Comparative Study Of Various Properties Of Refrigerant Using CFD Study

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Abstract- *Freon CFC's are posing a great threat to humanity as they react with ozone oxygen and depleting our earths protection from sun's harmful rays refrigeration industry over decades are depending on CFC's but to cope up with environmental norms, it is decided to stop using R-22 group giving rise to the search for equivalent eco-friendly refrigerants.*

In this research for the same refrigerant cycle , R-22 is replaced with eco-friendly refrigerants R404A and R410A,its behaviour Pressure drop and Quality of refrigerant is elaborately studied along the capillary tube expansion device. Using ANSYS 18.1 Further a comparison is made between R-22, R404A & R410A are presented and it is concluded that the refrigerants R404A and R410A shows good outcomes in performance compared with the refrigerant R22.

I. LITERATURE SURVEY

"CFD Analysis of Two Phase Flow in a Horizontal Pipe – Prediction of Pressure Drop". P. Bhramara, V. D. Rao, K. V. Sharma, and T. K. K. Reddy.

In structuring of condensers, the expectation of pressure drop is as critical as the forecast of warmth exchange coefficient. Displaying of two stage stream, especially fluid – vapour stream under adiabatic conditions inside a flat cylinder utilizing CFD investigation is troublesome with the accessible two stage models in FLUENT because of constantly changing stream designs. In the present investigation, CFD examination of two stage stream of refrigerants inside a level container of inward measurement, 0.0085 m and 1.2 m length is completed utilizing homogeneous model under adiabatic conditions. The refrigerants considered are R22, R404A and R410A. The investigation is performed at various immersion temperatures and at various stream rates to assess the neighbourhood frictional pressure drop. Utilizing Homogeneous model, normal properties are gotten for every one of the refrigerants that is considered as single stage pseudo liquid. The so acquired pressure drop information is contrasted and the isolated stream models accessible in writing.

"Impact of Geometrical Parameters on Capillary Behavior with New Alternative Refrigerants". S. M. Sami, Ph.D., P.E., H. Maltais and D. E. Desjardins.

The test information acquired on capillary tube conduct, utilizing different new choices under various geometrical parameters will be displayed and examined. Slim geometrical parameters will incorporate length, distance across, and in addition entrance conditions. The outcomes plainly demonstrated that the pressure drop over the capillary tube is fundamentally impacted by the measurement of the capillary tube, bay conditions to the fine and refrigerant sort. The information shown that the slender pressure drop diminishes with the expansion of the slim distance across and that choices all in all experience higher pressure drop than that of R-22.

"Test examination of the execution of R22, R404A and R410A in a few capillary tubes for forced air systems". S.G.Kim, M. S. Kim1*, S. T. Ro.

The goal of this examination is to exhibit test results and to build up a dimensionless connection based on the exploratory information of adiabatic capillary tubes for R22 and its options, R404A (R32/125/134a, 23/25/52 wt.%) and R410A (R32/125, 50/50 wt.%). A few capillary tubes with various length and inward width were chosen as test areas. Mass stream rate through the capillary tube was estimated for a few consolidating temperatures and different degrees of sub cooling at the gulf of every capillary tube. Test conditions for the gathering temperatures were chosen as 40, 45 and 50oC, and the degrees of sub cooling were changed in accordance with 1.5, 5 and 10oC. Mass stream rates of R404A and R410A were contrasted and those of R22 for a similar test conditions. The outcomes for straight capillary tubes were additionally contrasted and those of wound capillary tubes. Another connection dependent on Buckingham π hypothesis to anticipate the mass stream rate through the capillary tubes was introduced dependent on broad trial information for R22, R404A and R410A. Dimensionless parameters were picked thinking about the impacts of cylinder geometry, capillary tube channel conditions, and refrigerant properties. Dimensionless connection anticipated trial information inside relative deviations extending from 12% to +12% for each test condition for R22, R404A and R410A. The expectations by the created connection were in great concurrence with the outcomes in the open writing.

"Surmised investigative arrangements of adiabatic capillary tube". Chunlu Zhang, Guoliang Ding.

Surmised investigative arrangement of capillary tube is significant for hypothetical examination and designing estimation. In this work, two sorts of estimated scientific arrangements of adiabatic capillary tube have been produced. One is the unequivocal capacity of capillary tube length. Another is the express capacity of refrigerant mass stream rate. In these arrangements, the stifled stream condition is considered without iterative estimations. The inexact expectations are found to concur sensibly well with test information in open literary works.

"Summed up relationship of refrigerant mass stream rate through adiabatic capillary tubes utilizing fake neural system". Chun-Lu Zhanga, b.

A capillary tube is a typical extension gadget broadly utilized in little scale refrigeration and cooling frameworks. Summed up connection strategy for refrigerant stream rate through adiabatic capillary tubes is produced by joining, Dimensional investigation and counterfeit neural system (ANN). Dimensional investigation is used to give the summed up dimensionless parameters and decrease the quantity of information parameters, while a three-layer feed forward ANN is filled in as an, all inclusive approximate of the nonlinear multi-info and single-yield work. For ANN preparing and test, estimated information for R12, R134a, R22, R290, R404A, R410A, and R600a in the open writing are utilized. The prepared ANN with only one shrouded neuron is adequate for the preparation information with normal and standard deviations of 0.4 and 6.6%, individually. By examination, for two test informational collections, the prepared ANN gives two unique outcomes. It is very much deciphered by assessing the anomaly with a homogeneous balance demonstrate.

"Adiabatic and Separated Flow of R-22 and R-404A in Capillary Tube". Ahmed Abdulnabi Imran.

The adiabatic stream in capillary tube is examined and demonstrated for R-22 and elective R-404A. The conditions of coherence, vitality and pressure drop through a capillary tube are displayed. A scientific model of sub– cooled stream locale and two– stage stream district is created. The consequences of the figuring contrasted and trial information exhibited in the specialized writing will be appeared in the present article with the end goal to approve the model created. This numerical model is fit for giving a successful way to break down capillary tube execution to advance and control a R– 22 and R– 404A in cooling frameworks.

Objective of the present work:

The present work reports the qualities of the HFCs (R404A and R410A) in factor parameters like

a. Pressure drop,
b. Quality of refrigerant along length of the capillary tube

The correlations made between the refrigerants R22, R404A, and R410A were likewise exhibited.

1. Need of the Alternatives of the Refrigerants

Refrigerants like CFCs and HCFCs (R22) are steady and spreading into the air for some more years and after that diffuse into the stratosphere. This causes the ozone pulverization because of discharging of chlorine in to the climate because of the breakdown of the refrigerant atoms in the air. In this way, these issues can be overwhelmed by utilizing the compelling elective refrigerants as HFCs. These HFCs are successful contrasted with HCFCs and CFCs as far as pressure drop and temperature.

2. Portrayal of Capillary Tube

a. Tube Type: Air-Conditioning and Refrigeration.
b. Standards: ASTMB 280.
c. A tube with a length of 2223 mm.
d. An inside radius of 1.0795 mm.
e. Refrigerants are R22, R404A and R410A with inlet temperature of 26ºC..
f. Inlet pressure of 1100 KPa. & Outlet pressure of 35 KPa.
g. Mass flow rate: 15 g/sec.
h. Density of copper: 8960 kg/m.

II. TECHNIQUE OF ANALYSISSYSTEMATIC PROCESS FOR SOLVING FLOW THROUGH CAPILLARY TUBE

The pre-processor utilized for taking care of the issue is ANSYS 18.1. The Solver and Post-processor utilized is Fluent 18.1.

- ANSYS WORKBENCH is opened and the name for the issue is given as "narrow".

- The FLUID FLOW which infers a multi-material science code dependent on limited volume strategy on the liquid issues is chosen in the given examination frameworks toolbar

- The sub-menualternatives are shown on the working screen as :
  1. Geometry
  2. Mesh
  3. Setup
  4. Solution
  5. Results

Numerical Analysis

One of the principle targets of FLUENT is to decrease the greatest computation time. This makes FLUENT an extremely agreeable investigation and streamlining apparatus to take care of liquid stream issues including stage change. A settled lattice system is utilized, in which an equation for the inactive warmth content is comprehended and the enthalpy equation is illuminated with additional source terms because of the stage change.

The basic equations administering capillary tube stream are coherence and Navier-Stokes equations.

$$[\rho\, u\, A] = 0 \quad \ldots\ldots (1)$$

Where:

ρ: is the Density.
u: is the velocity of refrigerant, and
A: is the cross segment region of capillary tube.

$$u_t + \nabla.(u\,u) = -\frac{1}{\rho}[\nabla p - \nabla.(2\mu S)] + \frac{1}{\rho}F_{SF}, \nabla.u = 0 \quad \ldots\ldots (2)$$

Where:

p: is the pressure, and
S: is the distortion tensor which is given by:

$$S = \frac{1}{2}\left(\nabla u + [\nabla u]^T\right) \quad \ldots\ldots (3)$$

Where:
FSF: is continuum surface power vector.

The past equation is reliant on the volume parts of all stages through the properties ρ and μ. These properties were computed by the accompanying equations:

$$\rho = \sum \alpha_k \rho_k \quad \ldots\ldots (4)$$

furthermore,

$$\mu = \frac{\sum \alpha_k \rho_k \mu_k}{\sum \alpha_k \rho_k} \quad \ldots\ldots (5)$$

α k, ρk and μk : are the volume division, Density and consistency of the k th liquid, individually.

$$\alpha_2 = \begin{cases} 0, & (\text{Fluid 1}) \\ 1, & (\text{Fluid 2}) \\ 0 < \alpha_2 < 1 & (\text{Interface between two fluids}) \end{cases} \quad \ldots\ldots (6)$$

The interface between two liquids was followed by volume division work. It convicts with the stream and protection of this capacity can be spoken to with the assistance of interface mass parity equations by unadulterated convection equation:

$$\frac{\partial \alpha_k}{\partial t} + u.\nabla\alpha_k = 0 \quad \ldots\ldots (7)$$

The volume part for the essential stage was not comprehended and was acquired from the accompanying equation:

$$\sum \alpha_k = 1 \quad \ldots\ldots (8)$$

These equations can be coordinated and comprehended all the while by an iterative procedure for each control volume with the assistance of limited volume strategy (FVM). The procedure can be rehashed along the capillary tube length including single-stage and two-stage cells. For the two stages stream locale an isolated stream show is expected

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$$\sum \alpha_k = 1 \quad \ldots\ldots (8)$$

The model was created with the accompanying contemplations:

- The capillary tube is level (gravity impacts are dismissed), and of consistent cross segment.
- The stream in the capillary tube is relentless, one-dimensional.
- When the liquid achieves the immersion pressure, the liquid begins to dissipate.

- The liquid is dependably in nearby thermodynamic balance relating to its neighbourhood pressure.

Pressure misfortunes can be characterized by:

- Pressure drop by passage impacts (from the upstream cylinder to the capillary tube)
- Pressure drop by rubbing: Single-stage erosion from passage up to the immersion point, and two stage grinding from immersion point up to the end.

The preservation equations and equations of state establish an arrangement of non direct equations. For a given capillary tube geometry (inward measurement and length) and given agent equations, the entire issue turns out to be completely certain. The figuring of the capillary tube execution for given working equations (upstream and downstream) begins from the gulf area and continues till the finish of the capillary tube. Incorporating the preservation equations over length, for non basic equations, the ascertained capillary tube length must be the genuine capillary tube length. The procedure begin ascertaining the pressure, temperature and afterward the quality at every cell can be figured.

Organized rectangular matrix produced with the assistance of Gambit 2.2 (Fluent v.6 Inc., USA) was utilized for reproduction. An entire and nitty gritty clarification of the numerical technique with the equations can be found in FLUENT programming client manual.

III. RESULT AND DISCUSSION

Plots of variety in pressure, temperature and quality with position along the capillary tube are incorporated into Figures 1-6. Figures1,2 and 3 show how pressure changes with position along the capillary tube for three refrigerants. The outcomes demonstrates that in the sub-cooled single stage locale, pressure diminishes straightly because of cylinder divider rubbing of course. When the stream achieves the soaked condition blazing happens and the pressure drop quickens along the cylinder (However, because of the deferral of vaporization, the genuine purpose of origin of vaporization may not happen toward the finish of the sub-cooled fluid area). This impact of blazing causes the vapor and speed in the refrigerant stream to increment further which results in quick increments in both the frictional and increasing speed pressure drops in the two stage district.

It ought to be noticed that contrasting the pressure drop attributes of R22, R404A and R410A (Figure 10), the stream of R410A through the capillary tube gives a higher pressure drop than that of R22.

Looking at the pressure drop attributes for the refrigerants demonstrates that for all Cases in the single-stage stream area, the more up to date elective refrigerant gives a somewhat higher pressure drop than the customary refrigerants in light of the higher consistency of the elective refrigerant. Then again, in the two-stage stream area the elective refrigerant gives an altogether bigger pressure drop than the conventional refrigerant for a similar cylinder length. This is because of the immersed properties of elective refrigerants contrasted with customary refrigerants which results in a higher stream speed.

<u>Pressure Profile</u>

From the diagrams demonstrated as follows, the capillary tube length expands, the refrigerant temperature and pressure diminishes. The two-stage stream pressure profile in the capillary tube was portrayed by the quick decline of the pressure towards the finish of the capillary tube. No stifle stream wonder was watched. The capillary tubepressure profile recommends that equivalent wonders happened with the choices of R-22. Then again, R-404A and R-410A have the most noteworthy pressure drop contrasted and different choices including R-22.

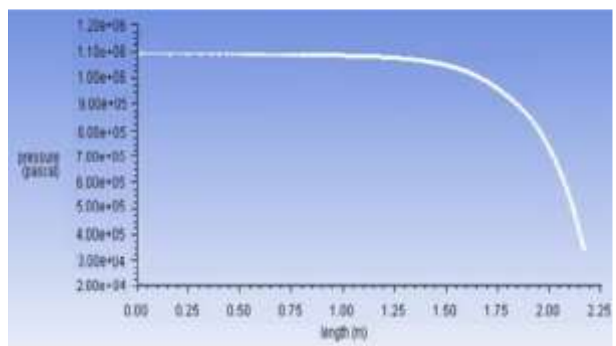

Fig. 1. Variation of the pressure of R22 along length of capillary tube

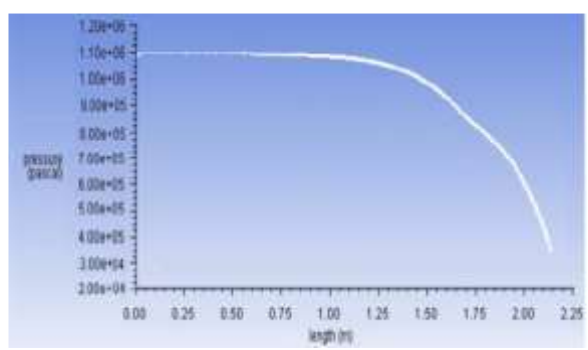

Fig.2. Variation of the pressure of R404A along length of the capillary tube.

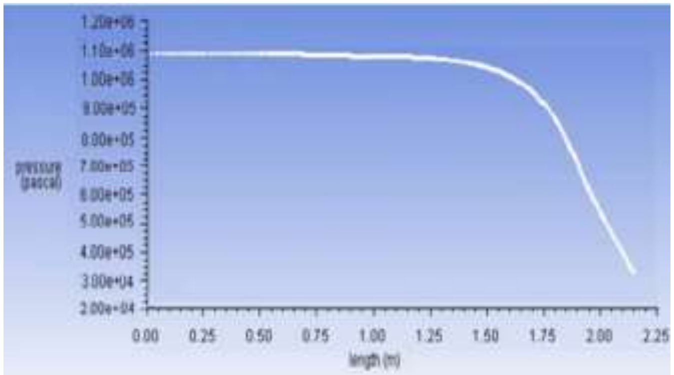

Fig.3. Variation of the pressure of R410A along length of thecapillary tube.

Refrigerant Quality (dryness frication):

Figures 3 to 9 demonstrate the adjustment in quality with position along the capillary tube. Of course, for all cases, the quality is zero up to the glimmer point and after that increments in a non-direct form, rising all the more quickly as the basic length is drawn nearer. It is likewise demonstrated that every elective refrigerant vaporizes sooner than their relating conventional refrigerants

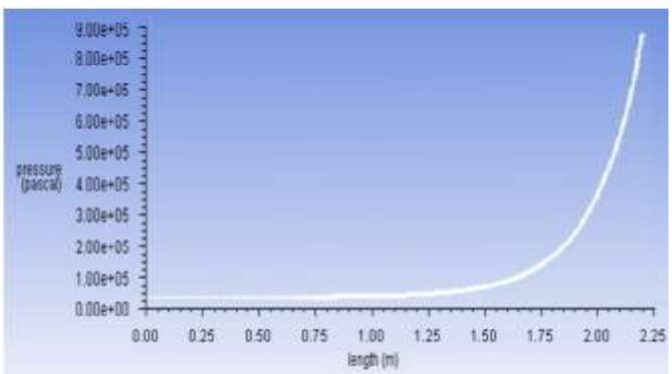

Fig.4. Variation of the Vapor Phase of R22 along length of the capillarytube

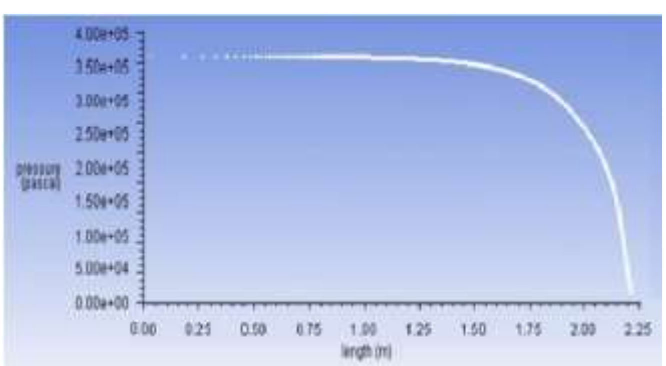

Fig.5. Variation of the Liquid Phase of R22 along length of the capillary tube

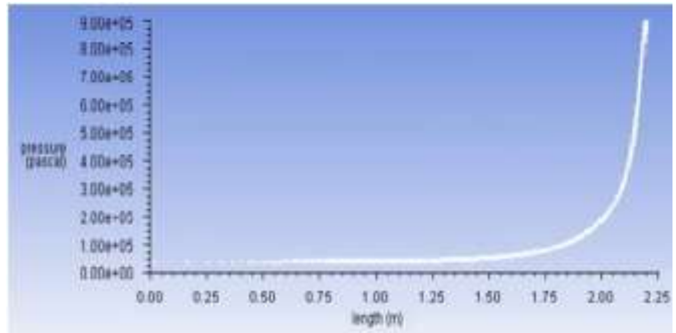

Fig. 6. Variation of the Vapor Phase of R-404A along length of the capillary tube

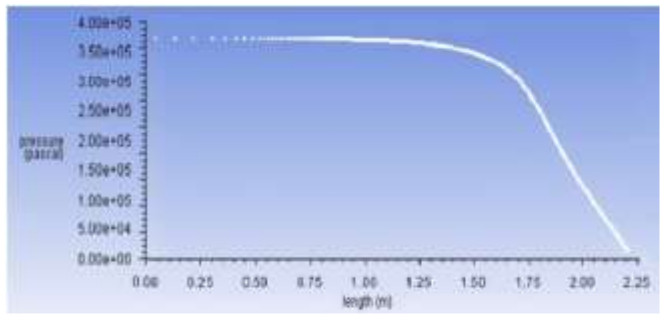

Fig.7. Variation of the Liquid Phase of R404A along length of the capillary tube

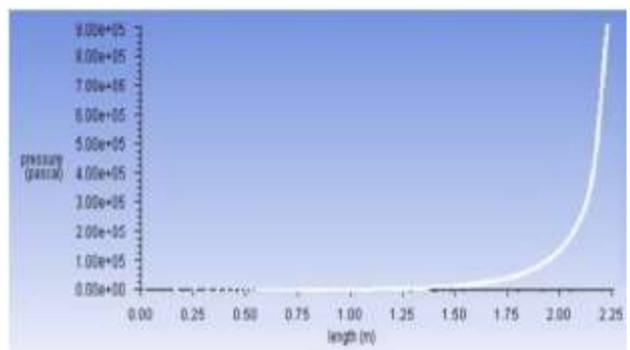

Fig.8. Variation of the Vapour Phase of R410A along length of the capillary tube

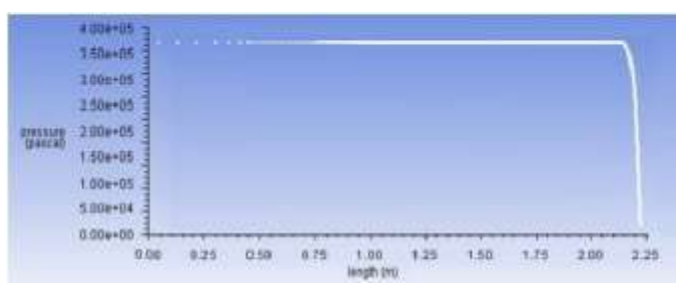

Fig.9. Variation of the Liquid Phase of R-410A along length of the capillary tube.

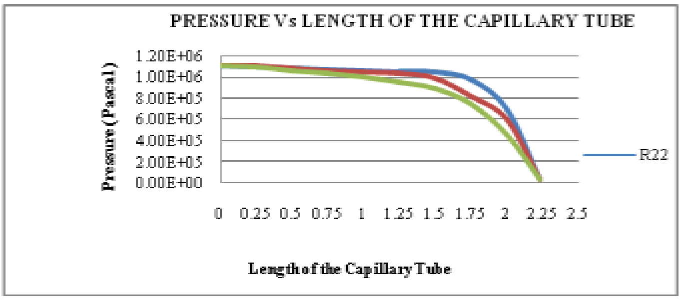

Fig.10. Pressure examination diagram

Tab.1. Pressure examination Table

LENGTH (m)	R22	R404A	R410A
0	1.10e+06	1.10e+06	1.10e+06
0.25	1.09e+06	1.10e+06	1.09e+06
0.5	1.08e+06	1.08e+06	1.06e+06
0.75	1.07e+06	1.06e+06	1.03e+06
1	1.06e+06	1.04e+06	1.00e+06
1.25	1.05e+06	1.03e+06	9.50e+05
1.5	1.04e+06	9.90e+05	8.90e+05
1.75	9.70e+05	8.20e+05	7.40e+05
2	6.90e+05	6.00e+05	4.50e+05
2.23	3.50e+04	3.50e+04	3.50e+04

IV. CONCLUSION

A two-stage homogeneous stream show has been connected to decide the refrigerant stream qualities in adiabatic capillary tube. The fundamental physical conditions overseeing capillary tube stream are built up from the preservation of mass, vitality and energy. By utilizing the familiar, Simulation was performed utilizing the present model for the majority of the refrigerants R-22, R-404A and R-410A. By fluctuating the model info parameters for all refrigerants, it was discovered that the more current elective refrigerants R-404A and R-410A gives a higher pressure drop than the conventional refrigerants R22 for both single-stage and two-stage areas which came about along capillary tube length.

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