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Thermal performance evaluation of split fin pattern and parallel horizontal fin pattern under force convection

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Abstract
Heat transfer is most important phenomenon as due to it temperature change occurs and so heat energy exchange happen also heat transfer is important in case of internal combustion engine, refrigeration, casting and welding process too. The fin is one of the unique application of heat transfer to enhance heat transfer by increasing heat transfer are. The present work aims to fabricate split fin pattern and parallel horizontal fin pattern and compare their thermal performance under force convection condition.

Keywords: Split fin pattern, parallel horizontal fin, force convection, heat transfer, temperature

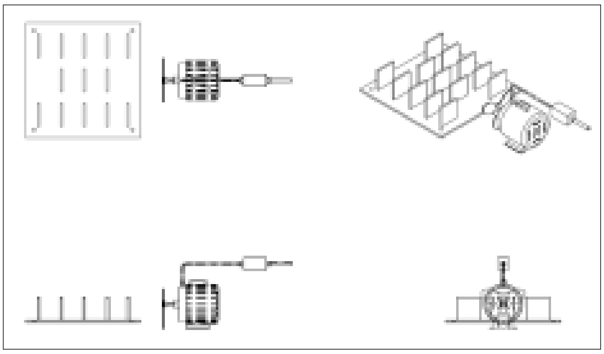
1. Introduction

Extended surfaces (or so-called fins) are often used when the warmth is to be dissipated from backyard boundaries with a greater rate. It represents the most realistic way considering Newton's regulation of cooling states that the warmness switch vicinity is at once proportional to the price of convective warmness transfer. Subsequently, expand in the floor region will end result in amplify in the warmness dissipation from the surface. The software of prolonged surfaces can be considered in all places there is a device of convective warmness transfer, for instance, the condenser of air conditioners are made in a range of shapes and measurement even although the precept is to only extend the whole warmness switch region the usage of aluminum fins. When the device is getting smaller, the warmness dissipation turns into extra imperative and as an alternative complicated due to the fact of house restrictions. However, the warmth is nevertheless dissipated by prolonged surfaces and taken away via distinctive slender tunnels. Azarkish *et al.* [1] optimized a longitudinal fin cross-sectional profile under natural convection and radiation. Kundu *et al.* 2005 [2] proposed an analytical methodology to optimize a thin-fin profile with or without volumetric heat generation. Ullmann *et al.* 1989 [3] minimized fin mass or volume for a specified heat-transfer. Kobus and Cavanaugh 2006 [4] developed a theoretical model to investigate the optimum fin shape using a minimum amount of material for a given amount of heat dissipation rate. Arab *et al.* 2013 [5] modeled two-dimensional heat-transfer in a single fin with a parabolic profile using the finite-volume and artificial neural network (ANN) methods. Jasinski 2006 [6] considered heat dissipation rate and pressure drop in a fully developed 3D flow in tubes with micro-fins on the wall. Shivdas Kharche *et al.* 2007 [7] reported the possible attempts can be made in cross section areas of the fin. P. Raghupati and Dr. Sivakumar 2014 [8] explained about thickness to length ratio to be taken for an ideal design for optimization of the heat transfer rate through the compressor body. Mohammad Mashud *et al.* 2009 [9] have discussed much more on the keeping cylindrical fin as the base fin. Fengming Wang, Jingzhou Zhang *et al.* 2012 [10] made an experiment setup for acquiring the maximum heat transfer characteristics in a rectangular fin. Mehendi Ehteshum *et al.* 2014 [11] explained the effects of perforation on the rectangular fin body. SM Wange *et al.* 2013 [12] focused on the notch creation which makes an attempt to increase heat transfer. He Fa Jiang *et al.* 2012 [13] explained about the physical setup and analysis done on the on various fin structures. Esmail MA Mokheimer 2002 [14] investigated the performance of annular fins of different profiles which are subjected to locally variable heat transfer coefficients. S. H Barhatte *et al.* 2012 [15] experimentally proved that increasing the area of heat transfer will definitely help in increase the heat transfer rate. Sikindar Baba. Md *et al.* 2014 [16] explained some techniques that help in the increasing the heat transfer rate by increasing the surface area. Naidu *et al.* 2010 [17] performed an empirical and numerical study of the natural convection problem from fin plates with different inclination angles.

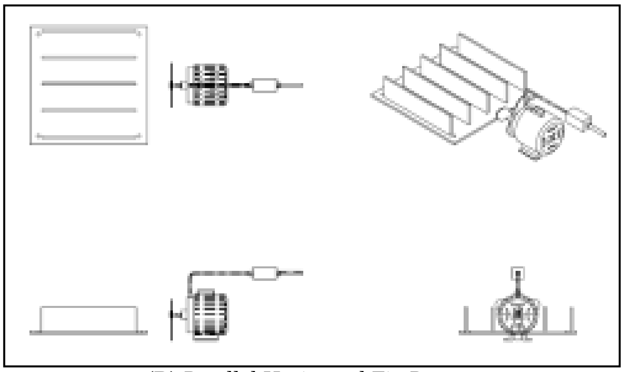
Fahiminia *et al.* 2011 [18] performed computational analysis using finite volume method to estimate natural convection heat from extended vertical surfaces. More *et al.* 2013 [19] performed a synthesis study of free convection from a heating plate with different configurations and inclinations of the fin arrays. Hireholi *et al.* 2013 [20] examined the natural thermal convection of the IC heat sink. Tiwari *et al.* 2014 [21] studied natural convection in layers on a sheathed flat plate to investigate the influence of certain parameters among others; ambient temperature, surface roughness, surface inclination and flow rate for convective heat transfer coefficient at different heat input streams. Shivdas Kharche 2007 *et al.* [22] reported that possible efforts could be made in the transverse region of the asterisk. P Raghupati *et al.* 2014 [23] explained the thickness to length ratio for an ideal design to optimize the heat transfer rate through the compressor body. Mohamad Mashud *et al.* 2009 [24] further discussed maintaining the cylindrical fin as the base fin. A few minor changes to the cylindrical configuration will be responsible for increasing heat transfer through the compressor body. Fengming Wang *et al.* 2012 [25] performed an experimental setup to obtain maximum heat transfer characteristics in a rectangular fin. Mehendi Ehteshum *et al.* 2014 [26] explained the effect of perforation on rectangular fin bodies. SM Wange *et al.* 2013 [27] focused on grooving to increase heat transfer. He Fa Jiang 2012 *et al.* [28] explained the physical setup and the analysis performed on different fin structures. Esmail M.A. Mokheimer 2002 [29] investigated the performance of annular fins of different configurations subjected to locally varying heat transfer coefficients. SH Barhatte *et al.* 2012 [30] demonstrated experimentally that increasing the heat transfer area inevitably increases the heat transfer rate. Sikindar Baba MD *et al.* 2014 [31] explained several techniques that increase the rate of heat transfer by increasing the surface area. A various studies were reviewed which performs thermal performance to enhance the heat transfer by optimizing the design and material for similar devices of fins such as heat spreader devices [32] Patel Anand *et al.* for Cooling tower; [33, 34, 35, 36] Anand Patel *et al.* 2023 [37] Thakre, Shekhar *et al.* 2023 for heat exchanger; [38-40] Anand Patel *et al.* for hybrid solar heater and heat exchanger; [41-51] Patel Anand *et al.* for solar air and water heater.

2. Experimental Construction

In the present work two fins made of aluminum material with dimensions of 200 X 200 mm with 2 mm thick and fins are placed as shown in Fig. 2 and Fig. 3 for horizontal parallel fin and split fin respectively. The 200 W plate heaters is used for heating purpose and dimmer is used to regulate voltage and current to heater and five K type thermocouples are used for temperature measurement at various location of set up and one thermocouple is used measured air outlet temperature. 12W1ADC fan is used to allow of flow on set up.



(A) Split Fin



(B) Parallel Horizontal Fin Pattern

Fig 1: CAD model of experimental set up

Fig 2: Parallel Horizontal Fin Pattern

Fig 3: Split Fin Pattern

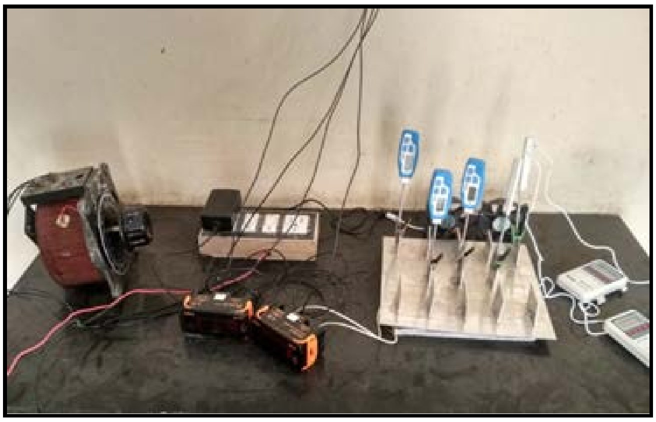


Fig 4: Actual experimental set up of parallel split fin pattern

3. Result and Discussion

Table 1: Observation Table

Voltage V	Ammeter A	T_1 °C	T_2 °C	T_3 °C	T_4 °C	T_5 °C	T_o °C
Parallel horizontal fin pattern							
95	1.11	42.2	41.3	40.2	42.3	44.4	33.3
101	1.19	43.3	43.2	41.3	42.8	43.1	33.8
Split fin pattern							
93	1.1	38.6	41.8	41.8	41.9	44.5	37.2
102	1.2	39	42.2	44.9	40.7	42.8	36.4

Calculation
Parallel horizontal fin pattern
At = N.Af + Ab

Cross section area of fin, Acs = 20 × 0.3 = 6 cm2 = 0.0006 m^2
Af = 5× [20×4×2 + 4×0.2] = 804 cm^2
Ab = 20×20 - 6×5 = 370 cm^2
At = 804+370 = 0.1174 m^2
V-fin pattern
At = N.Af + Ab

Cross section area of fin,
Acs = 2× [10 × 0.2] = 6 cm2 = 0.0004 m^2
Af = 5× [2(10×4×2) + 4×0.2] = 812 cm^2
Ab = 20×20 - 6×5 = 370 cm^2
At = 804+370 = 1182 cm2 = 0.1182 m^2

Split fin pattern
At = N.Af + Ab

Cross section area of fin,
Acs = 5 × 0.3 = 1.5 cm^2 = 0.00015 m^2
Af = 15×2× [5×4 + 4×0.2] = 624 cm^2
Ab = 20×20 – 1.5×15 = 377.5 cm^2
At = 624+377.5 = 10975 cm2 = 0.10015 m^2

Table 2: Result Table

T_{avg} °C	Q W	Area m^2	H W/ m^2-°C
Parallel Horizontal Fin Pattern			
42.08	105.45	0.1174	102.30
42.74	120.19	0.1174	114.52
Split Fin Pattern			
41.72	102.3	0.10015	225.99
41.92	122.4	0.10015	221.41

Table 1 and Table 2 represent observation table and result table respectively and from observation table it is observed that in case of both set up the surface temperatures at various locations are almost same and fin area is almost same in case of both set up but due to arrangement of spilt fin creates more turbulence in the flow which enhances the rate of heat transfer and so heat transfer coefficient value is high in case of split fin.

4. Conclusion

The major outcome of this work is by modifying the fin arrangement better heat transfer results can be obtained.

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