefficient of stepped rectangular fin is 22.92% more than uniform rectangular fin in natural whereas it is 69.06% more in forced convection analysis.
- Efficiency of stepped rectangular fin is 1.70% more than uniform rectangular fin in natural whereas it is 5.78% more in forced convection analysis and is increasing as the supplied voltage increases..
- Material requirement for Stepped Rectangular fin is less compare to Uniform Rectangular fin for same performance.

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DOI : 10.35291/2454-9150.2019.0425