ENHANCEMENT OF COMPACT HEAT EXCHANGERS IN DIFFERENT INDUSTRIES - A REVIEW

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ABSTRACT:

In many industrial applications compact heat exchangers role became important because to enhance of heat transfer rate and for better performance. Further the compact heat exchangers are being considered for heavy duties to increase more heat transfer by involving the phase change processes at boiling and also condensation. Heat transfer enhancement plays an important role in many industries. Their applications include heat exchanger, air conditioning, heating and cooling in evaporators, chemical reactors and refrigeration systems. There are different techniques to enhance heat transfer such as active, passive or a combination of both. Several techniques are used to increase heat transfer and decrease cost and size of equipment. During design of compact heat exchangers, proper selection of passive insert is done according to heat exchanger working conditions. Compact heat exchangers the phase change vitally important. But for those compact heat exchangers, which have long been used for boiling and condensation duties, the design procedures are based on local two-phase characteristics. As new type of compact heat exchanger with modified design and with enhancement are capable of handling single phase as well as phase change duties. These new exchangers are being increasingly used in single-phase applications, and at the same time, they are also being considered for two-phase duties.

1.0 Introduction:

Compact heat exchangers which have been used for phase change application for long time. Plate-fin heat exchangers used in cryogenic industry belong to this category, where the exchangers have long been used for boiling and condensing duties, along with the single phase vapor and liquid applications. Compact finned-tube exchangers of various designs have been used in air to two-phase service for many years in refrigeration and air-conditioning applications Heat exchangers play an important role in many industries as an energy storage and recovery. Use of conventional fluids such as water and ethylene glycol for increasing heat transfer are challenging and therefore various techniques are develop to enhance heat transfer. There are basically two concepts to increase the rate of heat transfer, one is the active method and the other is the passive method. The active method requires external sources and the passive method requires certain surface geometries or fluid additives. The benefits of heat transfer enhancement have been demonstrated in many experimental and numerical studies. The motivation behind this activity is the desire to obtain a more efficient heat exchangers and thermal transport devices for other industrial applications, with the main objective being to provide energy, material, and economic saving for users of heat transfer enhancement technology. Corrugated tubes are widely used in modern heat exchangers, because they are very effective in heat transfer enhancement. Spirally corrugations are considered as tabulators; as it is considered as an integral surface of the wall. There are few studies concerned with spirally corrugated tube, a helically Heat transfer enhancement is the process of increasing the effectiveness of heat exchangers. This can be achieved when the heat transfer power of a given device is increased or when the pressure losses generated by the device are reduced. A variety of techniques can be applied to this effect, including generating strong secondary flows or increasing boundary layer turbulence these techniques plays major role in improvement of thermo hydraulic performance of heat exchangers. Heat transfer enhancement techniques such as active, passive and compound are used in various fields such as process industries, heating and cooling in evaporators, thermal power plants, air-conditioning equipment, refrigerators, radiators for space vehicles, automobiles, etc. Heat transfer enhancement techniques can be classified into three different categories corrugated tubes was experimentally investigated by They studied the effects of pitch-to-diameter ratio and rib-height to diameter ratio on heat transfer enhancement. Isothermal friction and thermal performance factor in a concentric tube heat exchanger were also examined. Their results show that the heat transfer and thermal performance of the corrugated tube was considerably increased compared to those of the smooth tube depending on the rib height/pitch ratios and Reynolds number. Also, the pressure loss result reveals that the average friction factor of the corrugated tube is in a range between 1.46 and 1.93 times more than that of the smooth tube. Heat transfer and isothermal friction pressure drop for two tubes of three-start spirally corrugated combined with five twisted tape inserts was tested by the results show a higher friction factor and inside internal heat-transfer coefficients than those of the smooth tube under the same operating conditions. Correlation equations developed by Based on the heat-momentum transfer analogy for the heat transfer and pressure drop in tubes having simple and multiple helical internal ridging. Heat transfer enhancement of up to 2:5 to 3 times was reported. Other studies on pressure drop and heat transfer coefficient for flow inside doubly-corrugated tubes were achieved by Twelve different geometries have been analyzed and the results showed that only some of them yield an improved performance, expressed by the authors in terms of heat exchanger volume reduction

Motivation for Heat Transfer Enhancement:

From last few years, efforts have been made to produce more efficient heat exchangers by employing different scheme of heat transfer enhancement. The study of enhanced heat transfer has taken into weighty momentum during recent years. Due to increased demands by industry for heat exchange equipment that is less expensive to constitution and operate than standard heat exchange devices. Savings in materials and energy use also provide strong motivation for the advancing of improved methods of enhancement. When conspiring cooling systems for spacecraft, automobiles, it is importunate that the heat exchangers are especially small in size and light weight .Also, enhancement devices are important for the high heat service exchangers found in power plants i. e. nuclear fuel rods, air cooled condensers.

These applications, as well as numerous others, have force to the development of various enhanced heat transfer surface. Enhancing the efficiency of heat transfer is useful in a variety of practical applications such as macro and micro scale heat exchangers, gas turbine internal airfoil cooling, fuel elements of nuclear power plants, power semiconductor devices, electronic cooling, combustion chamber liners, bio medical devices, Compact heat exchangers have been one of the subjects of study for number of researchers over the recent years to improve heat exchanger performance. In a compact heat exchanger

Objectives:

- To review the different researches made on heat exchangers
- To understand the behaviour of heat exchangers with different industries.
- To improve the heat transfer system size - reduction

3.0 literature review:

[1] S. Ray, A. W. Date,(2002) carried out experiments to compare pressure drop and heat transfer coefficients for a plain, micro fin, and twisted tape insert tubes. Laminar flow was considered. Steam was used as heat source for uniform wall temperature condition in Single shell and tube heat exchanger and Oil flows inside the tube. It was observed that as the twist ratio decreases, the twisted tape gives better heat transfer enhancement. Also it was seen that the tight fit tape performs better than the loose fit tape. It is recommended that for a low twist ratio and high pressure drop, a loose fit is to be used for design of the heat exchanger as it is easy to install and to remove for cleaning [2] **Liu and Lee, (2003)** A varieties of novel cooling schemes have been proposed and investigated to meet this demand requirement, among which, the micro channel heat exchanger is especially promising for its superior thermal performance. Compared with conventional heat exchangers, the main advantage of the micro channel heat exchangers is their extremely high heat transfer area per unit volume. As a result, the overall heat transfer coefficient per unit volume can be as greater than 100 MW/(m3 K), which is much higher than that for conventional heat exchangers **[3] Neshumayevet. al.(2004)** experimentally investigated the heat transfer enhancement by various tabulator inserts in gas heated channels. Twisted tape insert, the straight tape insert, and the combined tabulator insert were tested. The combustion products of light oil fuel and wood pellets were used as working fluid. The experiments were also conducted in the two fire tube boiler without any inserts. It was observed that heat transfer coefficient for twisted tape insert is higher than the straight tape insert. Also the mean heat transfer of the combined tabulator is high as compared to the mean heat transfer for the twisted tape and the helical wire coil insert. **[4] R.K Shah (2006)** in his elaborate discussion over the classification of heat exchangers has defined the "compact heat exchangers" as one having a surface area density of more than 700 m2/ m3. Such compactness is achieved by providing the extended surfaces i.e. fin on the flow passages which work as the secondary heat transfer area. Heat exchangers are used to transfer heat from one media to another. It is most commonly used in space heating such as in the home, refrigeration, power plants and even in air conditioning. It is also used in the radiator in a car using an antifreeze engine cooling fluid. Heat exchangers are classified according to their flow arrangements where there are the parallel flow, and the counter flow. Aside from this, heat exchangers also have different types depending on their purpose and how that heat is exchanged. But the fact is that there are heat exchangers even in the circulation system of fishes and whales. **[5] Al-bakhit and Fakheri (2006)** numerically investigated the parallel flow micro channel heat exchanger with rectangular ducts. They showed that the overall heat transfer coefficient is rapidly changed below 0.03, and therefore the assumption of constant overall heat transfer coefficient is not valid if the Graetz number based on the heat exchanger length is of the order of 0.03. Also, the accurate results can be obtained by solving the thermally developing energy equation using fully developed velocity profiles.**[6] Chang et. al.(2007)** experimentally investigated the turbulent heat transfer in a swinging tube with a Serrated Twist Tape insert under seagoing conditions to examine the effects of swinging oscillations on heat transfer. This swirl tube swings about two orthogonal axes under single and compound rolling and pitching oscillations. It was found that synergistic effects of compound rolling and pitching oscillations with either harmonic or non-harmonic rhythms leads to improvement in heat transfer performance. Buoyancy effects existing in the swinging swirl tube are found to increase the local Nusselt number but as the swinging force increases Nu gets weakened. Nussle number correlations were developed. **[7] Valery Ponyavin et al. (2008)** performed a study of the heat transfer and fluid flow distribution in a compact ceramic heat exchanger. It is found that the flow mal distribution due to design limitations may result in reverse flow of fluids. This may affect the performance of the heat exchangers. Different types of improved designs are analyzed for the proper fluid flow in exchanger in considerations with a reduced pressure drop values The summary for the above review results revealed that the proper designs for the fluid flow in compact heat exchangers is essential. The axial heat conduction affecting parameters are Reynolds number (Re), thickness of separating wall and thermal conductivity ratio.**[8] Hasan (2009)** made numerical investigation to study the counter flow micro channel heat exchanger with different channel geometries and working fluids. He studied the effect of axial heat conduction on the performance of counter flow micro channel heat exchanger with square shaped channel and he found that the existence of axial heat conduction leads to a reduction in the effectiveness of this heat exchanger. **[9] Weikla et al. (2013)** had performed a comparative study of two types of heat exchangers namely Shell and Tube heat exchanger (STHE) and Coil wound heat exchanger (CWHE) for the special service conditions (molten salt service). Furthermore, the applications of these CWHE in the thermal energy storage plants are analyzed. The results obtained are that the CWHE have advantages over the STHE for the reasons like less heat transfer area, lower pressure drop, lower pumping cost and less number of shells and piping. These configurations have advantages like prevention against thermal shocks.**[10] Jiin-Yuh Jang et al.**

(2013) conducted an analysis regarding the span angle and location of the vortex generators provided in a plate – fin and tube heat exchanger with in-line and staggered arrangements. Block type vortex generators are mounted behind these tubes. Comparing the plain surface and surface with vortex generators, the area reduction ratio is better in surface with vortex generators. Span angle range considered for vortex generators is from 30° to 60° and transverse location (Ly) range is from 2mm to 20mm. In-line arrangements in above exchangers is considered to be more effective regarding heat transfer enhancements The literature review results revealed that the provision of baffles in the heat exchangers causes huge pressure drop of the heat transfer fluid. This limitations can be overcome by using dimples, fins, full length twisted tapes and vortex generators.**[11] Guo- yan Zhon et al. (2014)** proposed a simple model to predict the temperature distribution in the shell and Tube heat exchanger by using the basis of differential theory. Based on the baffle arrangements and number of tube passes, the heat exchanger has been divided into number of small elements. The tube side current is considered series and shell side current is parallel. Two heat exchangers (AES and BEU) are considered for analysis by using the Cell model and Heat Transfer Research Incorporations (HTRI) method. From this paper, it is seen that the HTRI method used for predicting temperature of heat exchangers is more accurate. **[12] Saneipoor et al. (2014)** had done an analysis of heat transfer with the Manroch heat engine using water/ glycol mixture as the working fluid. Four shell and tube exchangers are used in this experiment. The shell side fluid is the compressed air and the tube side fluid is water/ glycol (propylene glycol) mixture. The transient heat transfer analysis has been done as the hot fluid after passing through one set of heat exchangers become cold fluid and then sent through another set of heat exchangers. This procedure can be used for studying the heat exchangers working under transient conditions. **[13] Eiamsa-ard et al. (2014)** assessed the thermal performance of a heat exchanger tube equipped with regularly- spaced twisted tapes as swirl generators. The factors like heat transfer, friction factors and thermal performance factors in a heat exchanger are reported in case of a heat exchanger provided with the regularly - spaced twisted tape (RS-TT) across fluid flow. This is studied in comparison with the effect of full length twisted tape. Further, the physical behavior of fluid flow, fluid temperature and Nusselt number are observed. The observations from this paper is that the full length twisted tapes showed higher heat transfer rate, thermal performance factors and friction factors.**[14] Hitami et al. (2014)** had done the numerical study of the finned type heat exchangers for IC Engines exhaust waste heat recovery. Two cases of heat exchangers are studied as follows: one type of heat exchanger is used in the Spark ignition exhaust recovery system and another type of heat exchanger is used in the Compression ignition exhaust recovery system. The Compression engine heat recovery system has water as cold fluid while in case of the Spark ignition system, a mixture of water (50%) and ethylene glycol (50%) has been used as cold fluid.**[15] Mushtaq Ismael Hasan a, Hayder Mohammed Hasan (2014)** the governing equations are discretized using finite-volume and the hybrid differencing scheme with FORTRAN code was used. Various parameters that can have effect on the axial heat conduction were investigated. The results showed that, the axial heat conduction plays an important role in a parallel flow micro channel heat exchanger and the factors affecting the local and average axial heat conduction he parameters that affect the axial heat conduction in an isosceles right triangular micro channel heat exchanger are: thermal conductivity ratio Kr, Reynolds number Re, hydraulic diameter Dh, channel volume and wall thickness it's The axial heat conduction increased with increasing Kr up to Kr = 10 after this value the axial conduction is equal to zero.**[16] T.Venkateshan, Dr. M. Eswaramoorthi (2015)** the study of heat exchangers is a thrust area as it is an eco-design model. The concept of heat exchangers plays a major role in the refrigeration and air conditioning system. An attempt is made in this paper to review the literature related to the heat exchangers and modifications made to improve the efficiencies. The achievement of the thermal comfort conditions optimizes the size of the heat exchangers. CWHE could be preferred over STHE depending on the suitability. The provision of baffles in the heat exchangers causes huge pressure drop of the heat transfer fluid. This limitations can be overcome by using dimples, fins, full length twisted tapes and vortex generators. The increase in Nussle number increases the heat transfer rate. The glycerin based Nano fluid (SiO2-nanoparticle) showed the better heat transfer characteristics. **[17] Tonio Sant et al. (2015)** had done the discussion about the analysis of the wind powered system using the thermocline thermal energy of the sea water. The cold water (deep sea water) and the hotter are utilized in tapping the thermal energy with assistance of hydraulic turbine and heat exchanger. The water to be supplied for the purpose of cooling/ heating the buildings in townships is conditioned as per requirements using the heat exchangers. **[18] Mahesh Jadhav ,Rahul Awari (2016)** various methods for comparing different types of heat transfer enhancement devices using first or second law resolution are presented .Heat transfer enhancements of both experimental and analytical studies have been reported in view of their industrial and domestic significance. The heat transfer enhancement can be increases by both active and passive method. In that we focus mainly on active method, they require external power, such as electric or audile fields and surface vibration. The electric force of the liquid far from the heating wall is more than the electric force of liquid near the heating wall which generates electro convective movement's .So that heat transfer increases.**[19] Kalase Rajesh S. , Dr.Uttarwar Sanjay(2017)** different shapes and sizes are used in the flow passage to enhance the heat transfer rate, are advantageous compared with active techniques, because the insert manufacturing process is simple and these techniques can be easily employed in an existing heat exchanger The Main Advantage of the rectangular way offset strip fin is one of the most widely used finned surfaces, particularly in high effectiveness heat exchangers employed in automobile applications especially in tracked vehicles. Heat transfer process involved in operation of an automotive radiator has been analyzed. The analysis of radiator includes nearly all of the fundamentals discussed in heat transfer class, including the internal and external fluid flow through the heat exchanger and the design and analysis of heat sinks and exchangers. **[20] Divyesh Prafulla Ubale (2017)** heat exchangers, proper selection of passive insert is done according to heat exchanger working conditions. This paper contains a review of the use of passive enhancement techniques in the past and will help the designers to implement these techniques in heat exchange. Most commonly used passive heat transfer enhancement techniques considers use of Twisted tapes, wire coils, rough surfaces, ribs, fins, etc. This paper focuses on the use of Twisted tapes in heat transfer enhancement limited work is carried in case of minimum twist ratio for obtaining better heat transfer. Also use of twisted tapes in different geometries such as helical, spiral coils are to be investigated and effects on heat transfer and pressure drop is to be evaluated.

BASAWARAJ S. HASU (2017) in many industrial applications compact heat exchangers role became important because to enhance of heat transfer rate and for better performance. Further the compact heat exchangers are being considered for heavy duties to increase more heat transfer by involving the phase change processes at boiling and also condensation. In mean while understanding the thermal-hydraulic characteristics of flow passages for compact heat exchangers the phase change vitally important. Use of modern measurement techniques such as liquid crystal thermography etc. to establish the heat transfer coefficient variation heat exchangers role became important because to enhance of heat transfer rate and for better performance

4.0 Results and discussions

References	**Year**	**Study**	**Results**
Kalase Rajesh S. Dr.Uttarwar Sanjay	**(2017)**	In design of compact heat exchangers, passive techniques of heat transfer enhancement	Heat exchangers in automobile applications boundary layers and results in better heat transfer enhancement.
BASAWARAJ S. HASU	**(2017)**	Performance of compact heat exchangers with different configurations is presented.	heat exchangers role became important because to enhance of heat transfer rate and for better performance
Eswaramoorthi	**(2015)**	heat exchangers is a thrust area as it is an eco-design model	to the heat exchangers and modifications made to improve the

			efficiencies.
Hitami et al.	**(2014)**	the numerical study of the finned type heat exchangers for IC Engines exhaust waste heat recovery	Spark ignition exhaust recovery system and another type of heat exchanger is used in the Compression ignition exhaust recovery system
Hassan	**(2009)**	the effect of axial heat conduction on the performance of counter flow micro channel heat exchanger	heat exchanger with square shaped channel and he found that the existence of axial heat conduction leads to a reduction in the effectiveness of this heat exchanger.
Valery Ponyavin et al.	**(2008)**	Performed a study of the heat transfer and fluid flow distribution in a compact ceramic heat exchanger.	Results revealed that the proper Designs for the fluid flow in compact heat exchangers is essential

Discussions:

Heat exchangers constitute the most important components of many industrial processes and equipment's covering a wide range of engineering applications. Increasing awareness for the effective utilization of energy resources, minimizing operating cost and maintenance free operation have led to the development of efficient heat exchangers like compact heat exchangers. The need for development of heat exchanger by considering industrial applications to fulfill requirement with less occupation area due to industrial globalization. Researches needed to develop as a consideration and this is an attempt of developing fin type heat exchanger with better performance. Furthermore, sometimes there is a need for miniaturization of a heat exchanger in specific applications, in some specific applications, such as heat exchangers dealing with fluids of low thermal conductivity and desalination plants there is a need to increase the heat transfer rate. The heat transfer rate can be improved by introducing a disturbance in the fluid flow but in the process pumping power may increase significantly and ultimately the pumping cost becomes high.

5.0 CONCLUSIONS:

In order to further accelerate the use of compact heat exchangers for phase change duties heat exchanger passages, especially for cross corrugated channels of plate heat exchangers. This information would be useful for developing flow pattern specific models for compact heat exchangers further; the usage of various nanoparticles in the base fluid for the heat transfer enhancement along with these configurations had been studied. A review on the compact heat exchangers had been also done to extract some useful facts regarding heat transfer. This innovative technique can be implemented in micro-channel heat exchanger especially in the inferior heat transfer side to Enhance overall thermal performance of the heat exchanger. Jet position influence overall performance of the heat exchanger and need to optimize for a specific condition and geometry. Jet velocity can be controlled with the constriction that induced jet and with the increase of jet velocity local heat transfer rate increases.

Future scope:

Heat exchanger optimization is an important field and full of challenges. The task of optimization may be considered as a design process, in which any possible candidates will be evaluated based on requirements. Savings of materials or energy, as well as capital cost and operating cost, are common objectives for industrial applications of heat exchangers.

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