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"A REVIEW ON HEAT TRANSFER OF NON NEWTONIAN FLUIDS IN HEAT EXCHANGER"

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ABSTRACT

In this research, the flow and thermal characteristics of a non-Newtonian fluid flowing through a Shell and tube heat exchanger with helical fins around the inner tube have studied numerically. The non-Newtonian power law fluid is flowing in the laminar steady state through the annulus side. A 3D-CFD computational model has been conducted to determine the mean heat transfer coefficients and pressure lost in the annulus with constant temperature tube walls. Shell and tube heat exchanger is made of two concentric pipes which is often used in petrochemical, nutrition, oil industries and heat pumps . The advantage of Shell and tube heat exchanger is that it is used in high pressure situations and wide range of fluid temperature. Moreover, it can be used at harsh fouling states since it can easily be cleared and getting good parallel or counter flow sequences. Nowadays, engineers in HVAC industry consider the Shell and tube heat exchanger as an applicable device to save energy consumption. Shell and tube heat exchanger's are often used as condensers or evaporators in air conditioning systems. The low cost of design and maintenance also causes the small industries use this kind of heat exchanger. While most researchers are interested in studying to Newtonian fluids , recent investigations on non-Newtonian fluids have been more popular, due to the key role of these fluids in the chemical and food industries, the procedure of digging and accessing fossil fuels, transmission of factories wastages and heat exchangers. Non-Newtonian fluids generally have low heat transfer due to high apparent viscosity, so this infers the importance of studying the thermal behavior and flow dynamics of these fluids in industrial device designs to increase heat transfer.

Keyword: *Non-Newtonian , Shell and tube heat exchanger, baffle, segmental baffle, helical baffle.*

I. INTRODUCTION

A device whose primary purpose is the transfer of heat energy between two fluids at different temperature named as heat exchanger. A heat exchanger may be defined as equipment which transfers the energy from a hot fluid to a cold fluid, with maximum rate and minimum investment and running costs. There are various types of heat exchangers available in the industry, however the Shell and Tube Type heat exchanger is probably the most used and widespread type of the heat exchanger's classification. It is used most widely in various fields such as oil refineries, thermal power plants, chemical industries and many more. This high degree of acceptance is due to the comparatively large ratio of heat transfer area to volume and weight, easy cleaning methods, easily replaceable parts etc. Shell and tube type heat exchanger consists of a number of tubes through which one fluid flows. Another fluid flows through the shell which encloses the tubes and other supporting items like baffles, tube header sheets, gaskets etc. The heat exchange between the two fluids takes through the wall of the tubes.

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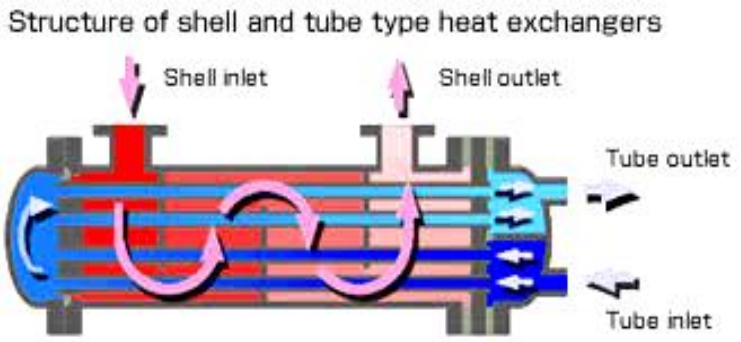

Fig.1 Heat exchanger

II. DESIGN METHOD

Shell and tube heat exchangers are designed normally by using either Kern's method or Bell-Delaware method. Kern's method is mostly used for the preliminary design and provides conservative results whereas; the Bell-Delaware method is more accurate method and can provide detailed results. It can predict and estimate pressure drop and heat transfer coefficient with better accuracy. In this paper we have described Kern's method of designing in detail. The steps of designing are described as follows:

1) To find out the values of some unknown temperature first we consider the energy balance. In this energy balance certain inputs like hot fluid inlet and outlet temperatures, cold fluid inlet temperature, mass flow rates of the two fluids are used to serve the purpose. The equation may be given as :

Some contents under this heading have been cited from Wolverine Tube Heat Transfer Data Book.

$$Q = m\ h\ C_{ph}\ (\ Th_1\text{-}Th_2\ ) = mc\ C_{pc}\ (\ Tc_2\text{-}Tc_1)$$

2) Then we consider the LMTD equation to find its value:

$$LMTD = \frac{(\Delta T1 - \Delta T2)}{\ln(\frac{\Delta T1}{\Delta T2})}$$

Where, $\Delta T1 = T_{h1}\text{-}T_{c2}$ and $\Delta T2 = T_{h2}\text{-}T_{c1}$

III. REVIEW WORKS

While reviewing the works of renowned scholars it has been seen that significant amount of works has been done in field of STHE. Some important works have been described in detail as under:

Hadidi et al [2013] considered cost minimization of shell-and-cylinder heat exchangers. They built up another shell and cylinder heat exchanger streamlining approach dependent on a radical serious calculation (ICA). ICA strategy was applied to limit the absolute expense of the hardware. In view of proposed strategy, a full PC code was produced for ideal plan of shell and cylinder heat exchangers and distinctive experiments were comprehended to show the adequacy and precision of the proposed calculation. The outcomes from the investigation showed that the ICA calculation can be effectively applied for ideal plan of shell and cylinder heat exchangers. [1]

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Arjun K.S et al [2014] At the point when the helix edge was shifted from 00 to 200 for the heat exchanger containing 7 tubes of external distance across 20 mm and a 600 mm long shell of internal breadth 90 mm, the recreation demonstrates how the weight change in shell because of various helix edge and stream rate. The heat transfer coefficient when recorded demonstrated a high esteem when the weight inside the heat exchanger enlisted a decay esteem and this incremental climb was observed to be profoundly huge in the present investigation. This may be expected to the rotational and helical nature of stream design following the geometry change by the presentation of nonstop helical perplexes in the shell side of the heat exchanger. The reproduction comes about acquired with Computational liquid elements instruments for the confound slice given to the altered heat exchanger are used for the count of different parameters like the weight decay, wanted perplex tendency edge and mass stream rate, outlet temperature at the shell side and distribution at confuse side for the specific geometry of the heat exchanger. Little corners at variable points of the fluid stream are the after effect of presentation of segmental confounds which enhances heat transfer and enormous decrease in weight in this way expanding the fouling obstruction. This recorded a successful heat transfer climb by the effect of helical astound. The most alluring heat transfer coefficient of the most astounding request and weight decrease of the least request are the outcome created in heat exchanger. Along these lines, the present investigation decisively enhanced the execution of the heat exchanger by the utilization of helical astound instead of segmental confound from the numerical experimentation comes about.[2]

Tabatabaeikia, et al [2014] investigated into the usage of levered tapes and changed twisted augmentations for heat move development during course through funnels. [3]

Ebenezar Paul, et al [2014] analyzed increment of warmth move in copper oxide by the usage of wound tape installs with trade rotate. [4]

T.Venkateshan et al [2015] The necessity of the momentum assembling and generation ventures directs the analysts in finding an elective framework which ought to be powerful in the most effective way. This empowers us to focus on the field of heat exchangers where the energy preparing occurs from the waste outlet. The investigation of heat exchangers is a pushed zone as it is an ecodesign display. The idea of heat exchangers assumes a noteworthy part in the refrigeration and cooling framework. An endeavor is made in this paper to survey the writing identified with the heat exchangers and changes made to enhance the efficiencies. Catchphrases: heat transfer upgrade, heat exchanger setups, minimal heat exchangers, nano-fluid. [5]

Subramaniyan et al [2015] investigated into warm conductivity of metallic and oxide nanofluids. Warm conductivity of Cu_2O-TiO_2nanocomposites with water as base liquid using Maxwell model for different volume parts of nanophae is investigated. Most raised warm conductivity was looked for Cu_2O-TiO_2 (1:9) with water as base liquid [6]

S. P. Kulakarni et al [2015] explored probably into heat move development of CuOnanofluid using helical curl wire implants. Careful relations that can be used were abbreviated at this moment. [7]

A.Hasanpour et.al [2015] inspected that The warmth move and contact factor are probably packed in twofold funnel HE which has internal layered chamber stacked up with V-cut ,U-cut, typical , and punctured injury tape insert. The distort extents are 3, 5 and 7, the initial broadness extent are 0.11 and 0.33, the width and significance extent of the cuts vary from 0.3 to 0.6 and the Reynolds number is changed from 1 5000 to 15,000 of furious regime.es appear differently in relation to plain chamber. the Nusselt number and contact factor for layered chamber equipped with adjusted bended tapes are higher than common tapes beside those of punctured sorts which lead to cut down Nusselt number and grinding variable Over the extent of Reynolds number considered, the estimations of Nusselt number for all TT furrowed chambers are perceptibly higher than that of plain wrinkle tub.[8]

Sawarkar et al [2015] tentatively investigated into the effect of semi-round cut twisted increments into devlopment of warmth move in level funnels. Speculative calculations that can be used for heat move coefficients are furthermore point by point in their work. [9]

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Prakash et al .[2015] using preliminary assessments demonstrated that using turned tapes with wires and rectangular cuts there is a 207% development in heat move coefficient. As communicated in Nusselt number and contact factor gained for louvered strip (with forward backward blueprint) >Nusselt number and grinding component for louvered strip (with semi-forward semi-in switch arrangement)>Nusselt number and disintegration factor for louvered strip (with forward strategy). A 3-D numerical model was made to examine the presentation of (I) uncovered chamber in-tube heat exchanger, (ii) tube in tube with bended tape expansion and (iii) helical enhancement at annulus and twisted tape implant inside the internal compartment of the warmth exchanger in . The use of vortex generator for heat move redesign was discussed in [10].

Avinash Savekar et.al [2015] Twisted tape is comprehensively used warmth move redesign strategy. Present paper battles the concealed physical wonder of warmth move and liquid course through a funnel with wound tape installs. Effect of twist extent for $2.0 \leq p/d \leq 5.0$ and Reynolds number for $800 \leq Re \leq 2000$ (where p/d is the pitch extent and Re is Reynolds number) on Nusselt number and grinding component have been numerically gotten. It is seen that decrease thusly extent propels extended convection while increase in Reynolds number advances vital convection. This is clear through understanding the assortment of paces and temperature over a particular territory; especially close the wall.[11]

Ranjith.et.al [2015] had considered the bended tape incited whirl stream on the different sides of twofold funnel heat exchanger. Bowed tape implants are commonly used for improving warmth move in heat exchangers. They improve heat move by actuating spin stream in the stream channel, thusly engaging extraordinary mixing inside the liquid and by extending the amazing stream length of the stream channel. It similarly increase pressure drop anyway their general execution has seen as important all around. At the present time, try has made to explore the introduction of a balanced twofold channel heat exchanger with distorted tape induced spin stream on the different sides. The numerical examination has done in vicious stream conditions with bended tape augmentations of turn extent 5 and 3. From The result the warmth move increase with decrease in bend extent of the twisted tape and the distort extent of turned tape 3 give better warmth move execution. With the additional preferred position of cutting edge effect of bended tape and extraordinary OER values, we can assume that the warmth move improvement over the weight drop discipline achieved. [12]

K shiv kumar et al. [2015] A test assessment was passed on for evaluating heat move, Reynolds number, and scouring factor fitted in concentric chamber with reshaped tape inserts. The unmistakable bend extent y=2.52, 3.00 and 3.20 were perused for the laminar stream using computational liquid components pack. An aluminum internal holder of 18 mm inside separation across and 20mm outer estimation and 220mm length was used for preliminary examination. The outer chamber material is delicate steel of 28mm inward separation across and 32mm outside expansiveness was used for the exploratory record. A copper twisted tape of different breeze extent of bend was implanted and the got plain chamber data were affirmed with turned tape installs and ensure the endorsement of reenactment results. The results are penniless down that the bowed tape accessible high warmth move with increases in crushing variable. In moreover the preliminary estimation of bended tape as differentiated and numerical proliferation. A CFD heap of business Ansys Fluent were utilized for repeat the bended tape.[13]

Ahmed A. et al [2016] General Heat move coefficients were surveyed for two-phase stream in shell and cylinders heat exchanger for different stream plans. A two-phase heat move exploratory arrangement was worked for this assessment and a total of 44 two-phase heat move data with different stream structures were obtained. For these data, the shallow Reynolds number went around between (650-4,000) and (27,000-170,000) for the liquid (ReSL) in first and second warmth exchangers independently and ran generally between (2,600-11,000) and (87,000-162,000) for the gas (ReSG) in the first and second warmth exchanger separately. Results show to the general warmth move coefficient (U) and weight drop) increases with ReSG increases for a settled ReSL. General warmth move coefficient (U) increase for low ReSL with increase ReSG in which stretched out between (2-8%) and (3-21%) for first and second warmth exchanger independently, yet for high ReSL the general warmth move coefficient is extended ceaselessly when increase ReSG for both warmth exchangers in the range between 0.5-1% and from 10 to 14% for first and second warmth exchangers

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independently. In like manner the execution of shell and cylinders heat exchanger is increasingly successful and improved for two-phase stream in tubes than one phase, that provoking progressively gainful current applications.[14]

Sisodiya&Geete et al [2016] investigated, using CFD frameworks, into the usage of Al_2O_3-Water nanofluid in helical loop heat exchangers. Diverse volume parts are considered during the assessment. [15]

Bianco, et al [2016] used two phase atom entertainment model to numerically imitate and choose the warm properties of nanofluid. These disclosures are affirmed using connections available.[16]

R. **Vishwakarma et al** [2016] investigated into overhaul of warmth move for CuOnanofluid using spin generator. Emprical relations identifying with this strategy are similarly analyzed. [17]

Mohan Kumar and Rajan et al [2016] put likely into the warmth move properties of CuOnanofluid with three unmistakable obsessions and differentiated the results and open correlations.[18]

Shrirao, et al [2016] performed exploratory assessment on the mean Nusselt number, scouring segment and warm redesign figure qualities an indirect plain chamber and inside hung chamber under uniform divider heat movement limit conditions for unadulterated water and Al2O3 nanofluid as working liquid. [19]

Mir Majid Etghani [2017] In this investigation paper, numerical model of shell and helical cylinder heat exchanger is explored to assess heat move coefficient and exergy mishap. Four structure boundaries including pitch circle, tube measurement, hot and cool stream rate, which are increasingly important for the warmth exchanger execution, were taken to thought.
By then, sixteen cases with grouped structure boundaries are shown and separated numerically. The results are exhibited that tube width and cold stream rate are the most enormous structure boundaries of warmth move and exergy hardship, independently. Moreover, the most raised Nusselt number are practiced by progressively both cool and hot stream rates and furthermore, heat move coefficient are diminished by growing of pitch twist and by extending of hot stream rate, the exergy setback increases. The perfect levels for heat move coefficient are: pitch 13 mm, tube width 12 mm, crisp and hot stream rate 4 LPM. Also, the perfect level for exergy hardship are: pitch 13 mm, tube distance across 12 mm, cool and hot stream rate 1 LPM.[20]

Tahery et al [2017] considered new structure methods dependent on the cylinder pack impact in the monetary advancement of shell-and-cylinder heat exchangers. They created cost estimation methods for shell-and-cylinder heat exchangers by presenting new target capacities. The joined decrease of yearly capital speculation and working cost prompted a decline in the general expenses of about 10% to 24%. [21]

Azar et al [2017] appropriately changed the current warmth move and weight drop adjustment elements of the altered Bell–Delaware technique and utilized for heat exchangers with segmental astounds, contemplating the helical confound geometry. These rectification factors were available in parametric recipes for divided perplexes. These recipes are elements of the geometrical and physical boundaries of irregular helical perplexes. The parametric equations were introduced graphically too. So as to figure the shell-side warmth move coefficient and weight drop utilizing the current strategy, a computational code was created. The outcomes from the examination indicated that the proposed technique was exact and can be utilized by architects unhesitatingly.[22]

Nilesh kumar kushwaha et al [2018] Shell and cylinder heat exchangers have assumed a crucial job in practically any application, be it oil and gas, process, refrigeration, cooling or pharmaceutical industry and that's only the tip of the iceberg. The three diverse cylinder design is embraced for the examination for example Square, Rotated Square and Triangular example tube course of action. A relative report has been done among all the three cylinder designs. Numerical reproductions are done to examine the correlation in the middle of three cylinder course of action based on thermo-water powered execution of shell-and cylinder heat exchangers The target of the investigation is to survey of

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the presentation examination of various plan (tube game plan) shell and cylinder heat exchanger premise on past exploration papers. [23]

Hardik V Solanki et al [2018] Heat exchanger Is gadget that utilization ceaselessly move the warmth starting with one medium then onto the next medium. This task for the most part manages utilization of twirl stream gadgets or bent tape turbulator in twofold funnel heat exchanger. This warmth exchanger broadly utilized in sanitization process, digester warming, heat recuperation, pre-warming. In present investigation the four kind of bent tape is utilized, average wound tape, punctured curved tape, V-cut turned tape, U-cut contorted tape in layered cylinder. The punctured contorted tape decline the weight drop however the warmth move same as the regular bent tape .and the U-cut wound tape make disturbance at the divider surface of internal funnel. In this undertaking the mix of two turned tape punctured wound tape and U-cut contorted tape alteration will be use and examination of warmth move and weight drop.[24]

R.Santhaseelan et al [2019] This paper reports numerical assessments of warmth move characteristics in twirling stream conditions using CFD reproduction. A business CFD bundle, STAR CCM+, was used in this assessment. 3D models for round cylinder fitted with curved tape embeds were made for the reenactment. The twirling stream was introduced by using wound tape set inside the round funnel. The results got from the curved tape embed are contrasted and those without turned tape. The data obtained from the CFD multiplication was affirmed with channel and outlet temperature differentiation and warmth trade properties. The results show that there was a noteworthy increment in heat move coefficient and Reynolds number in the channel fitted with turned tape.[25]

Seyed Shahab et. al [2019] In this research, the flow and thermal characteristics of a non-Newtonian fluid flowing through a double pipe heat exchanger with helical fins around the inner tube were studied numerically. The nonNewtonian power law fluid is flowing in the laminar steady state through the annulus side. A 3D-CFD computational model has been conducted to determine the mean heat transfer coefficients and pressure lost in the annulus with constant temperature tube walls. A numerical analysis is performed for different values of Graetz number of (Gz 55) and fin pitch (25 mm p 100 mm). The model was validated for a smooth double pipe heat exchanger, and it's found a good agreement with empirical correlations. The use of helical fin established rotationally flow with vortex core, which enhances the heat transfer and pressure drop simultaneously. In addition, thermal performance was enhanced by the increase of fin pitch. By data reduction, valuable and applicable correlations for Nu and f are presented, which can be used in industrial designs of double pipe heat exchangers.[26]

IV. CONCLUSION

After the study and above discussion it is to be said that the shell and tube heat exchanger has been given the great respect among all the classes of heat exchanger due to their virtues like comparatively large ratios of heat transfer area to volume and weight and many more. And in this work A model will be developed to evaluate analysis of a Helical and Segmental Baffle Heat Exchanger as well as the Comparative analysis between the thermal Parameters between the Segmental and helical angle has been showed.

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