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Review Article

Review on Heat Transfer Enhancement of a Plate Fin Type Heat Exchanger by Different Shapes of Fins

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Abstract

Heat transfer enhancement techniques as passive, active or a combination of passive and active methods are commonly used in areas such as process industries, heating and cooling in evaporators, thermal power plants, air-conditioning equipment, refrigerators, radiators for space vehicles, automobiles (in tracked vehicle it plays very important roll), etc. Passive techniques, where inserts, extended surfaces like fins of various shapes and sizes are used in the flow passage to enhance the heat transfer rate, are benefited compared with active techniques, because the insert manufacturing process is easier and it can be easily applied in an existing heat exchanger. In design of compact heat exchangers, passive techniques can play an important role if a proper passive configuration/combinations can be selected according to the heat exchanger working condition (both flow and heat transfer conditions). Ribs, fins, dimples, Vortices etc., are the most commonly passive heat transfer enhancement devices. In this paper, major emphasis is given to work with different shapes of fins, and their arrangement because, these are found effective heat transfer enhancement tools.

Keywords: *Heat transfer enhancement, Rectangular Offset Serrated Plate Fins, Wavy fins, Pressure Drop, Ejector cooling, rating method.*

1. Introduction

Heat transfer enhancement techniques are powerful tools to increase heat transfer rate and thermal performance. Heat transfer enhancement in thermal systems can be carried out either by-

Active method: Here, there is need of supplying external power source to the fluid or the equipment and surface vibration-using Piezoelectric Device; some examples of active methods include induced pulsation by cams and reciprocating plungers, by using magnetic field, fluid vibration technique, Injection, Suction etc.

Passive method: In this, heat transfer enhancement is done without using any direct external power source For example, use of turbulent promoter, fluid additives, rough surfaces, extended surface like fins (Ramesh k. Shah and Dussan P. Sekulic)etc.

Compound method: Combination of above two methods using simultaneously to obtain enhancement in heat transfer that is greater than that produced by either of them when used individually, is known as compound enhancement. This technique contains complex design and hence has limited applications. Extended Surface /Fins- Extended or finned surface technique includes finned tube, pins and plates of various shapes for compact heat exchanger and finned heat sinks for electronic cooling. Finned surfaces enhance heat transfer in natural or forced convection which can be used for cooling devices. (W. M. Kays and A. L. London)Plate fin type of compact heat exchangers, where the finned surfaces provide a large surface area density, are used increasingly in many automotive (like in radiators,Intercoolers,Oil,Coolers),refrigeration and air conditioning devices, cryogenic, and etc. A variety of extended surfaces like rectangular offset strip fins, angular fins, louvered fins, perforated fins and wavy fins.

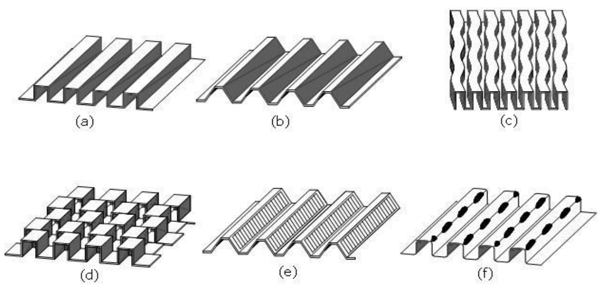

Fig.1: Types of plate fin surfaces: (a) Plain rectangular (b) Plain trapezoidal (c) Wavy (d) Serrated or offset strip fin (e) Louvered (f) Perforated

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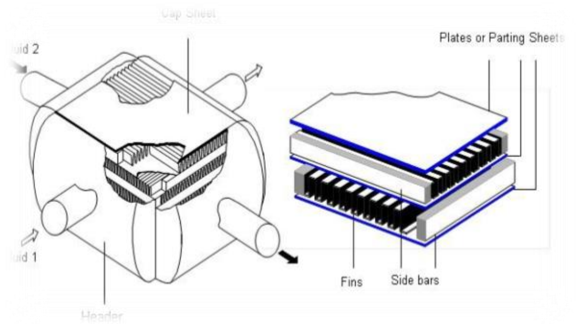

Fig.2: Plate fin heat exchanger assembly and details with cross flow of fluids.

2. Methodology

The performance of compact heat exchanger in which he has taken example of automobile radiator. He used engineering methodology based on thermal balances and correlations and CFD methods based on the finite control volume approach. Compactness, low pressure drop, low cost and new material should be considered in the radiator design. He suggested that as radiator size increases, more heat can be brought away from the engine (Bengt , 2010).

Some paper shown to have circular radiator core where other radiator cores are in either square or rectangle shaped which have following limitations; fan deliver air flow in circular shape so its air distribution is not uniformly distributed .Over the entire core, less at corners and almost zero at center along axial direction. He has done CFD analysis, of radiator and the fan in CATIA V5 software. CFD model has following new specifications: no material at center area which is equivalent to fan's hub area, design of tubes and the fins are so arranged that the outlet air had nearly constant velocity, fins of varying depth, maximum at the outer periphery which reduces along the inner periphery. With the help of these data by LMTD and NTU method effectiveness of radiator was calculated. Conclusions made: compact design, less material, less power consumption by fan. Model was having problems like bending of tubes in circular shape which increase loss of head in flow, insertion of fins in circular tubes is itself a problem and dies required to be manufactured for circular shape radiator core increases its overall production cost (Chavan, *et al*, 2013).

J P Yadav studied made research of parametric studies on automotive radiator. In this paper the detailed study of automobile radiator and its working, various ant freezing agents and their functions and use are focused. In this modeling of radiator has been described by two methods, one is finite difference method and the other is thermal resistance concept. A radiator is mounted into a test-setup and the various parameters including mass flow rate of coolant, inlet coolant temperature, etc. are varied. He done analysis as one coolant as water and other as mixture of water and propylene glycol in a ratio of 40:60 is used. It is observed that the water is still the best coolant but its limitation is that it is corrosive and contains dissolved salts that degrade the coolant flow passage (JP Yadav, *et al*, 2011).

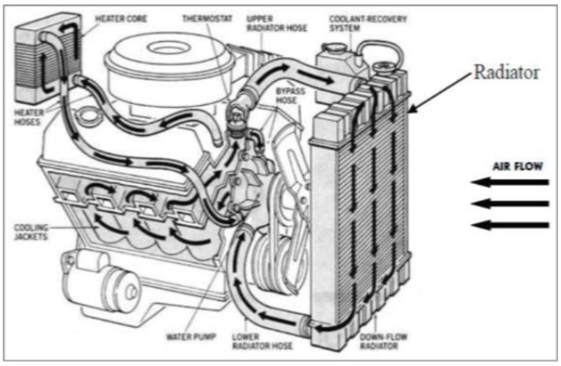

Fig.3: Working of Radiator

Simulation approach for automotive radiator sizing and rating. In this study the ε-NTU method is described to do the heat transfer calculations of radiator. This is based on the concept of heat exchanger effectiveness. For this approximate size has been assumed according to available space. Based on this size heat transfer rate has been calculated which can fulfill the requirement. Radiator size and heat transfer rate have been finalized accordingly. The 1-D simulation software has been used to decide radiator size (Amrutkar, *et al* ,2013).

Thermal analysis of radiator in this paper. For this the ε -NTU method is described to do heat transfer calculations and to decide radiator size. Size has been verified through 1-D simulation. The coolant used is 50% 50% water and ethylene glycol(having Anti Corrosive Property) accordingly its thermo-physical properties like inlet temperature, viscosity, density etc. Similarly properties for air can be considered and accordingly radiator is designed and tested. He set up the procedure for Heat transfer performance of radiator by analysis with theoretically, simulation and experimental values by all means (Amrutkar, *et al*, 2013).

Ramesh K. Shah and Dussan P. Sekulic Fundamentals Heat Exchanger Design: In this book variety of heat exchangers has been described. The various methods for heat exchanger design include Ɛ-NTU method, P-NTU method and the LMTD method. Out of these methods Ɛ-NTU method is the most accurate and frequently used method for designing the cross-flow heat exchanger. The various solution methods of determining exchanger effectiveness include exact analytical methods, approximate methods, numerical methods, matrix formalism, chain rule methodology, the flow symmetry etc. Detailed Thermal design and analysis of the heat exchanger can be done by Sizing and rating method.

(Kulshrestha, *et al*, 2014) this review focused on various research papers regarding CFD analysis to improve automobile radiator efficiency. Different research papers have applied different methodology and different tools for modeling, meshing, and numerical solution. Various results suggest that CFD have been proved very effective in reducing production time and cost. CFD results have high correlation results level with the actual experimental results.

W. M. Kays and A. L. London, Compact Heat Exchangers: in this book design methods of heat exchangers involve a consideration of both the heat transfer rates between the fluids and the mechanical pumping power expended to overcome fluid friction and move the fluids through the heat exchanger. Here heat exchanger thermal and pressure drop design; the transient response of heat exchangers; temperature dependent fluid properties ; contraction and expansion ; analytic solutions of flow in tubes; correlations for various geometries; experimental methods of heat exchanger design; various surface geometry geometries; heat transfer and flow-friction design data; etc. and various material properties have been discussed with some practical examples.
NTU Method is very useful.

W. S. James *et al*. (National Advisory Committee for Aeronautics): Here Author described effects of altitude on radiator performance. In this he described that as airplane raises to high altitude the reduction in density and temperature of air have important effects on the performance of radiator. He suggested to use antifreezing agents for high altitude radiator performance. Here tube fins type of Heat exchanger is used.

Enhanced heat exchangers require less heat transfer area for a given heat duty because of higher heat transfer coefficients. The heat transfer capacity of existing heat exchanger can be increased without changing actual size of the exchanger. This paper focuses on shell and tube and compact exchanger's performance. The methods consider whether the heat exchanger is performing correctly to begin with, excess pressure drop capacity in existing exchangers, evaluation of fouling factors, and the use of augmented surfaces, and enhanced heat transfer. Nano fluids can be used improve heat transfer and energy efficiency in heat exchangers. Here various geometries are discussed: tube inserts, tube deformation, baffles, finning (Charate, *et al*, 2015).

3. Ongoing Effort

Research is going on ejector cooling. Main Problem is the Overheating of Engine in peak summer. Temperature of cooling system goes beyond 120 deg. Celsius and vehicle is to stop until the temperature of cooling system goes down. (Up to app. 115 degree Celsius) Hence there is need to develop improved cooling system. This can be solved by rating method and Overheating of the Engine can be reduced by design, development, manufacturing, testing the new radiator which can give better thermal performance and effectiveness.

Conclusions

1) The easiest and accurate method for heat exchanger design among all the methods is the effectiveness-NTU method (Rating &sizing methods); the most preferred shape of heat exchanger fins are rectangular, wavy or combined which are better than circular shape.
2) The Main Advantage of the rectangular offset fin, wavy are that they are widely useful for high temp. Effectiveness heat exchangers employed in automobile applications especially military vehicles.
3) The fluid flow is thus interrupted, which leads to creation of fresh boundary layers and results in better heat transfer enhancement. Interruption of flow also leads to greater viscous pressure drop.
4) In addition to the effect of wall shear, resistance to flow also increases due to form drag over the leading edges of the fin sections facing the flow. The heat transfer coefficient and friction factor and pressure drop are combined effects of the above mechanisms.

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