International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 01, January-2019

Computational Fluid Dynamic Analysis of Refrigerator/Evaporator Pipes

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***Abstract*- Refrigerator pipe undergoes various phase changes and pattern in the flow properties. In order to establish the same and obtain the performance of different piping systems inside the refrigerator piping system a CFD model of the pipes has been established. The model was validated and further used for development of various types of fluids properties. Flow properties were analyzed with different cooling systems while the pattern of the system was also analyzed for attaining the best possible flow fluid.**

I.INTRODUCTION

Refrigeration and air-conditioning (RAC) plays terribly importance role in our day to day operating for cooling and heating needs. Refrigeration systems square measure wide used for dominant temperature in working/living setting to produce thermal comfort to grouping. The utilization of refrigeration technology for cooling isn't new; but, air-conditioning technology is needed to evolve because of several environmental laws. Its applications square measure several in several fields and sectors. Refrigeration systems conjointly used for storages of perishable food, and pharmaceutical formulations.

Conventional systems of refrigeration and air-conditioning consume an enormous quantity of (high-grade) electricity made by burning of fossil fuels the costs of fossil fuels area unit increasing day by day and supply availableness is additionally declining thanks to immense consumption. The considerations of accelerating fuel value for electricity generation, environmental pollution & environmental harm in terms of worldwide warming could be a world–wide concern.

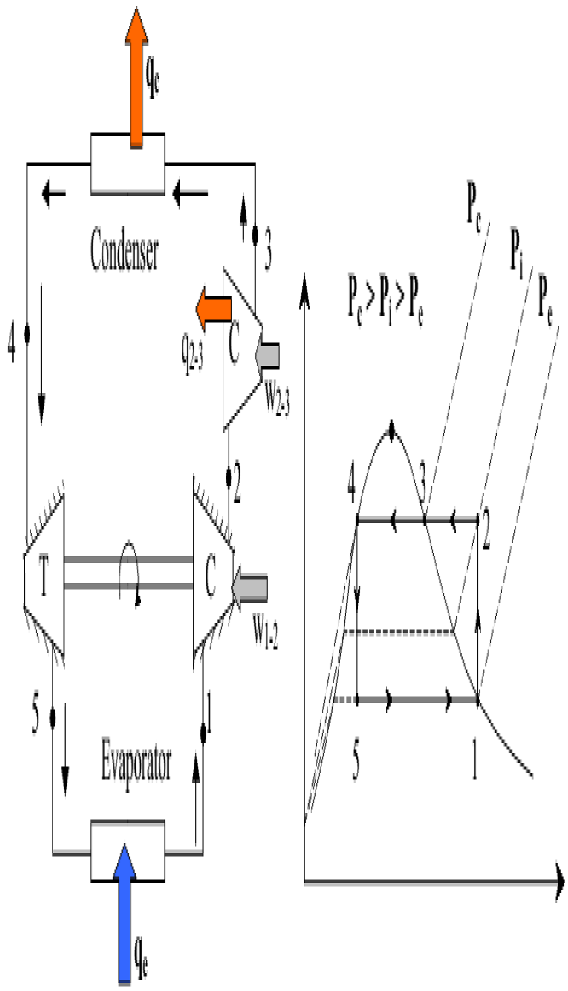

Fig.1. Vapour cycle refrigeration system

The earliest in order preeminent environmental involvement to make an impact the refrigeration –based industries was exhaustion of ozone layer as a outcome of issuance of manmade chemicals to the atmosphere. Over 25 years ago Molina and Rowland (1974) urge that the

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issuance of chlorinated manmade chemicals to the atmosphere could bruise the stratospheric ozone layer.

The second major environmental preeminent is climate change or global warming. The preeminent is that men's activities are accessing the consolidation of CO2 and alternative greenhouse gases in the atmosphere so causing amount of engrossed infrared radiation to access, leads to rise in atmospheric temperature and in long term climate change.

Recently, the ozone drain potential (ODP) and global warming potential (GWP) have adorn the most important yardstick in the progress of new refrigerants likewise the refrigerant CFCs and HCFCs. Both refrigerant CFCs and HCFCs have high ODP and GWP. The CFCs and HCFCs were the refrigerant fluids of finding for many applications for many years up to the early 1990s, after which the non-ozone depleting HFCs became favored.

However, bygone the last some decades, environmental preeminent about global warming and ozone depletion by chlorofluorocarbon, and hydro chlorofluorocarbon , refrigerants have led to a revival of enthusiasm in refrigeration framework. The Montreal Protocol accelerated the rate of CFC and HCFC phase out in order to reduce ozone depletion, and this was only possible by using HFCs in many applications. In 1997 the Kyoto protocol introduced goals for the reduction of global warming substances. Kyoto summit assured a devoir from EU countries to achieve 8% cutback in CO_2 exudation compared to the 1990 level by 2008-2012 (Kyoto protocol, 1997). A number of hydrocarbons have favorable characteristics as refrigerants from a thermodynamic as well as heat transfer point of view.

Therefore it becomes very important to find out the performance levels of various refrigerating fluids used in the system. It was also found development of such systems experimentally can be very difficult and costly. Therefore a need arises to find out the flow performance with the development of a CFD model.

II METHODOLOGY

The first step of an Computational fluid analysis is geometry creation. An evaporator pipe is designed in the present work to judge the performance of an evaporator further and study the phase variation of refrigerator in the evaporator. For the CFD analysis one single pipe is consider. It consist of 1 m length and 9 mm dia meter pipe is open both side and one end of pipe is inlet of flow and other end is pressure outlet. Other edges has been consider as wall temperature is applied on it .Half length of pipe is consider as super heated zone means after 500 mm from inlet conditions.

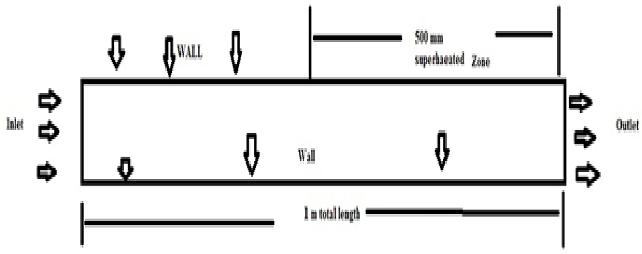

Fig. 2 Geometry of pipe

The pipe has been divide in two zone half of the pipe is normal zone and other half is superheated zone. In superheated zone sudden increase of temperature of working fluid has been achieve, to convert it in to gas form means sudden phase change has been achieved in this region.
Geometry is developed in gambit software, which is meshing software and meshing also has been done in that software the grid independent study has been done on three different cell size and optimize mesh has been selected.

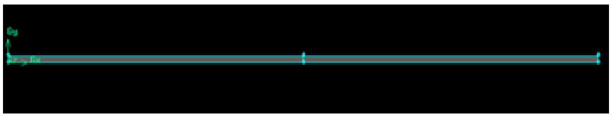

Fig. 3 Model of pipe in GAMBIT

For achieve better results grid independent study is done, element size 5 mm, 3 mm and 1 mm are selected. Different kind of mesh has been checked for simulations and 1 mm element size mesh is found optimum and selected for further analysis.

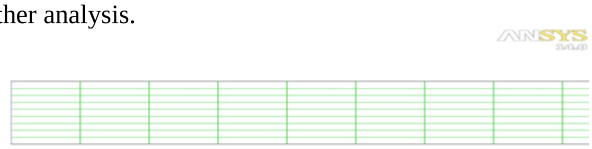

Fig. 4 5 mm mesh (close view)

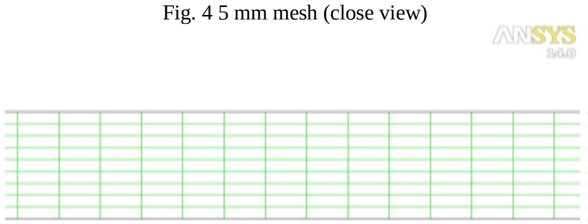

Fig. 5. 3 mm mesh (close view)

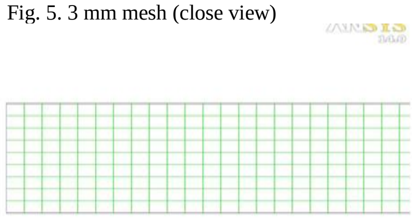

Fig. 6. 1 mm mesh (close view)

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It is found that the 1 mm mesh has 1179 elements, 3 mm mesh has 956 elements and 5 mm mesh has 742 elements. Since the number of elements in 1 mm mesh is more so it will provide us better results.

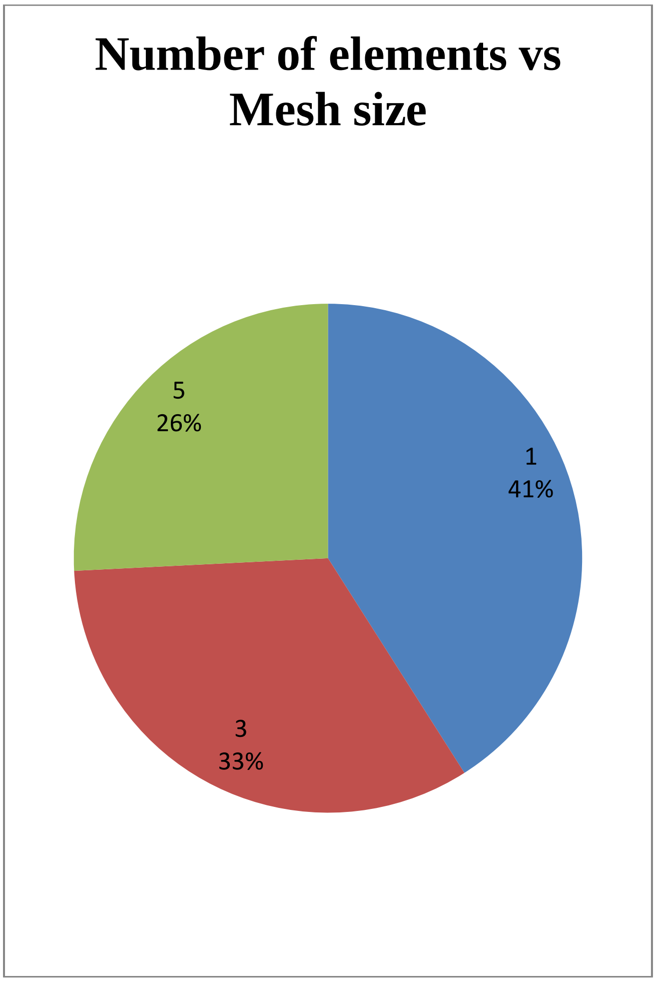

Fig. 7. Number of elements ratio vs Mesh size

III RESULTS

The evaporator pipe which is meshed with 1 mm mesh size is analyzed with ANSYS Fluent software with different boundary conditions and refrigerants. The refrigerants properties are set and then used in different phases i.e in both gas as well as liquid form. Initially R22 is taken as a fluid flowing through evaporator in both the phases.

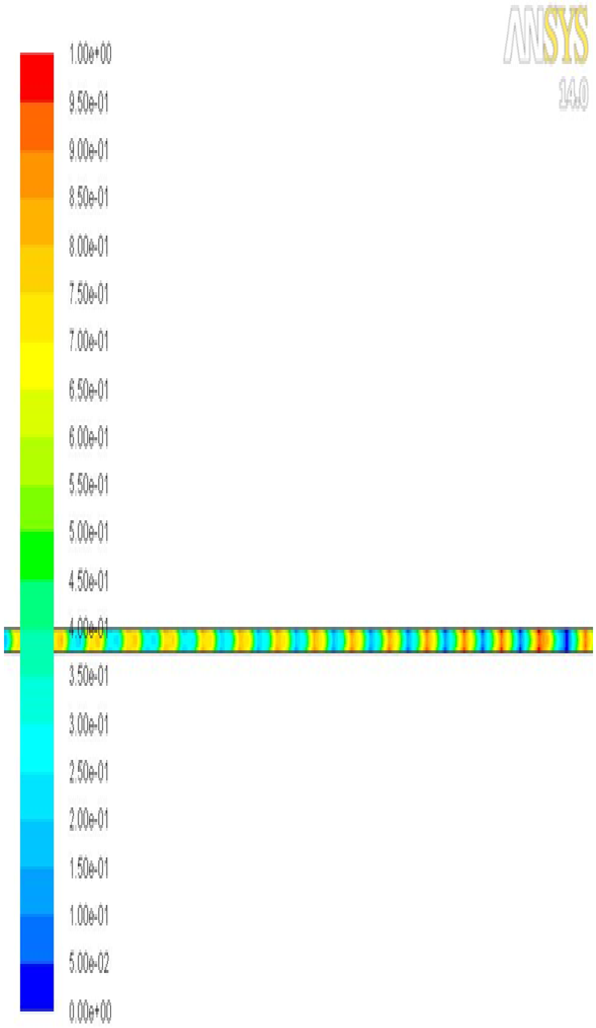

Fig. 8. Contour of phase I at time 7 seconds

It is clearly visible from all the contours within the evaporation tube the refrigerator phase changes occurs significantly and that can be considered as the main reason for the performance of the refrigerator system. The refrigerant which can perform better heat transfer means which can change its phase more promptly will be liable to perform better as a system. Thus the coefficient of performance of the refrigerator system with different refrigerants are compared to find out the best performing refrigerant. The main aim of the simulation was to check the phase changes of refrigerant occurring inside the evaporator pipe and to find out the heat transfer.

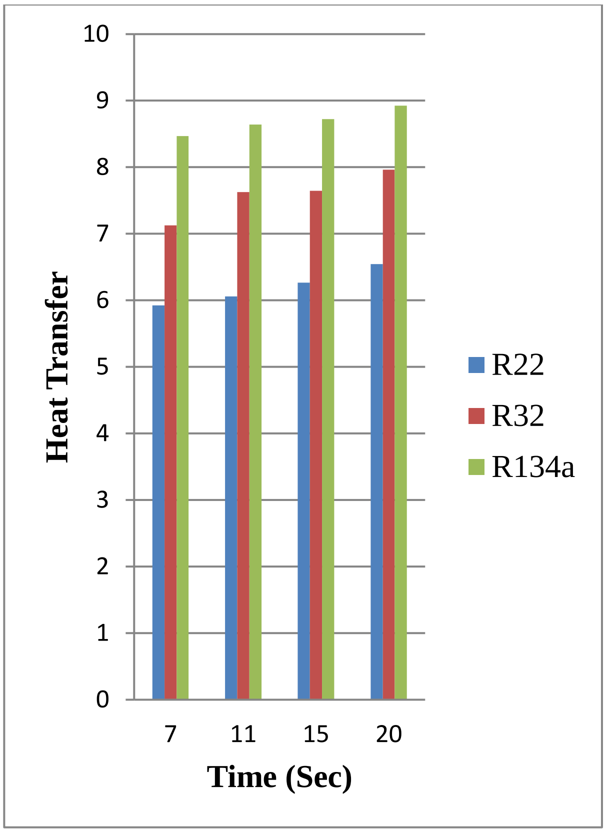

Fig. 9. Heat transfer In evaporator

The above figure illustrates the heat transfer occurred in evaporator section for all the refrigerants. It is clearly observed that R134a refrigerant is having better performance as compared to other two refrigerants. The heat transfer is better in R134a is better demonstrates that the performance of the refrigerator system incorporating it will be better than other two refrigerants. Similarly the Coefficient of performance of the Refrigerating systems can be calculated keeping the work input as constant for all the refrigerants by using the heat transfer value obtained from the simulation for each refrigerant.

It can be seen from the above graph that R134a perform better than other two refrigerants when used under same conditions and same input work as well as type of refrigerating system.

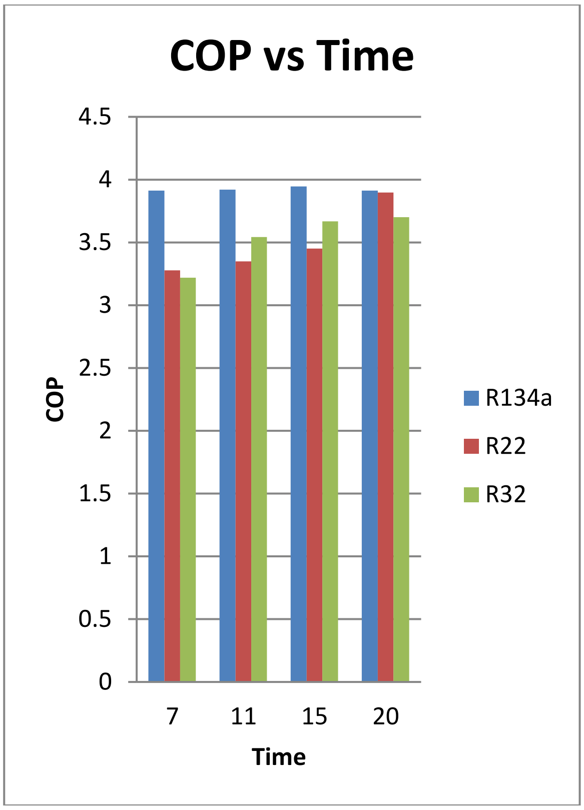

Fig.10. COP vs Time graph in evaporator

IV CONCLUSION

R22 was the most used refrigerant previously but in most of the refrigerating systems it is fastly been replaced by R134a. The present study illustrates that R134a performs better in evaporator and the COP of refrigerator running in R134a is better than the refrigerators running in R22 and R32 respectively. The present study mainly involves the computational fluid dynamics analysis of refrigerant flowing in evaporator. The transition of the phases and the existence of both the phases simultaneously is studied to illustrate that the heat transfer for R134a is more than the other two refrigerants. It is also a proven fact that R134a is known as a more environment friendly refrigerant and its performance is also better. Then obviously this refrigerant R134a can be used most frequently in all the refrigerating system without any problems.

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