ISSN: 2321-1067 Volume 11, Issue 3(2023), PP 1-7 https://doi.org/10.58443/IJREX.11.3.2023.1-7

# A Review on "Design and Performance Evaluation of Heat Exchanger for Food Processing Using Simulation Tool"

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***Abstract:***

***A heat exchanger is a device for transferring heat between two or more liquids. In the food and beverage industry, heat exchangers are commonly used to reduce or eliminate microbes, making products safe to consume and extending shelf life. Mechanical devices are available for some exchangers such as facing exchangers, stirred kettles, and stirred tank reactors. Heat transfer within the recuperator partition is generally by conduction. However, in a heat pipe heat exchanger, the heat pipe not only acts as a partition, but also facilitates heat transfer through condensation, evaporation, and conduction of the working fluid within the heat pipe. In general, if the fluids are immiscible, the partition can be eliminated and the interface between the fluids replaced by a heat transfer surface, as in a direct contact heat exchanger.***

**Keywords**: Heat Exchanger, run time, thermal efficiency, heat transfer.

## Introduction

The basic principle of heat exchangers is heat transfer between two liquids. It brings two liquids together but prevents them from mixing with a physical barrier. The temperatures of the two liquids quickly reach equilibrium temperature. Energy in each fluid is exchanged and no additional heat is added or removed. Since the heat in the process is not constant and the amount of heat in the fluid is not constant, heat exchangers must be designed to suit all heat exchange cases and provide optimum performance in all conditions. . It should also be designed so that heat exchange occurs at the specific rate required for the process.

## Literature Review

**Kansal Santosh et al. (2014)**[27] investigated that the most commonly used type of heat exchanger is the tube bundle heat exchanger and its optimal design is the main goal of this study. This paper deals with the design of tube bundle heat exchangers. The main purpose of this paper is to validate a Kahn-designed heat exchanger using commercially available computational fluid dynamics (CFD) software. The current study uses CFD simulations to study the temperature and velocity profiles through the tube and shell. .

**Gadave Nikhil M and Kothmire Pramod P (2019)**[21]**,** in this document, an effort was made to design a shell-and-tube heat exchanger using the Kern method and with reference to the TEMA standard. Flow behavior and heat transfer mechanism in a shell-and-tube heat exchanger with four different tube cross-sections. H. Circles, rectangles, squares and triangles are numerically analyzed using ANSYS-fluent. Numerical simulations were performed for a tube bundle heat exchanger with tube passages and a 25x cut. Finally, the simulation results suggest the optimal geometry for best thermal-hydraulic performance.

**Prof. Nagre Gajanan P. et al. (2018)[25],** This numerical comparison models a heat exchanger consisting of shells, tubes, and baffles. The numerical model predicts thermal performance with considerable accuracy and compares flow simulation results with experimental data for individual segment vanes. We further extended our work by performing his CFD analysis of a shell-and-tube heat exchanger with fins on the tubes and comparing these results to his Ansys simulation results without fins.

**Mandal Dipankar et al. (2015)[7],** in this paper, we propose the computational algorithm and software development in Visual Basic (Visual Studio 2012 Express Desktop) to study the heat when various heat exchangers (spiral triple tube heat exchanger, plate heat exchanger, etc.) are involved. Used for transmission studies. By inputting commonly known heat exchanger parameters into the developed DAIRY HE software, it easily calculates the heat transfer coefficient and designs and simulates the design parameters of the heat exchanger. Run a parametric study using the software interface to determine tube lengths or heat exchanger dimensions. .

**Surender Kumar (2018)[31],** This paper presents a model of a counterflow shell-and-tube heat exchanger with water acting as the interacting fluid for heat transfer. To perform a thermal analysis on a shell-and-tube heat exchanger, we decided to design the heat exchanger first. It was also built on the basis of data obtained from mathematical models and tested under real load conditions. Thermal analysis used modified materials for the heat exchanger components. All these observations and their discussion are discussed in detail in the paper.

**Made Arsana et.al (2020)[15],** This work reports on the design optimization of a shell-and-tube heat exchanger that is widely used in a small Indonesian food processing industry and integrated into a stove system. Optimization parameters are pipe diameter and working fluid flow rate, which are later related to the effectiveness (ε) of the heat exchanger. Therefore, this study recommends that the current food processing industry redesign existing shell-and-tube heat exchangers to increase production efficiency.

**Kumbhare Manoj B. (2013)[16],** presented experimental data by performing experiments on a plate heat exchanger in a water/water system with different flow rates and different hot water inlet temperatures under steady state. To evaluate the performance of plate heat exchangers, the overall heat transfer coefficient (U) is determined. The graphs presented in this work were drawn using Polymath 5 computer software and Microsoft Excel. A correlation of the convective heat transfer coefficient as a function of the Reynolds number (Re) and the Prandtl number (Pr) is proposed.

**Singh Digvendra (2016)[6],** this work is based on the design and performance evaluation of a shell-and-tube heat exchanger using Ansys (Computational Fluid Dynamics). Current manufacturing processes in the steel industry use water on both the shell and tube sides of heat exchangers. The shell-side fluid is water that exits the heat exchanger and is sent to the cooling tower to cool the fluid, but the water is not sufficiently cooled in the cooling tower and is reused in the heat exchanger. The current study uses CFD simulations to study the temperature and velocity profiles through the tube and shell. It is known that heat transfer is not uniform over the length of the tube.

**Madoumier Martial (2017)[17],** this work represents preliminary work to develop a methodological framework for modeling and optimizing dairy processes. It is to combine an environmental model based on the LCA concept.The simulated process concerns the production of milk powder, specifically the concentration of milk before drying, including the steps of preheating, pasteurization and evaporation. The performance of the process model is evaluated through a sensitivity study on impact numbers within the evaporator, and the environmental impacts associated with the various steam requirements involved are quantified using multiple scenarios.

**Mr. Katarki Santosh K and Mr. Malipatil Anandkumar S (2017)[19]** investigated that heat exchangers are being used more frequently in the process industry. Almost every process industry uses heat exchangers for cooling, heating, condensing and cooking. The results can be used to modify the design to improve efficiency. A feasible k-ε (RKE) model gives the best results.

**Prof. Bendekar Abhay, Prof. Sawant V. B. (2016)[24],** In this research work, the design of an unbaffled shell-and-tube heat exchanger is investigated in terms of heat transfer coefficient and pressure drop by numerical modeling. The heat exchanger contained 19 tubes in a shell 5.85 m long and 108 mm in diameter. The flow and temperature fields in shells and tubes are solved using his CFD package, which is commercially available, taking into account planar symmetry. A series of his CFD simulations are performed on a single tube bundle and compared with experimental results. On the one hand, it is due to cross-flow, and on the other hand, it is due to the large temperature difference between the tubes on the shell side and the fluid. Based on these results, the current design requires modifications to improve heat transfer.

## Research Methodology

First, you should identify the problem as completely as possible. Flow rate and composition, temperature and pressure at the inlet and outlet of both streams should be discussed in detail, as well as the exact requirements of the food processing engineer and the additional information needed by the designer. The food processing engineer's main job is to provide all the information to the heat exchanger designer. At this point in the design process, a tentative selection of a base configuration for the heat exchanger should be made. It may be U-tube, baffled single-walled shell, straight-through tube, baffled single-ended with fixed tube, or shell-and-tube heat exchanger with floating head to accommodate differential thermal expansion between tubes. Also, use shell if this is not strictly desired. The next step is to select a preliminary set of heat exchanger design parameters. Select a preliminary estimate of heat exchanger size and then evaluate the initial design. That is, the design calculates thermal performance and pressure drop for both flows. Refer fiureno.1 below given

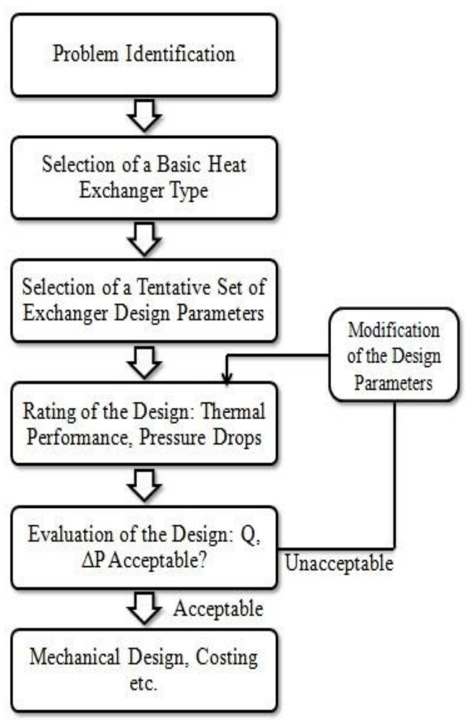


**Figure 1. Basic Logical Structure for food processing heat exchanger design**

There are two important issues in heat exchanger analysis.

(1) Evaluation of existing heat exchangers and

(2) Heat exchanger sizing for specific applications.

The evaluation includes determination of heat transfer coefficient, temperature change of the two fluids, and pressure drop across the heat exchanger. Sizing involves selecting a specific heat exchanger from those currently available or dimensioning a new heat exchanger design considering the required heat transfer coefficient and allowable pressure drop. The LMTD method can be easily used if the inlet and outlet temperatures of both the hot and cold fluids are known. LMTD can only be used in iterative schemes when the exit temperature is unknown. In this case, the -NTU method can be used to simplify the analysis.

## Conclusion:

- Hot-side and cold-side fluid flow velocities have the greatest impact on increasing the effectiveness of one-tube and two-tube pass type shell-and-tube heat exchangers with different thermodynamic property packages.
- Fouling coefficients are also calculated to improve heat exchanger temperature drop results.
- Protects against hazards due to temperature drop in heat exchangers.
- Nu is known to increase with increasing mass flow rate or Reynolds number.
- For turbulent flow in a pipe, the coefficient of friction decreases with increasing Reynolds number (Re) and the heat transfer coefficient increases with Re.
- The higher the thermal conductivity of the tube metallurgy, the higher the heat transfer coefficient.

## Gap Findings:

- Following gaps are supposed to be considered from the literature review:
- Application-based studies of different types of food processing heat exchangers used in different food industries.
- Suggest heat exchangers suitable for research studies commonly used in the industry on heat exchanger performance.
- Simulate a food heat exchanger using simulation tools.
- Evaluate outlet flow temperature, overall heat transfer coefficient, and heat exchanger area.

## Acknowldegements

I would like to acknowledge and give my warmest thanks to my supervisor Dr. Noopur Mahawar who made this work possible. Her guidance and advice carried me through all the stages of writing this paper. I would also like to thank my co-supervisor Dr. Nitin Gajanan Kanse for letting me write this paper and for your brilliant comments and suggestions, thanks to you.

I would also like to give special thanks to the research department family as a whole for their continuous support and understanding when undertaking my research and writing this project report.

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