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Numerical Study of Heat Transfer Enhancement in A Plate-Fin Heat Exchanger using Rectangular Winglet type Vortex generator

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ABSTRACT

The flow structure and heat transfer characteristics in a plate-fin heat exchanger, having built-in vortex generators mounted on the triangular fins have been analyzed by means of the solution of complete Navier-Stokes equations and energy equation. The vortex generators are in the form of a rectangular winglet and a rectangular winglet pair. These vortex generators can be mounted on the fin surfaces by either welding, punching. The savories disrupt the growth of the thermal boundary layer and serves to bring about. The geometrical configuration considered in this study is representative of a single element of the plate-fin heat exchanger.Air is taken as the working fluid. The flow regime is assumed to be laminar because, usually the fin spacing is small and the mean velocity is such that the Reynolds number so finterest are below the critical Reynolds number. The constant wall temperature thermal boundary conditions are considered. The finite difference method are discredited using a weighted average of second upwind and space centered scheme.Computer program has been developed in Visual FORTRAN using the MAC method to find the pressure and velocity field for the present problem. The validity of the code is tested by comparing the results for a two-dimensional lid driven square cavity with the published results. Further the validity of the present model is established by computing the combined span wise average Nussle number for awfully developed flow in a rectangular channel. The results are in good agreement with the published results.

Key Words: Heat Transfer A Plate-Fin Heat Exchanger using Rectangular Winglet Vortex generator

INTRODUCTION

The traditional method so freducing the air-side thermal resistance are by increasing the surface area of the heat exchanger, or by reducing the thermal boundary layer thickness on the surface of the heat exchanger. Increasing the surface area is effective but it results in the increase in material cost and increase in mass of the heat exchanger. One of the methods to reduce boundary layer thickness is by the generation of passive vortices. In this technique the flow field is altered by an obstacle to generate vortex oriented in the direction of the flow. The resulting change in the flow due to an obstacle alters the local thermal boundary layer. The net effect of this manipulation is an average increase in the heat transfer for the affected area. The present work is under taken to compute the heat enhancement levels achievable in a plate-fin heat exchanger

Classification of Heat Exchangers

Heat exchangers may be classified according to Shah(2002) and Hewittetal.(1994)as

(a) Recuperator sorre generators

(b) Transfer Process(Direct contactor indirect contact)

(c) Type of construction (tubes,plate sand extended surfaces)

(d) Heat transfer mechanism(single phase and two phase)

(e) Flow arrangement (Parallel flow,counter flow or crossflow)

Many applications require the space to be occupied by the exchanger to be kept as low as possible. The compact heat exchangers serve this purpose along with the required amount of energy exchange and low fluid inventory.

OBJECTIVE OF THE WORK

In this study the plate-fin heat exchanger having triangular fins, with a single rectangular winglet (with and without stamping) and a winglet pair mounted on the fin surfaces is considered with the following objectives

1. To obtain the understanding of the flow structure, heat transfer and pressure drop encountered in a plate-fin heat exchanger with a rectangular winglet mounted on the triangular fins.
2. To develop a numerical model using MAC (Marker and Cell) algorithm with the helpof governing equations to simulate the flow in a plate-fin heat exchanger having triangular fins.
3. To study the performance of the rectangular winglet at various angles of attack and different Reynolds numbers.
4. To study the performance of the rectangular winglet by varying the geometrical size(length and height)and the location of the winglet.
5. To compare the enhancement potential of a rectangular winglet with and without stamping and to find the reduction in exchanger length for same inlet and outlet temperature conditions at different angles of attack.

To study the flow structure and heat transfer with a rectangular winglet pair in the common-flow-down configuration and compare its performance with the single winglet. Also, to study the heat transfer enhancement with an inline winglet pair and compare its performance with a rectangular winglet pair

Result:-

A numerical investigation is performed to find the fluid flow structure and heat transfer in plate-fin heat exchanger with a winglet pair mounted on the triangular fins for Reynolds number 200 and angle of attack β=20°. The heat enhancement with a winglet pair is 13%more as compared to the plane ductevenat the exit.
The vortical structure formed by the winglet pair is different from what is formed by as in glee rectangular winglet.
the increase in Reynolds number from 200 to 500, and increases with the increase in the height of the winglet pair. In comparison to single rectangular winglet, the winglet pair yields higher transport enhancement. Heat transfer and fluid flow characteristics of aniline RWP with common-flow-down configuration is compared with a single winglet pair.

Conclusion-

The performance of the heat exchangers can be improved by mounting protrusions on the surfaces.The surface geometries, which are popular in different industrial applications are wavy fins, off-strip fins, perforated and louvered fins.

The geometrical configuration considered in this thesis is representative of single element of a plate-fin heat exchanger, having triangular fins between the plates. The potential of the longitudinal vortex generators in the form of a winglet and winglet pair placed on the triangular fins have been evaluated in detail. The numerical model using MAC algorithm has been developed to study the suitability of the modification on the surface geometry of the above mentioned heat exchanger. This chapter summarizes the important results discussed in Chapter-4 and Chapters-5. The conclusions drawn from the research work are:

- The rectangular winglet mounted on the triangular fins of the plate-fin heat exchanger disturbs the flow structure and creates longitudinal vortices. Due to the existence of complex stream wise vortices system in the flow passage, the heat transfer between the fluid and its neighboring surfaces is significantly enhanced with a moderate pressure drop.
- At the same Reynolds number, the combined span wise average Nusselt number (Nu_{sa})and pressure drop increases with increase in the angle of attack. The average value of Nusselt number (w.r.t plane duct) increases from 8.3% to 20.4% with an increase inangle of attack from 20º to 37° at Reynolds number =100. The corresponding pressure drop (w.r.tplane duct)increasesfrom18.7%to31.3%respectively.
- With the increase in the Reynolds number, the combined spanwise average Nussel tnumber (Nu_{sa}) increases. As the Reynolds number changes from 100 to 200, the averagevalue of Nusselt number increases from 8.3% to 26.03% for β=20°, from 19.2% to37.9%forβ=26°and from20.4%to 46.9%forβ=37°.
- For the fixed area of the winglet, increasing the length and decreasing the height of the RWLVGis a good idea toget more heat transfer enhancement.
- The heat transfer enhancement decreases when the rectangular winglet is moved away from the inlet ofthe duct.
- Thecomparisonofwingletwithandwithoutstampingshowsthattherectangularwinglet with stamping is inferior to the attached winglet, but the stamping is a practicalcaseinmassproduction.TheaveragevalueofNusseltnumberforwingletwithstamping (w.r.t plane duct) increases from 4.4% to 11.36% with an increase in the angle of attack from 20º to 37° at Reynolds number =100. The corresponding pressure drop(w.r.t plane duct) increases from 10.18% to 18.0%. The reduction of the exchanger length is 16.8% at an angle of attack 37°, (with stamping) for the same inlet and outlet bulk temperature conditions.
- The flow structure and heat transfer with a winglet pair is also evaluated. The vortical structure formed by the winglet pair is different from what is formed by the single rectangular winglet.
- The potential of heat transfer and fluid flow characteristics of an inline RWP with the common-flow-down configuration is also evaluated. The vortices produced by the firstpair of the winglet pair are further amplified by the second winglet pair, causing moreheat transfer as compared to single winglet pair. Further, with an inline RWP, theNusselt number increases with the increase in the Reynolds number and angle of attack between the winglet pair.

REFERENCES

1. Achaichia, A. and Cowell, T.A., 1988. Heat transfer and pressure drop characteristics of flat tube and louvered plate fin surfaces. *Experimental Thermal and Fluid Science*, *1*(2), pp.147-157.
2. Allison, C.B. and Dally, B.B., 2007. Effect of a delta-winglet vortex pair on the performance of a tube–fin heat exchanger. *International Journal of Heat and Mass Transfer*, *50*(25-26), pp.5065-5072.
3. Biswas, G., Deb, P. and Biswas, S., 1994. Generation of longitudinal streamwise vortices—a device for improving heat exchanger design.
4. Chen, Y., Fiebig, M. and Mitra, N.K., 1998b. Conjugate Heat Transfer of a Finned Oval TubePart(B):Heat Transfer Behaviors.NumericalHeatTransferA-33,387-401.
5. Dupont, F., Gabillet, C. and Bot, P., 2003. Experimental Study of the Flow in a Compact HeatExchanger Channel with Embossed-Type Vortex Generators.Journal of Fluids Engineering 125,701-709.
6. Edwards, F. J., and Walker, J. R., 1974. The Improvement of Forced Convection Surface Heat Transfer Using Surface Protrusions in the Form of (a) Cubes and (b) VortexGenerators.In:ProcFifthInt.HeatTransferConf.JSMETokyo2,2244-2248.
7. Fiebig M., 1995a. Embedded Vortices in Internal Flow: Heat Transfer and Pressure Loss Enhancement.International Journal of Heat and Fluid Flow 16,376–388.
8. Ghaddar,N.K.,Korzak,K.Z.,Mikic,B.B.andPatera,A.T.,1986a.Numerical Investigation of Incompressible Flow in Grooved Channels. Part-1, Stability and self-sustained oscillations,J.FluidMech.163,99-127.
9. Karwa, R., Solanki, S.C. and Saini, J.S., 1999. Heat Transfer Coefficients and FrictionFactor Correlations for Transitional Flow Regimes in Rib Roughened Rectangular Ducts.Int.Journal of HeatandMassTransfer42,1597-1615,
10. Karwa, R., Solanki, S.C. and Saini, J.S., 2001. Thermo-Hydraulic Performance of SolarAirHeatersHavingIntegralChamferedRibRoughnessonAbsorberPlates.