International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 10 | Oct 2021 www.irjet.net p-ISSN: 2395-0072

Enhancement of Heat Transfer Rate in Concentric Tube Heat Exchanger Using Surface Modifications and Nano-Fluid: A Review

Santosh Kumar Ramji Gupta[1], Dr P M Meena[2]

[1]PG Student Department of Mechanical Engineering, MBM Engineering College, Faculty of Engineering, Jai Narain Vyas University, Jodhpur, Rajasthan.
[2]Professor, Department of Mechanical Engineering, MBM Engineering College, Faculty of Engineering, Jai Narain Vyas University, Jodhpur, Rajasthan.

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Abstract - *This report represents an overview for improvement of heat transfer rate in concentric tube H.E. along with a review of relevant studies conducted in the several years for improving the performance of heat Exchanger. A great percentage of energy being utilised for industrial purpose and the energy resources are exhausting day by day at very fast rate. Energy management is consequently, become a most important subject. Now a day high-performance H.E. In many areas of the industries, become is one of the promising energy-saving manners. by the heat transfer improvement method, the high-performance heat exchangers can be obtained. Normally heat transfer augmentation generates one or more amalgamations of the subsequent circumstances that are favourable for the improvement in heat transfer rate with an unwanted increase in friction, disruption of boundary layer growth and intensifying degree of turbulence, generating of swirling and/or secondary Flows and increase in heat transfer area, and. Several improvement methods are used for example, surface tension devices, swirling flow devices, coiled tubes, treated surfaces, and rough surfaces Which increases heat transfer rate due to better mixing of fluid and bulk motion transfer, increase in residence time and increased turbulence*.

In this case studies we also reviewed the performance of convective heat transfer for numerous Nano fluids in both turbulent and laminar regimes. Due to introduction of nanoparticle in the base fluid the results of this studies improvement in thermal conductivity the fluid. And improvement in heat thermal performance of H.E. The improvement of heat transfer using Al_2O_3 *and water-based Nano fluid in a concentric tube with twisted tape inserts and 19.19% and 32.35% enhancement obtained in Nusselt number within the Re number of 2500 and 35,000, respectively. The friction factor of 0.02% nanofluid flowing in concentric tube associated with similar concentration, fluid for two different Reynolds number. As an inference, the thermophysical character and the heat transfer rate for nanofluids was improved considerably by temperature, flow rates and concentration.*

We reviewed the detailed comparison between concentric plain tube H.E. with concentric dimple tube H.E. exch along with application of Nano fluid and found that:

1. In comparison to plain pipe, heat exchanger with dimpled tube has shown an increase in heat transfer rate and Overall heat transfer coefficient, due to disturbance of boundary layer, hence leading to better mixing, and increased turbulence.

2. Heat transfer rate increased from 13% to 18% when dimple tube was used in concentric tube H.E. at place of plain tube. Heat transfer rate was maximum at volume flow rate of 15 LPM of Nano fluid.

3. The overall H.T. coefficient on the inner side of the dimpled tube increases from 17% to 23% as related to plain tube.

4. The overall H.T. coefficient on the outer side of the dimpled tube increases from 16% to 22% as related to plain tube.

Keywords: Double pipe heat exchanger, dimple tube, Al2O3 nanoparticle, Nusselt Number, Overall heat transfer coefficient, CFD

1.INTRODUCTION

In A present scenario very large amount of energy is used for production of thermal energy for electricity production or for industrial use.as we know the energy resources are limited on the earth because of this the energy resources are depleting at a very high rate. Which is the matter of concern for sustainable use of energy resources available on the earth. for which Energy conservation become an important aspect. Due to this The high-performance H.E. is designed by the consideration of heat transfer improvement method for many areas of the industrial use is, one of the auspicious energy-saving manners.in most of heat transfer augmentation method utilises one or more amalgamations of this favourable circumstances for the improvement in heat transfer rate with an interruption of boundary layer development undesirable increase in friction, and growing degree of turbulence, producing swirling or secondary Flows, and by increasing the net heat transfer surface area. Numerous heat transfer improvement methods have been presented, for example surface tension devices, swirling flow devices, rough surfaces, , coiled tubes, and treated surfaces.

1.1Heat Exchanger (H.Ex.)

H.E. is an instrument which is used for transmission of thermal energy in the form of heat occurring between the fluids, between solid particulates matters and fluid on a solid surface and fluid, or, at altered temperatures and in direct thermal interaction. No outside heat and work interactions are considered in heat exchangers. It finds applications generally where a cooling or heating of a working fluid and evaporation or condensation of single- or multicomponent fluid streams is required. In other applications, the aim can be to recover or reject heat, fractionate, concentrate, crystallize, or control a process fluid. The H.T. takes place in three modes namely, convection, conduction and radiation. Radiation H.T. can takes place in vacuum that means no medium is required for the propagation of heat, whereas for conduction and convection the medium requirement in necessary for the heat transfer.

1.1.2 Taxonomies of heat exchangers (H.E.)

The H.E. can be basically categorized in 3 main categories

1.1.2.1: According to functioning principle: In this class, H.E. are further categorized in to three sub class.

1.physical contact type Heat Exchanger: transfer of energy occurs due to direct physical incorporation of the two streams of fluids. this type of heat exchangers is used in situation in which direct physical mixing of the fluid does not incorporate any problem for heat exchange between the two fluid. for ex. jet condensers used in the steam power plants

2. Regenerator Heat Exchanger: in which first the warm fluid is allowed to transfer over a solid medium identified as matrix. In which the transfer of heat takes place from warm fluid to solid matrix. Then the cold fluid is allowed to pass through the matrix and it takes heat from matrix and becomes worm. This type H.E. used in gas turbine.

3. Recuperator Heat Exchanger: In which 2 fluids flow concurrently which is differentiated by a wall. There is no direct physical mixing occurs between 2 flowing fluids while heat transfer. In these class of H.E. heat transfer occurs due to both by convection between fluid and separating wall of the heat exchanger and also by conduction through the wall. The application of these are super heaters boilers, and condensers etc.

1.1.2.2 According to direction of fluid flow: in this class H.E. are classified into three main categories

1.Parallel flow heat exchangers: In these types of heat exchanger both cold and hot fluid enters from the same side of the heat exchanger and they flow parallel to each other in the same direction and Transfer of heat takes place from hot fluid to cold fluid.as shown in fig.1.1.

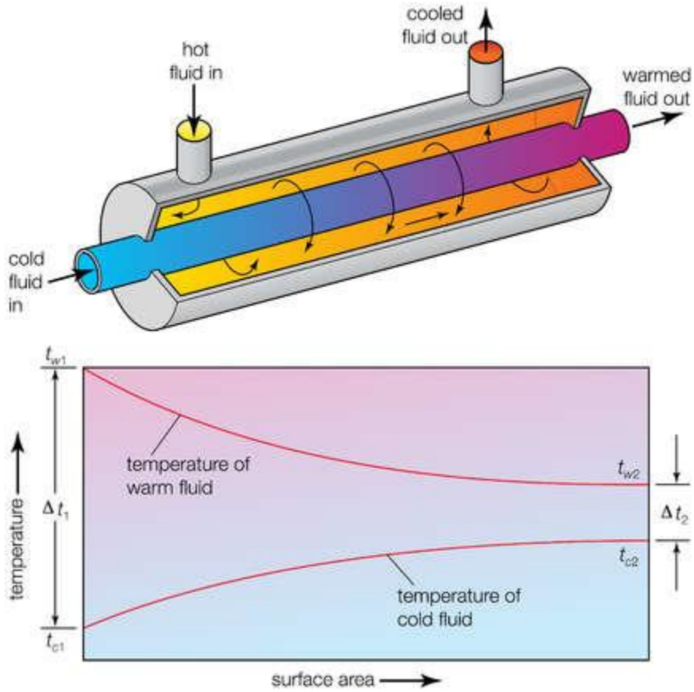


Fig.1.1: Parallel Flow Heat Exchanger

Counter flow heat exchangers: in this H.E. each fluid enters from opposite sides of heat exchanger the hot and cold fluid travels analogous to each other but in opposite direction.as shown in Fig

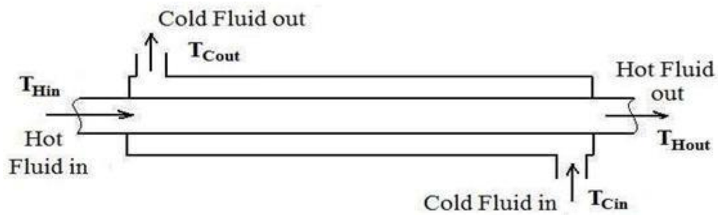


Fig.1.2: Counter flow heat exchanger

Cross flow H.E.: the fluid flow perpendicular to each other in cross flow heat exchangers, It is mainly used in air or gas heating purpose.as shown in Fig 1.4

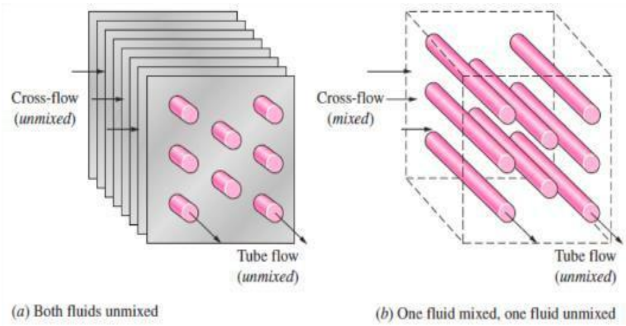


Fig.1.3: Cross flow heat exchanger

1.1.2.3 According to mechanical structure: The H.E. can be classified as follows:

1.Double pipe H.E.: It has two concentric conduit or tube. One of the fluids passes from the inner side of the tube and the another one of the fluids passes from the outer tube. The fluid flow direction may be either counter or parallel to each other. The required conditions in concentric tube H.E. is that the material of inner tube must have thermal conductivity of very high order to give maximum possible heat transfer. Construction of these H.E. simple and also maintenance cost required id less.

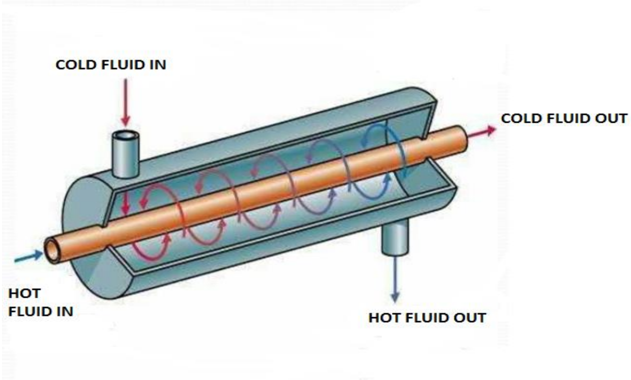


Fig.1.4: Double pipe heat exchange

2. Shell and pipe H.E.: Shell and tube H.E. contains of a pack of conduit that are built-in a shell. as we know One of the fluid flows through the group of conduits and the another one passes through the shell. The fluids may be either gases or liquids.as shown in fig1.5. It is commonly used in oil refineries and chemical industries

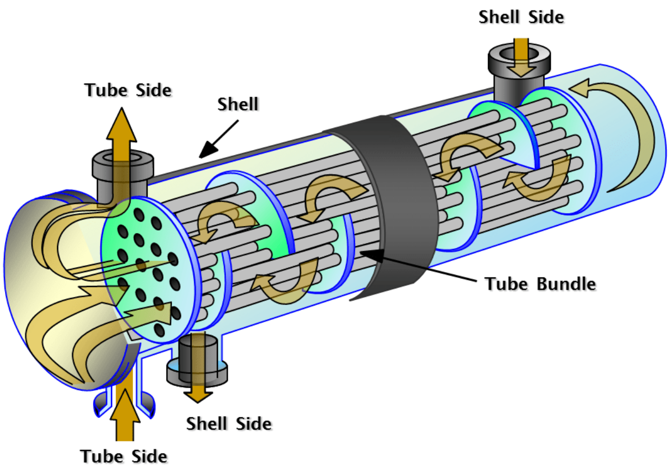


Fig.1.5: Shell and pipe heat exchanger

3. Plate H.E.: – Plate H.E. are made by assembling the multiple thin metal plated together. With the help of rubber gasket, a very gap is maintained between two consecutive plates. The flow of two streams of fluid takes place according to the consecutive channels of plate H.E. This H.E. is more efficient as compared to the shell and tube H.E. because of their very larger surface area is exposed and it mostly used in air conditioning plant and refrigeration system.

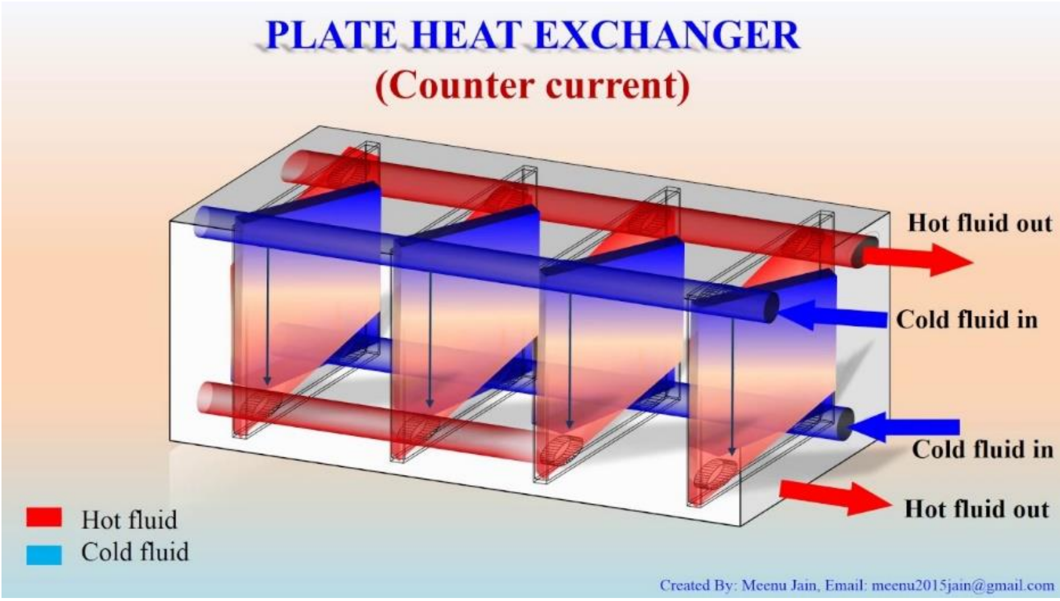


Fig.1.6: Plate heat exchanger

4. Spiral H.E: These H.E. are constructed by winding the flat plates in the spiral's shapes. The two fluids at different temperatures flow one after the another in different passages. Spiral heat exchangers are compact in size and they are of widely used where less space is an available.

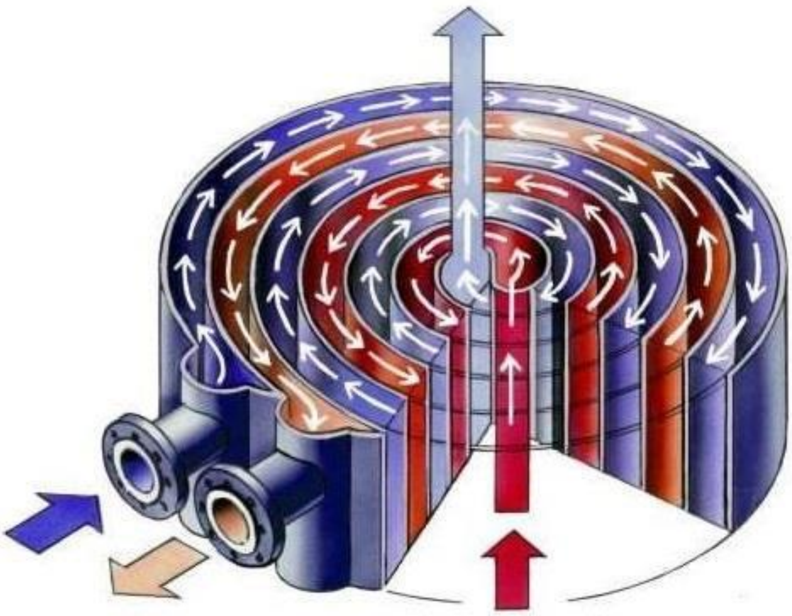


Fig.1.7: Spiral heat exchanger

5. Tubular Fin H.E.: The extended surface called fins are used and it is mounted on the circumference of the tube and it is called tubular fin H.E. The flowing fluid generally it is liquid which flows through inside of the tube and another fluid generally gas flows on the extended surface called fins. and due to these heat exchange takes place. As shown in Fig 1.9. They are widely used in condensers and waste heat recovery systems.

Fig.1.8: Tubular fin heat exchanger

1.2 Need of Heat Transfer Improvement: In the present era due to energy emergency, available energy resources are exhausting day by day and scientists are trying to develop a technique to capitalise every bit of available energy on the earth. In H.E. design industries tries to maximise the efficiency of heat exchanger and to minimise the energy losses to minimum. Because of the Following reasons the heat transfer improvement methods are incorporated in the design of heat exchanger.

1. Minimizing the required capital cost investment in the heat exchange operation

2. Reducing size of H.E.

3. Increasing efficiency of existing systems

4. Reducing fouling effects

5. Reduction in maintenance costs

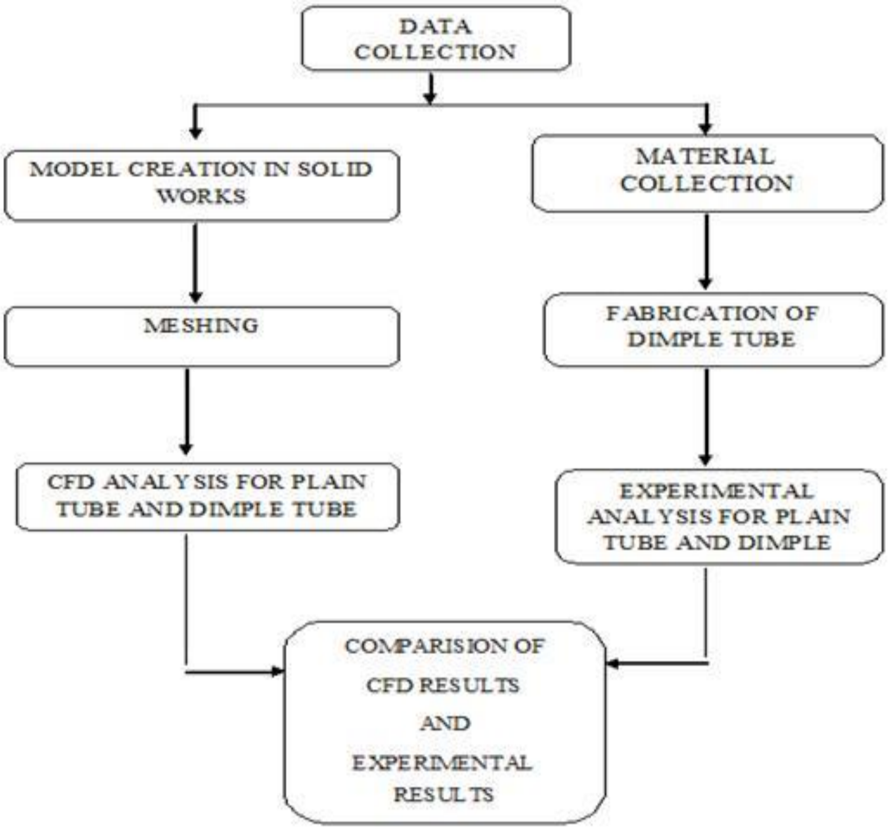
1.3 Aim and Objectives: There are many researches done on the double pipe heat exchanger or concentric tube H.E. to increase the heat transfer rate experimentally and analytically by various methods. The aim of the current seminar work is to do literature review on the various methods employed for heat transfer rate. And selecting best methods of heat transfer. So, in this report my study is focused on increasing the heat transfer rate by surface modification and by the application of Nano fluid.

The overall objectives of the current work are as followings, to

1.To carry out the literature survey in the field of Heat transfer augmentation method and find out the scope of future work.
2.To find the recent advancements taking place in the field of heat exchanger design for enhanced heat transfer rate
3.Development of light weight, cost effective, highly efficient and economical with high efficiency heat exchanger device.
4.Design heat exchanger system for its parameter and performance relation with each other, like its materials properties, thermal energy source.
5.To suggest recommendation on the basis of the study for better development of Heat Exchanger.

1.4 Process Methodology: A great percentage of energy being utilised for industrial purpose and the energy resources are exhausting day by day at very fast rate. Energy management is consequently, become a most important subject. Now a day high-performance H.E. In many areas of the industries, become is one of the promising energy-saving manners. by the heat transfer improvement method, the high-performance heat exchangers can be obtained So, developing efficient and inexpensive heat exchanger is important for efficient use of available thermal energy resources on earth. Under methodology, the following processes take place; the process followed to achieve the aforesaid objectives is simply the methodology
1.The comprehensive literature inspection was performed for assessment of the various types and design of H.Ex, their possible applications, advantages and limitations.
2.Various types of heat enhancement techniques have been studied.

3.Theoretical and experimental reviews on design of heat exchanger and Also discuss the all the parameter which can affect the performance of the system.
4.The feasibility study, techno-economic viability and potential savings have been done and processes are quantified for further improvement.



2. LITERATURE REVIEW:

This review is done to justify the requirement of the work undertaken and is based on the literature in the topic of interest, the concerned subjects and works of other researchers in this field. Various methods and strategies adopted by different researchers and research papers on enhancement of Heat Transfer Technique have been reviewed

2.1 Introduction

These days, heat transfer improvement for achieving thermally efficient industrial equipment is a key parameter to conserve energy. Hence, the method of enhancement of heat transfer are as follows.

(a) Introducing a foreign surface for heat transfer

(b) Interference of unenhanced fluid velocity.

(c) Interruption of laminar sub boundary layer in turbulent flow.

(d) Use of secondary flows.

(e) Stimulating the separation of boundary layer.

(f) Indorsing flow attachment and reattachment.

(g) Augmenting effective thermal conductivity of fluid under dynamic and static conditions.

(h) Increasing boundary layer formation time.

(i) Thermal dispersion of fluid molecules.

(j) Increasing randomness of fluid molecules.

(k) Change in distribution of flow.

(l) Alteration of radioactive characteristics of convective medium.

(m) Increment in surface and fluid temperature.

(n) Enhancing thermal conductivity of solid phase using nanotechnology.

(o) Fins can be used as passive device.

(p) Passive increment in fluid flow rate.

2.2: THE ENHANCEMENT TECHNIQUES

2.2.1: Active Techniques

2.2.2: Passive Techniques

2.2.3: Compound Techniques

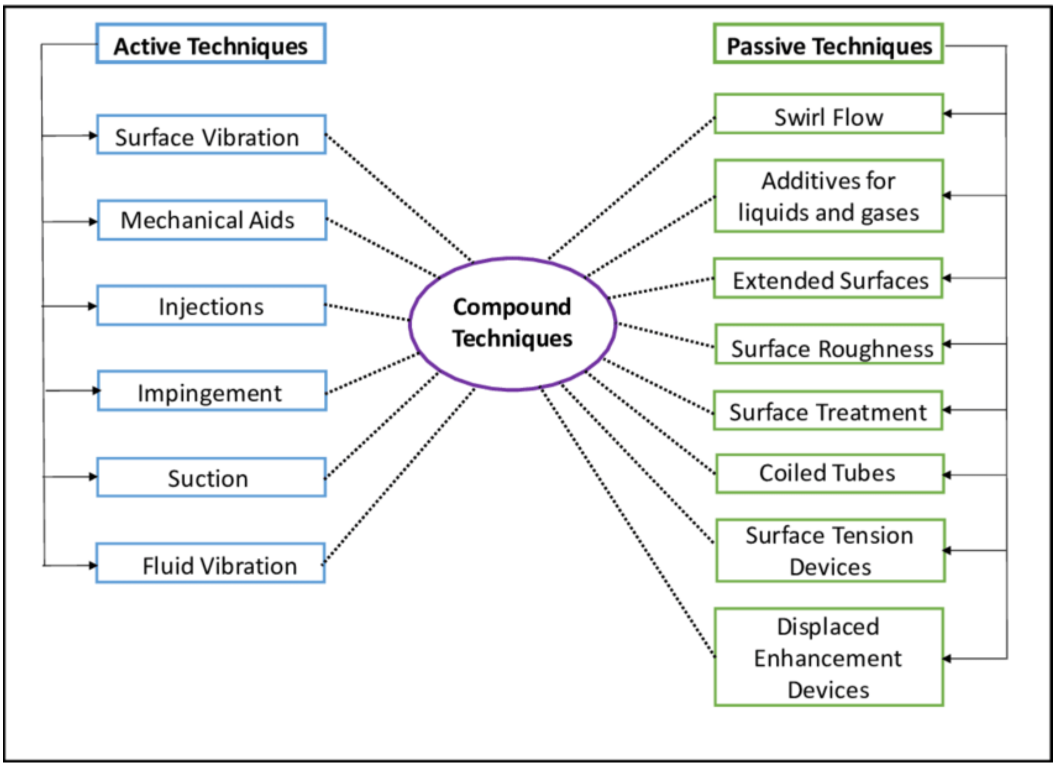


Fig.2.1: The Heat Transfer Rate Enhancement Techniques

2.2.1 Active Techniques: Active techniques involve an exterior power supply which is used to produce the required flow adjustment and the enrichment in the rate of heat transfer. The following active techniques can be used to the increase of heat transfer which are as follows

1.In mechanical aids, the fluid is agitated by mechanical method or by rotating the surface. Mechanical surface scrapers, are used for viscous liquids in the chemical process industry and can be used in duct flow of gases. The rotating tubes are a general example of this type.

2.To augment the heat transfer is distinct phase, surface vibration methods can be used. To promote spray cooling, a piezoelectric instrument is used which produces vibration on the surface and impinges small droplets on a heated surface.

3.Fluid vibration is mainly used in single phase flows and are feasibly the most practical type of vibration enrichment technique.

4.The heat exchanger in which the working fluids used is a dielectric material, in which electrostatic fields will be generated. Bulk mixing can be produced. Forced convection can be induced. Electromagnetic pumping used to enhance the heat transfer rate. Injection is provided by supplying gas through a porous heat transfer surface to a flow of liquid or by introducing the same liquid upstream of the heat transfer section. It leads to the escalation of single-phase flow.

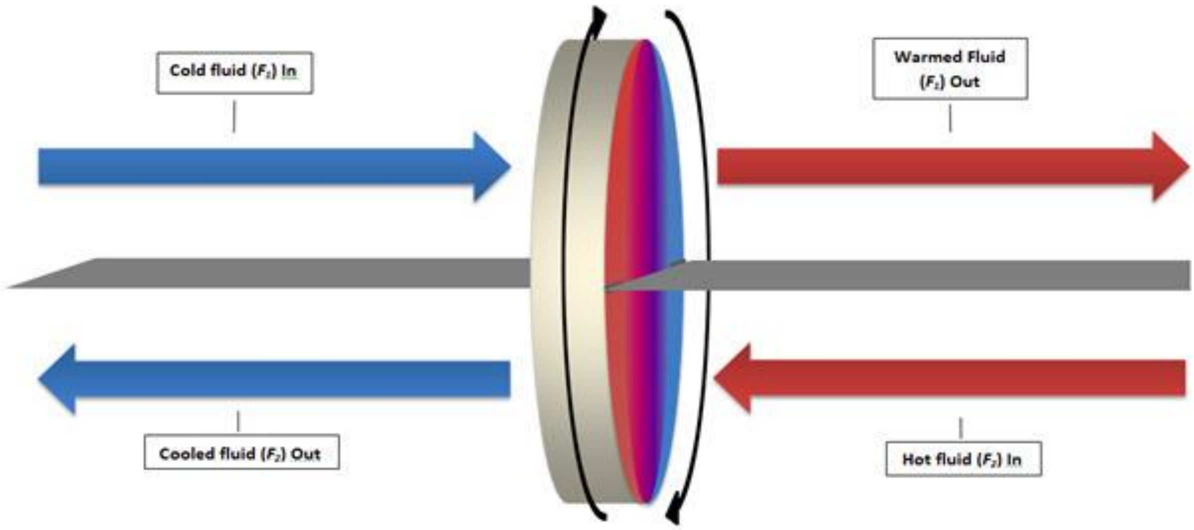


Fig.2.2:Active Heat Enhancement Technique

2.2.2 Passive Methods: In this method of heat transfer improvement, there is not required any supply of power by any external means. The heat transfer improvement is obtained by varying the various configuration for example by making changes in design of the H.Ex. and by altering the geometry of the H.Ex surface or This can also contain mixing of some the additives in the fluids that consequences in improved thermal conductivity and hence there will be increased in heat transfer rates. Numerous methods adopted under passive category

1. Extended surfaces: These are characteristically employed in many H.Ex. Heat transfer increment is observed with its application in the heat exchanger. This disturbs the pattern of the boundary layer which produces very high turbulence flow of fluid which ultimately increases the heat transfer rate. In extended surfaces or fins, the plane fin only increases the net heat transfer surface area. However, the development of a special contour shaped extended surface will also increase the heat transfer coefficient. Current heat transfer augmentation efforts for gases are focused toward extended surfaces that deliver a higher heat transfer coefficient as compared to plain fin design. These surfaces involve repeated formation and destruction of thin thermal boundary layers. Extended surfaces for liquids use much smaller fin heights than those used for gases. Shorter fin heights are used for liquids because liquids typically have higher heat transfer coefficients than gases and another reason is lower operating pressure. Use of high fins with liquids would result in low fin efficiency, poor material utilization, and higher operating pressure.

2. Coated surfaces: in this category coating is done on the surface which is either non-metallic or metallic. For Examples hydrophilic coating which enhance the condensate drainage on evaporator fins, which reduces the wet air pressure drop, or a non-wetting coating.

3. Displaced insert devices: These are devices inserted into the flow channel to improve energy transport at the heated surface indirectly. They are used with single- and two-phase flows. These inserts devices mix the main flow, in addition to that in the wall region. The wire coil insert is placed at the edge of the boundary layer, and is intended to promote mixing within the boundary layer, without significantly affecting the main flow

4. Swirl flow: These devices include many geometrical arrangements or tube inserts for forced flow that create rotating or secondary flow. Such devices include full-length twisted-tape inserts, or inlet vortex generators, and axial core inserts with a screw-type winding. There are also flow invertor or static mixer intended for laminar flows. They alternately swirl the flow in clockwise and counter clockwise directions

5. Coiled tubes: Mostly used more in compact H.Ex. Subordinate flow in the twisted tube generates higher single-phase coefficients and improvement in most boiling regimes. However, a very small dia of coil is required to obtain moderate enhancement

6. Perforations or wings: There are used to disturb the boundary layer, increase residence time of fluid and for better mixing. These can be made on inserts, having any shape like triangular, circular etc

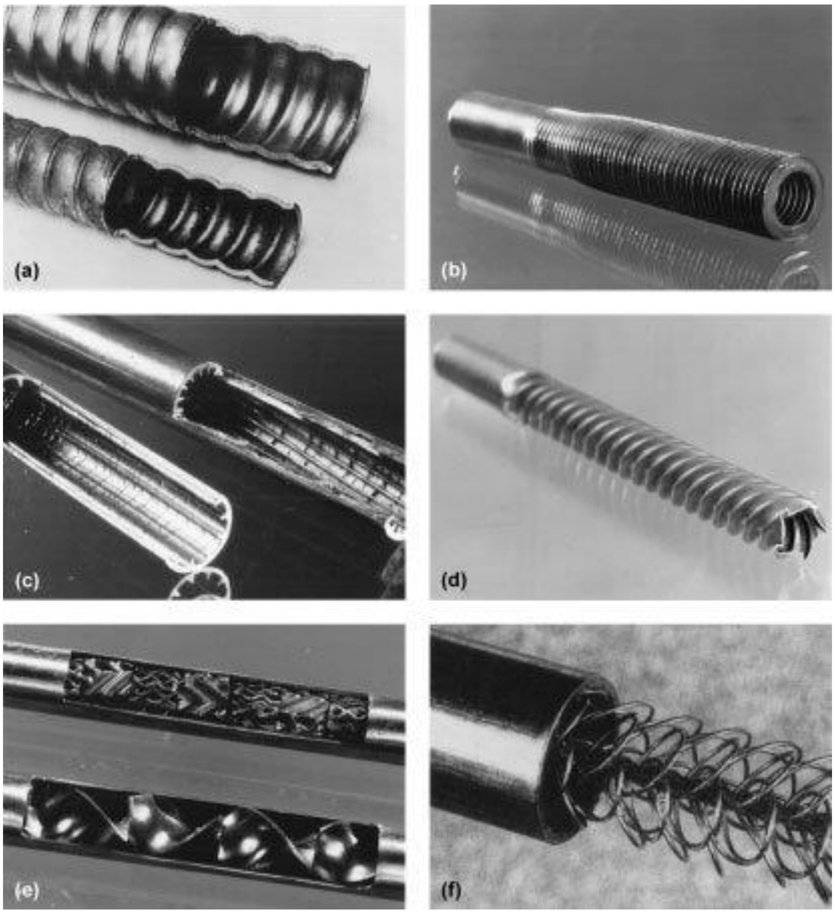


Fig.2.3:Passive Heat Transfer Enhancement Technique

2.2.3: Compound Techniques: When any two or more of the above are utilised, for the increment in magnitude of heat transfer which is greater than the magnitude of heat transfer which is produced by any one when utilised independently, is termed as a compound method for enhancement of heat transfer rate. This technique requires composite design and finds very limited applications.

2.3 Concept of Nano fluid: Despite extensive earlier research and advance efforts on heat transfer improvement major developments is constrained due to very low thermal conductivity of conventional heat transfer fluids. metals in solid form have high thermal conductivity than those of fluids at room temperature. The thermal conductivity of copper as compared to water is 650 times more at room temperature. about 2500 times larger than that of engine oil. The thermal conductivity of metallic liquid is more than that of non-metallic liquids. Consequently, the thermal conductivities of liquids that comprise suspended solid metallic atoms or metal oxides have higher then conventional heat transfer fluid.

2.3.1 Importance of Nano size: the method of suspending solid particle in fluid medium is not a new concept for improving the thermal conductivity of fluid. The added solid particle in fluid conduct heat more heat as compared to liquid. But the main problem is the fast settling of these particles in the fluids. Other problems are abrasion and clogging, which seriously damage the application devices. Nanofluids have overcome these problems by forming stable suspensions and by lasting for longer duration than millimetre or micrometre sized particles.

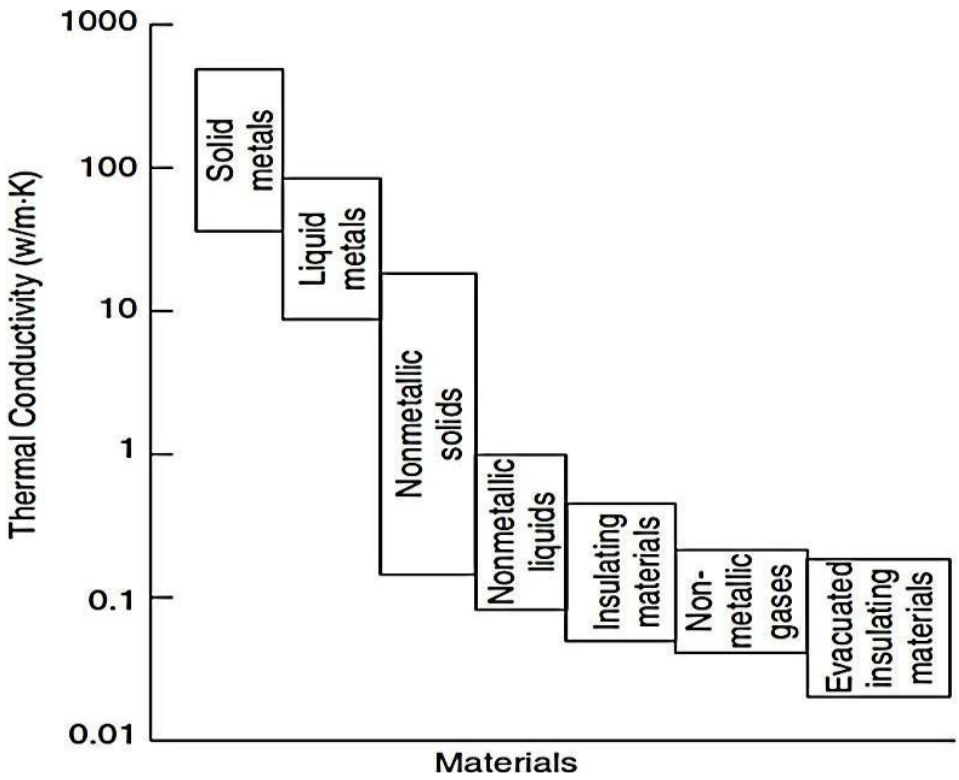


Fig.2.4: Thermal conductivity of materials

2.4: EFFECT OF SURFACE MODIFICATIONS

Hameed and Hussein (2017): experimented with triangular copper fins, which were used as extend surfaces on the outside of the tube. Also, another type of passive enhancement is used at the inside in the form of twisted tapes with various twisted ratios. The results had shown that the overall heat transfer coefficient (htc) rate for only a finned pipe was found to be (3 times) greater than plain pipe. Also, as the various twisted tape ratios which were used in the inner pipe, the heat transfer rate was found to be increased by 4, 6, and 8 times the case of plain pipe, with the twist ratios of 7, 5, and 3 respectively. But the pressure drops and hence the friction factor also increased across the inner tube.

Marwa AM Ali et al. (2017): investigated the performance of the heat transfer process in a double pipe heat exchanger by introducing the rotation of a inner pipe of heat exchanger combined with changing the eccentricity of the pipe. Three-dimension steady state CFD model was constructed for investigating the effect of eccentricity and rotation. The result shows the significant enhancement by 223% in the heat exchanger due to the eccentricity change up to 40 mm at the inner pipe rotation of 500 rpm. The pressure drops increases by 53%.

Yaningsih and Wijayanta (2017) examined the effects of twisted tapes by providing various wings with different axes on heat transfer properties in a concentric tube heat exchanger. The experiments have been done using twisted tape with following measurements:

- constant wing-chord ratio (d/W) = 0.30,
- constant wing-span ratio (b/W) = 0.25
- constant twist ratio (y/W) = 3.9

- Reynolds number range of 5900–19,000.

The results had shown that there was consistent increment in friction factor and heat transfer rate with twisted type of tapes in comparison to without twisted tape. while maintaining the similar operating conditions friction factor, thermal performance factor and Nusselt number, found by the tape with trapezoidal wings and alternate-axes were more than those obtains by the others.

Goudiya et al. (2016) explored the effects of plain and twisted aluminium tapes with and without perforation inserted in a double pipe heat exchanger. The heat transfers in tube with aluminium twisted tape with perforation insert was found to be more as compared to smooth tube i.e. without using any inserts. Friction factorwas found to be maximum in aluminium twisted tape with perforation inserts followed by aluminium twisted tape without peroration, aluminium tape with perforation, aluminium tape without perforation and lest friction factor is obtained in smooth tube.

S. Suresh etal (2010) did the experimentation investigation on friction factor and convective heat transfer rate in the plain and dimpled tube under turbulent flow with the constant heat flux using CuO as a Nano fluid. The effect of dimples and Nano fluid on the Nusselt number and friction factor were determined in a circular tube with fully developed turbulent flow having a Reynold number in the range of 2500-6000.The experimental result shows that use of Nano fluid in the dimple tube increase the heat transfer rate with negligible increase in the friction factor.

Akpinar et al. [2004]: examined the consequences of introducing swirl generator in the medium of fluid in a double pipe heat exchanger. The investigational study was done for obtaining friction losses and exergy loss and heat transfer rates. Swirl generators with different number of holes and different diameter was introduced. Hot air flows through the inner tube and cold-water flows through the annulus. Investigational study was done for Reynolds number varying from 8600 to 16000 for both the counter flow arrangements and parallel flow arrangement. the outcomes obtained after alteration were compared with the results without introduction of swirl generators. The Nusselt number increased by 125%. The increase in Nusselt number obtained for 20 holes' circle of diameter 6mm is 113% .and that for arrangement of 20 holes' circle if diameter of 9mm was 110%. The available energy loss increases with increasing in number of holes in the swirl generator and decreased with increase in hole diameter.

Smith Eiasma ard et al. [2008] performed on practical investigation on turbulent flow heat transfer and pressure drop obtained in a double pipe heat exchanger with louvered strip inserts. The louvered strip inserts were placed inner side of the pipe of the double pipe heat exchanger. Hot water flows through inner side of the tube and cold-water flows through the annulus section of the tube. Investigation was done for both forward and backward placements of louvered strip inserts. Three altered louver angles were done for

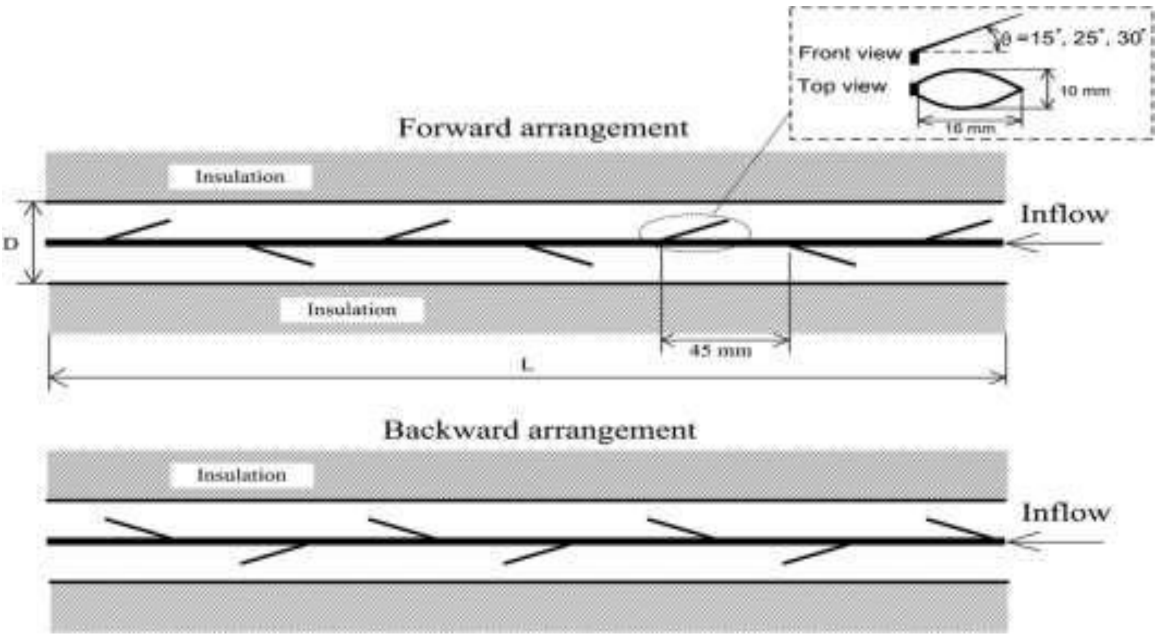


Fig.2.5: Louvered Strip inserts used by Smith Eisma ard et al. in experimental analysis

both backward and forward arrangements i.e. 15°, 25° and 30. Test has been performed on turbulent fluid flow by changing the Reynolds number from 6000 to 42000. the louvered strip inserts produce turbulence in fluid flowing medium. due to this the heat transfer rate improved at the cost of increased pressure drop. The improvement in heat transfer rate was obtained because of increase in Nusselt number and pressure drop was obtained due to friction factor. The mean increment in Nusselt number for forward configuration were 285 % and for backward arrangement was 264 % over the values when plane pipe was used without any inserts. Similarly, the improvement in friction factor for forward configuration of louvered strips has been obtained 415 % and that for backward arrangement was 235 %. For the mean increment in Nusselt number values and friction factor values, it is pretty clear that although the forward inclined louver arrangement gives more heat transfer improvement but it also produces very high pressure drop. On the other side heat transfer rate for backward inclined louvers is lesser. And also introduces low increase in pressure drop comparatively. Hence, the backward inclined arrangement gives overall better results for heat transfer improvement process.

C. Thianpong et al. [2012] inspected the consequence of the perforated twisted tapes which have parallel wings that improve the overall heat transfer rate in tube H.Ex. such type of twisted insert is used to improve the heat transfer rate by generating turbulence with the help of wings also with the help of number of holes in twisted tape the pressure drop is reduced by restriction to the flow. The investigational study was done by varying Re number from 600 and 21500. The variable parameter was diameter ratio of wing hole (d/W = 0.12, 0.32 and 0.56) and having wing depth ratio of (w/W = 0.12, 0.23 and 0.34). by using twisted tape inserts, heat transfer

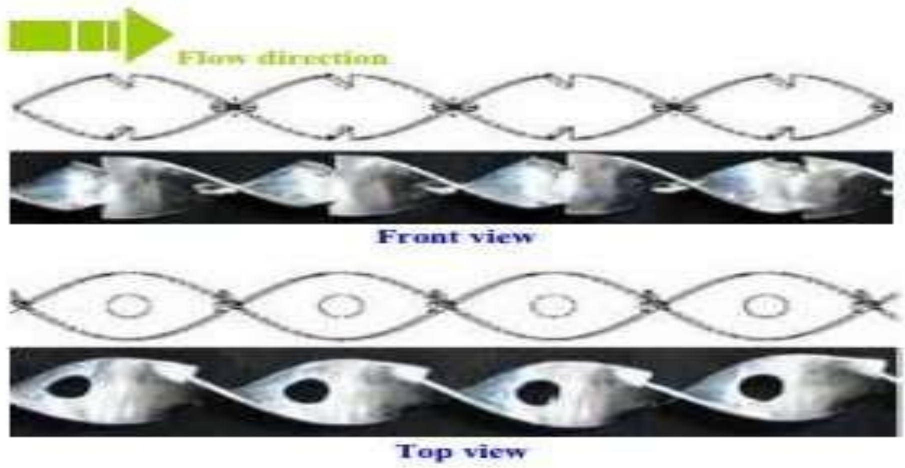


Fig.2.6: Perforated twisted tapes with parallel wings used by C. Thianpong et al

increased by 195 % equated to the plain pipe and for the Perforated twisted tapes having 210%. The highest thermal performance factor obtained for perforated twisted tape with wings for Re number 5500 for the d/W = 0.11 and for w/W = .33. the Empirical correlations were produced for friction factor and heat transfer, and thermal performance factor. Using dye injection method, the flow patterns were Visualised.

2.5: EFFECT OF DIFFERENT TYPES OF NANOPARTICLES AND ITS CONCENTRATION ON HEAT EXCHANGER

Kim et al. (2018) compared CFD analysis with the experiment done on heat exchanger for heat transfer characteristics for aqueous Al_2O_3 Nano fluid in heat exchanger tube. The volume concentrations used were 0.25, 0.5, and 1% by weight. Obtained test Results point out that the heat transfer coefficient and Nusselt number increased with Reynolds number and it also known that the Prandtl number was getting down when the concentration of Nano fluids enlarges and showed the equation by the linear method of the result value.

Nishant et al. (2018) investigated paraffin, ethylene glycol and water based Al_2O_3 Nano fluid with a volume concentration ranging from 0.01% to 0.08% in a step of 0.01% in a shell and tube heat exchanger. Various parameters like sonication time, temperature, base fluids, pressure difference were considered for calculation of heat transfer coefficient. And it has been seen that with increasing volume concentration of Nano fluid, the heat transfer was significantly increased.

Azmi et al. (2017) examined the heat transfer rate in forced convection for Al_2O_3 based Nano fluids in different ratio of ethylene glycol (EG) and water (W) based mixture. The Al_2O_3 Nano fluids were prepared for three based mixture ratios of 60:45, 60:50 and 50:60 (Water: Ethylene Glycol) by volume. The experiments had shown that Nano fluids in 60:45 base mixture had the best results as compared with the other two. Also, he concluded that the thermo-physical characteristics and the forced convection heat transfer for Nano fluids in various base mixture were significantly influenced by concentration, temperature and base ratio of mixture.

Durga Prasad et al. (2016) performed an experimental study to improve the rate of heat transfer with Al2O3 and water-based Nano fluid in u-shaped tube exchanger with inserts, and the volume concentrations used were 0.01% and 0.03% and different twist ratios ranging from 5-20 for twisted tapes were used. The best performance was observed with a twist ratio of 6 and 0.03% volume concentration of Nano fluid, and correlations were also developed.

Somchai et al. (2007]. Furthermore, Nano fluids are likely to be theoretically appropriate for practical applications as its application produces very less pressure drop due to Nano particles are in very small in size. Therefore, it works like a single-phase fluid compare to solid–liquid mixture. The very fine size particles called Nano particles has been used to produce Nano fluids in the studying the reviewed literature paper are: copper (Cu), copper oxide (CuO), silica, silver (Ag), gold (Au), aluminum oxide (Al_2O_3), Nano particles and carbon Nano tube.

Mujumdar et al. (2007) done study on recent investigation performed in research paper on heat transfer and fluid flow characteristics of Nano fluid in free convection and forced convection flow. Recognized the prospects for future research. Convective heat transfer rate would be increased by passively by altering changing boundary conditions, flow geometry, or by increasing thermal conductivity of the fluid. Various method is employed to increase the heat transfer performance of fluids. copper oxide and Alumina (Al_2O_3) are mostly used and inexpensive Nano particles taken into consideration for investigation by many researchers. All the experimental study has been established the improvement of the thermal conductivity by the use of Nano particles.

Das et al (2003): done mathematical study on heat transfer rate and turbulent flow for three different Nano fluids (Al_2O_3, SiO_2 and CuO), in an ethylene glycol and water mixture having flow through circular pipe under constant heat flux. Introduced new viscosity correlation for nano fluids as a function of temperature and volume concentration. Calculated results are authenticated with present well-known correlations. as size of Nano particle reduces its viscosity and nusselt number increases. with increase in volume concentration of Nano fluids and Reynolds number the heat transfer coefficient increases. with increase in the volume concentration of the Nano fluids pressure loss increases.

Khandekar et al. (2008) for closed two-phase thermosiphon using viscous water and pure water having Nano fluids (laponite clay, CuO and Al_2O_3) as working fluids for experimental study of overall thermal resistance. It is found that all of these Nano fluids have inferior thermal performance as compared to pure water. Moreover, it has been investigated that the wettability of all Nano fluids based on copper substrate, contain same value of average roughness as compared to that of the thermo-syphon container pipe, also it is good as compared to pure water. A scaling study shows that with increase in entrapment of Nano particles and wettability in the grooves of the surface roughness effect decrease in Peclet number on evaporator side that gives poor thermal performance.

Gherasim et al. (2009) performed experimental study for use of an Alumina/water Nano fluid flow analysis inside a radial flow cooling system. Results obtained by this experimental study indicates enhanced rate of heat transfer by use of this type of Nano fluid. average Nusselt number have seen that increases with Reynolds number and particle volume fraction, and with decrease in disk spacing.

James K. Carson (2019) shows that there is large number of option available for enhancements of heat transfer enhancements by using Nano fluids as data reported by different studies. but at present we don't have any methodology to overcome sedimentation of Nano fluid particle over period of time. However, with the help of stabilizing agents, for example surfactants, used to enhanced stability significantly. Such Nano fluids have better option for enhancement of heat transfer, in application such as solar thermal, and refrigeration applications in particular presently being the focus of many studies.

2.6: Inference from Literature Review

1.From the various research papers it is concluded that augmented surfaces can generate different combinations for set of condition that are advantageous for increasing the heat transfer rate with a consequent increase in the friction factor.
2.Due to the surface modification, there is an interruption in the development of boundary layer (breaking of laminar sub layer), increase in effective heat transfer area, generation of rotating or secondary flows.
3.Among various techniques of heat transfer enhancement, dimpled tube has less friction factor and lower pressure drop. So less pumping power will be required. Heat transfer rate will be always higher. Application of nanofluids will increase the thermal conductivity of the fluid.

4.Heat transfer is high for dimpled tube
5.The increase in heat transfer coefficient due to presence of Al_2O_3 nanoparticles is much higher than the conventional fluids

3. System Selection and Design Parameters

3.1 Selection of H.Ex.: There are many types of heat exchangers available in the market but not any one can fit into any application. Hence, for different areas of application, different types of heat exchangers are used. Therefore, the proper selection of heat exchanger must be done, and it depends on several factors which are described below

1.Heat transfer rate: it is the most critical parameter for selecting H.Ex. A H.Ex should be proficient of transferring heat at the definite rate to attain the required temperature change of the given fluid at the definite mass flow rate.

2.Cost: This plays important role in the selection of heat exchanger excluding for those cases where "money is no object, but the objective must be fulfilled." The heat exchanger should be designed by keeping in focus that the designing, manufacturing, operation and maintenance cost are optimised.

3.Pumping Power: the fluid flow in heat exchanger is generally governed by the external source of power supply which is given by fluid pump that consumes electrical power. hence while selecting the heat exchanger the annual cost of electricity bill must be taken into consideration.

4.Size and Weight: Depending upon the application, size and weight are determined, for example if it is used in automotive or aerospace industries, the size and weight norms are stringent, whereas in other applications, it can be adjusted. Normally, it is said that the smaller and lighter, the better it is.

5.Type: According to the size and weight limitations, the presence of any phase-change processes and type of fluids involved, the direction of fluids, the temperature difference required. Hence, according to the application, the most suitable one is selected.

6.Materials: In the selection of H.Ex the material used for the construction H.Ex is the critical consideration. In various applications, where the working temperatures are high, thermal expansion of tubes can take place, or when there are corrosive fluids, corrosion resistant materials should be used, etc

3.2 System design parameters

All technical parameters are discussed in previous chapter in detail; in this section only research methodology is discussed in detail. Both analytical and CFD/FEM techniques and their mathematical models are discussed in detail.

3.2.1 BASIC DESIGN PROCEDURE

Heat exchanger must be designed so that it transfers maximum possible heat which has been not obtained by the simple heat exchanger. Following is the basic requirements for maximum heat transfer rate. (design or process needs) and allowable pressure drop (pumping capacity and cost).

The sequence in designing of a heat exchanger **c**an be enumerated as:

a) Recognize the key problem

b) deciding of type of a heat exchanger required

c) evaluate initial design parameters

d) Calculate thermal performance and pressure drops

e) Evaluate the design

f) Modification of design parameters.

The step-in typical design parameter is

a) Define the heat duty (Q) ex, heat to be transfer

b) Based on fluid flow rate, temperature specific heats

c) Select the overall heat transfer coefficient (U)

d) Calculate the log mean temperature difference (LMTD)

e) Calculate the cross sectional or surface area required from equation (Ao).

3.3 Governing Heat Transfer Equation

Heat duty can be calculated for both fluids. Shell and tube side mass flow rates is known, specific heat at given fluids is known. unknown temperature values are finding out from the second formula. finally find out the heat duty (Q)

Q = m Cp (Ti –To) hot fluid

Q = m Cp (Ti –To) cold fluid ……………………………………………………………………………… (1)

heat transfer coefficient *on shell side*(a)

h_a is the heat transfer coefficient on the tube side

$$h_a = \frac{Nu_a . k}{\mathrm{D_e}}$$ …… (2)

h**a**– outside heat transfer coefficient

Nu—nusselt number

k – Thermal conductivity De -equivalent diameter

Tube side heat transfer coefficient (hi)

hypothetical calculations of inner side of heat transfer coefficient for fully developed turbulent flow having constant properties in a circular tube with constant heat flux boundary conditions. Tube side heat transfer based on the materials and velocity of fluids

$$h_i = \frac{Nu_i . k}{\mathrm{d_i}}$$ ……………………………………………………………… (3)

h_i –inside heat transfer coefficient

Nu—nusselt number

k – Thermal conductivity

Estimation of overall heat transfer coefficient (U)

The calculation of overall heat transfer coefficient U for the outside diameter of tubes which can be estimated from the individual heat transfer coefficients (h) Shell wall, outside & inside tube

$$U = \frac{1}{\frac{d_o}{d_i h_i} + \frac{d_o \ln (d_o/d_i)}{2k} + \frac{1}{h_o}}$$ ……………………………… (4)

Mean temperature difference (LMTD)

The temperature distribution across the length of the tube is variable for both cold and hot fluid hence to simplify the study logarithmic mean temperature difference is taken for consideration which can have calculated as below.

$$\Delta T_{lm} = \frac{\Delta T_1 - \Delta T_2}{\ln(\frac{\Delta T_1}{\Delta T_2})} \quad (5)$$

Heat Transfer surface area: Surface area calculate from the below equation and all values are known, from that we find out the surface area of shell and tube heat exchanger. It doing

$$A_s = 2\pi d_0 L \quad (6)$$

4. Conclusion and Future Scope

A great percentage of energy being utilised for industrial purpose and the energy resources are exhausting day by day at very fast rate. Energy management is consequently, become a most important subject. Now a day high-performance H.Ex. In many areas of the industries, become is one of the promising energy-saving manners. by the heat transfer improvement method, the high-performance heat exchangers can be obtained. So, developing efficient and inexpensive heat exchanger is important for efficient use of available thermal energy resources on earth. So, in this study I have learned various method emphasises to enhance the heat transfer rate.

Associated to my study I learned further about the theory of heat Exchanger in which I have studied types of heat exchanger and their application and various method employed to improve the heat transfer rate for example Active heat transfer augmentation Technique, Passive heat transfer improvement technique and compound technique.

In this study, heat transfer enhancement in a heat exchanger with the dimpled tube has been studied with two working fluids namely DI water and DI water based Al2O3 Nano fluids. It is found that the presence of Al2O3 nanoparticle in DI water can enhance the heat transfer rate. from the study we found that The degree of the heat transfer enhancement depends on the quantity of nanoparticles added to the base fluid.

In This study we found that the use of Spherical dimples can enhance heat transfer characteristics for a circular tube. The simulation of the concentric heat exchangers with plain tube and dimple tube was done in CFD analysis and it is found that temperature and velocity increases in the dimple tube as compared with plain tube. The pressure is reduced in dimple tube as compared with plain tube. We studied how The dimpled geometries on the wall of a tube and plain tube were tested experimentally for different flow rates by keeping inlet temperature as constant. The Inside and Outside overall heat transfer coefficient of concentric dimple tube heat exchanger was increases to 58% to 66% as compared with concentric plain tube heat exchanger. The Effectiveness obtained by concentric dimple tube heat exchanger was increases to 58% as compared with concentric plain tube heat exchanger.

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