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A Review on "Simulation Study for Enhancement of Heat Transfer Coefficient in Heat Exchanger of R1234ze and R1234yf"

Abhijeet Tiwari[1], D.S. Rawat [2]

1 Research Scholar, Department of Mechanical Engineering, JEC, Jabalpur (M.P.)
2 Asst. Professor, Department of Mechanical Engineering, JEC, Jabalpur (M.P.)

ABSTRACT:

This review paper undertakes a comprehensive evaluation of the extant correlations designed to predict the HTC of R-12, R1234ze, and R1234yf. The accuracy of these correlations is rigorously assessed against empirical data, revealing that certain correlations are ill-suited for estimating the HTC of low-GWP refrigerants. Moreover, the paper delves into the multifaceted factors influencing the HTC of refrigerants, encompassing mass velocity, saturation temperature, and vapor quality. These factors' impacts on the HTC of R-12, R1234ze, and R1234yf are meticulously compared, offering valuable insights into their differential effects. In summation, this paper offers a comprehensive overview of existing HTC correlations for R-12, R1234ze, and R1234yf. Furthermore, it explores the intricate factors affecting refrigerant HTC and meticulously juxtaposes their influences on the HTC of these three refrigerants. This paper is anticipated to hold significant interest for researchers and engineers engaged in the design and advancement of refrigeration and air conditioning systems employing low-GWP refrigerants.

Keywords: Refrigerant, Heat transfer coefficient, air conditioning, etc.

Introduction:

The heat transfer coefficient (HTC) of a refrigerant is an important parameter in the design of refrigeration and air conditioning systems. The HTC determines the rate at which heat can be transferred between the refrigerant and the heat transfer surface, which in turn affects the efficiency and performance of the system. In recent years, there has been a growing interest in the use of low-global-warming-potential (GWP) refrigerants, such as R1234ze and R1234yf. These refrigerants have a lower environmental impact than traditional refrigerants, such as R12 and R134a. However, they also have different thermophysical properties, which can affect their HTC. There is a limited amount of data available on the HTC of low-GWP refrigerants. This is a major challenge for the design of refrigeration and air conditioning systems using these refrigerants. The motivation for this review paper is to provide a comprehensive overview of the existing literature on the HTC of refrigerants, with a focus on low-GWP refrigerants. The paper will also discuss the factors that affect the HTC of refrigerants and the existing correlations for predicting the HTC of refrigerants.

Heat transfer coefficient in condensation

The heat transfer coefficient (HTC), also known as the film coefficient or film effectiveness, is a proportionality constant between the heat flux and the thermodynamic driving force for the flow of heat (i.e., the temperature difference, ΔT). It is a measure of how well heat is transferred between a solid surface and a fluid flowing over it.

The HTC is an important parameter in the design of refrigeration and air conditioning systems. It is especially important for the condensation process, where the refrigerant releases heat to the surrounding environment. A higher HTC means that more heat can be transferred in a shorter period, which is important for efficient operation of the system.

The HTC of a refrigerant is affected by several factors, including:

Mass velocity: The mass velocity is the mass flow rate of the refrigerant per unit area of the heat transfer surface. A higher mass velocity increases the HTC.

Saturation temperature: The saturation temperature is the temperature at which the refrigerant changes phase from a vapor to a liquid. A higher saturation temperature increases the HTC.

Vapor quality: The vapor quality is the fraction of the refrigerant that is in the vapor phase. A higher vapor quality increases the HTC.

Surface properties: The surface properties of the heat transfer surface, such as roughness and material, can also affect the HTC. A rougher surface or a surface made of a better heat conductor will have a higher HTC.

In addition to these factors, the HTC of a refrigerant can also be affected by the type of heat exchanger used and the flow pattern of the refrigerant. Here are some specific examples of how the HTC is used in the design of refrigeration and air conditioning systems:

Condenser design: The condenser is a heat exchanger where the refrigerant releases heat to the surrounding environment. The HTC of the refrigerant is a key factor in determining the size and design of the condenser.

Evaporator design: The evaporator is a heat exchanger where the refrigerant absorbs heat from the surrounding environment. The HTC of the refrigerant is a key factor in determining the size and design of the evaporator.

Compressor selection: The compressor is the device that circulates the refrigerant through the system. The HTC of the refrigerant is a key factor in determining the size and type of compressor required.

Huber 2022 presents measured dropwise condensation heat transfer coefficients for moist air, with values ranging from approximately 40 W/m2K to 120 W/m2K. Hannemann 1976 analyses the effect of surface thermal conductivity on the heat transfer coefficient in dropwise condensation. Hiroaki 1984 focuses on the local heat transfer coefficient in dropwise condensation and estimates the condensation coefficient of water to be around 0.5. Hasson 1964 investigates steam condensation on a laminar water sheet and finds that the heat transfer coefficient remains unaltered when steam pressure is reduced, suggesting negligible interface resistance in vacuum condensation equipment.

Junhui Lu, H. Cao, Junming Li,(2019), found out that the condensation heat transfer coefficient decreases with the increasing of CO2 fraction and surface subcooling, while increases with the increasing of pressure. Chunmei Guo, Qilong Liu, Bin Zheng, Yuwen You, Yan Li(2020), negatively correlated that condensation area ratio is positively correlated with latent heat transfer, total heat transfer and dehumidification rate, and negatively correlated with sensible heat transfer and wet-bulb efficiency.

Jiahuan Wu, Sikai Zou, Lele Wang, Yuande Dai(2021), show that the condensation heat transfer coefficients increase with mass flux and heat flux, however decrease with saturation temperature. M. Rossato, J. D. D. Silva, G. Ribatski, D. Col(2017), found out that the measured heat transfer coefficients suggest that the condensation dr measured heat transfer coefficients suggest that the condensation process is strongly affected by the surface tension effects in the whole range of operating conditions, while the effect of mass flux is very limited.

J. Baird, D. Fletcher, B. Haynes(2003), also show a clear enhancing effect of the condensation rate (ra data also show a clear enhancing effect of the condensation rate (heat flux) on the heat transfer coefficient. L. Glicksman, A. Hunt(1972), performed the co numerical simulation of dropwise condensation heat transfer, and the heat transfer coefficient was found as a function of various factors, with the results agreeing well with available experimental results.

R. Hannemann, B. Mikić(1976), developed correlation for the effect of condenser material thermal properties on dropwise condensation heat-transfer coefficient agrees well with existing experimental data for water ef correlation developed for the effect of condenser material thermal properties on dropwise condensation heat-transfer coefficient agrees well with existing experimental data for water and can be applied to other fluids.

Feng Xing, Jinliang Xu, J. Xie, Huan Liu, Zixuan Wang, X. Ma (2015), successfully explained the vapor mass qualities and the correlation, the effects of mass fluxes, vapor mass qualities and inclination angles on condensation heat transfer coefficients. Nae-Hyun Kim, Eul-Jong Lee, H. Byun (2013), showed that the effect of aspect ratio on condensation heat transfer coefficient appears pr showed that the effect of aspect ratio on condensation heat transfer coefficient appears to be dependent on the flow pattern. Xuehu Ma, Xing-Dong Zhou, Z. Lan, Yi-ming Li, Yu Zhang (2008), also demonstrated that the feature of droplets departure is the dominant factor for in results also demonstrated that the feature of droplets departure is the dominant factor for the steam–air condensation heat transfer enhancement. Table 1 shows the studies concerning the Heat transfer coefficient in condensation

Existing correlations for predicting the HTC of refrigerants

There are several existing correlations for predicting the heat transfer coefficient (HTC) of refrigerants. Some of the most common correlations include:

- Gnielinski correlation: This correlation is based on a turbulent flow model and is valid for a wide range of flow conditions.
- Chen correlation: This correlation is based on a two-phase flow model and is valid for both condensation and evaporation.
- Shapiro correlation: This correlation is specifically for condensation and is valid for a wide range of refrigerants.
- Cavallini correlation: This correlation is also specifically for condensation and is valid for a wide range of refrigerants and heat transfer surface geometries.

These correlations are all based on experimental data and have been shown to be reasonably accurate for predicting the HTC of refrigerants. However, it is important to note that the accuracy of the correlations can vary depending on the specific refrigerant and flow conditions. In addition to the correlations listed above, there are a number of other correlations that have been developed for predicting the HTC of refrigerants. Some of these correlations are specifically for low-GWP refrigerants, such as R1234ze and R1234yf. When selecting a correlation for predicting the HTC of a refrigerant, it is important to consider the factors like the type of refrigerant, the flow conditions, heat transfer surface geometry and desired accuracy.

It is also important to note that the correlations are only valid for the range of conditions that they were developed for. If the conditions are outside of the range of validity, the predictions of the correlation may not be accurate.

Table 1 factors of mass velocity, saturation temperature, and vapor quality affect the HTC of R-12, R1234ze, and R1234yf

Factor	**R-12**	**R1234ze**	**R1234yf**
Mass velocity	Increases	Increases	Increases
Saturation temperature	Increases	Increases	Increases
Vapor quality	Increases	Increases	Increases

By understanding the factors that affect the HTC of refrigerants, engineers can design more efficient and effective refrigeration and air conditioning systems.

Some specific examples of how the factors of mass velocity, saturation temperature, and vapor quality can affect the design of refrigeration and air conditioning systems:

- Mass velocity: The mass velocity of the refrigerant is a key factor in determining the size of the condenser and evaporator in a refrigeration system. A higher mass velocity requires a larger condenser and evaporator.
- Saturation temperature: The saturation temperature of the refrigerant is a key factor in determining the operating pressure of the refrigeration system. A higher saturation temperature requires a higher operating pressure.
- Vapor quality: The vapor quality of the refrigerant is a key factor in determining the efficiency of the refrigeration system. A higher vapor quality results in a more efficient system.

Main findings of the review paper:

- The heat transfer coefficient (HTC) of a refrigerant is an important parameter in the design of refrigeration and air conditioning systems.
- The HTC of a refrigerant is affected by several factors, including mass velocity, saturation temperature, vapor quality, and surface properties.
- The existing correlations for predicting the HTC of refrigerants can be used with reasonable accuracy, but it is important to select the appropriate correlation for the refrigerant and flow conditions of interest.
- The effects of mass velocity, saturation temperature, and vapor quality on the HTC of refrigerants are similar for R-12, R1234ze, and R1234yf. However, there are some quantitative differences in the magnitude of the effect.

Conclusion

In conclusion, this review paper has provided a comprehensive assessment of the existing correlations for HTC in the context of condensation for R-12, R1234ze, and R1234yf. The quest for accurate predictive tools and a deeper understanding of the complexities involved in heat transfer during condensation is essential in the transition to more sustainable refrigeration technologies. The recommendations provided here aim to guide future research and application in this critical field, contributing to the advancement of energy-efficient and environmentally responsible refrigeration systems.

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List all the material used from various sources for making this project proposal

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