DESIGN & CFD ANALYSIS OF HIGH VOLUME HEAT EXCHANGER FOR LIGHT WEIGHT VEHICALS

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ABSTRACT

The heat exchanger for 'Light weighted Vehicle' calls for an ingenious design for turning around the high volume of milk in short span of time.This work shall focus on determining the design alternatives for the heat exchanger. The current needs are met with a shell and tube type heat exchanger with support offered for volume of about five thousand liters of milk per day. Mathematical modeling coupled with computational methodology shall be explored for ramping up the volume in excess of twenty thousand liters. ANSYS Fluent shall be deployed for finding solution while mathematical model shall offer alternative methodology for validating the solution.

KEYWORDS – Heat Exchanger, Shell & Tube, and Light weighted Vehicle Application, Material change, CFD Analysis.

INTRODUCTION

Heat exchangers are basically used to transfer heat between two process streams. Heat exchanger can be used for cooling, heating, condensation, boiling or evaporation purpose. They are named according to their application e.g. heat exchanger being used for cooling are called as condensers and similarly heat exchangers used for boiling are known as boilers. The performance and efficiency can be measured through the amount of heat transfer using least area of heat transfer and pressure drop. The required amount of heat transfer provides an insight about the capital cost and power requirement of the heat exchanger.

Heat Exchanges are of Two types-

- Direct Contact Heat Exchanger- wherein both media between which heat is exchanged are in direct contact with each other.
- Indirect Contact Heat Exchanger- wherein both media between which heat is exchanged are separated by a wall so that they never mix.

Shell and tube type exchanger are indirect contact type exchanger. It consists of a series of tubes, through which one of fluid runs. The shell is container for shell fluid. Generally it is a cylindrical in shape with circular cross section, but shell with different shape can be also used. The tubes may have single or multiple passes, there is one pass on shell side, while the other fluid flows within shell over the tubes to be heated or cooled. Plate heat exchangers are used for achieving high heat efficiency. They are easy for maintenance and disassembly. Plate heat exchangers are used for HTST (High Temperature Short Time) pasteurization due to their excellent thermal characteristics.

Baffles are used to support the tubes for rigidity, to prevent vibration, sagging and to divert the flow across the bundle to obtain a higher heat transfer coefficient. Helical baffles give better performance than single segmental baffles but they involve high manufacturing, installation and maintenance cost. The effectiveness of heat transfer and cost are two important parameters in the design of heat exchanger. 'Computational Fluid Dynamics' is now an established industrial design tool offering many advantages. CFD model of shell and tube heat exchanger is being considered in this scope. The flow structure and heat distribution is obtained by modelling the geometry.

PROBLEM DEFINITION

The collection center at a typical Light weighted Vehicle processing unit records around twenty thousand liters of milk in a day. The same needs to be processed immediately upon receipt from the vendors since the perishable nature of milk makes it mandatory to pasteurize the same on priority. The volume dictates the nature of heat exchanger to be engaged for processing needs. Smaller volumes have been handled in the past using shell & tube heat exchanger with tubes made of steel.The existing heat exchangers pose limitations for handling the increased volume of the milk. Multiplying the units of the current design of heat exchanger does not seem to offer an efficient solutionto the problem.

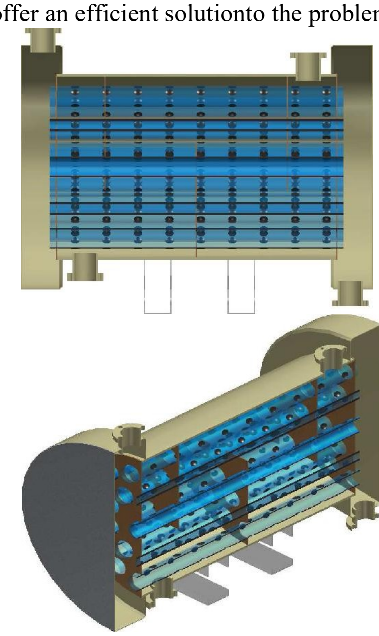


Fig.1-Shell and Tube Heat Exchanger for this work

LITERATURE REVIEW

After studying the Literature it can be concluded that a lot of work has been done in the field of Design & analysis of heat exchanger. Pramod S. Purandare et al. [2014] In this paper An experimental analysis is carried out to study the heat transfer phenomenon in conical coil heat exchanger with cone angle 90 degree. M. Ghazikhani et al. [2013] the experimental investigation of the effect of wedge-shaped tetrahedral VGs (vortex generator) on a gas liquid finned tube heat exchanger was studied using irreversibility analysis. Dillip Kumar Mohanty et al. [2012] In that paper the statistical analysis is used as an invaluable tool for investigation of performance of a shell and tube heat exchanger under fouling condition. A. I. Zinkevich et al. [2010]. In this paper shown that non uniform distribution of liquid flow among the tubes of a shell and tube apparatus has to be taken into account in determining the efficiency of heat transfer. The authors of this paper have proposed a method for taking this non uniformity into account and for analyzing its effect on the intensity of heat transfer. LIU Wei et al. [2009] in this paper heat transfer enhancement in the core flow, and with the analysis of the disturbance mechanism of longitudinal flow, a new type of high efficiency and low resistance heat exchanger with rod-vane compound baffler was designed and investigated numerically. Seong Yeon Yoo et al. [2009] The heat transfer rate of the external tube surface of the heat exchanger for a closed wet cooling tower can be divided into sensible and latent heat transfer rates. These in turn are expressed by heat and mass transfer coefficients.

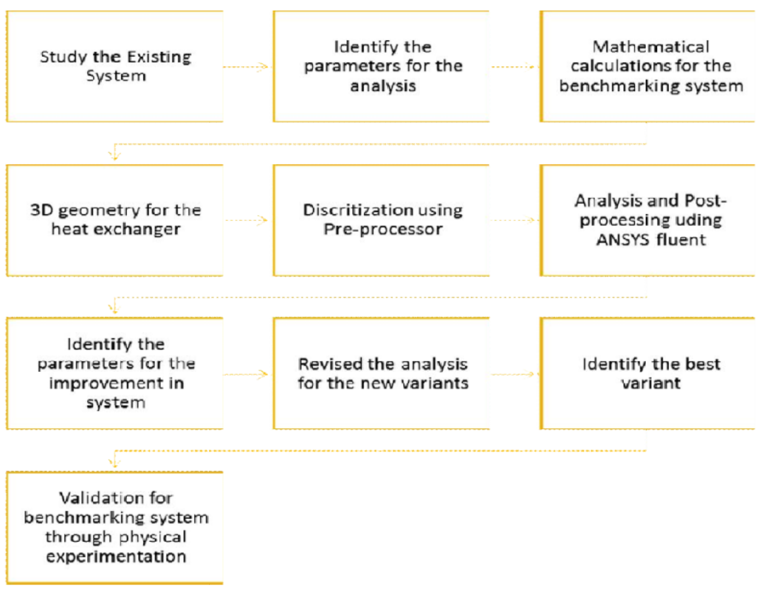
SCOPE

Input data in the form of CAD geometry for the current heat exchanger shall be secured from the Sponsoring Company. The scope outlined for this work shall encompass activities involving the pre-processor for 'Analytical' software followed for solving and post-processor. The material properties for the working fluid and the input conditions applicable for the problem case shall be administered while working on the CAD interface. Mathematical modelling is considered for alternative methodology to validate the results obtained by computational techniques.

OBJECTIVES

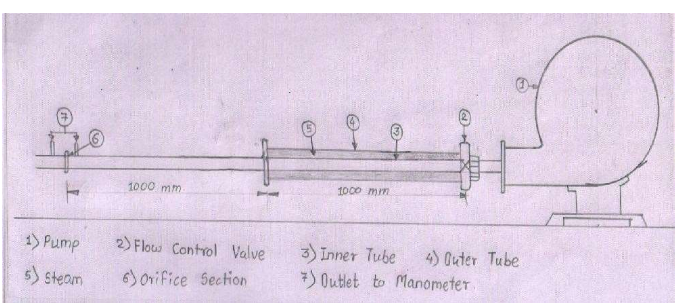
- Review current process and design aspects of the heat exchanger.
- Benchmark the performance for reference, the same shall be validated with mathematical modelling.
- Propose design alternative/s for the type or construction of heat exchanger.
- Analyse the proposed variant/s using CFD software.
- Recommend the solution.

METHODOLOGY



EXPERIMENTATION

Upon reviewing the 'Analytical results' for the benchmark (existing) facility of the shell and tube heat exchanger, an experiment is planned to validate these results. The analytical results for the existing setup shall be compared vis-à-vis the experimental results for the same benchmark (existing) setup. Thermocouples shall be deployed for measuring temperature, while suitable instruments like 'flow meter' shall be used for assigning the requisite mass flow rate of the working fluid and the milk. The temperature shall be recorded at a steady state expected in about an hour from the assignment of correct operating conditions as per the input data used for problem solving in the mathematical model and/or the analytical/computational solution.



EXPECTED OUTCOME / CONCLUSION

The study over the topic reveals that the rate of heat transfer can be enhanced using alternative material or incorporating a change in the geometry of the tube. The provision of fins or protrusions to increase the surface area of contact can result in enhanced performance. This work shall mainly focus on arrangement of tubes while varying with pitch and/or the diameter. The requisite mass flow rate shall be calculated to achieve the given temperature (72^0C) in the specified time. The actual variation to be done shall be discussed upon securing the existing configuration of the shell and tube heat exchanger.

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