NOVATEUR PUBLICATIONS
INTERNATIONAL JOURNAL OF INNOVATIONS IN ENGINEERING RESEARCH AND TECHNOLOGY [IJIERT]
ISSN: 2394-3696
VOLUME 2, ISSUE 7, JULY-2015

NUMERICAL ANALYSIS OF THERMAL PERFORMANCE OF LOUVER FIN

Deepak Hasurkar
Department of Mechanical Engineering,
Indira College of Engineering & Management, Pune

Dr. Vinayak Kale
Department of Mechanical Engineering,
Indira College of Engineering & Management, Pune

ABSTRACT

Louver fins are widely used in heat exchanger for automotive applications such as radiator, intercooler, condenser, heater core etc. This study presents numerical analysis of effect of variation of louver pitch on heat transfer rate of louver fins. The three dimensional governing equations for fluid flow and heat transfer are solved using ANSYS Fluent 14.5 for air flow of 4 m/s to 9 m/s. The variations of temperature, pressure and heat transfer rate are studied using computational model. The enhancement of heat rate is observed as louver pitch is reduced.

INTRODUCTION

Automobiles such as trucks, buses, cars use compact heat exchangers for their thermal management, heating and cooling systems. These heat exchangers are air cooled and are made up of number of tubes & fins Louver fins as shown in figure 1 are used on air side in these heat exchangers due to their high heat transfer rate capacity. The heat transfer rate can be varied by varying fin parameters like fin pitch, louver pitch, louver angle, louver patterns etc. This study presents numerical analysis of effect of variation of louver pitch on heat transfer rate.

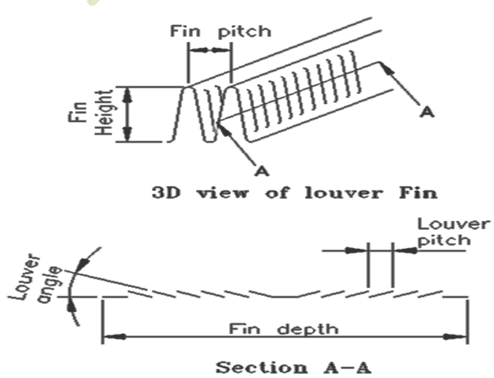


Figure 1 Geometrical parameters of louver fin

LITERATURE SURVEY

Zoran Carija, Bernard Frankovi c, Marko Per ci c and Marko Cavrak [1] studied the heat transfer and pressure drop characteristics of plain & multi louver tube heat exchanger through experiment & using CFD. The comparison of heat exchanger performance with plain and louvered fins was performed over the range of Re numbers within 70-350. The greatest increase in heat transfer performance of 58% was obtained with Re = 350 when using louver fins instead of plain fins, with increase the pressure drop. The interrupted surface can then provide a higher average heat transfer coefficient due to periodical renewal of the boundary layer development when the heat transfer from a solid boundary to the moving fluid reaches its peak intensity.

Wei Li and Xialing Wang [2] studied experimentally, the air-side heat transfer and pressure drop characteristics for brazed aluminium heat exchangers with multi-region louver fins and flat tubes. A series of tests were conducted for heat exchangers with different numbers of louver regions at the air-side Reynolds numbers of 400–1600 based on the louver pitch. The air-side thermal performance data were analysed by using the effectiveness-NTU method. The characteristics of the heat transfer and pressure drop for heat exchangers with different geometry parameters were presented in terms of the Colburn j factor and Fanning friction f factor as function of the Reynolds number. The results shows that as numbers of louver region are increased, the Colburn j factor is increased and it decreases with increased Reynolds number

V.P. Malapure, Sushanta K. Mitra, A. Bhattacharya [3] performed numerical simulation of a compact louvered fin heat exchangers for the determination of heat transfer and pressure drop characteristics. Fifteen different configurations were studied. Design curves are provided for air side heat transfer and pressure drop characteristics of finned heat exchanger. The simulation results are compared with experimental data. The computed Stanton numbers and friction factors are found to be in good agreement with the experiment except at low Reynolds number. It is found that at low Reynolds number the flow is fin directed and at higher Reynolds number the flow is louver directed. The local Nusselt number estimation suggests that Nusselt number is substantially high at the fin tip and at the leading and trailing edges of the louver. It is also found that both Stanton number and friction factor decrease with the increase in fin pitch. For any configuration there exists an optimal louver angle for which heat transfer coefficients maximum. A parametric variation of the geometry provides a desired configuration for which the heat transfer coefficient is maximum and the pressure drop is within the allowable design limit.

Ching-Tsun Hsie and Jiin-Yuh Jang [4] studied successively increased or decreased louver angle patterns and 3-D numerical analysis on heat and fluid flow are carried out. Five different cases of successively increased or decreased louver angles (+2°,+4°, -2°, -4°, and uniform angle20°) are investigated: case A (20°, 22°, 24°, 26°, 24°,22°, 20), case B (20°, 24°, 28°,32°, 28°, 24°, 20), case C (26°,24°,22°,20°,22°,24°,26),case D (32°, 28°, 24°,20°, 24°, 28°, 32°), case E (uniform angle 20°) . For case A (+2°), case B (+4°), case C (-2) and D (-4°), the maximum heat transfer improvement interpreted by j/j0 are 115%, 118%, 109% and 107%, and the corresponding friction factor ratio f/f0 are116%, 119% 110% and 108%, respectively, where j/j0 and f/f0 are the Colburn factor ratio and friction factor ratio between successively variable louver angles and uniform angle, respectively. It is also shown that the maximum area reduction for case B can reach up to25.5% compared to a plain fin surface. The present results indicated the successively variable louver angle patterns applied in heat exchangers could effectively enhance the heat transfer performance. The heat transfer rate increase by 15%, 18%, 9% & 7% respectively compared to uniform louver angle.

A Vaisi, M. Esmaeilpour, H. Taherian [5] investigated experimentally air-side heat transfer and pressure drop characteristics of flow over louvered fins in compact heat exchangers. The test samples consist of two types off in configurations. A series of tests were conducted to examine the geometrical parameters of louver pitch, louver arrangement and number of louver regions. The calculated results indicate that a symmetrical arrangement of louvered fins provides a 9.3% increase in heat transfer performance and a 18.2% decrease in pressure drop than the asymmetrical arrangement of louvered fin. Also, for a constant rate of heat transfer and pressure drop, a 17.6% decrease of fin weight is observed for the symmetrical arrangement of fins and this is following by considerable decrease in total weight and cost of the heat exchanger. The results from this investigation indicate that the configuration of the louvered fins has the dominant influence on the heat transfer and pressure drop from that louver.

OBJECTIVES

The objective of present study is to numerically investigate heat transfer rate of louver fin with different louver pitch & study the compare the results to find best fin pitch which provides highest heat transfer rate. This study also aims to investigate effect on pressure drop with variations of louver at different air velocities.

NUMERICAL ANALYSIS

The Numerical analysis is done in following steps using CFD software ANSYS fluent 14.5.

PROBLEM DEFINITION

3D models are prepared in ANSYS Design Modeller 14.5 for three types louver pitch. The single face of louver fin model is made surrounded by air volume flow as shown in figure 2. The fin height, fin thickness, fin depth, louver angle are same for all three louver fin and these values are 30 mm, 0.1 mm, 192 mm, 20° respectively. The louver pitches used are 8 mm, 16mm and 24 mm. The temperature difference at air outlet & inlet are to be solved numerically.

ASSUMPTIONS

Both fluid flow and heat transfer are in steady state and three dimensional. Fluid is assumed to be incompressible. Properties of both fluid and fin material are temperature independent. At solid wall of fin, no slip condition & constant temperature are assumed.

NOVATEUR PUBLICATIONS
INTERNATIONAL JOURNAL OF INNOVATIONS IN ENGINEERING RESEARCH AND TECHNOLOGY [IJIERT]
ISSN: 2394-3696
VOLUME 2, ISSUE 7, JULY-2015

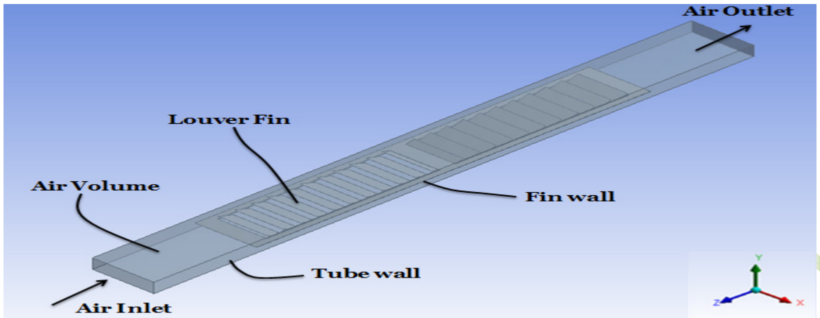


Figure 2 Three Dimensional fluid flow domain

MESHING

Mesh is generated for fin & air volume using ANSYS Mesh 14.5. Tetrahedral mesh is selected with fine meshing with min & max face sizes as 0.5 & 1 mm respectively. Programme controlled inflation chosen. Fin mesh & air volume mesh are shown in figures 3 & 4 respectively.

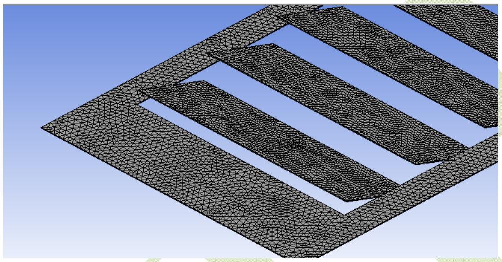


Figure 4 Fin Meshing

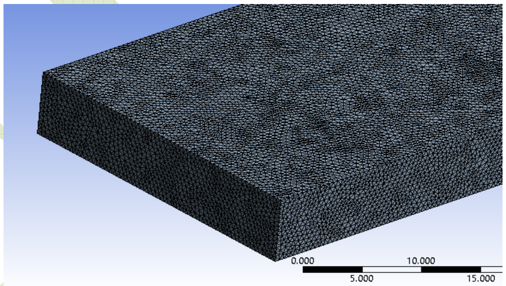


Figure 3 Air Volume Meshing

BOUNDARY CONDITIONS

Air Inlet:
Velocity,   u=0, v=0, w= 4 m/s to 9 m/s
Temperature of air = 35 °C
Pressure = 400 Pa gauge
Air Outlet:
Temperature & pressure solved by solver,
Fin wall (in contact with tube wall):
Temperature = 95 °C
Tube wall:
Temperature = 95 °C
Other fin surfaces & Air surfaces temperatures are calculated by solver

SETUP & SOLUTION

ANSYS Fluent 14.5 is used as solver. The boundary conditions mentioned above are filled. The three dimensional governing equations for fluid flow & heat transfer are solved using solver. The solver type is set to pressure based and velocity formulation as absolute. Viscous model of k-e and standards wall function are chosen. Material of Air chosen as fluid and Aluminium for fin, Cell zone conditions for Air & fin are set to fluid & solid respectively. The solution is initialised with hybrid initialization & solution is run with 125 iterations.

RESULTS & DISCUSSIONS

Figures 4 & 5 shows temperature contour for air outlet, air inlet respectively, figures 6 & 7 shows fin temperature distribution & air volume temperature distribution at air velocity 4 m/s at tube wall temperature of 95 °C obtained from results of solution run in fluent.

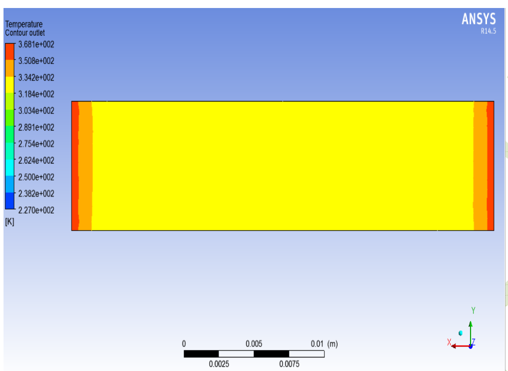


Figure 5

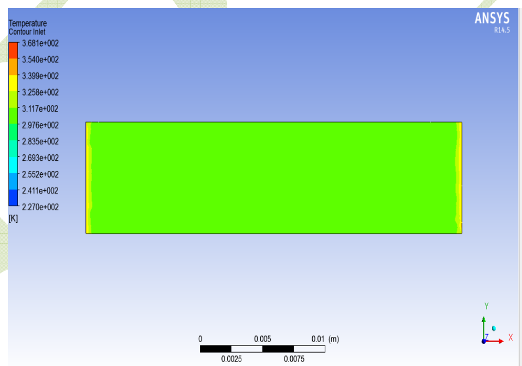


Figure 6

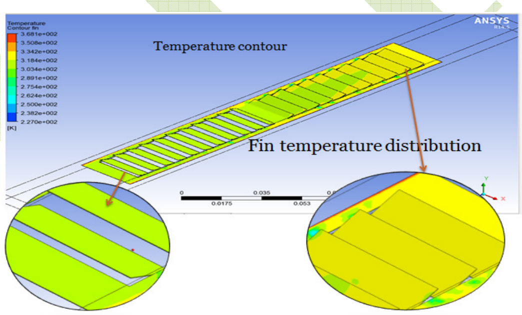


Figure 7

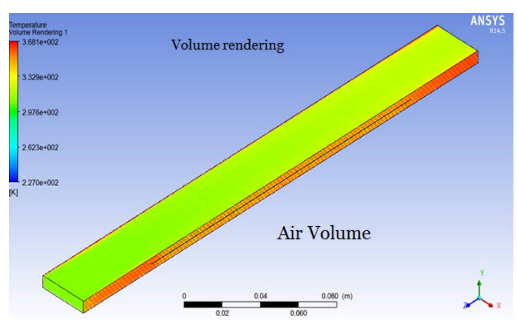
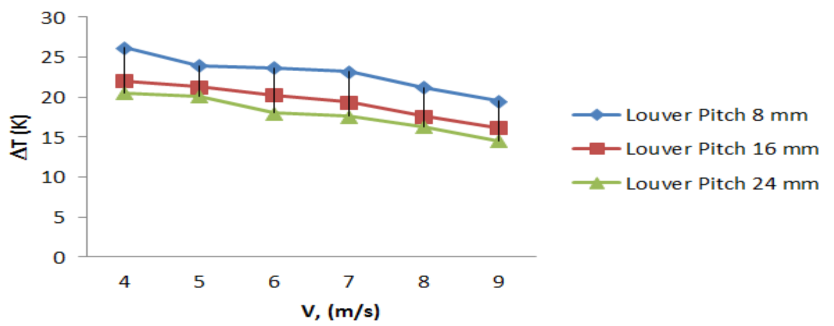


Figure 8

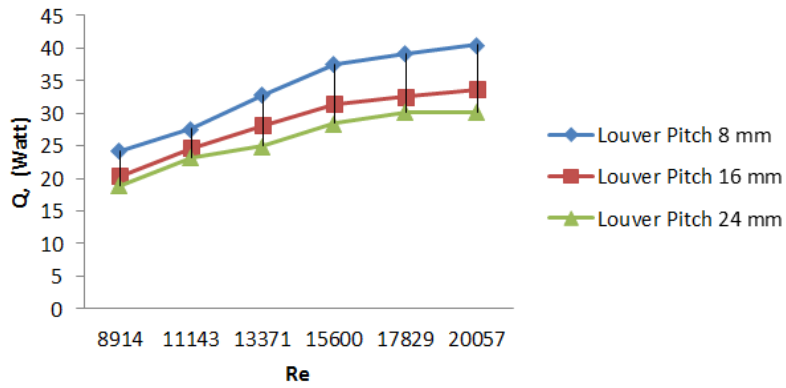
Similar results are obtained for different air velocities & are presented in Table 1. The graph 1 shows that as air velocity is increases, the temperature difference ΔT reduces. The trend is followed by all three fins with different louver pitch. The ΔT is maximum at lower velocity. The graph 2 shown variation of heat transfer rate as Reynolds number is increased.



Graph 1 Temperature Difference vs. Air Velocity

Table 1

Louver Pitch	Parameter	Air Velocity (m/s)					
		4	**5**	**6**	**7**	**8**	**9**
		Reynolds Number					
		8914	**11143**	**13371**	**15600**	**17829**	**20057**
8 mm	Ti, (K)	308	308	308	308	308	308
	To, (K)	334.2	331.9	331.7	331.2	329.2	327.5
	ΔT, (K)	26.2	23.9	23.7	23.2	21.2	19.5
	Q (Watt)	24	28	33	38	39	41
16 mm	Ti, (K)	308	308	308	308	308	308
	To	330	329.3	328.3	327.4	325.6	324.2
	ΔT, (K)	22	21.3	20.3	19.4	17.6	16.2
	Q (Watt)	20	25	28	31	33	34
24 mm	Ti, (K)	308	308	308	308	308	308
	To	328.5	328.1	326	325.6	324.3	322.5
	ΔT, (K)	20.5	20.1	18	17.6	16.3	14.5
	Q (Watt)	19	23	25	28	30	30

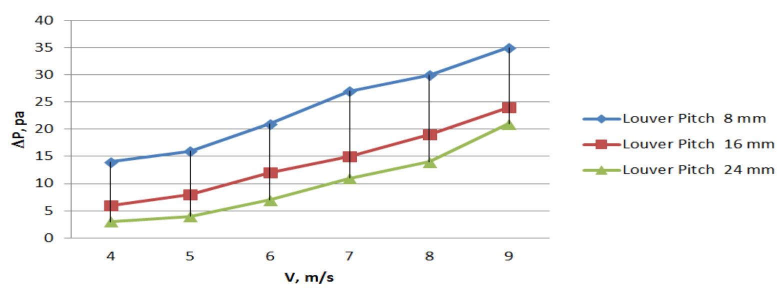


Graph 2 Heat Transfer Rate vs. Reynolds Number

The Pressure drop across fins is given in table no 2. The graph 3 shows that pressure drop increases as air velocity increases. Also it can be seen from graph 3 that as louver pitch is reduced from 24 mm to 16 mm, the pressure drop increases and it further increases for louver pitch 8 mm.

Table 2

V, m/s	Pressure Drop ΔP, Pa		
	Louver Pitch 8 mm	Louver Pitch 16 mm	Louver Pitch 24 mm
4	14	6	3
5	16	8	4
6	21	12	7
7	27	15	11
8	30	19	14
9	35	24	21



Graph 3 Pressure Drop vs. Air Velocity

CONCLUSION

This numerical study provides effect of one of parameter louver pitch on temperature difference between air inlet & outlet and heat transfer rate. The results show that the temperature difference reduces as air velocities increases. Among three louver pitch considered here, 8 mm louver pitch shows highest temperature difference. The fin with louver pitch 8 mm shows 34.5% and 20.4% heat transfer rate enhancement than louver pitch 24 mm & 16 mm respectively. But at the same time the pressure drop is increases as the louver pitch is increased. This analysis also provides the temperature distribution at outlet, along fin material & any cross section of air flow.

REFERENCES

[1] Xialing Wang Wei Li, "*Heat transfer and pressure drop correlations for compact heat exchangers with multi-region louver fins," vol. 53, no. 2955-2960, 2010.*

[2] Sushanta K. Mitra, A. Bhattacharya V.P. Malapure, *"Numerical investigation of fluid flow and heat transfer over louvered fins in compact heat exchanger," vol. 46, no. 199-211, 2007.*

[3] Ching-Tsun Hsieh and Jiin-Yuh Jang, "*3-D thermal-hydraulic analysis for louver fin heat exchangers with variable louver angle," vol. 26, no. 1629-1639, 2006.*

[4] M. Esmaeilpour, H. Taherian A. Vaisi, *"Experimental investigation of geometry effects on the performance of a compact louvered heat exchanger," vol. 31, no. 3337-3346, 2011.*

[5] Bernard Frankovi c, Marko Per ci, Marko Cavrak Zoran Carija, "*Heat transfer analysis of fin-and-tube heat exchangers with flat and louvered fin geometries," vol. 45, no. 16-167.*