Study and Compare of Heat Transfer Enhancement in Interruped Louvered Fins and Rectangular Fins

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Abstract
To increase the heat transfer rate of heat exchanger as well as internal combustion engine through fins in compact region the louvered interrupted plate fins has designed for increasing fins surface area and compare both fins models on the bases of temperature, velocity and heat transfer coefficient. FLUENT and Multi-physics software are used in order to develop a 3-D numerical model for investigation of interrupted louvered fins and rectangular fin. ILF and rectangular fins both analyzed by CFD tool, on the basis of geometrical parameters the compact relationship for Nusselt Number exhibits enhancement of thermal performance. Interrupted louvered Fin-plate weight reduces while surface area increases. Air is taken as the working fluid and The flow regime is assumed to be turbulence, and the mean velocity is such that the Reynolds numbers of interest are above the critical Reynolds number. This study gives a performance data for a rectangular fin in simple and ILF in a plate-fin heat exchanger. In order to evaluate the performance, bulk temperature and combined span wise average Nusselt number (Nusa) are calculated.
Keywords: force convection air cooling; thermal management; heat transfer; fluid flow; CFD Modeling heat sink design; radiator modeling. Interrupted Louvered Fins (ILF).

1 INTRODUCTION

A fin is used to transfer thermal energy of heat source to surround in IC engine as well as in other heat source. According to present scenario in heat exchanger and in IC engine we need to such type of a fin that can maximum heat transfer from the object or cylinder base to environment. During some passed year there are lot of research occurs and suggest different type of fins design such as tapered fin, louvered fin etc. in present there has been great demand for high performance fins, lightweight fins, 'compact fins. ILF fins are recognized as most effective means of increasing the heat dissipation. The design criteria of fins are different for various applications, but the primary concern is heat transfer rate, weight and cost. Therefore it is highly desirable to optimize on a CFD tool for optimum design of fin which have maximum heat transfer rate and low weight and size.
The following assumptions are made in the analysis:
(1) Steady state holds;
(2) The material is homogeneous and isotropic;
(3)The temperature of the surrounding fluid is constant;
(4) There is no heat source in the fin;
(5) The base temperature is uniform;
(6) The thermal properties of the fin, such as density, specific heat, and conductivity, are constant.

2 PROBLEM DESCRIPTION:

The present work focuses on computational fluid domain (CFD) study of the flow structure and heat transfer characteristics of the fluid flowing in a plate-fin heat exchanger with interrupted louvered fins and Rectangular fins mounted on the base plate of heat exchanger and internal combustion engine. The geometry of the proposed design is shown in Figure 1Two different shapes of the fins i.e. rectangular fins, and interrupted louvered fins investigated for heat transfer enhancement potential in a plate-fin heat exchanger

2.1Geometry of fins

2.1.1 Rectangular fin geometry parameters

Geometrical parameters of the base plate fins
Fin pitch 15 mm
Fin Thickness 3 mm
Number of horizontal fin 2
Length of fins =97mm
Base plate thickness =3mm
Range of geometrical parameters used for parametric analysis

Fig-1

2.1.2 Interrupted louvered fin geometry parameters

Fin pitch 15 mm
Fin Thickness 3 mm
Number of horizontal fin 2
Length of fins =97mm
Base plate thickness =3mm
Interruption pitch=25mm

Interruption angle= 40^0,

2.1.3 For two interruption

Interruption plate length=6mm, 8mm,

Louvered shape and size =rectangular (length=30mm, width=4mm)

Range of geometrical parameters used for parametric analysis,

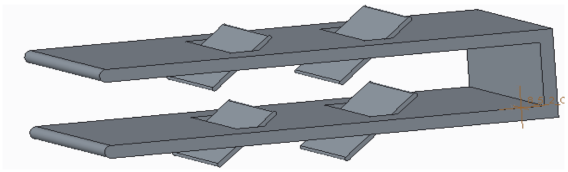


Fig-2

3 MODEL GENERATION (CREO SOFTWARE)

The base model is created with the help of CREO and SOLID WORKS Modeling Software. Model has these parts mainly. All are designed separately and assembled together. Tested in specified condition.

1. Solid Base
2 Solid Fin Surface
3. Solid interruption plate
4. Louvered area,
5. Enclosure.

3.1 Surface Area of interrupted louvered fin = Area of top and bottom of fin - Area of top and bottom of hole + Area of front and back of interruption plate +area of side of interruption fin +Area of four inside louvered face + Area of the side of the fin

3.2 Boundary Conditions for the Confining Surfaces

(a) Velocity Boundary Conditions at the No-Slip Planes

X=Y=Z=O

(b) Velocity Boundary Conditions at the Plane

The U velocity is taken symmetric along the plane

Y = Z = 0

(c) Inflow Boundary Conditions at the Channel Inlet

The inflow velocity is taken as constant

X = -150 (8.5) 0R (10.5)

Y=+45

3.3 Boundary Conditions for the interrupted fin

The interruption fins is a part of 1mm thickness. Since it is a no-slip

In the surface the velocity boundary conditions on the surface of the interruption fin are

X= 1 ,Y = Z = 0

4 MESH INDEPENDENCY TEST

A mesh independency test has been performed for a rectangular fin case, in this modeling case size length x=0.2015m, length y=0.006m and length in z direction=0.0035m shown in figure .this case is meshed with five different mesh size, in that there was tetrahedral meshing and triangular meshing. There was maximum size $5.3407 * 10^{-5}$ m and minimum size of mesh $5.3407*10^{-3}$ m.

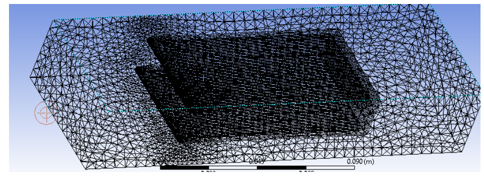


Fig-3

s.no.	length from base	T fin (K)	vel.(m/s)	H
1	10	724	20.9	128
2	20	674	18.2	97.8
3	30	632	16.1	90
4	40	596	14.7	85
5	50	565	13.8	83
6	60	539	13.4	80.9
7	70	518	13	80
8	80	502	12.9	85
9	90	489	12.8	161
10	100	481	14.2	527

Table 1

4.1 Interrupted louvered fin

length of mesh is 0.2015 m and width of this in z direction 4.35e-002 m and height of this in y direction 6.4e-002 m, choosing a mesh number of 1.0759e-002 and used 357069 nodes and 2119091 elements more than these nodes and elements there was very less percentage change in nusselt number.so these value is suitable for all calculation and investigation purpose.

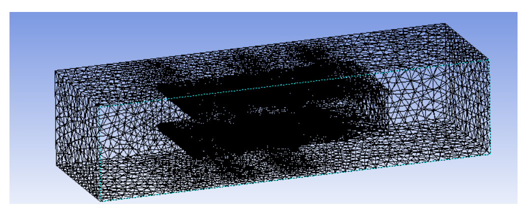


Fig-4

5 SIMULATION SOLUTIONS AND DISCUSSION

In this discussed comparative study of rectangular fin to interrupted louvered fin at velocity 10 m/s and different interruption angle 40^0 and with 2 interruption plate. A commercial finite volume analysis package, ANSYS FLUENT 16.0 selected to perform numerical analysis on the model. The realizable green-gauss cell based turbulence model with standard wall function was set for each model.

Performance of rectangular fin and heat transfer rate at 10.5 m/s

Velocity contour Temperature contour

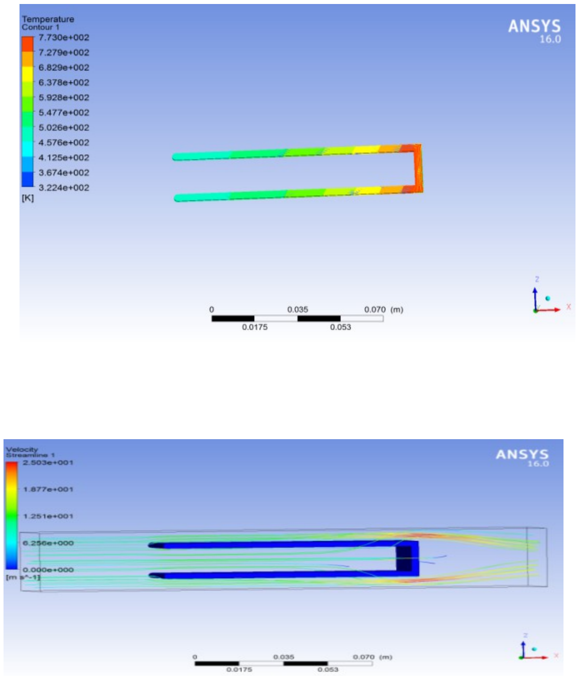


Fig 5

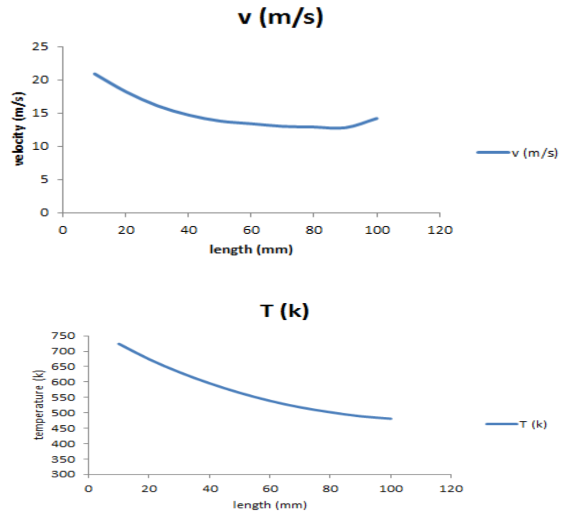


Fig 6

Table 2

Performance of interrupted louvered fins and heat transfer rate at 10.5m/s with 2 interruption plate.

Temperature contour at 40^0 Velocity contour at 40^0

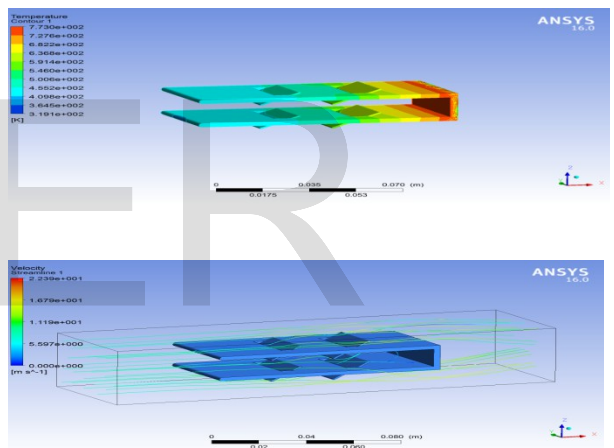


Fig-7

s.no .	length from base	T fin (K)	vel.(m/s)	H
1	10	712	15.5	121
2	20	654	16	131
3	30	612	15.8	344
4	40	575	16.4	148
5	50	489	14.5	195
6	60	460	16.4	977
7	70	445	14.3	239
8	80	421	10.7	93
9	90	412	10	74
10	100	408	11.8	318

s.no.	length from base	Rectangular fin	T fin (K) at 40°
1	10	724	712
2	20	674	654
3	30	632	612
4	40	596	575
5	50	565	489
6	60	539	460
7	70	518	445
8	80	502	421
9	90	489	412
10	100	481	408

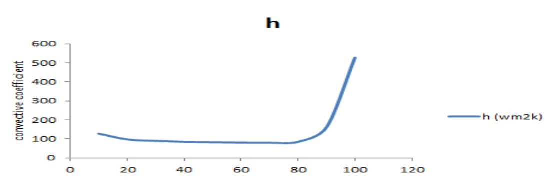


fig-8

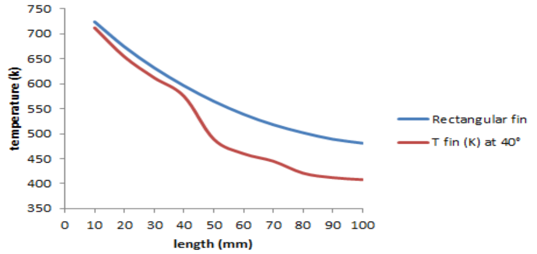
Performance of interrupted louvered fin and heat transfer rate at 10.5m/s with 2 interruption at 40^0

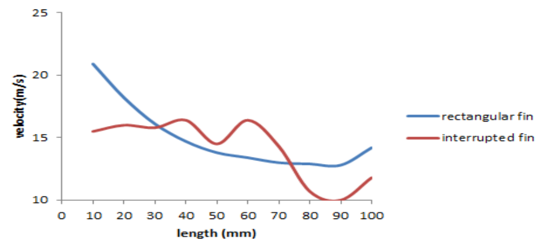
in this I find the value along the length of fin at 10mm 20mm 30mm 40mm 50mm 60mm 70mm 80mm 90mm and 100 mm or tip of the fin, along the vertical plane of these point and horizontal plane mid of fins. In this model base plate temperature of is given by us is 773 k.

Performance of interrupted louvered fin and heat transfer rate at 8.5m/s with 2 interruption at 40^0

Comparative tabular data of rectangular fin and interrupted louvered fin at 10.5m/s at 40^0

Table 3





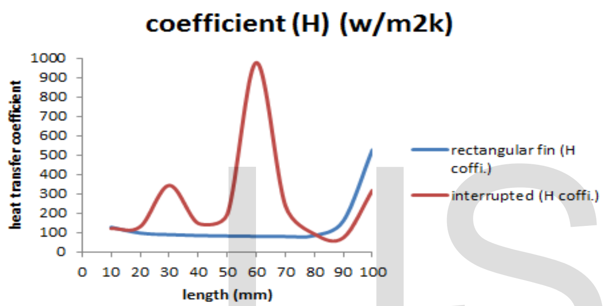


Fig 7

6 CONCLUSIONS

The performance of fins used in heat exchanger and internal combustion engine may improve by best designing fin shape. Performance of heat exchanger and internal combustion engine can be improved by mounting of interrupted louvered fin on the Surface of heat exchanger and internal combustion engine. The surface geometries of fins, which are well known in different industrial applications as well as engines, are wavy fins, off-strip fins, perforated and louvered fins.

The conclusions drawn from the research work are:

• The interrupted louvered fin as compare to simple rectangular fin Disturbs the flow structure and creates more turbulence.

• At the same, geometry parameter interrupted louvered fin with angle 40^0 more efficient compare to rectangular fins and the combined span wise average Nusselt number (Nusa) And heat transfer coefficient is max .Nusselt number (w.r.t plane duct) increases from 4.4% .and surface heat transfer coefficient will increase 7.36%.

• After making louvered and attach interruption plate area increase 19% (with 2 interruptions) and mass reduce 9.6 % (with 2 interruptions) and so fin cost will economical.

s.no .	Fins	base plate tem (k)	Fin tip tem.	Nusselt no.	h surface
1	rectangular fin	773	458	67.47	1.63
3	interrupted louvered fin at 40°	773	408	70.45	1.75

Table -4

As we know that heat transfer rate in fin is combination of heat conduction and heat convection as per this study base and tip temperature difference is more in interrupted louvered fin heat so conduction rate in interrupted louvered fin will be more. Create more cooling effect on the base plate as compare to rectangular fin.

So $Q_{\text{interrupted fin}} > Q_{\text{ractangular fin}}$

7 SCOPE FOR FUTURE WORK

In the present computation, constant temperature boundary conditions are considered along the walls. The model presents an idealized situation. A more accurate model could be to consider the finite thickness of the plates of the plate-fin exchanger and the interrupted louvered fin and solve the conjugate heat transfer problem. The solution of the conjugate heat transfer problem can be expected to yield predictions that are more exact. The computations can further be performed comparing different types of fin shapes.

• The present work can be further extended for different geometries of the inserts (fins) being used between the plates of the compact heat exchanger.

• The computations are performed assuming the flow regime to be turbulence model and force convection. And changes of geometry make in only rectangular fin may be similar type of geometry can change in different geometry shape.

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