SHORT REVIEW ON PERFORMANCE ENHANCEMENT OF SHELL AND TUBE HEAT EXCHANGER

Vigneshwar.P[a], Surendran.S[b], Vignesh.K.R[b], Venkatesh.M[b], Yuvaraj.R[b]

[a] - Assistant Professor, Mechanical Engineering, Saranathan College of Engineering, Trichy-12

[b] - Mechanical Engineering, Saranathan College of Engineering, Trichy-12

ABSTRACT

A heat exchanger is a promising thermal device in which heat is transferred between hot and cold fluids. Researchers focused on indirect contact type compact heat exchangers among various classifications of warmth exchangers. Among these, the shell and tube device is a fluid-to-fluid heat transfer device. Shell and tube device feed devices are commonly used in process industries, refineries, chemical plants, and power plants. The analysis of shell and tube heat exchangers is typically divided into two parts: shell side analysis and tube side analysis. Shell side analysis is simple and requires little modification. The tube side analysis is more complex, and it is accomplished by varying baffle design and elevation in relation to arrangements. The most significant disadvantage of the shell and tube device is the pressure drop that occurs at the ends of the tubes that may affect the heat transfer efficiency. Researches on enhancing the heat transfer through shell and heat exchanger by optimization of parameters is in recent trends now-a-days. This paper focuses on reviewing literatures on enhancement of heat transfer rate of shell and tube heat exchanger.

INTRODUCTION:

The shell and tube device is made up of a bundle of tubes that is baffled and placed inside a shell. Warmth is always exchanged between hot and cold fluids. Hot fluid flows through the tube and cold fluid flows through the shell in this type of heat exchanger. The operating fluid can be in single or two phases and it can flow in either a very parallel or cross/counter flow configuration. The configuration of the shell and tube device affects the general heat transfer coefficient and thus the heat transfer rate. The tube surfaces are also an important factor to consider if you want to have an extremely high heat transfer rate.

Operating parameters:

Investigations made on Area of the tubes and materials, Increasing baffle cut, Increasing shell side passes by increasing number of baffles, Reducing baffle spacing, Reducing shell diameter and Changing the shell type and using shells in series and by choosing best suitable tube arrangements.

Area of tubes and materials:

Ingrid Snustad et.al[3] Experimentation on heat transfer characteristics of CO_2 condensation was made on various materials revealed the effect of condensation heat transfer properties. The differences in heat transfer among the various materials rely on the surface roughness and surface energy of the materials used. Cu being higher surface roughness material than Al and steel, Condensation heat flux and heat transfer coefficient for Copper resulted as the highest.

Qi Lia et.al[1] analyzed the performance investigation and enhancement of shell and tube thermal energy storage device containing molten salt based phase change materials for medium and high temperature applications. This paper reviewed the current state of the art development in molten salt based PCMs that suitable for medium and high temperature applications with range over 200–1000 °C and the experimental and numerical investigations on the heat transfer performance of shell and tube LHTES device containing molten salt PCMs.

Le Li et.al[4] mentioned that the effect of heat exchanger tubes on flow behaviour and heat/mass transfer of the bubble/slurry reactors. The specific alterations in flow pattern, mixing intensities and generally

hydrodynamics due to insertion of heat exchanger tubes in BCR/SBCR(Bubble/Slurry bubble column reactors). It showcases the effect arise when changing the internal design parameters by changing the angles of the flow pattern. Square 32,Square 45,Triangular 32,Triangular 45 are the angles made and the results are graphed.

Tomas Venegas et.al[2] examined that the future prospects for desiccant coated heat exchangers: Materials, design, and manufacturing. This review focused on the DCHE(Desiccant coated heat exchanger) device itself, its design, materials, and manufacturing processes, as well as designs of heat exchangers that might be suitable for solid-desiccant coating purposes. To overcome the weakness of the Vapour compression system (VCS) alternative dehumidification processes that is solid-desiccant-based dehumidification (SDD) system is mentioned.

Increasing baffle cut:

A.G. Ostrogorsky et.al[5] reviewed that the Disk-driven flows and interface shape in vertical Bridgman (VB) growth with a baffle. By using the disk shaped baffle, natural convection can and should be made negligible compared to forced convection. The steady laminar disk-driven flows, are steady than the complex unsteady flows driven by (accelerated crucible rotation technique) ACRT. Therefore, numerical models are the most effective tools for studying interface shape and convection in VB systems with the baffle.

M.S. Soliman et.al[6] studied that the present trend of developing heat exchanger- reactors suitable for conducting heterogeneous and catalytic exothermic reactions, these reactors have lower capital and operating costs. It is found that the dimensionless mass transfer equations can be used to calculate the outer side heat transfer coefficient (by analogy) which is required to calculate the overall heat transfer coefficient and the rate of heat transfer to the cooling fluid flowing inside the serpentine baffle.

J.R. McDonough et.al[7] stated that the meso-OBR has been used to screen gas–liquid bio-processes and rapidly screen homogeneous liquid reactions, liquid–liquid reactions and solid–liquid–liquid reactions. Additionally, rapid bivariate screening has been demonstrated where two operating variables were varied in a single experiment to find the optimum operating condition with minimal waste.

William P.Barber et.al[8] presented that the laboratory, pilot and full-scale work has shown that the Anaerobic Baffled Reactor(ABR) is capable of treating a variety of wastewaters of varying strength (0.45 < 1000 g/l), over a large range of loading rates (0.4 < 28 kg/ m3 d), and with high solids concentrations with satisfactory results.

Increasing shell side passes by increasing number of baffles:

Azher M. Abed et.al[12] reported that the results from heat transfer showed that nanofluids are especially effective in enhancing the flow boiling heat transfer and falling-film flow of binary nanofluids of refrigerants.

Nianben Zheng et.al[9] examined that the Multi-longitudinal vortices help to improve the synergy between the flow and temperature fields and reduce the entropy generation, power consumption, and the exergy destruction of the heat transfer process and Techniques which are developed according to the optimal flow fields such as DDIR-tube, AEA tube, conical stripes, longitudinal vortex generators, and vortex rods show excellent heat transfer and flow performance with less pressure drop.

Inderjot Kaur et.al[11] analyzed that the Surface roughness is the common and key-consideration in determining the thermal and hydraulic characteristics of the different types of metal HXs fabricated by powder bed-fusion technologies such as SLM(Selective Laser Melting) and DMLS(Direct Metal Laser Sintering). The AM(Additive manufacturing) technologies have paved ways to manufacture optimized geometries which can be designed by coupled numerical tools and AM technologies. Cellular structures depicted higher heat transfer and pressure drop than considered convectional baseline configurations, but the overall relative benefit is dependent on the unit cell topology.

Bao Meng et.al[10] mentioned that the fabrication process of compact heat exchangers involves multiple materials, multi scales and multiple passes. Both interdisciplinary design methodologies and hybrid micro-manufacturing processes derived from current micro-fabrication techniques, are necessary for overcoming the key issues encountered in the production of compact heat exchanger for Hypersonic Pre-cooled Combined Cycle Engine (HPCCE).

Reducing baffle spacing:

Jianjun Hu et.al[16] reviewed that the increasing artificial roughness can reorganize the airflow in the laminar sublayer and create the turbulence to enhance the heat transfer between airflow and absorber plate. The jet impingement on absorber plate is an effective technique to enhance the rate of heat transfer by reorganizing the airflow near the absorber plate and making the boundary layer much thinner. The double/multi-pass collector has the advantages of increasing the heat exchange area and residence time of air by introducing double or multiple flow passage to reorganize the airflow of main stream in the SAC, which can also reduce the heat loss to the ambient. Setting baffles can introduce disturbance to the fluid and reorganize the airflow in the whole collector chamber as expected.

Jie Wua et.al[15] examined that there are a range of design options, dependent on Reynolds number, which can be employed to improve the mixing of viscous slurries in industrial processing tanks. This could have benefits of reduced stagnant zones, increased wall velocity and reduced sedimentation depth, with the same power input as the initial installation. Swirl flow via removal of baffles can be considered for Re > 500, even for viscous non-Newtonian slurries with yield stress.

Tabish Alam et.al[14] founded that perforated baffles are considered to be thermo-hydraulically better in comparison to solid baffles because perforation in ribs/blocks/baffles enhances the heat transfer due to elimination of hot spot just behind the ribs.

Sunil Chamoli et.al[13] founded that small height roughness element of different configuration was widely investigated both analytically and experimentally and numerical studies also predict same the behavior as the experimental results.The compound delta winglets can be used to enhance heat transfer and perforated winglets may found suitable in performance enhancement of solar thermal systems.

Tube arrangements in heat exchangers:

Ali Sadeghianjahromi et.al[18] compared the heat transfer in fin and tube heat exchangers using different mechanisms. Increased heat transfer area, increased heat transfer coefficient, and improved temperature difference are three mechanisms used. The developed correlations for estimating the heat transfer and pressure drop characteristics of fin-and-tube heat exchangers with various fin types and circular and flat tubes in dry and wet situations, as well as comparisons between them. Heat transmission area may be increased by using plain and wavy fins. By restarting the boundary layer, louvre and slit fins improve heat transfer coefficient, whereas vortex generators improve mixing of hot and cold fluids, which improves heat transfer coefficient.

Dawei Wang et.al[17] investigated the tube external heat transfer for passive residual heat removal heat exchangers in nuclear power reactors was given. The heat transfer mechanism and correlations investigation concerning(passive residual heat removal) PRHR heat exchangers in different (nuclear power plant) NPPs are the major subject of this work. By comparing the many correlation you may find out which ones are the most relevant connections for heat exchanger heat transfer calculation in NPP passive safety system

Bipin Kumar et.al[19] stated that the source of heat transfer increases achieved by this passive approach is revealed by a careful examination of heat transfer and fluid flow mechanisms in a flow through a circular tube fitted with various insert shapes. Twisted tape inserts have been documented in the literature to provide significant heat transfer increases, however they are typically chosen for laminar flow since turbulent flow results in significant frictional losses.

A.K.M. Sadrul Islam et.al[20] Estimated that the Thermal and hydraulic performance of finned-tube heat exchangers under different flow ranges. It was discovered that when the longitudinal pitch (Ll) of the tube increases, the heat transfer and pressure drop performance decreases because the flow becomes more loose and less compact. Because the pressure drop is greater than the heat transfer, the efficiency improves when tube pitch is increased.

Using shell in series:

Meijie Liu et.al[24] Experimentally says that the Photocatalysts with a core–shell metal organic frame for solar energy conversion it is worth mentioning that the photocatalytic effectiveness of composite materials varies depending on whether they're exposed to simulated or real sunshine. For the development of more intelligent core–shell MOF-based photocatalysts, understanding the impact of numerous parameters on photocatalytic performance, such as core size and shape, porosity, shell thickness, and hydrophobicity, is critical.

Abdellah Hamdaoui et.al[21] studied that the Several numerical experiments were performed to demonstrate the effectiveness of this vectorial Padé approximant in solving these types of issues. Comparison of the outcomes of the three algorithms CS, CCP, and CPP[1, N 1] for the truncation orders N = 10, 15, and 20 with the stated tolerance settings. We concluded from the acquired data that by using this vectorial Padé approximant CPP[1, N l], we may get huge step lengths when compared to the CS and CCP algorithms.

Jin-Soo Park et.al[22] discussed that it has a unique cellular structures Activated Carbon derived from the coconut shell biomass have the highest quality and this article mainly focusing on the activation method used for developing desired pore structure and nitrogen doping is to improve the electrocatalytic properties of activated porous carbon materials that is derived from the coconut shell biomass.

Haiyang Sua, et.al[23] In this article we design of NanoPorous Core at Shell Praticles and also we discuss the preparation methods of NPCSPs defining the larger bottom-up and top-down approach groups and the preparation and design of the core at shell particles including the structure and surface chemistry that will affect the particles function in biocatalysis which is then correlated with the synthesis methods to addressing this issue use efficient method of low toxicity nanozymes.

Reducing Shell diameter:

Yunho Hwang et.al[28] investigated that shell-and-tube type phase change plate study for temperature uniformity and thermal storage. Theoretical research demonstrates that increasing the size and decreasing the size resulted in a bigger specific heat transfer area and a higher transient heat transfer rate. conclude that the average temperature of the air at the exit is lower, and the overall heat transfer time is shortened.

R. Manikandan et.al[25] discussed the effect of the various phase change materials in a heat exchanger with manufactured shell and tubes. When compared to other phase transition materials, the efficacy (coefficient of thermal expansion) of Paraffin wax was significantly higher and the efficiency of Paraffin Wax is greater than that of vegetable PCM, suggesting that it be used in the aforementioned applications. It exhibits a 40 percent and a 27 percent increase in vegetable oil and paraffin wax, respectively, as compared to no PCM material.

Yuanpeng Yao et.al[27] experimentally to analyze the phase change process in latent heat thermal energy storage (LHTES) The results of the experiments reveal that PCMs implanted in porous medium can improve heat conduction and charging/discharging rates. This paper develops a numerical model for the PCM embedded in metal foam, which is then applied to a shell-and-tube LHTES unit.

A.H. Sofiyev et.al[26] analyzed using different shell theories are used to analyse the nonlinear vibration of reasonably thick multilayer shell-type structural components with twofold curvature made up of Carbon Nano Tube (CNT) patterned layers. In particular situations, we find formulas for the nonlinear frequencies of multilayer spherical and hyperbolic-paraboloid shells, rectangular plate produced by CNTs in shear deformation, and classical shell theories.

Changing the shell type**:**

Jin Zhang et.al[30] examined that a primarily review current breakthroughs in core-shell structured CdS nanocomposites, such as rational design, synthesis, and solar energy utilisation applications. First, the core-shell structured CdS nanocomposites' synthetic methodologies are discussed. Second, examine the solar energy conversion of core-shell structured CdS nanocomposites in detail, including photocatalytic, photoelectrochemical, and solar cell applications.

Ting Wang et.al[31] stated that the pesticide residue detection may be done using SERS, which is a potent and quick analytical approach. The detection sensitivity of the Au@Ag core–shell nanostructure is improved. The magnetic core–shell construction can enrich insecticide and reuse it, lowering detection costs and time. The ultra-thin SiO2 shell can prevent the impact of charge exchange between nanostructures and the detection environment, and the SiO2 core provides superior stability in the synthesis method.

Meng Tang et.al[32] suggested the cytotoxicity of quantum dots with a core-shell or non-shell structure, as well as considerations for environmentally friendly quantum dots. That QD functionalized with long ligands showed greater cytotoxicity than QD functionalized with short ligands. To summarise, the toxicity of QDs is induced by a number of factors, including ligands and electricity, rather than by a single factor.

Majid Pakizeh et.al[29] investigated that the Chitin/chitosan is usually derived chemically from shrimp shells on an industrial basis. The current paper describes the existing chemical techniques for recovering chitin from shrimp shell wastes and producing its most common derivative, the deacetylated form known as chitosan.

Conclusion:

The inferences obtained by the researches so far have been enlisted below

1. The large surface area afforded by the plates means that plate and frame heat exchangers can allow more heat transfer between the two fluids, for a given volume relative to shell and tube heat exchangers.
2. A higher baffle cut reduces the heat transfer coefficient on the shell side.
3. The significance of baffle cut on the shell side heat transfer coefficient increases as the baffles.
4. Higher baffle spacing reduces the pressure drop, but this will allow more longitudinal flow, which decreases the coefficient of heat transfer.
5. The most common type of heat exchangers, shell and tube heat exchangers are constructed of a single tube or series of parallel tubes (i.e., tube bundle) enclosed within a sealed, cylindrical pressure vessel.
6. In counter flow type applications, exchangers are added in series in order to increase the tube velocity and thus the heat transfer coefficient.
7. Heat transfer coefficient for shell side reduced by 15.15% by increasing baffle space by 0.2 from shell diameter and the pressure drop by 41.25%.
8. It is used in several industrial process for Removal of process heat and feed water preheating. Cooling of hydraulic and lube oil. Cooling of turbine, compressor, and engine.

References:

1) Chuan Lia, Qi Lia, Feng Jiangb, Yulong Dinga, Zheng Dua- A review of performance investigation and enhancement of shell and tube thermal energy storage device containing molten salt based phase change materials for medium and high temperature applications.
2) Kashif Nawaz b , Lingshi Wang, Ming Qu, Tomas Venegas-Critical review and future prospects for desiccant coated heat exchangers: Materials, design, and manufacturing
3) Amy Brunsvold,Ingrid Snustad, Asmund Ervik ,Anders Austegard, , Jianying He ,Zhiliang Zhang- Heat transfer characteristics of CO2 condensation on common heat exchanger materials: Method development and experimental results.
4) Chun Han, Le Li, Qian Zhang,Wei Huang,Wenhao Lian, Yansheng Zhao- Review on the effect of heat exchanger tubes on flow behavior and heat/mass transfer of the bubble/slurry reactors.
5) A.G. Ostrogorsky- Disk-driven flows and interface shape in vertical Bridgman growth with a baffle.
6) G.H.Sedahmed,M. Hussein,M.S. Soliman,S.A. Nosier-Mass and heat transfer behavior of a new heterogeneous stirred tank reactor with serpentine tube baffles.
7) A.N. Phan,A.P. Harvey,J.R. McDonough - Rapid process development using oscillatory baffled mesoreactors – A state-of-the-art review.
8) DAVID C. STUCKEY,WILLIAM P. BARBER-THE USE OF THE ANAEROBIC BAFFLEDREACTOR(ABR) FOR WASTEWATER TREATMENT: A REVIEW
9) Fang Yan,Kang Zhang,Nianben Zheng,Tian Zhou,Zhiqiang Sun-A review on single-phase convective heat transfer enhancement based on multi-longitudinal vortices in heat exchanger tubes.
10) Bao Meng,Huoxing Liu,Min Wan,Rui Zhao,Zhengping Zou- Micromanufacturing technologies of compact heat exchangers for hypersonic precooled airbreathing propulsion: A review.
11) Inderjot Kaur, Prashant Singh- State-of-the-art in heat exchanger additive manufacturing.
12) Ali Najah Al-Shamani,Azher M. Abed,K. Sopian,M.A. Alghoul,Mohammad H. Yazdi-The role of enhancement techniques on heat and mass transfer characteristics of shell and tube spray evaporator: a detailed review
13) J.S. Saini, Sunil Chamoli, N.S. Thakur-A review of turbulence promoters used in solar thermal systems.
14) J.S. Saini, R.P. Saini, Tabish Alam- Heat and flow characteristics of air heater ducts provided with turbulators—A review.
15) Bon Nguyen, Graeme Lane ,Greg Short, Jie Wua, Jörg Rüster, Lachlan Graham, Steven Wang- Improved viscous slurry agitation for minerals processing.
16) Guangqiu Zhang, Jianjun Hu-Performance improvement of solar air collector based on airflow reorganization: A review.
17) Yanbin Liu, Xuesheng Wang, Xiangyu Meng, Dawei Wang-A review on tube external heat transfer for passive residual heat removal heat exchanger in nuclear power plant.

18) Ali Sadeghianjahromi, Chi-Chuan Wang- Heat transfer enhancement in fin-and-tube heat exchangers – A review on different mechanisms.
19) Bipin Kumar, Gaurav Prakash Srivastava, Manoj Kumar, Anil Kumar Patil-Review of heat transfer and fluid flow mechanism in heat exchanger tube with inserts.
20) Arafat A. Bhuiyan ⇑ , A.K.M. Sadrul Islam- Thermal and hydraulic performance of finned-tube heat exchangers under different flow ranges: A review on modeling and experiment.
21) Rachida Ayane, Abdellah Hamdaoui, Bouazza Braikat ∗, Noureddine Tounsi, Noureddine Damil- An improved Padé approximant in the ANM algorithm: Application to the post-buckling of shells.
22) Satpal Singh Sekhon a,b,* , Prabhsharan Kaur c , Jin-Soo Park-From coconut shell biomass to oxygen reduction reaction catalyst: Tuning porosity and nitrogen doping.
23) Haiyang Sua, Qiang Tianb, Cameron-Alexander Hurd Price b,c, Lin Xua, Kun Qiana,∗∗, Jian Liub-Nanoporous core@shell particles: Design, preparation, applications in bioadsorption and biocatalysis.
24) Meijie Liu a , Zipeng Xing a,⇑ , Zhenzi Li b,⇑ , Wei Zhou a,b,⇑- Recent advances in core–shell metal organic frame-based photocatalysts for solar energy conversion
25) R.Manikandan, Mohd F.Shabir, P. MunirajaChandra, T.Raja, Syed Salman, I.Vasim Akrama- Effect of various phase change materials (paraffin wax/hydrogenated vegetable oil) packed in a fabricated shell and tube type heat exchanger.
26) M.Avey, N.Fantuzzi, N.Kuruoglu, A.H.Sofiyev- Nonlinear vibration of multilayer shell-type structural elements with double curvature consisting of CNT patterned layers within different theories.
27) Huiying Wu, Yuanpeng Yao, Zhenyu Liu- Numerical modeling for solid–liquid phase change phenomena in porous media: Shell-and-tube type latent heat thermal energy storage.
28) Hwang, Jiaqi Li, Rang Tu, Yunho-Study of temperature uniformity and thermal storage performances of a shell-and-tube type phase change plate.
29) Ali Moradi, Majid Pakizeh, Toktam Ghassemi-Chemical extraction and modification of chitin and chitosan from shrimp shells.
30) Hanbo Yu, Jin Zhang, Longbo Jiang, Mengying Si, Xingzhong Yuan-Core-shell structured cadmium sulfide nanocomposites for solar energy utilization.
31) Bingpu Zhou ,Hao Hu, Jinchao Wei, Lele Yang, Peng Li, Shuangpeng Wang, Ting Wang, Yitao Wang, Zehua Cheng, Zhangfeng Zhong-Emerging core–shell nanostructures for surface-enhanced Raman scattering (SERS) detection of pesticide residues.
32) Meng Tang, Zhihui Wang-The cytotoxicity of core-shell or non-shell structure quantum dots and reflection on environmental friendly: A review.