International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 06 | June 2021 www.irjet.net p-ISSN: 2395-0072

Study and Design of Shell and Tube Heat Exchanger

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Abstract- This paper is based on review of performance of heat exchanger. The main focus of this paper is on shell and tube heat exchanger. Since it is the most popular heat exchanger among others. This heat exchanger is most widely used in industries and power plants as it has more heat transfer area for transfer of heat from one fluid to another fluid. The main focus of this paper is to put light on different parameters, arrangements, and adjustments which can be applied on the shell and tube heat exchanger to increase the efficiency of this device. The paper contains information and conclusion on comparison between heat exchanger with and without baffles and comparison between segmental and helical baffles. And Modification in efficiency and coefficient of heat transfer in HX. The parameters which are been discussed are tube cross section such as circular and elliptical, and pitch layout, pitch ratio, length, baffle parameters. The paper also has information on hyperbolic and parabolic distribution. The paper also tell about the characteristics of some special parameters at a specific range of Reynolds number such as heat transfer coefficient, LMTD, Nusselt number, pressure drop. The impact of nano fluid in the transfer of the heat is also discussed. All this parameters are discussed in detailed in this paper.

Key Words: 1)**Shell and Tube Heat Exchanger**

2)Baffles

3)Pitch

4)Shell Side and Tube Side Fluid

5)Solidworks Software

6)Pressure Drop

1.INTRODUCTION

Heat Exchanger is one of the most Important Equipment in the industry .It is used to Transfer heat between two fluid Streams .One of the applications of Heat Exchanger is that they are used as a phase changing Medium in Condensation ,Evaporation, Cooling and Boiling. Fluids are heated or cooled before it undergoes a Phase Change. There are Different types of Heat Exchangers According to their Application .For eg-For condensing, there is Condenser and for Boiling Purpose there is Boiler .The Effectiveness of Heat Exchanger depends on the Inlet temprature Difference between hot and cold Fluid Streams. Effectiveness increases with Decrease in inlet Temprature Difference of Hot and Cold Fluid Streams .Performance And Efficiency of Heat Exchanger can be Calculated by determing Overall Heat Transfer Coefficient, pressure drop ,etc .Running Cost of Heat Exchanger Depends on the Application, Capacity Required etc.

1.1 Components of Shell and Tube Heat Exchanger

1)Tubes: In heat exchanger ,tubes are made up different materials. Both ferrous and non-ferrous materials used to made tubes such as carbon steel, stainless steel, brass, etc. Wall thickness defined by BWG for these materials. Proper tolerance on outside diameter is provided according to IS standards.

2)Tube Pitch:It is defined as the shortest distance between two adjacent tubes. Tube holes cannot be drilled close as it structurally weakens the tube sheet.

3)Tube Sheet::A tube sheet is a circular metal plate which is used to support the tubes in a shell-and-tube heat exchanger.

4) Baffles: Baffles perform the function of supporting the tubes, for desired velocity to be at the shell side fluid. For higher heat transfer coefficient turbulence state should be maintained. Hence, for turbulence state baffles are employed outside the tube.

5)Nozzles: A nozzle is a device perform the function to control the direction of a fluid flow as it exits an enclosed chamber . Nozzles distribute fluid uniformly on both side of shell and tube heat exchanger.

6)Tie Rods And Spacers: Tie rods perform the function of supporting the baffles. Tie rods made up of metal bar. Spacers perform the part of maintaining space between baffles.

7)Shell: Shell are the cylindrical in shape made up of carbon steel plates .Generally, the type of shell used are one or two shell passes per shell . Because of high cost of shell as compared to tubes. Mostly, three or four shell passes are observed in heat exchangers.

1.2 Classification of Review Papers

1) Research Based on Type of Baffle to be used.

2)Research Based on type of tubes

3)Research Based on type of Pitch to be Used

4)Research Based on Experimenting with Nusselt Number,Reynolds Number etc.

5)Research Based on Type of Fluid to be used.

2. Literature review

[1]:- In this paper we Compare Between the use of Segmental and Helical baffles and the Result Indicates that the higher heat transfer and lower Pressure drop is achieved in helical baffles as compared to segmental baffle. A model of helical and segmental baffle was Created in Solidworks and analyzed in a CFD Software i.e ANSYS. Based on the performance of parameters such as Pressure Drop, Heat Transfer Coefficient, Baffle spacing and pitch angle Baffle Spacing is the Deciding Parameter Between the two . After the Numerical Calculation Results it is confirmed that the Performance of a Heat Exchanger can be improved by Helical Baffles instead of Segmental Baffles. Use of Helical Baffles In Heat Exchanger Reduces Shell side Pressure drop, pumping cost, weight, fouling etc as compared to Segmental Baffle for a new installation.

[2]:- The shell and tube heat exchangers are one of the most important devices in Industries .In this Project the designing and Modelling of the Heat Exchanger on Catia and then Analysis on the CFD Software Ansys. The Main Objective Of this Project was to come up with such Modification so that the Efficiency and the coefficient of Heat Transfer of Heat Exchanger is Improved. In this Project Specifications are Shell Diameter-90mm, Length-600mm, Number of tubes-7, Baffle angle-40 Degree. The Result Derived from this Project is that Wave type flow Breakers are more Efficient than Step Strip flow Breaker. And the Efficiency also depends on Parameters like Pressure Drop, Inlet and outlet temperature, Surface Area and Efficiency changes according to change in these Parameters. These Parameters play very Important role in improvement of Efficiency as well as Effectiveness of Heat Exchanger.

[3]:- Heat Exchanger is an important device which is used to transfer heat between two different fluid streams and this process is widely used in many industries for Condensation, Evaporation, Cooling towers etc. Are the examples of Heat Exchanger devices. The thermal Efficiency Depends on Design and Modelling of Heat Exchanger as well as Property of Working Fluid. Some Important Design Parameters are Pitch of Tube, Length of tube, Baffle Spacing etc.In this Project we deal with Modification of two Parameters i.e Baffle Spacing and Travel tube Design. By modification of these two parameters heat transfer Efficiency is Improved. First we Modelled the Heat exchanger on Catia then did the Analysis on ANSYS Software, and then from these Simulation Results we found out the Optimum Baffle spacing and travel tube design. It also Deals with Suitable Fluid for Maximum Heat Transfer rate. From Simulation Results it was found that Heat Exchanger Straight gets Replaced by Angle and Step tube as it gives good Thermal heat Transfer Capacity and Higher Efficiency as Compared to Straight Tubes. The analysis was Carried out on angles step by step such as 5,10,15,20,25,30,35 Degree, and then we found out that at 35 Degree heat transfer Capacity is Maximum as compared to other angles. Copper oxide nano Particles was Selected as Coolant fluid which is added with water and used as coolant Medium.

[4]:- In this Paper we Designed the oil cooler for liquid to liquid Heat Exchanger having high heat transfer Coefficient. Modelling of Heat Exchanger is done on Solidworks and the analysis of Heat Exchanger is done on Catia. In this Paper there is Comparision between Heat Exchanger with Baffles and without Baffles. Thermal analysis Result which was observed shows that Heat Transfer rate is increased with use of Baffles and Brass material. The observation in Structural Analysis Results the displacement and Stresses are less in heat exchanger when the Baffles are used.

[5] :- In this Project the axial temperature profiles is calculated for a maldistributions on the tube side for a shell and tube heat exchanger. A comparison has been done for the same maldistributions with the help of hyperbolic and parabolic dispersion model for the axial dispersion coefficient with its value. The analysis results clearly indicates that for the steady state axial temperature profile the hyperbolic model is the best between the two models.

[6]:-In this paper it is cleared that there are different factors which affect the performance of shell and tube heat exchanger and the effectiveness of HEx obtained through the formulas tells about the effect of all the these factors on the performance of the heat exchanger. It is said that the insulation can provide increase in heat transfer rate if used under critical thickness. Effectiveness of heat exchanger also depends on the turbulence offered. In this experiment, among the material used cotton wool and tape have given best value of effectiveness. It is seen that there is no direct relation obtained between turbulence offered and effectiveness of heat exchanger.

[7] :-In this study, A shell and tube heat exchanger with a 25% baffle cut was used . Tubes having different cross-sections such as circular, elliptical with different attack angle(0°and 90°)were studied in detail. In this ,a combination of elliptical tubes with different attack angles and circular tubes was introduced. In this study, It was observed that heat exchanger with ellipsoidal tubes with attack angle of 90°and circular tubes in the centre of the shell shown the higher heat transfer compared to elliptical tubes with an attack angle of 90°and 0°.The pressure drop was also studied. It was observed that tubes that are located near the shell had a greater impact on heat transfer rate as

compared with the tubes that are located in the centre of the shell.

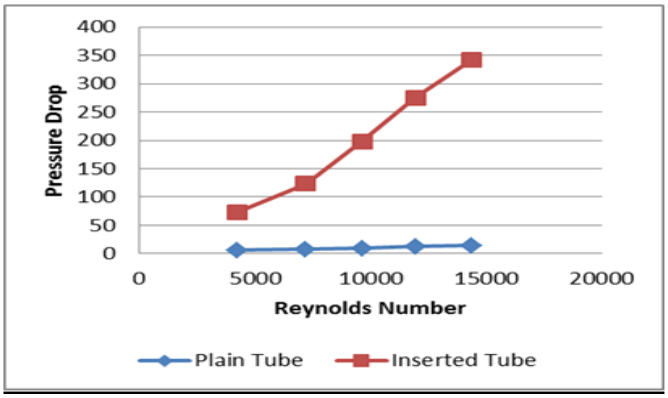

Chart -1: Re VS Pd

[8]:-As shell and tube heat exchanger are the most important device installed to assist power plants and several industries .(for eg. Harar Brewery share Company).In this paper, the shell and tube heat exchanger functioning is observed in which the cold fluid varies between 35°C-40°C. Here optimization and redesign part of the machine is done for mechanical and thermal terms and simulation of heat transfer between two fluids is analysed using CFD and fluent software. The final results shows that the redesign of shell and tube heat exchanger can achieve the required temp ,at which the beer is ready to use.

[9]:-In this paper, how the heat exchanger performance is affected by various parameters such as pitch layout, baffle spacing, etc.are discussed. Standard analytical calculation are used to study the same. In this paper, the simulation work carried out using 'Solidworks 2016' software . Further it can be concluded that the overall heat transfer coefficient gets affected by different parameters such as baffle spacing, tube pitch layout ,etc. It is also observed that square pitch decrease overall heat transfer coefficient ,while decrease in baffle spacing increase overall heat transfer coefficient.

[10]:- In this paper after going through the experimental work heat transfer coefficient ,LMTD ,Nusselt number, and pressure drop at Reynolds number (300-1500)are calculated.1)On the basis of this it has been concluded that when there is increase in Reynolds number increase in heat transfer coefficient is observed .2) Also Nusselt number increases with increment in Reynolds number. 3)Variation in pressure is also observed due to increase in Reynolds number.4) LMTD significantly increases with increase in Reynolds number.

[11] :- The main objective of this paper is the way to design the shell and tube device of fluid- to- fluid type which is majorly used. In this paper design procedure and considerations are also illustrated. In design manually calculated results are verified using HTRI software. In this pumping power is increase due to increase in pressure drop and in fluid flow rate. The important design parameters which features a direct effect on pressure drop and causes a major conflict between the efficiency and cost are tube parameters such as pitch ratio, length and layout and also the baffle parameters such as baffle spacing and spacing ratio.

[12]:- In this paper the heat transfer and the different distributions of fluid flow is discussed in detail and the data is compared with the increasing angles of baffle. The paper predicts the heat transfer and pressure drop with an error of 20%. In this paper the observations shows the causes of low rate of heat transfer was due to the fluid were passing over the helical baffles without any consistent contact and was passing through the space between the shell inner side and the baffles. This problem can be solved by either of the two ways first by reducing the shell diameter or second by increasing the size of baffles so that the shell and baffles should have a continuous contact. So that the fluid could not pass through the tube in parallel form. Due too continuous contact of shell and baffles it will create the tubulance in the fluid which will create high heat transfer rate. In this paper 2 theorys are used the Nusselt number and Reynolds stress model theory.

[13]:- This paper cares with the study of shell and tube heat exchanger and also the factors affecting the performance of heat exchanger device is studied. The design in the paper is mainly focused on a small and counter flow arrangement style of device. The calculation and analysis is administered by considering various parameters such as baffles spacing and inclination of baffles, flow rates of both sides fluids, tube diameter etc and analysis done by CFD software.

[14]:-In this paper results viewed and the discussion which had been done concerning the various factors that can improve the heat transfer rate. In this paper an improvement had been studied configuring the use of nano fluid particles as base fluid. Additionally an over view is done on small and compact heat exchangers had been done to find some helpful facts. The conclusions that are drawn from literature review of the paper are listed below: The accomplishment of the thermal conditions helps to optimize- the dimensions of the heat exchangers. With respect to stability CWHE may be more popular than STHE. A main cause of large amount of pressure drop is due to the presence of baffles in the heat exchanger . This limitations are typically overcome by using fins, full length twisted metal stripes and vortex generators. The rise in Nusselt number range will increase the heat transfer rate. The glycerine an nanofluid (SiO2-nanoparticle) showed the higher characteristics of heat transfer rate. The water an another nanofluid (H2O/ water) showed higher performance in heat transfer rate. The correct styles for the fluid flow in small and compact heat exchangers are essential. The axial heat conductivity affecting parameters are Sir Joshua Reynolds range (Re), thickness of shell side and tubes sides wall (ts) and heat conduction quantitative relation (Kr).

[15]:-The study in this paper presents a planned optimization of shell-and-tube type heat exchangers. The drawback consist of the reduction in the heat transfer area and involvement of variables. In this paper to achieve additional original answers some extra constraints are represented by compiling the geometrical options and speed conditions. The improvement in formula relies on research on tube count table wherever the constraint is established and therefore the candidates are utilized to finish non-optimum constraints, so decreasing the rating. The performance of the formula and every single element are searched through 2 types examples. The results finding tells the capability of the projected way to direct the improvement towards more practical styles, by keeping a note of necessary limitations sometimes unnoticed within the article. The conclusion of the study is the improvement of the design of shell-and-tube type heat exchangers. The accumulation of the matter seeks the decrease of the heat transfer rate of surface of the instrument, by making sure to minimize excess space and pressure drop, by considering separate variables. And necessary extra constraints, sometimes unnoticed in last optimization schemes, are enclosed to approximate the answers. The draw backs which were developed are optimized by applying formula that involves a search in tube count table, and supported by a controlled way on the choosing variable. The definition of bounded variables, practicability test and understanding procedures enable a wise decrease of process prices. The formula is associated to thermal evaluation and hydraulic evaluation.

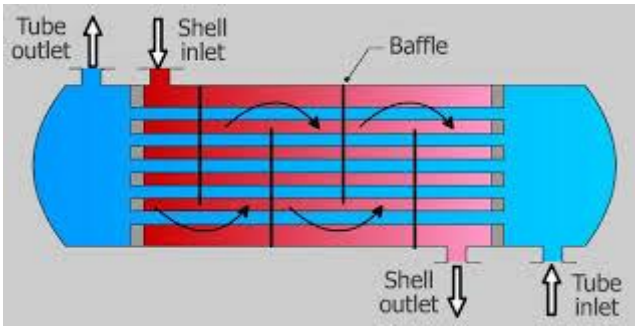

Fig -1: Shell and Tube Heat Exchanger

3. CONCLUSIONS

Heat Exchanger is one of the most versatile device to transfer heat from fluids to other fluids. In present day shell and tube heat exchanger is the most common type heat exchanger widely used in all refineries ,health services and other large chemical process, because it suits high pressure application. In this review paper design of shell and tube heat exchanger through software like CFD , Ansys are taken into consideration along with thermal design. After going through experimental part and analysis through different software, we came to know that efficiency of STHX depends on various factors which includes counter current flow, surface area, turbulence, Reynolds Number, pressure drop, baffle inclination, heat transfer coefficient, etc. So, by using helical baffles at 35o angle with wave type flow breakers increases heat transfer and reduces pressure drop. Also tube material, tube cross-section , tube pitch plays important role in order to increase heat transfer rate. With Increase in Reynolds number, tube side efficiency increases and shell side efficiency decreases. Hence, for designing an efficient shell and tube heat exchanger parameters like (tube pitch ratio , tubelength , tubelayout, baffle spacing ratio ,use of nanofluids ,etc)should be considered.

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