EFFICIENCY IMPROVEMENT OF A SHELL AND TUBE HEAT EXCHANGER

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Abstract : A modification is made in the existing concentric heat exchanger design to enhance its heat duty. A standard concentric tube heat exchanger is modified by considering inner tube with a sinusoidal coil. Numerical studies are performed in this fluid heat exchanger to assess its thermal performance by taking into account mass flow rate, fluid temperatures, heat transfer, which are governed by fundamental heat transfer equations.

Thermal analysis methodology Hot water are used as working fluids in sinusoidal coil, respectively. Cooling water is used as shell side fluid. The attainment of high heat-load-per-unit-area and high surface-area-to-volume ratio is used as optimizing parameter in the simulations. The sinusoidal coil provides an increase in heat transfer rate and overall heat transfer coefficient increases by a percentage 13% for varying hot fluid flow rates. The pressure drop for the sinusoidal coil increases .

I. INTRODUCTION

Enhancement of heat for a heat exchanger is one of the most common tasks confronted by industries employed to the thermal systems. Enhancement techniques include increasing the surface area or increasing heat transfer coefficient by introducing turbulence promoters, inserts, roughness, and other parameters.

The helical and sinusoidal coils are known to improve heat transfer without the requirement of additional turbulence or surface area. Many researchers have studied the functioning of tubular heat exchanger with three concentric tubes. conducted theoretical studies on triple concentric tube heat exchangers and developed effectiveness-NTU relations for both parallel and counter flow configurations. calculated overall heat transfer coefficients for triple tube heat exchangers and determined temperature profiles for all three streams in the axial direction.]

reported the numerical results for heat transfer characteristics of a helical coil heat exchanger using CFD simulation software and validated with experimental results after testing the heat duty of a fabricated helical coiled heat exchanger. In addition, correlations were developed in terms of Nusselt number to estimate heat transfer coefficient for helical coil. applied transient onedimensional analysis of fluid flow in the numerical simulation for the analysis of heat transfer performance of triple concentric tube heat exchangers. Optimum values of heat exchanger efficiency shall be obtained by using this model.

Also various metal oxide-water nano fluids were used to evaluate heat exchanger performance. It was concluded that maximum efficiency was realized when the heat exchanger used rib type insert and Tungsten metal oxide nano fluid. Both computational fluid dynamics (CFD) and experimental analyses validated the results.

Performed theoretical studies on a threeconcentric tube heat exchanger with ribs, to evaluate its performance, by employing crimped spiral rib and alumina-water nano fluid. It was observed that this particular type of rib-nano fluid combination enhanced the heat exchanger effectiveness due to the generation of strong swirl flows and vortices. Compared the performance of triple tube heat exchanger with and without ribs by performing numerical analyses by using CFD.

Different shapes of rib geometries and different types of nano fluids were used in the numerical model. It was found that ribbed heat exchanger performed better than heat exchanger without ribs. Also, staggered arrangement of ribs enhanced the heat transfer when compared with inline rib arrangement. Similarly, when a hybrid nano fluid consisting of aluminum, magnesium and silicon oxides was used, heat transfer was improved by percentage 25% compared to other nano fluids. In a recent paper, have carried out an exhaustive exploration on pressure drops and temperature variation in parabolic trough solar collector absorber tubes using RNG k-epsilon model in a CFD analysis.

In their analysis, the superheated steam has been considered as working fluid. Numerical results are in good agreement with the experimental data received from solar test facility in Spain. Studied heat transfer and friction characteristics of concentric tube heat exchangers with coiled wire turbulator, experimentally and numerically and it was concluded that heat transfer Journal of Energy Systems 48 enhancement was obtained using turbulator, though at the expense of pressure and pumping power.

Also conducted similar explorations by using helical tabulators and obtained better heat transfer enhancement when compared with coiled wire turbulator. Savitribai Phule Pune University JSPM's JSCOE BE Mechanical Engineering (2019 course) 3 analyzed the performance of similar heat exchangers with spring type turbulator using RNG kepsilon turbulence model with different wall functions and found that standard wall function yielded better results when compared with non-equilibrium wall and enhanced wall functions.

In spite of enormous literature on triple concentric tube heat exchangers, there exist renewed research interests on triple fluid, one shell two tube heat exchangers with various tube configurations and investigations. In the present work, performance of a concentric tube heat exchanger with two inner tubes of helical and sinusoidal configurations is explored numerically by employing both CFD simulations and element-by-element effectiveness-NTU method

I.   RESEARCH METHODOLOGY

We began our project's work by conducting a market and literature survey. We gatheredseveral research papers that were relevant to our issue and reviewed them in order to better understand the heat exchanger. Collected the raw data on previous heat exchangers. We have chosen our standard and necessary pieces for this heat exchangerafter comprehending the results of the market study, Analyze the problem statement that needs to solve, which ended up with enhancement of efficiency. Designed the geometrical changes required.

Theoretical framework

Cutting is the separation or opening of a physical object, into two or more portions, through the application of an acutely directed force. Implements commonly used for cutting are the knife and saw, or in medicine and science the scalpel and microtome. However, any sufficiently sharp object is capable of cutting if it has a hardness sufficiently larger than the object being cut, and if it is applied with sufficient force.

Even liquids can be used to cut things when applied with sufficient force (see water jet cutter). The material as our required size. The machine used for this operation is power chop saw. A power chop saw, also known as a drop saw, is a power tool used to make a quick, accurate crosscut in a work piece at a selected angle. Common uses include framing operations and the cutting of moldings. Most chop saws are relatively small and portable, with common blade sizes ranging from eight to twelve inches.

Welding is a fabrication or sculptural process that joins materials, usually metals or thermoplastics, by using high heat to melt the parts together and allowing them to cool causing fusion. Welding is distinct from lower temperature metal-joining techniques such as brazing and soldering, which do not melt the base metal. In addition to melting the base metal, a filler material is typically added to the joint to form a pool of molten material (the weld pool) that cools to form a joint that, based on weld configuration (butt, full penetration, fillet, etc.), can be stronger than the base material (parent metal). Pressure may also be used in conjunction with heat, or by itself, to produce a weld. Welding also requires a form of shield to protect the filler metals or melted metals from being contaminated or oxidized. Square pipes of different lengths to make frame. The machine used for this operation is electric arc welding. Electrical arc welding is the procedure used to join two metal parts, taking advantage of the heat developed by the electric arc that forms between an electrode (metal filler) and the material to be welded.

Drilling is a cutting process that uses a drill bit to cut a hole of circular cross-section in solid materials. The drill bit is usually a rotary cutting tool, often multi-point. The bit is pressed against the work-piece and rotated at rates from hundreds to thousands of revolutions per minute. This forces the cutting edge against the work-piece, cutting off from the hole as it is drilled. In rock drilling, the hole is usually not made through a circular cutting motion, though the bit is usually rotated. Instead, the hole is usually made by hammering a drill bit into the hole with quickly repeated short movements. The hammering action can be performed from outside the hole (top-hammer drill) or within the hole (down-the-hole drill, DTH). Drills used for horizontal drilling are called drifter drills. In rare cases, specially-shaped bits are used to cut holes of non-circular cross-section; a square cross-section is possible.

Finishing is a broad range of industrial processes that alter the surface of a manufactured item to achieve a certain property. Finishing processes may be employed to: improve appearance, adhesion or wettability, solder ability, corrosion resistance, tarnish resistance, chemical resistance, wear resistance, hardness, modify electrical conductivity, remove burrs and other surface flaws, and control the surface friction. In limited cases some of these techniques can be used to restore original dimensions to salvage or repair an item. Savitribai Phule Pune University JSPM's JSCOE BE Mechanical Engineering (2019 course) 37 An unfinished

surface is often called mill finish. The edges with grinder using grinding wheel. The machine used for this operation is hand grinder. An angle grinder, also known as a side grinder or disc grinder, is a handheld power tool used for cutting, grinding and polishing. Angle grinders can be powered by an electric motor, petrol engine or compressed air.

Polishing is the process of creating a smooth and shiny surface by rubbing it or using a chemical action, leaving a surface with a significant specular reflection (still limited by the index of refraction of the material according to the Fresnel equations.) In some materials (such as metals, glasses, black or transparent stones), polishing is also able to reduce diffuse reflection to minimal values. When an unpolished surface is magnified thousands of times, it usually looks like mountains and valleys. By repeated abrasion, those "mountains" are worn down until they are flat or just small "hills." The process of polishing with abrasives starts with coarse ones and graduates to fine ones. The welded joints with hand grinder using grinding wheel. The machine used for this operation is hand grinder. With refinement, grinding becomes polishing, either in preparing metal surfaces for subsequent buffing or in the actual preparation of a surface finish, such as a No. 4 polish in which the grit lines are clearly visible.
 Generally speaking, those operations which serve mainly to remove metal rapidly are considered as grinding, while those in which the emphasis is centered on attaining smoothness are classified as polishing. Grinding employs the coarser grits as a rule while most polishing operations are conducted with grits of 80 and finer. If polishing is required, start with as fine grit as possible to reduce finishing steps. There is a wide range of grinding and polishing tools on the market and advice is available from ASSDA members to assist in particular applications. Polishing operations are conducted with the abrasive mounted either on made-up shaped wheels or belts which provide a resilient backing.

LITERATURE REVIEW

1] Rajendra, Syed Sameer et.al "Design of Heat Exchanger with Effectiveness Improvement Techniques by using Fins and Inserts" Engineers are continually being asked to improve processes and increase efficiency. These requests may arise as a result of need to increase throughput, in[crease probability, or accommodate capital limitations. The processes which use heat transfer equipment must frequently be improved for these reasons. This paper provides method for increasing efficiency of shell and tube heat exchanger performance by using rough surfaces and grooved tubes to increase surface area for heat transfer. External grooved surface on outside of tube (fins) make heat transfer faster because of more surface area. This paper also provides methods to improve turbulence inside the tubes of heat exchangers by using inserts Main purpose of any heat exchanger is to exchange heat between hot fluid and cold fluid and reduce the temperature of hot water by giving its heat to the cold water. Due to this, heat exchanger finds its use in most of the devices working on thermal principles. Heat can be exchanged naturally between two substances at different temperatures but heat exchanger boosts the speed of heat transfer and is hence has a very important part in industries. The heat exchanger used for this project is of shell and tube type which is one of the most commonly used heat exchangers of today.

[2] Farel H. Napitupulu, Romulus Situmorang et.al "Analysis of effectiveness of heat exchanger shell and tube type one shell two tube pass as cooling oil" Heat exchanger is a device that produces heat transfer from a fluid to another fluid, which can be applied as a cooling oil to maintain the oil temperature at the operating standard. This study was conducted to determine whether the oil temperature exit the shell and tube heat exchanger one shell and two tube pass, by calculating the effectiveness of the cooling oil on the tube (tube) using water as cooling fluid flowing through the shell (shell) using NTU-ε and experimental studies. Shell and tube heat exchanger one shell and two tubes pass effective used to cooling oil, because it can reduce oil temperature up to 32 %.

[3] Élcio Nogueira "Efficiency and Effectiveness Concepts Applied in Shell and Tube Heat Exchanger Using Ethylene Glycol-Water Based Fluid in the Shell with Nanoparticles of Copper Oxide (cuo)" This article consists of an analytical solution for obtaining the outlet temperatures of the hot and cold fluids in a shell and tube heat exchanger. The system analyzed through the concepts of efficiency, effectiveness (ε-NTU), and irreversibility consisted of a shell and tube heat exchanger, with cold nanofluid flowing in the shell and hot water flowing in the tube. The nanofluid consists of 50% of ethylene glycol and water as the base fluid and copper oxide (cuo) nanoparticles in suspension. The volume fractions of the nanoparticles range from 0.1 to 0.5. The flow rate in the nanofluid ranges from 0.0331 to 0.0568 Kg/s, while two mass flow rates, from 0.0568 and 0.5 Kg/s, for the hot fluid, are used as parameters for analysis. Results for the efficiency, effectiveness, irreversibility, heat transfer rate, and outlet temperatures for cold and hot fluids were obtained graphically. The flow laminarization effect was observed through the results obtained and had significant relevance in the results.

[4] Amir Ebrahimi-Moghadam,Farhad Goharie et.al "A comprehensive thermo-hydraulic analysis and optimization of turbulent tio2/W-EG nano-fuid fow inside double-pipe heat exchangers with helical coil inserts" The main aim in current work is to optimize tio2/W-EG nano-fuid (with 60 vol% of water and 40 vol% of ethylene glycol) fow within the inner tube of the double-pipe heat exchangers with helical coil inserts. The entropy generation is selected as the target function and is to be minimized. To reach this goal, at the frst step, a comprehensive sensitivity analysis is carried out taking into account all of the nano-fuid fow conditions (including nanoparticle volume fraction 획, Reynolds number Re and Prandtl number Pr) and geometric parameters of the helical coil inserts (including thepitch-to-diameter ratio of coil Π). Afterward, the genetic algorithm (GA) is utilized in the optimization process. The results of sensitivity analysis reveal that and Π, respectively, have the highest and lowest impact on the thermodynamics characteristics. Also, the addition of up to 0.02 vol% nanoparticles leads to a maximum of 13.93% improvement in dimensionless entropy generation (DEG). The outputs of the GA are 획opt=0.0198%, Reopt=8421.173, Propt =32.833, Попt=2.437 and degopt=0.005086. Furthermore, based on the optimization results, a useful correlation is proposed to fnd the optimum geometry of the helical coil based on the nano-fuid fow conditions.

[5] Saad NAJIM, Adnan HUSSEIN et.al "Performance improvement of shell and tube heat exchanger by using Fe3 O4 /water nanofluid" The objective of this paper is to study the effect of nanofluid on the performance of the heat exchanger, as well as the heat transfer rate, coefficient of total heat transfer, friction influence and average Nusselt number, and thermal efficiency factor and has been investigated and discussed. In this work, the output heat transfer of Fe3O4/water nanofluid through shell and tube heat exchanger has been numerically investigated under laminar flow. CFD simulations with ANSYS FLUENT 2020R1 were used adopting finite volume approach to solve the governing equations. Numerical calculations were carried out for Reynolds numbers ranging from 200 to 1400, with nanoparticles as the volume fraction (0.2% and 0.35%). The results show that the augmentation in increase Nusselt number and amount of heat transfer rate and the efficiency of nanofluid at the concentration of 0.35% are approximately 19%, 25% and 12% respectively. It was observed through the results that the friction decreases as the Reynolds number increase.

[6] Sara SAHRANE, Slimane NIOU et.al "Numerical Study of a Shell and Tubes Heat Exchanger: Impact of the Geometrical Change of the Tube Section on the Overall Exchange Coefficient and the Pressure Drop" Shell and tube heat exchanger is the most widely used type in industry because of its advantages: solid design, excellent reliability, compact, resistant to fouling fluids, having a very high exchange coefficient...etc. Several studies have highlighted the importance of this configuration. This study consists in the design and the thermo-fluid simulation by COMSOL software of a shell and tube exchanger with two different tubular geometries: i) circular, ii) square, iii) elliptical 90° using segmental baffles at 25% and two working fluids: water-air. The mass flow rates of the two fluids are varied and their influence on the energy performance of the heat exchanger is also examined. The results show that changing the geometry of the tube bundles affects the pressure drop especially on the shell side, the square geometry created a higher pressure drop than the circular tube geometry. A considerable improvement in the overall exchange coefficient was recorded for the exchanger with the circular tube bundle by increasing the fluid velocity.

[7] Abdullah Khan , Imran Shah et.al "Numerical and Experimental Analysis of Shell and Tube Heat Exchanger with Round and Hexagonal Tubes" Shell and tube heat exchangers are used to transfer thermal energy from one medium to another for regulating fluid temperatures in the processing and pasteurizing industries. Enhancement of a heat transfer rate is desired to maximize the energy efficiency of the shell and tube heat exchangers. In this research work, we performed computational fluid dynamics (CFD) simulations and experimental analysis on the shell and tube heat exchangers using round and hexagonal tubes for a range of flow velocities using both parallel flow and counter flow arrangements.

In the present work, the rate of heat transfer, temperature drop, and heat transfer coefficient are computed using three turbulence models: the Spalart–Allmaras, the k-epsilon (RNG), and the k-omega shear stress transport (SST). We further utilized the logarithmic mean temperature difference (LMTD) method to compute the heat transfer and mass flow rates for both parallel and counter flow arrangements. Our results show that the rate of heat transfer is increased by introducing the hexagonal structure tubes, since it has better flow disruption as compared to the round tubes. We further validated our simulation results with experiments. For more accurate results, CFD is performed in counter and parallel flow and it is deduced that the rate of heat transfer directly depends upon the velocity of fluids and the number of turns of the tube.

[8] Mariappan Suresh "Numerical investigations on a triple fluid heat exchanger with helical and sinusoidal coils" A modification is made in the existing concentric heat exchanger design to enhance its heat duty. A standard concentric tube heat exchanger is modified by considering two inner tubes with a combination of helical and sinusoidal coils. Numerical studies are performed in this triple fluid heat exchanger to assess its thermal performance by taking into account mass flow rate, fluid temperatures, heat transfer, which are governed by fundamental heat transfer equations. Computational fluid dynamics simulation methodology together with local and element-byelement method is applied with a matlab computer code.

 Hot water and milk fluids are used as working fluids in helical and sinusoidal coils, respectively. Cooling water is used as shell side fluid. The attainment of high heat-load-per-unit-area and high surface-area-to-volume ratio is used as optimizing parameter in the simulations.

The helical coil provides an increase in heat transfer rate and overall heat transfer coefficient increases by a percentage 13% for varying hot fluid flow rates, when it is compared with the sinusoidal coil. The pressure drop for the helical coil increases, exponentially.

**Design and Development Method:**

Computer-aided design (CAD) is the use of computer systems (or workstations) to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations. The term CADD (for Computer Aided Design and Drafting) is also used.
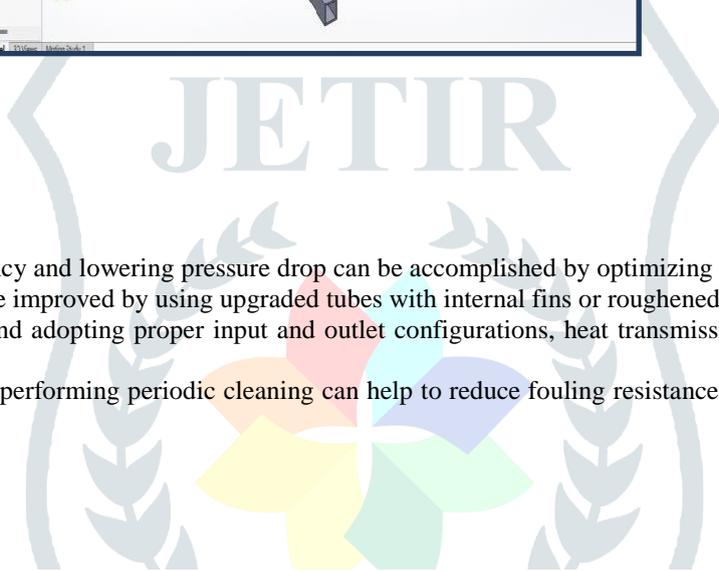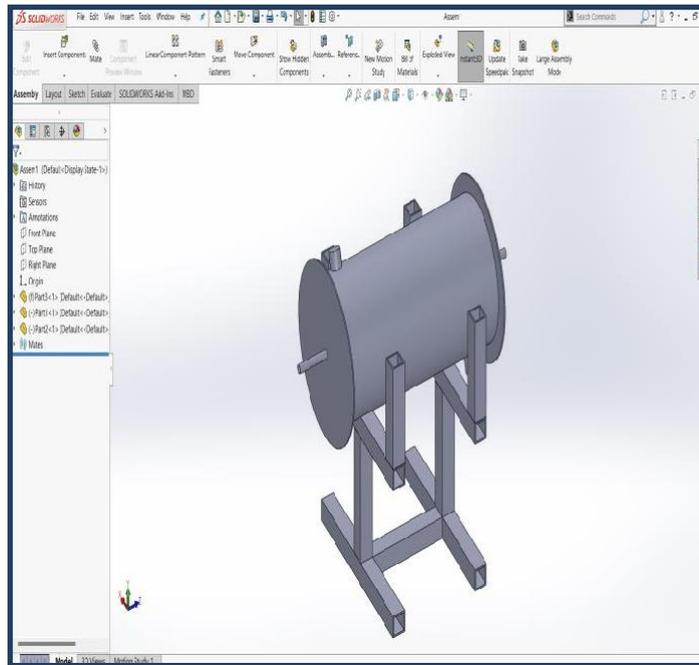
Results in Simulation:

Improving heat transfer efficiency and lowering pressure drop can be accomplished by optimizing baffle spacing and geometry. Heat transfer coefficients can be improved by using upgraded tubes with internal fins or roughened surfaces.

By adjusting fluid flow rates and adopting proper input and outlet configurations, heat transmission can be maximized while pressure loss is minimized.

Using anti-fouling coatings or performing periodic cleaning can help to reduce fouling resistance while maintaining high heat transfer rates.

Result Graph
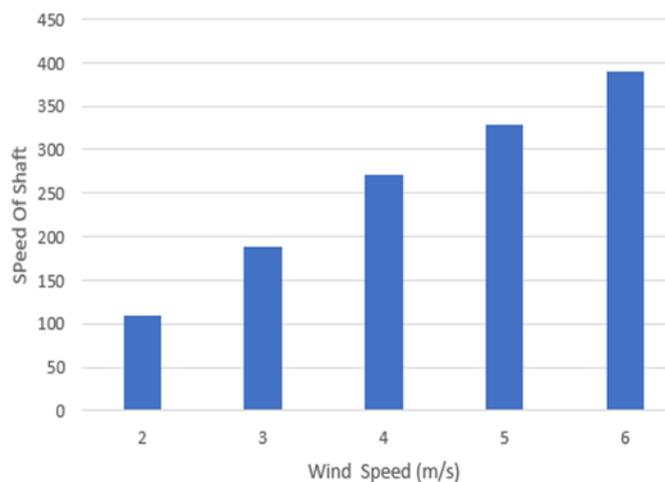
Referance

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