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A Review on Comparative Study of Performance of R1234yf Refrigerant and R134a Refrigerant

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Abstract:-*Design of heat exchanger for refrigeration system, involves improving the performance. The high performance of refrigeration system can be achieved by some of the factors such as enhanced heat exchanger, using appropriate cross section of the heat exchanger and using the high-performance refrigerants. This review paper :- 1) provides an overview on two phase flow condensation of a R1234yf and R134a refrigerants, 2) address the condensation in heat exchanger which is, influenced by various factors, 3) provides information about the correlations of Heat Transfer Coefficient (HTC) which is influenced by various factors. Finally from the literature it is concluded that, HTC increases with increasing in vapor quality. And also pressure drop increases with increasing in vapor quality due to molecular collision in two phase flows and also their is an opportunity to study the influence of various parameters such as mass flow rate, saturation temperature and surface roughness on flow condensation of R1234yf refrigerant to come up with new correlation which gives minimum error compared to experimental work.*

Conclusion: *From literature it is concluded that, HTC increases with increasing in vapor quality. And also pressure drop increases with increasing in vapor quality due to molecular collision in two phase flows.Annulus roughness of the tube in tube heat exchanger affect the heat transfer rate of the R134a refrigerant and annulus roughness is found to increase HTC of R134a refrigerant. COP of R1234yf is 25% less than that of R134a [11] & [13]. Since 25% of total power consumption is used for refrigeration and air conditioning field alone. If COP of a new refrigerant R1234yf is increased by using an appropriate design then there will be reduction in power consumption rate.*

Further, how the HTC is affected by mass flow rate, saturation temperature, and surface roughness during condensation of R134a and R1234yf is not investigated exhaustively.In literature, many authors predicted correlation for the heat transfer during, condensation of refrigerants. But these predictions are not satisfactory and the having deviation from the actual experimental work. There is an opportunity to study the influence of above discussed parameters on flow condensation of new refrigerant to come up with new correlation which gives minimum error.

Key Word*: Heat Transfer coefficient (HTC), Roughness, Pressure drop, Reynolds number (Re) and Nusselt number (Nu).*

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I. Introduction

According to the 17th Informatory note on Refrigerating Technology in the International Institute of Refrigeration, 25% of total electricity is consumed by refrigeration systems [6]. In 1987 Montreal protocol and recent Paris treaty call for ecofriendly new refrigerants. R1234yf is another synthetic refrigerant with the zero ozone depletion potential (ODP) and global warming potential (GWP) lower than (<) 4, in this way it consents to the new ecological laws.

In air conditioners condensation heat transfer can be increased by using enhanced (finned tube) heat exchanger. Under same operation conditions micro fin tube shows heat transfer enhancement compare to equivalent smooth tubes.

II. Literature review

A.SDalkilic et1al [1] conducted an experiment to find the HTC of HFC-R134a, inside a vertical smooth tube-in-.tube heat exchanger1of 0.5 mm diameter for different mass flow rates and quality in condenser test section. HTC is calculated by using energy balance equation. By analyzing the experimental results, they proposed an equation for condensation HTC. It is clear from their results that HTC of the refrigerant increases with increasing in the2vapor quality and decreases with increase in saturation temperature.

Refrigerants working under high pressure namely R404A, R407C and R410A were studied by TudeuszBohdal et al [2] in vertical smooth micro channel condenser for heat transfer coefficient with vapor quality ranging from 0 - 1. They established empirical correlation which describes the vapor, quality mass flow rate and HTC. Local pressure drop was increasing with increase in Nu. Experimental HTC compared with developed correlation yielded with 20% discrepancies.

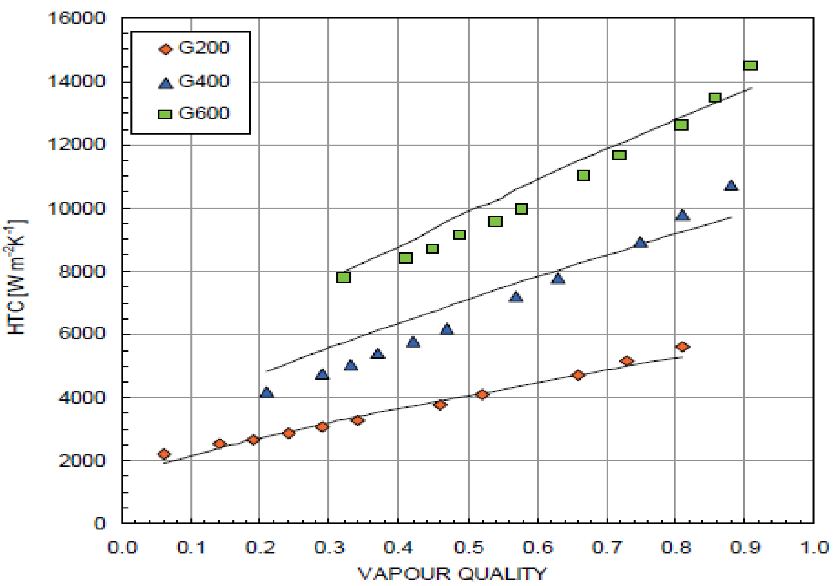
G. Aslan et.al [3] investigated R134a refrigerant heat transfer rate during .condensation in vertical tube. In their observation HTC decreases with increase in pressure drop and saturation temperature. And also they have found that HTC of refrigerant increases with mass flow rate. They have developed new correlation for experimental results and compared correlation with other authors and come up with following comparison as shown in Table 1.

Table 1. Comparison of correlation G.Aslan et al [3] with other authors

Sl No	*Authors*	*Absolute deviation*	*Mean Deviation*	*Standard Deviation*
1	*Akers et al*	*22.6*	*-16.7*	*24.6*
2	*Cavallini et al*	*25.8*	*-6.2*	*31.3*
3	*Shah et al*	*26.0*	*1.5*	*30.8*
4	*Traviss et al*	*26.5*	*-4.0*	*31.8*
5	*Jung et al*	*27.1*	*-11.2*	*33.3*
6	*Dobson and Chato et al*	*27.5*	*27.5*	*9.5*
7	*Chen et al*	*28.0*	*23.2*	*23.1*
8	*Haraguchi et al*	*28.5*	*8.9*	*31.2*
9	*Tandon et al*	*30.8*	*-30.8*	*15.9*

Alberto Cavallini1et.al.,[4], conducted an experiment to evaluate the. Local HTC of R134a refrigerant inside the micro channel heat exchanger during condensation and vaporization. They inferred from the results that the surface roughness inside annulus increases the vapour quality there by increases the HTC.

Figure 1. Variation of the HTC with vapor quality with different mass flow rate [4]



The black line shows deviation of result in Figure 1. The correlation is developed for uniform heat flux. In their experiment they evaluate the effect of heat flux, vapour quality and the saturation temperature on HTC. But heat flux is fundamental influence on HTC significantly by the other variables. Further no correlation developed for the surface roughness of the tube.

Andrea Diani et0al. [5] conducted an experiment on)condensation of the R1234yf inside a 3.4 mm inner diameter horizontal micro fin tubes. The experiment was conducted for different mass flow rates, vapour quality and saturation temperature. The outcomes indicate that both vapor quality and mass stream rate increment the HTC. An&experimental results were compared with the values predicted by empirical correlation available with Cavllin et al. (2009a). The model is applied to estimate1 the HTC of R1234yf, which result in 18% standard deviation and 15% mean deviation.

Qingpu Li et.al. [7] studied experimentally, the1condensation HTC of R134a inside four micro fin tubes and two horizontal smooth. The saturation temperature, pressure and surface structural parameters of the tube were considered as the experiment influencing- factor. Experimental results indicate that the HTC of refrigerant during condensation increases with condensation saturation temperature and increasing with mass velocity. And also it is observed that for a constant vapor quality the condensation film thickness. Decreases with increasing in mass velocity and flow regime is characterized by Re. From the results they developed new correlation's and compared with well-known correlations. In their prediction, 13.05%, 26.11% and 23.82% mean absolute deviation found for A Cavallini et al [4], Akers et.al [20] and J.R. Thome et.al. [24] correlation for smooth vertical tube.

A.Cavallini et al [8] directed an examination to explore HTC of R134a inside improved cylinder at high temperature. The^experimental segment is counter stream tube-in-tube. Condenser, where refrigerant flows inside. the internal cylinder, and cold water streaming in the annulus .By analyzing result, it*shows that as mass flow rate increase,HTC also increases for same vapour quality and on other hand the HTC increase with the increasing in the(mass flow rate .The experiment is also carried toby varying saturation temperature. It is observed from the results that the HTCdecrease)with increasing in the saturation temperature at starting of the condensation.

Pamela Reasor et al [9] found from simulation analysis that R1234yf having similar thermo physical properties compared to R134A refrigerant are suitable replacement for R134A. Since it is having better thermal Performance.

J. Navarroo–Esbri et)al.[10] conducted)an experiment)to investigate the performance of R1234yf refrigerant in vapor compression refrigeration(VCR) system replacement for R134a .They have conducted 104 steady state experiments in which they found COP of R1234yf is 19% less than the R134a and cooling capacity of R1234yf 9% less than the R134 a .

Chieko Kondu et.al [11] conducted an experiment to evaluate HTC of R134a and R1234Ze (Z) at higher temperature in horizontal micro tubes. HTC and pressure drop measured at 65^0 C and 30^0 C for condensation and evaporation respectively. The experimental result shows that pressure drop of R-134a is more compared to R-1234Ze. At higher vapor. qualities R-1234ze (Z) heat transfer exceeds that of R134a .The HTC of tested refrigerants is well predicted by Cavellin et al (2009) co-relation. The temperature distribution process is more than that of evaporation for both R134a and R1234Ze.

Andrea Diani et.al.[12] conducted an experiment on condensation 'of R1234yf inside a 3.4 mm inner diameter horizontal micro fin. The results of experiment compared with values predicted by empirical correlation available with Cavllin et al (2009a). The model is*applied to estimate the HTC of R1234yf, which result in 18% standard deviation and 15 % mean deviation. For low velocity, with enhancement factor 1.5 micro fin tube is advantageous compare to equivalent smooth tube. The experimental deviation is 12.8% and absolute deviation is 9.9%. The frictional pressure gradient increases at constant6mass velocity only.

II. Conclusion

From literature it is concluded that, HTC increases with increasing in vapor quality. And also pressure dropincreases with increasing in vapor quality due to molecular collision in two phase flows.Annulus roughness of the tube in tube heat exchanger affect the heat transfer rate of the R134a refrigerant andannulus roughness is found to increase HTC of R134a refrigerant.

COP of R1234yf is 25% less than that of R134a [11] & [13]. Since 25% of total power consumption is used forrefrigeration and air conditioning field alone. If COP of a new refrigerant R1234yf is increased by using anappropriate design then there will be reduction in power consumption rate. Further, how the HTC is affected by mass flow rate, saturation temperature, and surface roughness during condensation of R134a and R1234yf is not investigated exhaustively.

In literature, many authors predicted correlation for the heat transfer during, condensation of refrigerants. But these predictions are not satisfactory and the having deviation from the actual experimental work. There is an opportunity to study the influence of above discussed parameters on flow condensation of new refrigerant to come up with new correlation which gives minimum error.

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