Heat Transfer Phenomenon of Extended Surfaces in Form of Fins with Internal and External Configurations: A Review

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Abstract

fin is widely used to enhance heat exchanger's performance. The state-of-the-art of experimental and numerical researches of offset fins and its applications were reviewed in the present paper. The characteristics of heat transfer and frictional pressure drop of offset fins with different geometries and working fluids were analyzed including single phase flow (water, air, oil) and two phase flow (refrigerant). The proposed empirical correlations from literatures were summarized for both single phase flow and two phase flow. Its application in compact heat exchangers was also reviewed comprehensively. .

Keywords— internal tube fin, blossom shaped fin, CFD

I INTRODUCTION

Fins are surfaces that extend from an object to increase the rate of heat transfer to or from the environment by increasing convection. The amount of conduction, convection, or radiation of an object determines the amount of heat it transfers. Increasing the temperature gradient between the object and the environment, increasing the convection heat transfer coefficient, or increasing the surface area of the object increases the heat transfer. Sometimes it is not feasible or economical to change the first two options. Thus, adding a fin to an object increases the surface area and can sometimes be an economical solution to heat transfer problems.

A fin is a thin component or appendage attached to a larger body or structure. Fins typically function as foils that produce lift or thrust, or provide the ability to steer or stabilize motion while traveling in water, air, or other fluids. Fins are also used to increase surface areas for heat transfer purposes, or simply as ornamentation. Fins first evolved on fish as a means of locomotion. Fish fins are used to generate thrust and control the subsequent motion. Fish, and other aquatic animals such as cetaceans, actively propel and steer themselves with pectoral and tail fins. As they swim, they use other fins, such as dorsal and anal fins, to achieve stability and refine their maneuvering

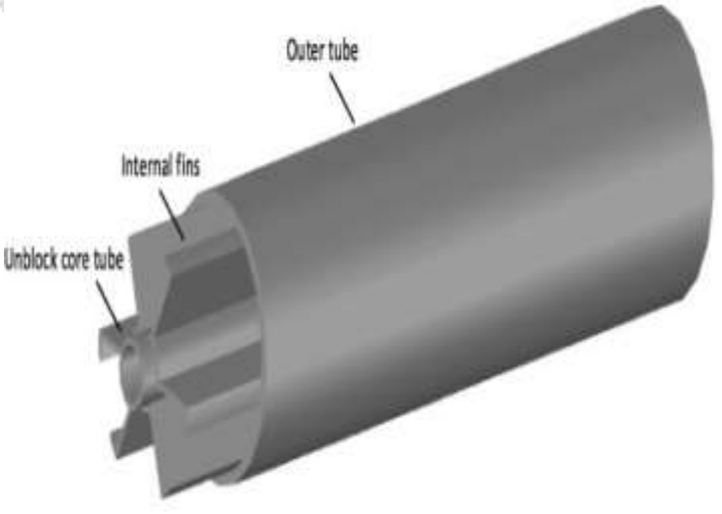

Figure 1.1 The schematic diagram of internal finned tube samples

II HEAT TRANSFER THROUGH FINS

Fins are extensions on exterior surfaces of objects that increase the rate of heat transfer to or from the object by increasing convection. This is achieved by increasing the surface area of the body, which in turn increases the heat transfer rate by a sufficient degree. This is an efficient way of increasing the rate, since the alternative way of doing so is by increasing either the heat transfer coefficient (which depends on the nature of materials being used and the conditions of use) or the temperature gradient (which depends on the conditions of use). Clearly, changing the shape of the bodies is more convenient. Fins are therefore a very popular solution to increase the heat transfer from surfaces and are widely used in a number of objects. The fin material should preferably have high thermal conductivity. In most applications the fin is surrounded by a fluid in motion, [1] which heats or cools it quickly due to the large surface area, and subsequently the heat gets transferred to or from the body quickly due to the high thermal conductivity of the fin. For optimal Heat transfer performance with minimal cost, the dimensions and shape of the fin have to be calculated for specific applications, and this is called design of a fin. A common way of doing so is by creating a model of the fin and then simulating it under required service conditions

III THERMAL CONDUCTION

Thermal conduction is the transfer of heat (internal energy) by microscopic collisions of particles and movement of electrons within a body. The microscopically colliding objects, that include molecules, atoms, and electrons, transfer disorganized microscopic kinetic and potential energy, jointly known as internal energy. Conduction takes place in all phases of matter including solids, liquids, gases and waves. The rate at which energy is conducted as heat between two bodies is a function of the temperature difference (temperature gradient) between the two bodies and the properties of the conductive medium through which the heat is transferred. Thermal conduction was originally called diffusion. Conduction: transfer of heat via direct contact. Heat spontaneously flows from a hotter to a colder body. For example, heat is conducted from the hotplate of an electric stove to the bottom of a saucepan in contact with it. In the absence of an external driving energy source to the contrary, within a body or between bodies, temperature differences decay over time, and thermal equilibrium is approached, temperature becoming more uniform.

In conduction, the heat flow is within and through the body itself. In contrast, in heat transfer by thermal radiation, the transfer is often between bodies, which may be separated spatially. Also possible is transfer of heat by a combination of conduction and thermal radiation. In convection, internal energy is carried between bodies by a moving material carrier. In solids, conduction is mediated by the combination of vibrations and collisions of molecules, of propagation and collisions of [phonons], and of diffusion and collisions of free electrons. In gases and liquids, conduction is due to the collisions and diffusion of molecules during their random motion. Photons in this context do not collide with one another, and so heat transport by electromagnetic radiation is conceptually distinct from heat conduction by microscopic diffusion and collisions of material particles and phonons. But the distinction is often not easily observed, unless the material is semi-transparent. In the engineering sciences, heat transfer includes the processes of thermal radiation, convection, and sometimes mass transfer. Usually, more than one of these processes occurs in a given situation. The conventional symbol for thermal conductivity is k..

IV FINITE VOLUME METHOD

Computation Fluid Dynamics (CFD) is the branch of fluid dynamics and heat transfer which deals with a variation occurs in fluid flow, basically computational fluid dynamics deals with a finite volume method as methodology and works on base equation it follows the Eulerian equation, i.e. when gravity forces weren't considered, pressure force and viscous force are used to simulate the desired fluid flow problem.

Fluent Solver

Computation Fluid Dynamics consists of several domains to solve fluid flow problem like CFX, fluent (poly flow), fluent (Blow moulding), fluent, and fluent solver works under computational fluid dynamics, it obeys the three governing equation with respect to base equation (Eulerian equation) i.e. energy equation, momentum equation and continuity equation by applying or solving through this algorithm, and the further results were obtained and variation could be determined.

Boundary condition for solving problem on fluent solver

In a finite volume method with respect to governing equation, boundary conditions were applied to simulate the present model. “inlet”, this boundary condition indicate the inlet of the fluid with the desired velocity on a model, and “outlet”, this definition of fluid indicates that the outlet flow of fluid, further heat flux, radiation, convection, mixed (conduction + convection) were applied to the present model for simulation.

Finite volume method (FVM)

Finite Volume Method is used to solve the fluid flow problems with obtaining the convergence of Eulerian equation and governing equation, this method works on volume of fluid or volume of fraction, it consists of the energy equation, momentum equation and continuity equations with respect to pressure force, viscous force or gravity force to solve the fluid flow problem, in case of heat exchanger, radiation, turbulence, laminar flows, acoustics and also deals with aerodynamics, HVAC etc.

Finite volume method is a method to obtain the variance on fluid flow due to external effects during the flow of fluid. In a particular volume, due to external forces, velocity, pressure drop and also temperature affects the viscosity of the fluid and which Reynolds stresses were calculated and the Nusselt number is also determined, to obtain convergence on the volume of fluid flow. Finite volume method is used for e.g. the method to obtain pressure based equation on fluid flow thus simple implicit pressure linked equation is used.

- Governing equations

Continuity Equation

A1 V1 = A2 V2

Where A1 = area of inlet
V1 = velocity at inlet
A2 = area of outlet
V2 = velocity at outlet

This equation shows the flow is pressure based or density based, i.e. if a flow is pressure based the vorticity and streamline of fluid is normal, if the flow is density based the fluid flow and streamline is in a high pressure.

Momentum Equation

This equation justified that the flow of fluid consists of definite mass and product of velocity with respect to mass to determine the momentum of fluid flow.

$$\rho \frac{Dw}{Dt} = -\frac{\partial p}{\partial z} + \frac{\partial \tau_{xz}}{\partial x} + \frac{\partial \tau_{yz}}{\partial y} + \frac{\partial \tau_{zz}}{\partial z} + \rho f_z$$

Energy Equation

This equation works on the present simulation model when heat flux and radiation were applied on boundary condition, to determine the temperature variation on fluid flow and on the heat transfer solid element to determine temperature variation.

$$\rho \frac{D\left(e+\frac{V^2}{2}\right)}{Dt} = \frac{\partial}{\partial t}\left[\rho\left(e+\frac{V^2}{2}\right)\right] + \nabla\left[\rho\left(e+\frac{V^2}{2}\right)\vec{V}\right]$$

Computational fluid dynamics (CFD) is one of the branches of fluid mechanics that uses numerical methods and algorithms to solve and analyze problems that involve fluid flows.

CFD is the art of replacing the differential equations governing the Fluid Flow, with a set of algebraic equations (this process is called the discretization), which in turn can be solved with the aid of a digital computer to get an approximate solution.

The commonly used discretization methods in CFD analysis are the Finite Difference Method (FDM), the Finite Volume Method (FVM), and the Finite Element Method (FEM).

The most well-established CFD codes are:
CFX
FLUENT
PHOENICS
STAR-CD
FLOW 3D etc.

BASIC STEPS OF CFD ANALYSIS

Preprocessing
Defining the problem
Mesh generation
Setting boundary conditions

Solving
Specifying the fluid and flow properties
Choosing the discretization scheme

Post Processing
- Examine the results
- Vector plots
- Contour plots
- 2D and 3D Surface plots

ADVANTAGES OF COMPUTATIONAL FLUID DYNAMICS

1. Complicated physics can be treated
2. CFD simulations can be executed in a short period of time
3. Practically unlimited level of detail of results.
4. Computational simulations are relatively inexpensive
5. Substantial reduction of lead times and costs of new designs.
6. Ability to study systems where controlled experiments are difficult or impossible to perform (e.g. very large systems)
7. Ability to study systems under hazardous conditions at and beyond their normal performance limits (e.g. safety studies and accident scenarios)
8. Improved design ability
9. Visualizing and enhanced understanding of designs when compared to testing
10. Time evolution of flow can be obtained
11. No restriction to linearity

V. METHODOLOGY

1. One important feature of finite volume schemes is their conservation properties. Since they are based on applying conservation principles over each small control volume, global conservation is also ensured.

2. Initially we consider how they are applied on rectangular Cartesian grids. In later lectures we see how to adapt them to non-orthogonal and even unstructured grids.

3. The method starts by dividing the flow domain into a number of small control volumes.

4. The grid points where variables are stored are typically defined as being at the centre of each control volume.

Literature Survey

Luanfang Duan et al. [1] Turbulent flow and heat transfer characteristics of double-tube structure internal finned tube with blossom shape internal fins were investigated. A sample with 3 pieces of blossom shape fins was investigated experimentally and numerically at 6 different air flow rates and a constant air inlet temperature, the Reynolds number at the air side varied from 3255 to 19580. The simulation results obtained are in good agreement with the experimental data. Then the effects of finned tube geometric structures (different fin numbers and different core tube diameter) on thermal behaviors were analyzed. The results demonstrated that the increase of fin numbers led to more uniform distribution of temperature and velocity field. The heat transfer performance of the internal finned tube with 3 pieces and 4 pieces of blossom shape fins were similar and both of them were appreciably higher than that of the internal finned tube with 2 pieces of blossom shape fins. There existed an optimal ratio of (do/Di 0.28) which led to better cost-effectiveness performances. Compared with wave-like fin, blossom shape fin is more suitable for the operating conditions with strict limits on pressure drop, especially in exhaust gas heat recovery system.

M.J. Li et al. [2] A new kind of plain plate fin with twelve vortex generators of delta winglet around each tube in fin-and-tube heat exchanger proposed by the present authors is experimentally studied in this paper. Experiments of four 4 heat exchanger surfaces of real size are conducted to compare the comprehensive characteristics of the proposed fin with a circular wavy fin: two wavy fin-and-tube heat exchangers with 6 rows of tubes at the fin pitch of 2.54mm and 2.117mm (10-wavy and 12-wavy for short) respectively; and two proposed fin-and-tube heat exchanger surfaces with five rows of tubes at the same fin pitches (10-LVG and 12-LVG) correspondingly. The inlet velocity of the air side varies from 1.5 m/s to 7.5m/s, and the water side flow rate is fixed at a certain value at each air inlet velocity. Experimental result indicates that the heat transfer rate and pressure penalty of heat exchanger surfaces using proposed fin with five-row tubes are almost the same with the six-row tubes wavy heat exchanger surfaces. Correlation of the Nusselt number Nu and the friction factor f on the air side are achieved. Entransy analysis is conducted to reveal the heat enhancement mechanism.

Mohammad. Sikindar Baba et al. [3] internal fins in tubes of heat exchangers is a good practice for heat transfer enhancement. This paper reports an experimental study of forced convective heat transfer in a double tube counter flow heat exchanger with multiple internal longitudinal fins using Fe_3O_4 –water nanofluid.The convective heat transfer enhancement and pressure drop are investigated for the nanofluid flowing in a horizontal circular tube with internal longitudinal fins under turbulent conditions ($5300<Re<49200$) and the volumetric concentration of Fe3O4 nanoparticles are in the range of $0<\varphi<0.4$ %. Results indicates that the heat transfer rate is 80-90 % more in finned tube heat exchanger compared to the plain tube heat exchanger for the higher volumetric concentration of nanofluid.Nusselt number ratio of Fe3O4- water nanofluid with base fluid (water) increases with the Reynolds number. Friction factor decreases with the increase in Reynolds number and pressure drop is more in finned tube heat exchanger compared to the plain tube heat exchanger due to the effect of fin geometry which offers resistance to the flow.Wilson plot method is used to develop the Nusselt number correlation for the flow of Fe_3O_4- water nanofluid through finned tube heat exchanger.

Swastik Acharya and Sukanta K. Dash [4] Three dimensional numerical simulations have been carried out by solving the continuity, momentum and the energy equations to predict the flow and the temperature field around an internally finned horizontal cylinder in natural convection. The fin height, fin spacing or the fin number and the length of the cylinder were varied at different Ra to predict the heat loss from the finned cylinder and interesting findings were obtained. The heat loss from a short cylinder (L/D < 1) can be maximum for certain height of the fin and certain fin number after which the heat loss can reduce if the fin height increases or the fin spacing decreases in the laminar range of Ra to within 107. When the length of the cylinder increases (L/D > 1) the maximum point of heat loss vanishes for all heights of the fins and fin spacing. A table has been generated to show the optimum configuration of fin height, fin number where maximum heat loss can take place. The average Nu of the finned cylinder was seen to be decreasing with H/D, L/D and increasing with Ra. From the enormous numerical simulations that has been done in the present study a general correlation for the Nu as a function of L/D, H/D, fin number, N and Ra has been developed to within an accuracy of ± 6% which can be beneficial to the industry and practical designers.

Guodong Qiu et al. [5] found it Finned-tube evaporators have been widely used in air source heat pumps. Coating a solar selective absorbing coating on the fin surface is proved an effective approach to improve the heat transfer effects of finned-tube evaporators using solar energy. However, currently, most attentions were paid to the performance improvement of heat pump systems assisted by solar energy, scarce of attentions were paid to the heat transfer characteristics of this kind of fin under solar radiation. Therefore, the heat transfer characteristics of this kind of fin under solar radiation were studied using the heat transfer theory. Based on the heat transfer models, the theoretical solution of temperature field was deduced, and its accuracy was validated by numerical simulation. The effects of various factors on the heat transfer characteristics of a plain fin were theoretically analyzed. The results showed that the solar radiation would lessen the convective heat transfer capacity and fin efficiency, and even make part of solar energy to release into the environment. The maximum loss of solar energy accounts for about 12.7% of the total solar energy, and twice the fin height only generates 60% increase of the total heat transfer capacity. In the condition of larger fin height and solar radiation, the smaller convective heat transfer coefficient will produce more total heat transfer capacity. This study is helpful to analyze this kind of heat transfer problem and guide the optimization design of finned-tube evaporators assisted by solar energy.

Evangelos Bellos et al. [6] Parabolic trough collectors are among the most mature solar concentrating technologies which are applied in numerous applications. The enhancement of their performance is a crucial issue in order to be established as a feasible technology. The use of internal fins is one of the most interesting techniques for enhancing the heat transfer phenomena in the flow as well as for increasing the collector's performance. However, their utilization leads to higher pressure losses. The objective of this paper is to investigate the optimum number and location of the internal fins in the absorber of a parabolic trough collector. The examined fins have 10mm length and 2mm thickness, while their shape is rectangular. Various numbers of fins are investigated in various locations inside the absorber and in every case, the collector's performance is investigated by taking into account the increase of the Nusselt number and of the friction factor. According to the final results, the internal fins have to be placed in the lower part of the absorber where the higher amount of the solar heat flux is concentrated. A multi-objective procedure proved that the absorber with three fins in the lower part is the optimum case with 0.51% thermal efficiency enhancement.

Mohammad Sepehr et al. [7] the heat transfer, pressure drop and entropy generation in shell and helically coiled tube heat exchangers, are numerically investigated. The heat transfer rate is intensified by installing the annular fins on the outer surface of the coiled tube. The fluid of coil side is the hot water which flows through the coiled tube at temperature of 70 °C and velocity of 1 m/s. While, on the shell side, the cooling dry air flows through the shell side at temperature of 10 °C and velocity of 1-4 m/s. The height and number of the fins change, as well as the velocity of the shell side fluid. The main results of this study are some correlations which are suggested for the estimation of the Nusselt number and friction factor of the shell side. Furthermore, the relationship between the NTU, the entropy generation rate and the thermal effectiveness are obtained.

Evangelos Bellos et al. [8], investigates a Parabolic trough collector is one of the dominant emerging solar technologies for producing heat at high temperatures (usually 200–400 °C). The objective of this study is to investigate the thermal performance of internally finned absorbers. Twelve different fin geometries are examined and compared with the smooth absorber case for various operating scenarios. More specifically, the investigated internal fins have thicknesses 2 mm, 4 mm and 6 mm, while their lengths are 5 mm, 10 mm, 15 mm and 20 mm. The examined parameters for the evaluation of the internally finned absorbers are the thermal efficiency, the Nusselt number, the pressure losses, as well as the thermal enhancement index. According to the final results, higher fin thickness and length lead both to higher thermal performance and simultaneously to higher pressure losses. The impact of the length on the results is found to be more intense than the thickness. According to the thermal enhancement index, the case with 20 mm length and 4 mm thickness is found to be the optimum case. For this absorber, the increase in the thermal efficiency and the thermal enhancement index are found 1.27% and 1.483 respectively for 600 K inlet temperature, while the Nusselt number is proved to be 2.65 times greater than in the smooth case.

Yong-Hui Wang et al. [9] A correlation of the critical Reynolds number for turbulent flow in horizontal helically finned tubes is proposed in this study based on the analysis of experimental data from the current and six previous studies. In the experiment, the main parameters of the two tubes (Tube-1 and Tube-2), include the number of fin (Ns), helix angle (α), and the ratio of fin height to diameter (e/Di), which are 38 and 60, 60° and 45°, and 0.0534 and 0.0222, respectively. Aqueous ethylene glycol was used as the test fluid. Pressure drop data were obtained under isothermal condition with Reynolds number spanning from 3100 to 39500 and Prandtl number spanning from 13.8 to 49.2. Results showed that the critical Reynolds numbers for turbulent flow in Tube-1 and Tube-2 were 11000 and 17000, respectively. The proposed correlation, which correlated the critical Reynolds number with four parameters (i.e., e, Di, α, and Ns) and a constant, predicted all the 14 groups of critical Reynolds number within 10% and could be applicable to internal helically finned tubes with $0.01<e/Di<0.0534$, $18° <\alpha<60°$, and $25<Ns<82$. This work offers a reference for the general correlation for heat transfer coefficient and friction factor of the internal helically finned tubes.

Peilun Wang et al. [10] Due to the poor thermal conductivity of the Phase Change Materials (PCMs), heat transfer performance of Latent Thermal Energy Storage (LTES) systems is usually unsatisfactory. In this work, a detailed numerical study is carried out to analyze the impact of fin geometry (including fin-length, fin-ratio and the angle between neighbor fins) and outer tube conductivity on PCM melting process; the influence of the natural convection in the horizontal sleeve-tube unit within the longitudinal fins is further examined. Results shows that small fin-ratio can reduce melting time, but not remarkably; the angle between neighbor fins has little impact on melting process, however, there is an optimization of the angle between neighbor fins to reduce melting time in the full-scale unit. The outer tube conductivity has great impact on melting process whether considering the natural convection or not.

Hao Peng et al. [11], The thermo-hydraulic performances of an internally finned tube (IFT) with innovative wave fin arrays were numerically and experimentally investigated. Firstly, a variety of performance tests were carried out fora range of Reynolds number from 2000 to 20000 at the air side. Then, the Nu number and friction factor f of IFT were simulated. It was found that the numerical results were well validated with the experimental data. Hence, the effects of the wave fin geometry (wave height, wave space, wave width, wave effective length, wave angle and wave arrangement) on novel IFT thermal behaviors (such as Nu & f factors, temperature & velocity profiles and secondary flow characteristics) were analyzed using the corresponding numerical model. The results indicated that the wave angle has a significant influent on the IFT thermal performance compared with the other fin geometric parameters. The vortexes generated near the corrugation of wave fin region will intensify the secondary flow and reduce the thermal boundary layer to improve heat transfer. The present work provides a framework for designing the configurations of IFT heat exchangers with this innovative wave fin arrays. .

Y. Naresh and C. Balaji [12] the results of an experimental investigation of heat transfer from internally finned thermosyphon charged with either water or acetone. Six constant area fins with a rectangular cross section are placed internally along the length at the condenser section. The ratio of initial liquid pool volume to the evaporator volume, known as the filling ratio in a ther- mosyphon system, has been varied in this study. Experiments are carried out for filling ratios of 20, 50, and 80œ for two working fluids (i) water and (ii) acetone. Results show that all ratios of 50% give better heat transfer performance. Providing internal fins at the condenser produces additional condensation which improves the thermal performance of the thermosyphon by 17% in terms of the temperature reduction at the source and sink and 35.48% in terms of reduction in thermal resistance at lower heat inputs. The thermosyphon is tested between power levels of 50 and 275 W.

Dong-Kwon Kim [13] thermal optimization of a tube with internal fins whose thickness varies freely in the direction normal to fluid flow was performed using a model based on the volume averaging theory. In the case of a water-cooled system, the thermal resistance of the optimized finned tube with variable fin thickness was reduced by up to 12% compared to that of an optimized straight-finned tube. The extent of the reduction was found to depend on the pumping power and tube length, and the conditions of the pumping power and tube length under which the reduction is more than 10% were evaluated. Because of their improved thermal performance, finned tubes with variable fin thickness have potential for use in cooling equipment in various thermal systems.

Younghwan Joo and Sung Jin Kim [14] investigate the thermal performance of vertically oriented, internally finned tubes in natural convection is optimized analytically. The total heat transfer rate is selected as the objective function for the optimization under a constraint of given base-to-ambient temperature differences. In order to predict the total heat transfer rate, a new correlation of the heat transfer coefficient is developed using the asymptotic method. In order to validate the new correlation, experiments are performed for internally finned tubes with different geometries. With the new correlation, the three parameters of fin geometry, i.e. fin thickness (t), fin height (H), and number of fins (nfin), are optimized under given tube sizes of tube diameter (D) and tube length (L). Finally, closed-form equations for the optimal fin geometry are proposed as design guidelines for internally finned tubes with various sizes.

Alaa Ruhma Al-Badri et al. [15] The influence of fin structure and density on the condensation heat transfer of refrigerant 1,1,1,2- tetrafluoroethane (R134a) is investigated on single finned tubes and in corresponding bundles. Experiments have been performed on standard and enhanced finned tubes with 39, 48, and 56 fins per inch (FPI) and different fin heights. The enhanced finned tubes are based on the standard ones, and are characterized by a non-uniform fin structure. The condensation heat transfer coefficient (HTC) is determined for single tubes as well as for each row of the tube bundles and compared with predictions from analytical models. In the single tube measurements, the enhanced finned tubes showed distinctly higher HTCs than the standard finned tubes. Different condensation flow modes have been observed during the tube bundle experiments where the additional structures on the fin flank of the enhanced finned tubes promote sheet mode condensation. It has been demonstrated that the standard finned tubes show a lower decrease in the condensation HTC with increasing tube row number in the bundle than the enhanced finned tubes. Among the standard finned tubes, the one with 48 FPI and larger fin height exhibits the highest HTCs for single tube and tube bundle experiments. The increase in the fin height seems to delay the formation of sheet mode condensation and thus to increase the condensation HTC. Among the enhanced finned tubes, the tube with 39 FPI yields the highest HTCs for both single tube and tube bundle measurements. Low fin density and large fin height obviously tend to keep the insulating effect of retained condensate in the fin channels low.

José Fernández-Seara et al. [16] Ammonia has been and is used as refrigerant in many industrial refrigeration systems. Flooded shell-and-tube evaporators are normally employed in such systems. However, it is crucial to reduce the size and refrigerant charge of these evaporators, which can be achieved by improving their heat transfer performance using tubes with enhanced surfaces. Tests were performed to analyse the enhancement achieved with a commercial integral-fin (32 f.p.i., 1260 f.p.m.) titanium tube, if compared to a plain tube of the same nominal external diameter, under pool boiling and using ammonia. The test conditions were those than can be found in water chillers and both in increasing and decreasing heat flux order to analyse nucleation hysteresis. The average enhancement factor achieved with this tube was of 1.2 (maximum 1.3). Hysteresis on nucleation occurred and should not be neglected, particularly with the integral-fin tube. An experimental correlation is proposed for both the plain and the enhanced tubes and it predicts the experimental results within 5.5%.

Min Zeng et al. [17] found it the thermal stress of the internally finned bayonet tube used for high temperature heat exchangers is numerically investigated by ANSYS software. Three kinds of lateral fin profiles, namely Z-shape, S-shape and V-shape are studied and compared. The significant temperature gradient and largest Von Mises stress are acquired. The largest stress is still generated in the joint of inner fin and outer tube due to the discontinuous change of the structure. The inner fin and inner tube are proposed to not be welded together to meet the reliability. The Z-shape has the best performance in both heat transfer and reliability, and is recommended for engineering application in high temperature heat exchangers.

Conclusion:-

A review on the methods and analysis of different parameters of internal fin fluid flow were carried by different method of analysis like experimental, numerical and simulation. The parameter considered here in this review paper are thermal–hydraulic performance, flow pattern, material and structure, pressure drop and heat transfer characteristics, fin geometry and heat transfer and pressure drop correlations. Still there is a strong need for proposing further techniques to improve the parameters in internal fin fluid flow which will have a direct impact on operational cost, and last and not least the use of nanofluids and their role in the design aspects of the exchanger, which is considered a new growing research area. As internal fin fluid flows are going more and more into sever process conditions, corrosion is crucial problem facing the industry due to high operational cost paid.

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