# Experimental Analysis of Heat Transfer Enhancement through Perforations on Rectangular Fin

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***Abstract*—Enhancement of heat transfer rate and reduction of fin dimension has major criteria in designing the heat exchanger components. This dissertation is an experimental analysis to investigate forced heat transfer of rectangular fin by comparing both solid and circular perforation along the lateral axis of the fin. Performance is analyzed experimentally by designing experimental setup for specific fin length. Thermal performance, effectiveness and efficiency of fins are primarily focused in this study. Due to increase in surface area or convective area heat transfer rate increases, Nusselt Number decreases. The large impact is that higher reduction in weight of fin is achieved by producing perforation which is the major requirement in heat transfer equipment as they were having numerous applications where weight of the material concerns.**

***Keywords*— Effectiveness, Enhancement, Fin length, Nusselt number, Perforation, Rectangular fin.**

## I. INTRODUCTION

The removal of excessive heat from system components is essential to avoid damaging effects of burning or overheating. Therefore, the enhancement of heat transfer is an important subject of thermal engineering. Heat transfer rate from fins can be improved by employing perforations, porosity or slots and also heat transfer improvement may be achieved by either increasing the heat transfer co efficient or the heat transfer surface area or by both. Extended surfaces (fins) are frequently used in heat exchanging devices for the purpose of increasing the heat transfer between a primary surface and the surrounding fluid. Extended surfaces that are well known as fins are commonly used to enhance heat transfer in many industries. There are various types of fins but rectangular plate fins are commonly used for the reason of simplicity in manufacturing. It is easy and effective way to make perforations in rectangular fin and hence the performance investigation of rectangular fin with perforations is considered.

## II. LITERATURE REVIEW

Recent experimental and numerical studies have shown that perforating fins can also offer substantial improvements in heat transfer with reduced pressure losses. Juan Li, Xiang Ling, HaoPeng et al. (2017)[1], the objective of their work is to investigate the boiling heat transfer performance of transverse serrated fin (TSF) channel and triangle perforated fin (TPF) channel in compact plate-fin heat exchanger. A series of boiling heat transfer performance tests are carried out for volume flow rate range of 0.03-0.3 $m^3/h$ and heat flux of 10-20 $kW/m^2$. The local andaverage heat transfer coefficient of TSF channel and TPF channel are examined. It indicates that both local and average boiling heat transfer coefficient of TSF channel was higher than that of TPF channel. The boiling heat transfer occurs in TSF channel at lower wall superheat.

M.J. Silva, P.S.B. Zdanski, M. Vaz Jr. et al. (2017)[2], the main goal of their work is to evaluate the convective heat transfer coefficient at the surface of grey cast iron plate-fins. A hybrid numerical/experimental approach was adopted, i.e. temperature was measured at selected points at the fin surface and an inverse problem technique based on optimization was used to obtain the heat transfer coefficients. The direct heat transfer problem was solved numerically using the finite volume method, whilst the optimization problem was resolved based on particle swarm optimization (PSO). Firstly, the temperature dependence is investigated by comparing uniform,linear and parabolic equations for the heat transfer coefficient. The hybrid approach was validated through an energy balance applied to the finned surface. The parametric study was performed by assessing the influence of the fin spacing and flow velocity on the convective heat transfer coefficient: the results indicate that the convective coefficient is enhanced with increasing Reynolds number and fin spacing. Finally, the experimental results for the Nusselt number in the parametric study were condensed into a single new empirical correlation with good accuracy.

## III. FINS USED FOR EXPERIMENTAL ANALYSIS

Fins are nothing but the extended area to increase the convective heat transferrate. By Newton's law of cooling the convective heat transfer rate is directly proportional to normal area to flow of fluid. Hence by increasing area heat transfer rate increases. In this setup, three different fins with perforation and without perforation are used. Out of those one rectangular fin is without perforation and other two are with perforation of different value of diameters. Fins have 10cm length, 5cm width and 3cm thickness. One fin is perforated with 6mm diameter of circular holes and other is 9mm of circular holes. Fins are made of pure aluminum by casting process with the help of wood pattern.

Fig. 1 Rectangular fin with perforations

## IV. EXPERIMENTAL SETUP

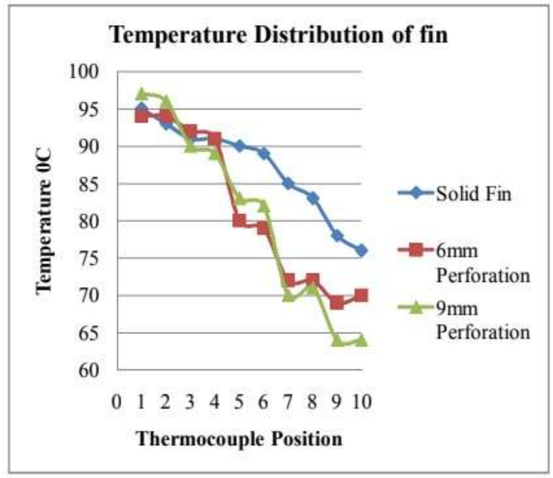
The following fig.2 represents the experimental setup to validate the performance of solid and perforated rectangular fins. The setup includes following main components.

i. Solid and perforated rectangular fins
ii. Galvanized iron duct
iii. Blower
iv. Ammeter
v. Voltmeter
vi. Temperature digital indicator
vii. Heater controller
viii. Dimmerstat

Fig. 3 Experimental setup

## V. RESULTS AND DISCUSSION

*A. Effect of temperature along the fin length*

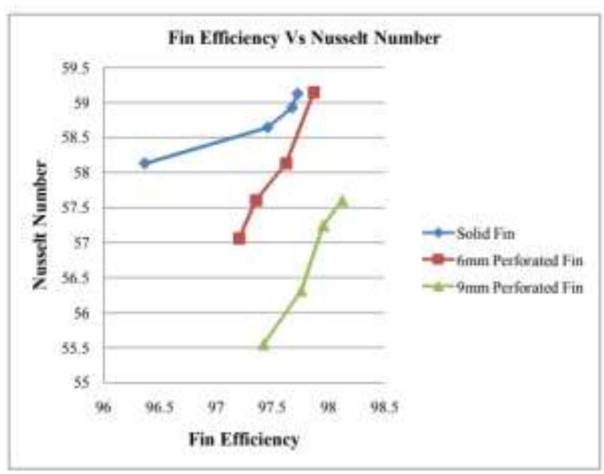



Graph 1 Temperature distribution along the length of fin

The results from the above graph clearly predict that that fin withoutperforation having the high end tip temperature as compared to perforated fin where as it required the lengthy fin to dissipate heat but the fin with perforation having lowend tip temperature than we can clearly suggest that the perforation must reduce the fin length which required the investment cost to dissipate large amount of heat from the extended surface.

*B. Effect of temperature along the fin length*

The significance of Nusselt number already discussed in previous chapter. From the discussion it is clear that the Nusselt number is of more importance to havelaminar flow. From the results plotted against fin efficiency and Nusselt number it is evident that for lower value of Nusselt number the fin efficiency is higher for 9mm perforated fin whereas 6mm perforated fin efficiency is in between former and solid fin so we can clearly conclude that the fin efficiency for solid fin is higher than that of 9mm perforated fin.




Graph 2 Fin efficiency Vs Nusselt number

## VI. CONCLUSION

By performing number of experiment on solid and perforated fins with 6mm and 9mm perforations it is evident that the solid fin having high end tip temperature as compared to perforated fin whereas 6mm perforated fin end tip temperature is higher than that of 9mm perforated fin. This temperature distribution decreases the fin surface temperature in result of that Nusselt number decreases whereas the higher perforated fin having high fin efficiency on low Nusselt number and hence perforations are suitable to decrease weight with increase in rate of heat transfer

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