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Comparative Study of Heat Transfer Enhancement in Rectangular And Interruped Louvered Fins (Newly Designed) in Internal Combustion Engine Using Cfd Tool

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Abstract: To increase the heat transfer rate of heat exchanger through fins in compact regionthe louvered interrupted plate fins has designed for increasing fins surface area. FLUENT and Multi-physics software are used in order to develop a 3-D numerical model for investigation ofinterrupted louvered fins. ILF analyzed by CFD tool, on the basis of geometrical parameters the compact relationship for Nusselt Number exhibits enhancement of thermal performance. Fin-plate weight reduces while surface area increases. Air is taken as the working fluid andThe 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. The heat transferenhancement is observed with the use of different interruption angles of 30^0, 40^0 and 50^0

Keywords: force convection air cooling; thermal management; heat transfer; fluid flow; CFD Modling heatsink design; radiator modeling. Interrupted Louvered Fins (ILF)

I. INTRODUCTION

A heat exchanger is a device which is used to transfer thermal energy between two sources. In recent years there has been great demand for high performance, lightweight, 'compact, and economical heat transfer components. The fins are recognized as one of the 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 of fins. The optimum dimensions are those for which maximum heat is dissipated for a given weight or mass of the fin. The most effective heat transfer enhancement can be achieved by surface area extension of fins. The purpose of this study is to determine heat transfer capacity of new designed fin and compare with rectangular fin and the optimum dimensions and shapes for rectangular longitudinal fins and interrupted louvered fins by including transverse heat conduction. Furthermore, the present study investigates the effect of a variable heat transfer coefficient on the optimum dimensions of the aforementioned fins. The variable heat transfer coefficient is generally expressed in the form h=hc(Ts-Tf)m/Lcn where *h*, is a Dimensional constant, *L*, is the characteristic length, and *m* and *n* aredimensionless constants, the values of which depend on the type of heat transfer (such as radiation in space, free convection, forced convection, nucleate boiling, or film boiling) and the nature of the flow (such as laminar or turbulent flow). Using an integral approach, we determine the optimum heat transfer coefficient and heat transfer rate of three dimensional interrupted louvered fins and compare them with the three-dimensional and the exact two dimensional solutions for the case of constant length. After establishing the validity of theintegral approach in determining the heat transfer rate rectangular longitudinal fins,technique is applied to interrupted louvered fins by considering a variable no. of interruptions and velocity. The fin performance has been obtained in an analytical form so that classical techniques can be adopted for optimization. In the present paper, a method has been suggested for optimizing longitudinal finsbased on a CFD.

II. GOVERNING AND CFD EQUATION

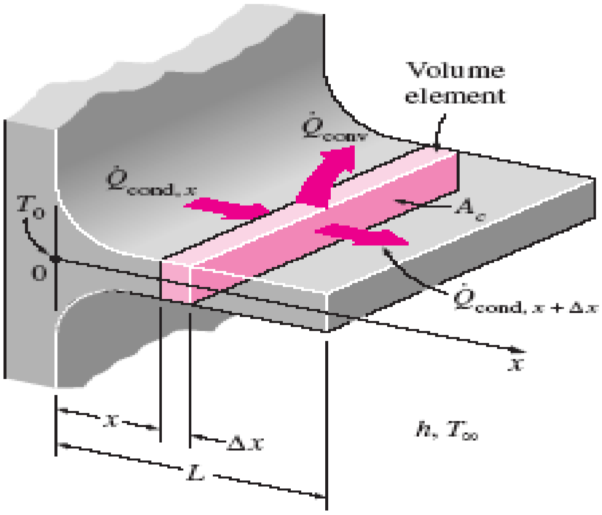
The following assumptions are made in theanalysis:

(1) Steady state holds;
(2) The material is homogeneous and isotropic;
(3) The temperature of the surrounding fluid isconstant;
(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.

Consider a volume element of a fin at location *x* having a length of Δx, cross sectional area of *Ac*, and a perimeter of *p*, as shown in Fig 1. Under steady Conditions, the energy balance on this volume element can be expressed as (Rate of heat conduction into the element at x) = (Rate of heat conduction from the element at x+Δx) + (Rate of heat convection from the element)

or **Qcond. x= Qcond. x+Δx+ Qconv.**

Where, **Qconv= h (p Δx) (T- T∞)**

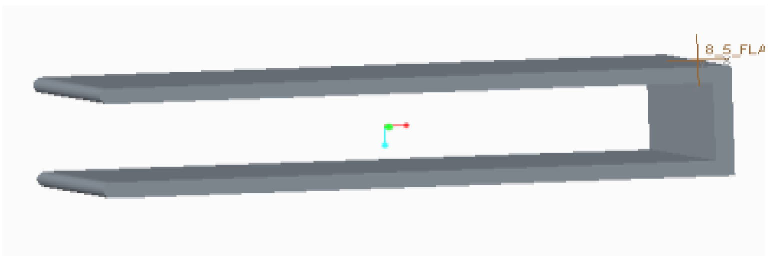


Problem description:

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 3.1(a).Two 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

Geometry of rectangular fins

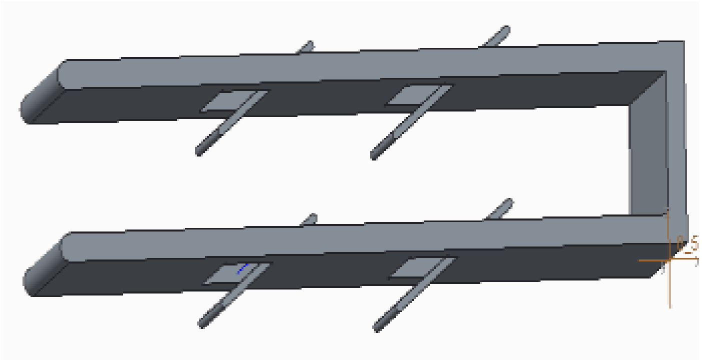
Geometrical parameters of the base plate fins
Fin pitch 15 mm
Fin Thickness 3 mm
Number of horizontal fin 2
Length of fins =97mm
Base plate thickness =3mm
Range of geometrical parameters used for parametric analysis



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=30mm
Interruption angle=case1=30^0,40^0,50^0

For two interruption
Interruption plate length=6mm,8mm,



Model Generation (Creo Software)

The model is generated with the help of CREO and SOLID WORKS ModelingSoftware. Model has five parts 1. Solid Base 2 Solid Fin Surface 3.solid interruption plate 4. Louvered area, 5.Enclosure. All were creating separately and assembled and nomenclature as part 1, part 2 and part 3 part 4 part 5. The length of fin was kept same for all models and size of louvered also was kept same for all case of fin. But the length of interruption fins varied with the distance of fin tip and fin pitch also was remains constant and surface area was increased with the changing of geometry and height (Length) of two fins was also same. Thereafter these two fins are mounted on a single solid base and putted in enclosure for extra work. If we consider "L" as the length of the rectangular fin ,the surface area can easily calculated from The following formulas: **Surface Area** = Areas of top and bottom +Area of the side

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

Boundary Conditions for the Confining Surfaces

(a) Velocity Boundary Conditions at the No-Slip Planes
X=Y=Z=O

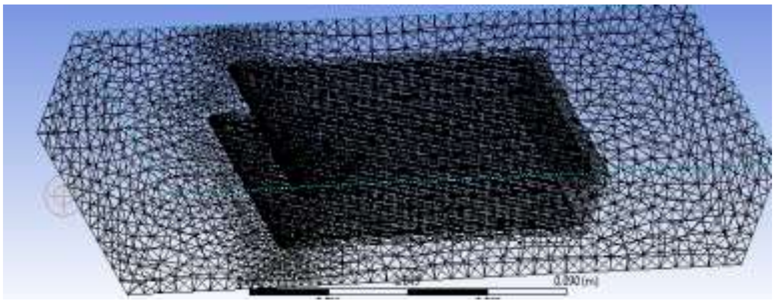
(b) Velocity Boundary Conditions at the Plane
The U velocity is taken symmetric along the plane
Y = Z = 0

(c) Inflow Boundary Conditions at the Channel Inlet
The inflow velocity is taken as constant
X = -150 (8.5) 0R (10.5)
Y=+45

3.4.2 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

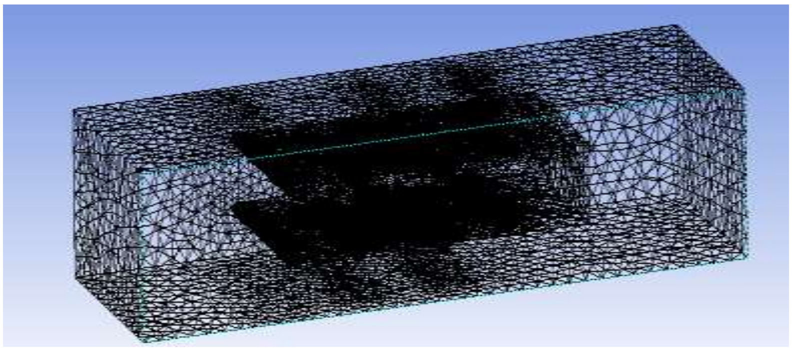
Mesh independency test

A mesh independency study has been performed for a continuous fin case, there was 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 seven 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.



Interrupted louvered fin

The computational domain, shown in Figure for the 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 put many down value of mesh no.and found 5.3793e-003 this is optimum value for meshing in the ANSYS meshing, 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 prefable for all calculation and investigation purpose.



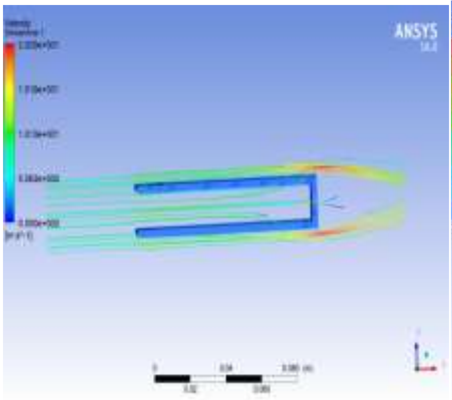
III. SIMULATION SOLUTION AND DISCUSSION

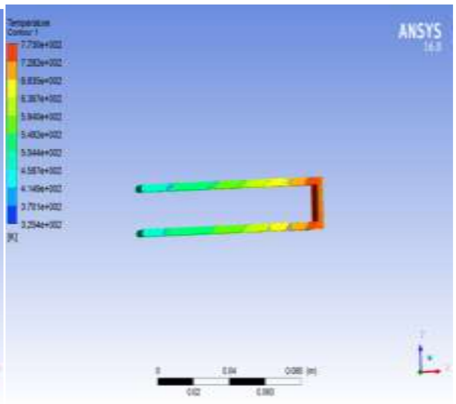
In this chapter discussed comparative study of rectangular fin to interrupted louvered fin at velocity 8.5m/s and different interruption angle like 30^0,40^0 and 50^0 and with 2 interruption plate. A commercial finite volume analysis package, ANSYS FLUENT 16.0 selected to perform numerical analysis on the model. The realizable green-gauss cell based turbulence modelwith standard wall function was set for each model. The Segregated 3D solver with an implicit formulation was set to solve the models

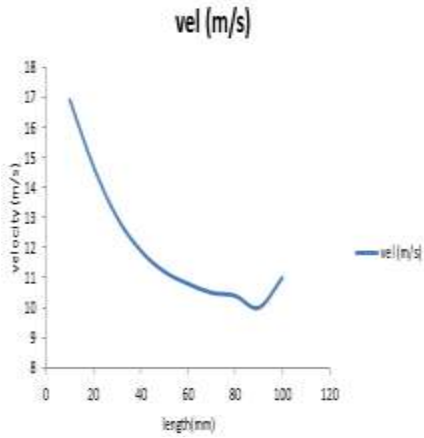
Performance of rectangular fin and heat transfer rate at 8.5m/s

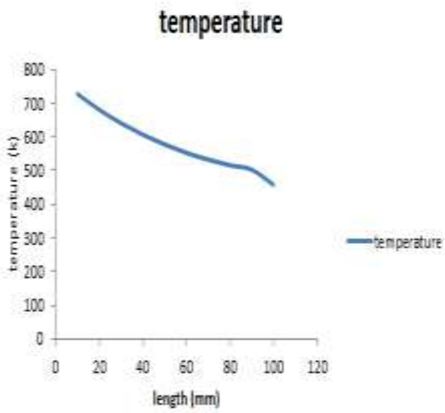
s.no.	length from base	T fin (K)	vel.(m/s)	p (pa)	h
1	10	728	16.9	258	122
2	20	681	14.7	249	85
3	30	641	13	237	79
4	40	607	11.9	226	74
5	50	578	11.2	219	72
6	60	553	10.8	215	70.7
7	70	533	10.5	212	70
8	80	516	10.4	210	83
9	90	503	10	213	161
10	100	458	11	216	527

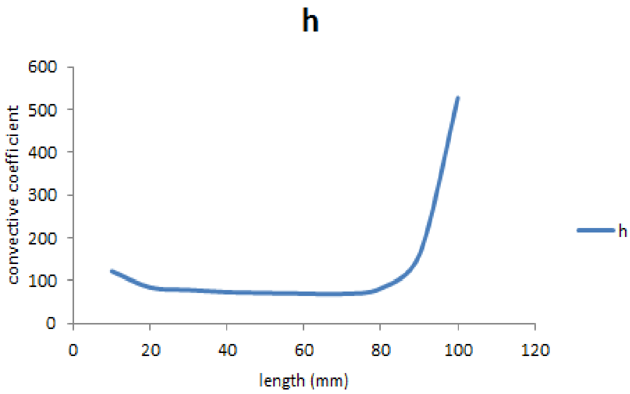
Velocity contourTemperature contour





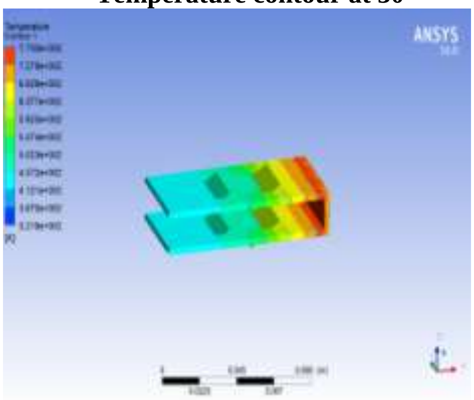




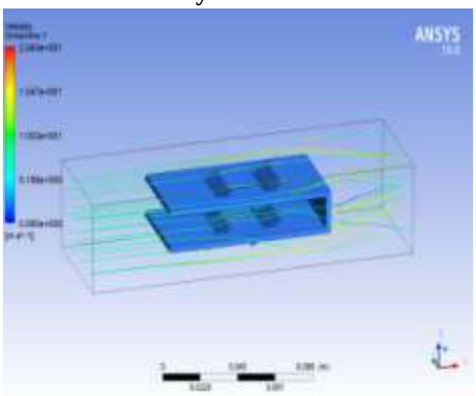


Performance of interrupted louvered fins and heat transfer rate at 8.5m/s with 2 interruption plate.

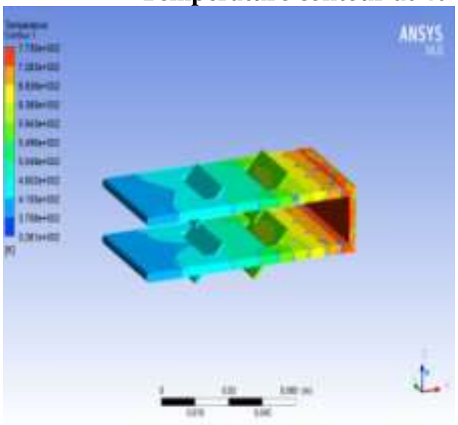
Temperature contour at 30^0

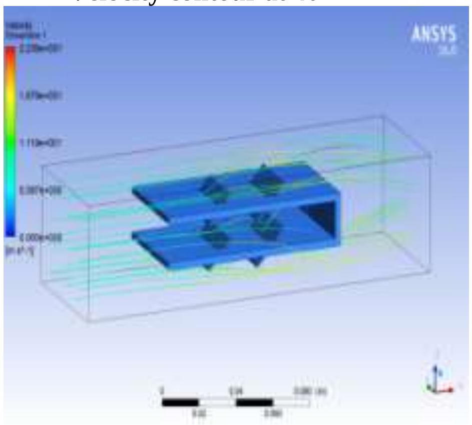


velocity contour at 30^0



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





Performance of interrupted louvered fin and heat transfer rate at 8.5m/s with 2 interruption at 30^0,40^0 and 50^0

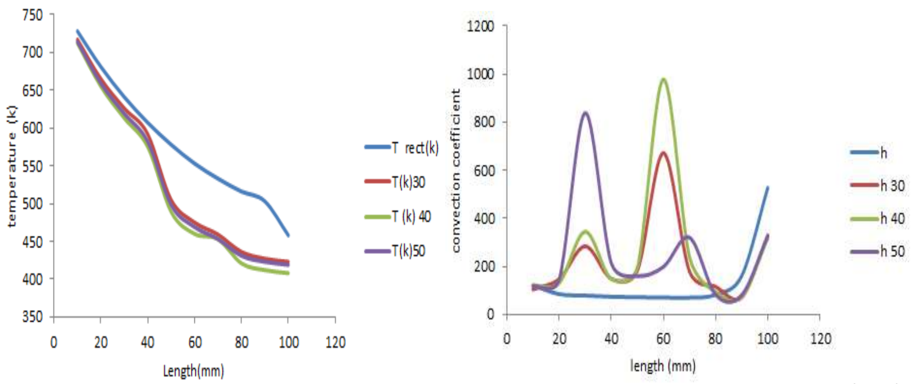
In this I find the value along the length of fin at 10mm 20mm 30mm 40mm 50mm 60mm 70mm 80mm 90mm and 100 mm or tip of the fin, along the vertical plane of these point and horizontal plane mid of fins. In this model base plate temperature of is given by us is 773 k.

Performance of interrupted louvered fin and heat transfer rate at 8.5m/s with 2 interruption at 30^0

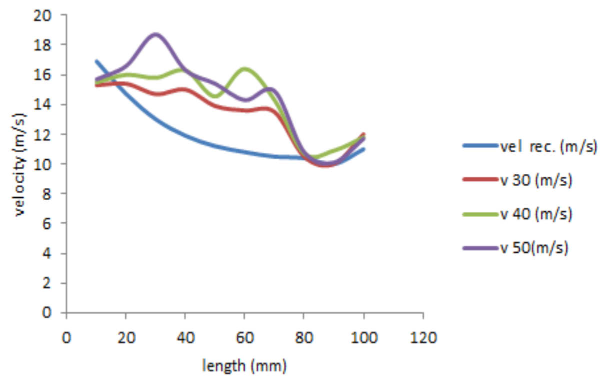
s.no.	length from base	T fin (K)	vel.(m/s)	p (pa)	h
1	10	717	10	112.3	105
2	20	665	10.5	109	147
3	30	626	13.5	108	284
4	40	592	13.6	107.2	149
5	50	505	13.9	105	183
6	60	475	15	94.3	671
7	70	459	14.7	85	179
8	80	436	15.4	95	116
9	90	427	15.3	128	72
10	100	423	16	130	329

Comparative tabular data of interrupted louvered fin at 8.5m/s at 30^0 40^0 and 50^0

s.no.	length from base	T fin (K) at 30°	T fin (K) at 40°	T fin (K) at 50°
1	10	717	717	714
2	20	665	655	659
3	30	626	613	619
4	40	592	575	582
5	50	505	489	498
6	60	475	460	469
7	70	459	453	453
8	80	436	421	431
9	90	427	412	423
10	100	423	408	419



Comparative temperature and heat transfer coefficient of interrupted louvered fin at 30^0 40^0 50^0



IV. CONCLUSION

The performance of the heat exchangers and internal combustion engine canbe improved by mounting of interrupted louvered fin on the Surface of heat exchanger and internal combustion engine. The surface geometries, which are popular in different industrial applications, are wavy fins, off-strip fins, perforated and louvered fins. Somewhat different concept for the reduction of thermal resistance and enhancement in heat transfer is the use of Interrupted louvered fins.

The conclusions drawn from the research work are:

The interrupted louvered fin mounted on the heat exchanger and internal combustion engine Disturbs the flow structure and creates more turbulence.

• At the same, geometry parameter of fin more efficient at interruption angle 40^0 and the combined span wise average Nusselt number (Nusa) And heat transfer coefficient is max at this angle between $30^{\,0}$ 40and 50^0 .Nusselt number (w.r.t plane duct) increases from 5.5% at 40^0 with an increase in angle of interruption this will start to reduce.

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

Table -5.1

s.no.	Fins	base plate tem (k)	Fin tip tem.	Nusselt no.	h surface
1	rectangular fin	773	458	59	1.43
2	interrupted louvered fin at 30°	773	423	56.3	1.36
3	interrupted louvered fin at 40°	773	408	62.07	1.51
4	interrupted louvered fin at 50°	773	419	62	1.5

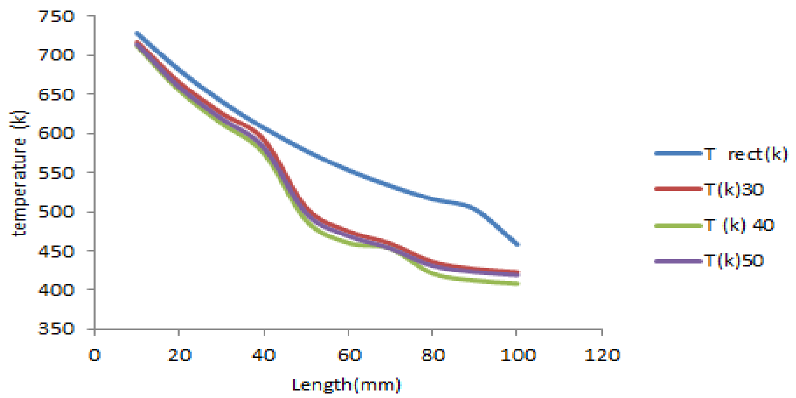


Fig-5.1

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.According to these analysis and compare all cases with rectangular fin. in first case of interrupted louvered fin case nussult no is less then rectangular fin so can say convection rate is low as compare to rectangular fin .but after increasing angle of interruption plate nussult no is increased and max at 40 degree angle so we can say that so we can say convection heat transfer rate will be more in these case so we can say fin is more effective as compare to simple rectangular fin

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

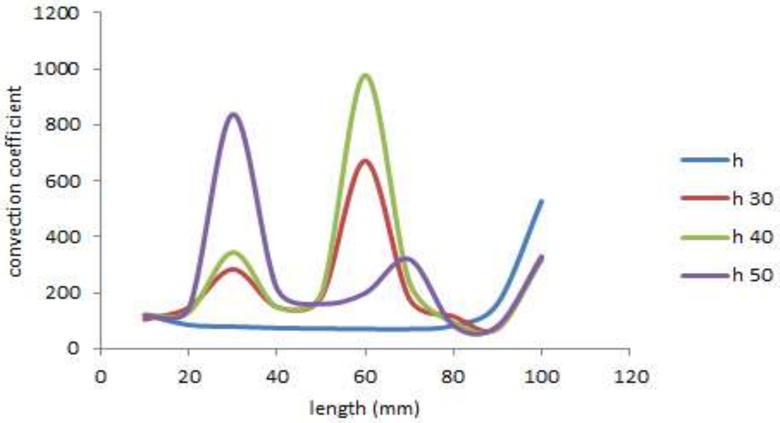


Fig-5.2

As we can see in graph due to geometry change the value of convective coefficient increased.in this interrupted louvered fin at 40 degree is more sufficient.

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 typestype 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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