Effect of Inlet Temperature on the Heat transfer in mixed refrigerants with variable composition

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Abstract

Refrigerants used for industrial cooling and domestic refrigeration occasionally results in decrease in Coefficient of Performance due to increase in cooling loads. As the mass of the refrigerant used, remains constant because of the fixed compressor capacity, therefore use of mixed refrigerants can prove to be a feasible solution to cater to the needs of cooling. Hence the present study aims at usage of mixed refrigerants R290 and R600a in industrial cooling systems. The objective of this project is to estimate heat transfer and temperature difference associated with the previously mentioned mixed refrigerants computationally. For this study, use of ANSYS FLUENT software is proposed. The operating pressure is set to be 3 MPa in a pipe of 0.064m diameter while simulation because higher pressures are maintained in the industrial cooling system. At fixed wall temperature of 350K, mixed refrigerants with varying composition is simulated in FLUENT. Initially, composition of 10% R290 and 90% R600a is selected and with varying Rate of flows i.e. from 0.05 kg/sec to 0.1 kg/sec, simulation is performed and heat transfer is estimated. After this step, simulations are performed for 20% R290 and R600a composition and composition is progressively increased to 90% R290 and 10% R600a. The analysis is then extended for corrugated pipes to obtain optimized results of heat transfer and temperature difference. Finally, Reynolds number and Nusselt number is calculated from Temperature difference and Heat transfer.

Keywords: Refrigeration, Computational fluid dynamics, hydraulic characteristics, industrial refrigeration, Inlet temperature, Rate of flow

1 Introduction

Refrigerators are the devices used for production of cooling effect in domestic appliances. This effect is carried by the flow of refrigerant through the refrigerator. The process in Refrigeration system are Isentropic Compression in Compressor, Isobaric Heat rejection in the Condenser, Isenthalpic expansion in Expansion valve and Isobaric Heat addition in Evaporator. Refrigeration capacity depends on refrigerant selection for enhancement of heat transfer rate. In the past, different refrigerants are used in refrigeration system such as R717, R290, R600a, R744, R11, R123, R134a etc., [1]–[3]. In the recent past, mixed refrigerants such as R152/R134a, R290/R134a etc., [4], [5] are used to enhance heat transfer rate and to increase COP of the system. Moreover, refrigerants are suspended with nano particles to form a colloidal solution of Nano refrigerant for improvement of cooling capacity. Different nano particles suspended in refrigerants are nano metal includes Al, Cu, Ti, Zn etc., and metal oxides includes Al_2O_3, CuO, TiO_2 etc., [6]–[10].

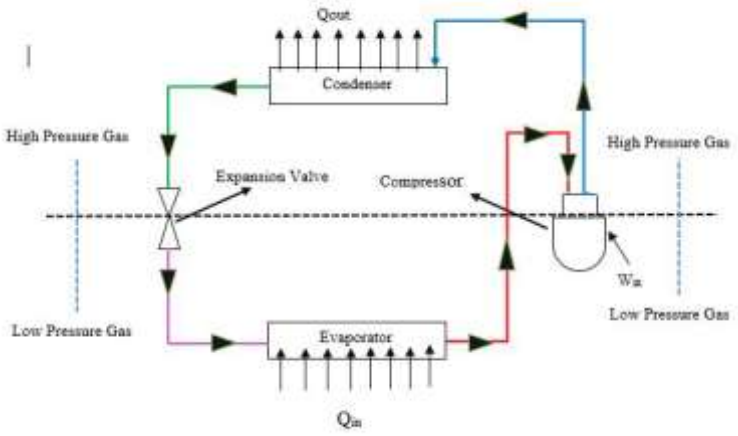

Figure 1 Components of refrigeration system

2 Problem description

In the present research heat transfer and Nusselt number are calculated for a mixed refrigerant. The analysis are done on mixed refrigerants, results are evaluated at pressure 3MPa, and different inlet temperatures such as 300 to 330K with the effect of different Rate of flows 0.05 to 0.1 kg /s at different compositions. Figure 2 represents mesh analysis of compressor pipe with dimension of length 1000m and diameter is 0.064m.

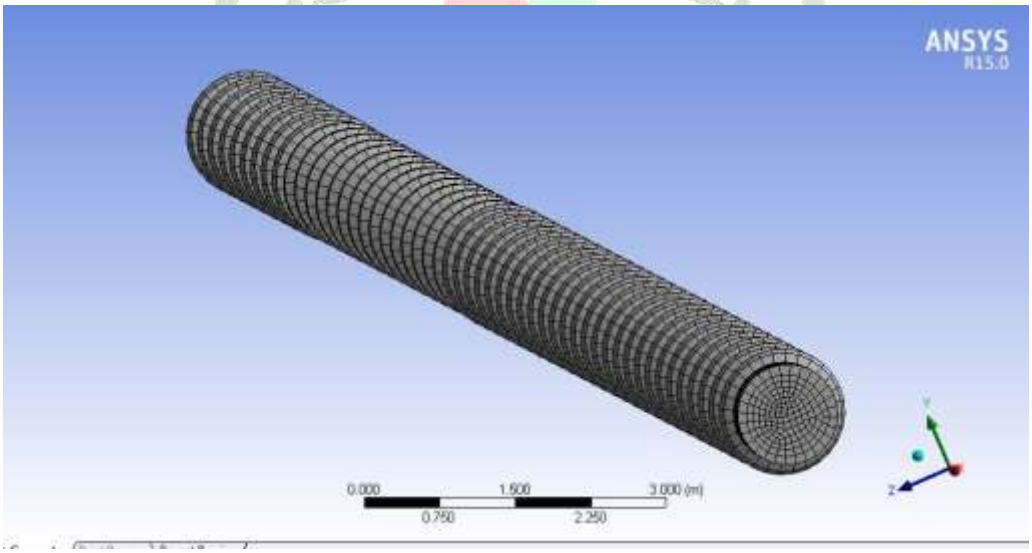

Figure 2 Computational geometry used for the analysis

3 Solution methodology

In the present research work, Reynolds number is evaluated for corrugated pipe in addition with respect to different Rate of flows at different temperatures varies from 300-330K for a mixed refrigerant at different compositions.

Nusselt number is calculated from the equation

$$Nu = h * L / k \quad (1)$$

The rate of heat transfer in the computational domain can be calculated using

$$Q = hA_s\left(T_w - T_f\right) \quad (2)$$

where, h is convective heat transfer rate, L is characteristic length, k is thermal conductivity, A_s is surface area of the computational domain, T_w is wall temperature, T_f is temperature of the fluid.

4 Results and discussion

The thermal analysis of mixed refrigerants in

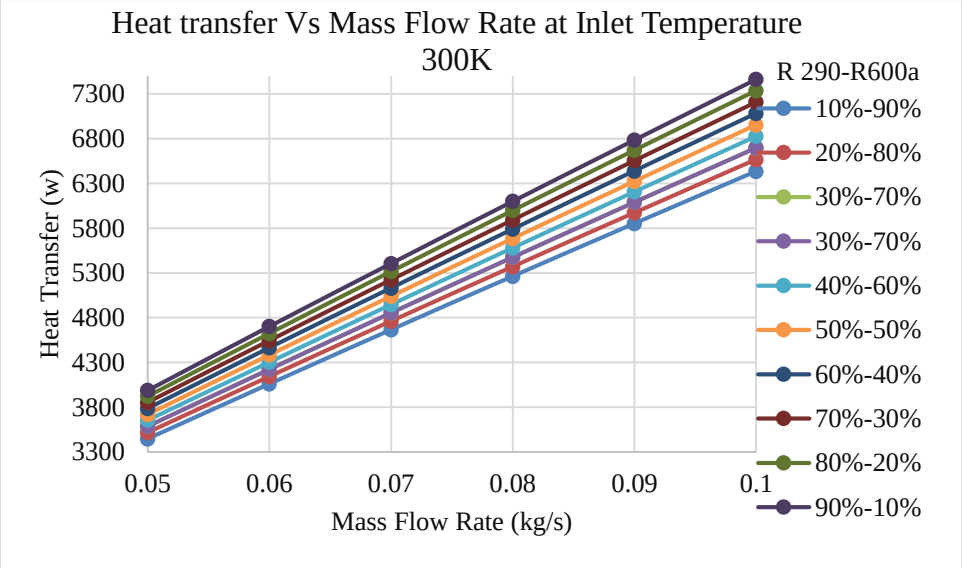

Figure 3 Heat transfer vs Rate of flow at 300K

Figure 3 shows that variation of heat transfer rate with respect to different Rate of flow at 300K inlet temperature and different compositions of a mixed refrigerant. Moreover, it was observed that as the Rate of flow increases and rate of heat transfer is increases linearly.

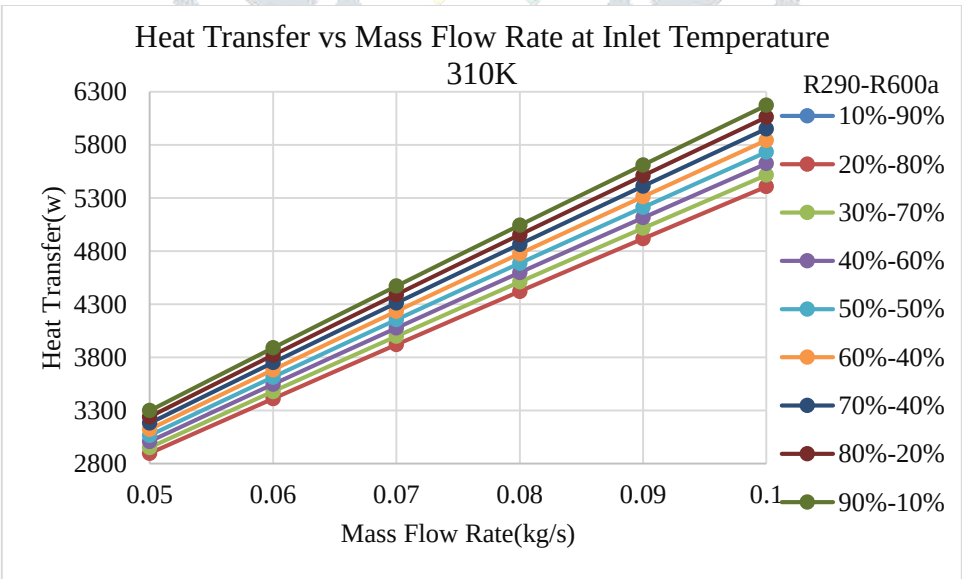

Figure 4 Heat transfer vs Rate of flow at 310K

Figure 4 shows that variation of heat transfer rate with respect to different Rate of flow at 310K inlet temperature and different compositions of a mixed refrigerant. Moreover, it was observed, that as the Rate of flow increases and rate of heat transfer is increases linearly

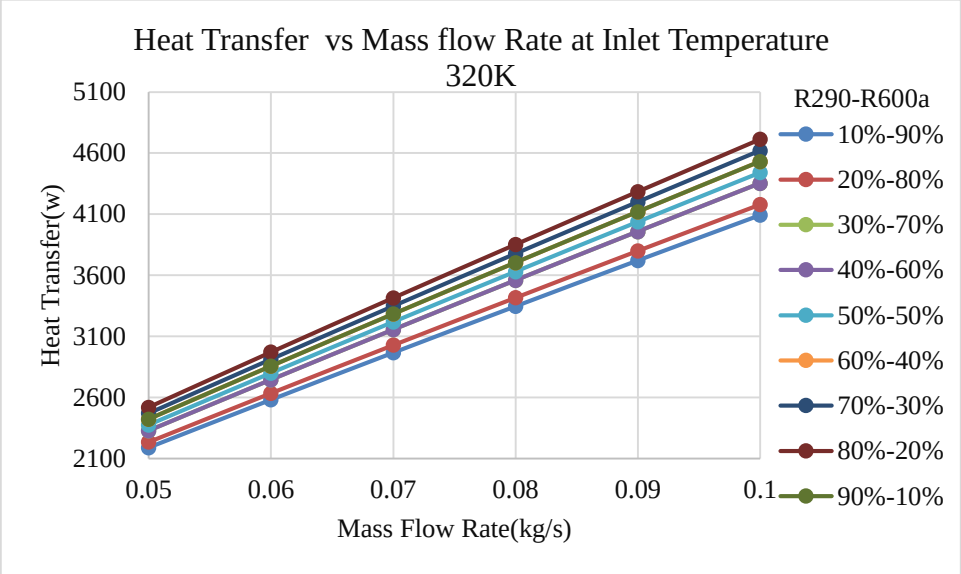

Figure 5 Heat transfer vs Rate of flow at 320K

Figure 5 shows that variation of heat transfer rate with respect to different Rate of flow at 320K inlet temperature and different compositions of a mixed refrigerant. Moreover, it was observed, that as the Rate of flow increases and rate of heat transfer is increases linearly

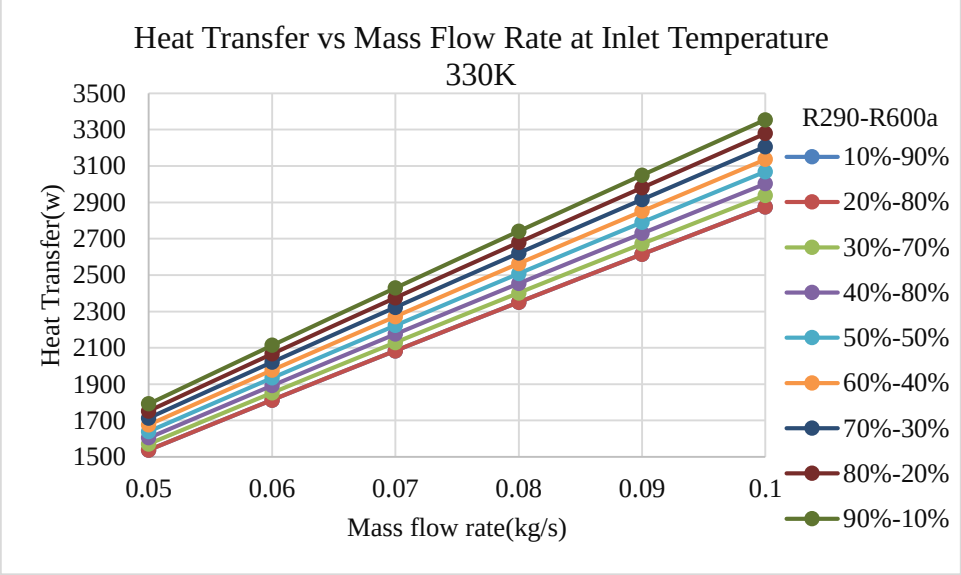

Figure 6 Heat transfer vs Rate of flow at 330K

Figure 6 shows that variation of heat transfer rate with respect to different Rate of flow at 300K inlet temperature and different compositions of a mixed refrigerant. Moreover, it was observed, that as the rate of flow increases and rate of heat transfer is increases linearly.

5 Conclusions

To estimate the Nusselt number with respect to Rate of flows for a mixed refrigerant operated at pressure 3MPa at different inlet temperatures, different Rate of flows at different compositions. To estimate the Heat transfer rate number with respect to Rate of flows for a mixed refrigerant operated at pressure 3MPa at different inlet temperatures, different Rate of flows at different compositions. Moreover, it was observed that as the Rate of flow increase (kg/s) heat transfer and Nusselt number increases at different compositions.

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