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Performance Analysis of shell & tube heat exchanger at different baffle inclination by Experimental & CFD Analysis

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ABSTRACT

The shell & tube heat exchanger is the heat transfer equipment most widely used in the current industrial production. Compared with other types, its main advantages are the large heat transfer area in the unit volume & good heat transfer effect. In this present study, numerical simulation & experiment analysis carried out to study the impacts of baffle inclination angles on fluid flow and the heat transfer characteristic of shell & tube heat exchanger for different baffle inclination angles.

Keywords:**CFD analysis, shell & tube heat exchanger, baffle, heat transfer, pressure drop**

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I. INTRODUCTION

Shell and tube are the most common type of heat exchanger. They consist of a number of tubes in parallel enclosed in a cylindrical shell. Heat is transferred between one fluid flowing through the tubes and another fluid flowing through the cylindrical shell in the space around the tubes. To increase the speed of shell fluid and intensify the turbulent level to improve the shell film coefficient of heat transfer, the traverse baffle is usually installed in the shell and tube heat exchanger. The most common one is segmental baffle. Fluid winds in the shell outfit with segmental baffle at the continuously changing speed in different directions, and is easy to separation especially in the baffle edge. Due to the flow dead zone between segmental baffles and the shell, fluid undergoes repeated movement of cross streams in the baffles, resulting in the reduction of driving force of heat transfer. For obtaining higher heat transfer performance, only the plate spacing is reduced, which is inevitably accompanied by a higher flow resistance at the cost of higher energy consumption. Therefore, the traditional form change of baffle is badly needed. Compared to the segmental heat exchangers, the heat exchangers with continual inclined baffles have higher heat transfer coefficients to the same pressure drop.

II. LITERATURE REVIEW

Emerson [1], investigated the total pressure drops in between two adjacent baffles, as comprising pressure drops due to contractions on entry to the window and to the tube rows, expansion on leaving the window and tube rows, turning of the fluid in the window and around the tubes, and friction. Empirical correlations of shell-side data from baffled exchangers are discussed. Methods for estimating the magnitude of the non-effective fluid streams in the shell are considered so that the effective flow through the tube bundle may be determined. However contraction loss in tube bundle neglected, leakage losses and also loss due to friction are neglected.

Gay et al [2],had done research work in the pressure drop on shell side as a function of geometry and flow rate of shell fluid in STHXs is studied. The data was more concerned to small heat exchangers. Finally it was concluded that inspite of availability of large amount of experimental data, no good model could be developed out of it.

Sparrow et al [3], the experiments have been performed to determine the response of the heat (mass) transfer and pressure drop on the shell side of a shell-and-Tube heat exchanger to changes in the interbaffle spacing. Per-tube, per-row and per-compartment heat (mass) transfer coefficients were obtained by means of the naphthalene sublimation technique, all for the fully developed regime. Pressure distribution measurements were made throughout the heat exchanger, and the pattern of fluid flow was visualized with the aid of the oil-lampblack technique. The greatest sensitivity of the per-tube heat transfer coefficient to the interbaffle be spacing occurred at the tubes situated in the inflow window of a compartment, where higher coefficients (by about 15%) were encountered for larger interbaffle spacing's. In the cross flow zone, the per-tube transfer coefficients corresponding to the smaller interbaffle spacing exceeded those for the larger interbaffle spacing by about 5%, and similarly in the baffle-adjacent row in the outflow window of the compartment. The other rows in the outflow window were ambivalent about the effects of inter baffle spacing. Owing to cancellations among the aforementioned per-tube responses, the compartment-average transfer coefficients were virtually unaffected by the spacing. The per-compartment pressure drop decreased as the inter baffle spacing decreased, but for a fixed stream wise length, the pressure drop was slightly larger for smaller spacing. The experimental results were compared with the predictions of the Tinker and Delaware Project design methods.

Gnielinski et al [4], procedure is presented for evaluating the pressure drop on shell side for shell and tube heat exchanger with segmental baffles.

The procedure is based on correlation for calculating the pressure drop in an ideal tube bank coupled with correction factors. It uses Delaware method and the results have been compared with experimental investigations.

Volker et al [5] found local heat transfer and pressure drop on the shell side of shell-and-tube heat exchangers with segmental baffles for different baffle spacing's. The distribution of local heat transfer coefficients on each tube surface within a fully developed baffle compartment ware determined and visualized by means of, mass transfer measurements Per tube, per row and per compartment average heat transfer coefficients were drawn from the local values. The local pressure measurements allow the determination of the shell side flow distribution. Through this work it was concluded that for same Reynolds number, the pressure drop and average heat transfer increased by increased baffle spacing due to a reduced leakage through the baffle-shell clearance. The experimental results were compared with literature values.

Vukić et al [6],found an iterative procedure for thermo-hydraulic calculation of shell and tube heat exchangers according to prescribed pressure drop, has been presented. From this procedure it is possible to predict the heat exchanger geometries for which one can expect in advance to satisfy the thermo-hydraulic conditions of project. It remains to the designer to pay a full attention to the analysis of possible solutions and to the choice of optimal heat exchanger geometry.

Gulyani et al [7], the research concludes with new approach of estimating the no of shells in STHXs. It defines a better design approach based on maximum permissible temperature cross. There is temperature cross, approach temperature & meet temperature based on this he design approach based on maximum permissible cross temperature in shell and tube heat exchanger.

Clark et al [8], developed CFD model for STHX s using FLUENT, CFD software. The model was used to study the fouling phenomenon for certain velocity and shell side temperature inputs. It was concluded that CFD enables to potential to design the STHXs by simulating the settling of fouling particles which act as precursors in fouling process.

Stevanović1 et al [9], an iterative procedure for sizing shell-and-tube heat exchangers according to prescribed pressure drop is shown, then the thermo-hydraulic calculation and the geometric optimization for shell and tube heat exchangers on the basis of CFD technique have been carried out. Modeling of shell and tube heat exchangers for design and performance evaluation is now an established technique used in industry. In this paper, a numerical study of three-dimensional fluid flow and heat transfer in a shell and tube model heat exchanger is described. The baffle and tube bundle was modeled by the 'porous media' concept. Three turbulent models were used for the flow processes. The velocity and temperature distributions as well as the total heat transfer rate were calculated. The calculations were carried out using PHOENICS Version 3.3 code.

Fahkeri et al [10] presented a single closed form algebraic equation to find Log Mean Temperature Correction factor for STHXs. The procedure is helpful in design of multiple shell and tube heat exchangers to estimate no of shells.

Kapale and Chand et al [11], developed theoretical model for shell-side pressure drop. The model incorporates the effect of pressure drop in inlet and outlet nozzles along with the losses in the segments created by baffles. The results of the model match more closely with the experimental results available in the literature compared to analytical models developed by other researchers for different configurations of heat exchangers.

Saini et al [12] showed that it is possible to evaluate the pressure drop in tube in tube helical heat exchangers. FLUENT 6.0 software was used to model the entire heat exchanger model and solved. Over all heat transfer coefficient and heat transfer coefficient of inner tube and outer tube were calculated. The results were compared with experimental data available and found that the CFD results agreed to that of experimental one.

Sadik et al [13],have been developed shell-side pressure drop expression using Bell Delaware method by summing the pressure drops for the inlet, exit and the internal cross flow sections. This method is called an evolutionary method since it uses the friction factor plots for an ideal tube bank and corrects for the deviations by introducing bypass and leakage factors and effect of sealing devices. The fluid flow across the tube bundle in which the pressure drop across the bundle due to fluid friction and that will cause the pressure drop in the shell and tube heat exchanger. Pressure drop inside the heat exchanger is due to the different factors i.e. due to baffle spacing which restrict the flow, the baffle percentage cut which increases turbulence inside the heat exchanger.

III. CONCLUSION

As per above literature review several studies have been reported on fluid flow & heat transfer on segmental baffle of shell & Tube heat exchanger with baffle spacing & baffle percentage cut. To the author’s knowledge, no research has been found on the inclined baffle heat exchanger regarding fluid flow & heat transfer of inclined baffle heat exchanger by the CFD technique & Experimental work. The effect of baffle inclination on fluid phenomena of shell and tube heat exchanger is less investigated , so the present work is selected for analyzing, the performance of shell and tube heat exchanger by different baffle inclinations, by experimental study & CFD technique.

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