Short Communication

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Study the Effect of Tube Designs on the Heat Transfer Performance of Condenser Chiller System Based on Industrial Standards

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Abstract

This study examines the tube design that wou affects the heat transfer performance of the condenser. The selected tube diameters are 15.88mm, 19.05mm, and 22.23mm. The boundary condition where the mass flow rate of the working fluid within the shell side (R134-a) is 1.0 kg/s at 98F inlet temperature, whereas the mass flow rate of the tube side fluid (liquid-water) is 2.1 kg/s at 85F inlet temperature. The result obtained was validated with analytical calculations. In conclusion, the condenser with the largest tube diameter (22.23mm) has the optimum performance of heat transfer. Tube design does affect the heat transfer performance of the condenser significantly.

Introduction

A condenser is a heat exchanger that converts vapours to a liquid state. There are two types of condensers, air-cooled and water-cooled condensers. This study focuses on water-cooled condensers, this type of condenser receives cold water as a processing fluid from the cooling tower and receives the vaporized refrigerant from the evaporator as a working fluid. The vaporized refrigerant and cold-water interchange inside the evaporator through the shell and tubes respectively. Therefore, the heat transfer between the two fluids occurs and the two liquids states will be changed (Park et al., 2008).

Chiller systems use tubular heat exchangers as a condenser and evaporators. In general, the shell and tube heat exchanger consists of a set of circular tubes placed in a cylindrical shell with a tube axis parallel to the wall. (Zohuri, 2016).

Heat transfer is the basic principle of heat exchange between tube and shell for the condenser. During the heat transfer process, fluid at a higher temperature transfers its energy to the other fluid at a lower temperature. These heat transfer mechanisms include conduction and convection (Shah et al., 2003).

There are different types of components and parts with different geometrical parameters that can be selected to construct the heat exchangers, as well as a wide variety of materials. Physical properties of the material such as thermal conductivity and geometrical parameters of the heat exchanger are the most important parameters to be considered for the tube design of the chiller condensers, the material selection is according to the heat transfer application and requirements.

Research Methods

In the initial study, the data for CAD design and CFD simulation were collected. The data collected for CAD design related to the specification of shell, tube sheet, and tubes used in chiller condenser. Then meshing and set up the boundary condition. The extraction of design data from industrial standards (Tube size Industrial catalogue, TEMA & ASME). Then, the mesh was created in the tetrahedral mesh boundaries, it was imported into the Fluent solver. The setup stages were divided into general conditions, models, materials, cell zone conditions, boundary conditions. The model option was on and the viscous was set as k-epsilon (2 equation), standard k-epsilon, and enhanced wall treatment. The numerical simulation with 40 iterations. CFD simulation conducted by the geometry the designed and created a 3D model in the pre-processing step using SOLIDWORKS Ver. 2021. The CAD model exported to ANSYS Workbench Ver. 2020R2. The workflow in the ANSYS software is completed within five main steps, which are: geometry, mesh, setup, solution, and result (post-processing) The post-processing shows the results of fluid velocity, temperature, heat flux, and many other parameters.

Results and Discussion

The outcome results obtained from CFD simulation were compared and evaluated to observe the influence of tube outer diameter on the different parameters that affect the overall heat transfer performance of the heat exchanger (condenser). The third design with the largest tube diameter (22.23mm) is the most efficient compared to the first and second design as its heat transfer rate is the highest, and its pressure drop is the lowest pressure drop in both tube side and shell side as shown in Table 1 and Figure 1. The result observed and analysed indicates that increasing tubes diameter for the tubular heat exchanger (condenser) results in a high rate of heat transfer within tubes. Therefore, the heat transfer increase as the theoretical relation between area and rate of heat transfer is proportional. High fluid velocity inside the tube causes high pressure to drop. Therefore, increasing tube diameters leads to decrease fluid velocity. Hence, reduce the pressure drop within tubes.

Table 1 Heat transfer rate for different tube diameter

Tube diameter (mm)	Heat transfer flow Q (W)
15.88	6322.556
19.05	8595.004
22.23	12113.359

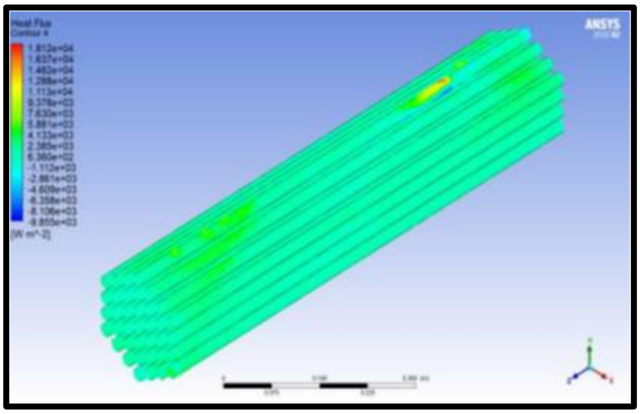

Figure 1 Heat transfer counter for tube diameter (22.23mm)

Conclusion

In conclusion, the result observed and analysed in this study indicates that tube design can affect the heat transfer performance of the heat exchanger (condenser) significantly. Therefore, influence the chiller system efficiency. The third design of the heat exchanger (condenser) with the largest tube diameter (22.23mm) shows the best heat transfer performance. It is observed that increasing the diameter of the tube for the tubular heat exchanger (condenser) results in a high rate of heat transfer and low-pressure drop within tubes. This improves the performance and efficiency of the heat exchanger.

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