

Review on the Thermodynamic Performance Nanoparticles Refrigerant in a Capillary Tube

Rakesh Kushwaha¹, Prof. Vishwajeet Kureel²

¹Research Scholar, Department of Mechanical Engg, GRKIST Jabalpur(M.P.)

²Asst. Professor, Department of Mechanical Engg, GRKIST Jabalpur(M.P.)

Abstract- The development gadgets utilized as a part of refrigeration frameworks can be isolated into settled opening write or variable opening compose. As the name suggests, in settled opening write the stream zone stays settled, while in factor opening compose the stream territory changes with changing mass stream rates.

In the present paper gives a brief review to develop mathematical model to determine the flow characteristics of refrigerant inside a straight capillary tube for adiabatic flow conditions on the basis of previous research.

Index Terms- adiabatic straight capillary tube, refrigerant R134a, ANSYS, simulation.

I. INTRODUCTION

1.1 General

Refrigeration is the way toward expelling heat, and the reasonable application is to deliver or keep up temperatures underneath the encompassing. Warmth is one of the numerous types of vitality and for the most part emerges from compound sources. The warmth of a body is its warm or inward vitality, and an adjustment in this vitality may appear as a difference in temperature or a change between the strong, fluid and vaporous states.

1.2 Expansion Devices

A development gadget is another essential segment of a refrigeration framework. The fundamental elements of a development gadget utilized as a part of refrigeration frameworks are to:

1. Reduce weight from condenser weight to evaporator weight, and
2. Regulate the refrigerant spill out of the high-weight fluid line into the evaporator at a rate equivalent to the vanishing rate in the evaporator under perfect conditions; the mass stream rate of

refrigerant in the framework ought to be relative to the cooling load.

In some cases, the item to be cooled is with the end goal that a consistent evaporator temperature must be kept up. In different cases; it is alluring that fluid refrigerant ought not enter the blower. In such a case, the mass stream rate must be controlled in such a way, to the point that lone superheated vapor leaves the evaporator. Once more, a perfect refrigeration framework ought to have the office to control it such that the vitality prerequisite is least and the required paradigm of temperature and cooling load are fulfilled. Some extra controls to control the limit of blower and the space temperature might be required moreover, in order to limit the vitality utilization. There are essentially seven sorts of refrigerant development gadgets. These are:

1. Manually expansion valves
2. Capillary Tubes
3. Orifice metres
4. Constant pressure or Automatic Expansion Valve (AEV)
5. Thermostatic Expansion Valve (TEV)
6. Float type Expansion Valve
7. Electronic Expansion Valve

Of the over seven kinds, Capillary tube and hole have a place with the settled opening compose, while the rest have a place with the variable opening write. Of the over seven kinds, the hand worked extension valve isn't utilized when a programmed control is required. The opening kind development is utilized just in some extraordinary applications.

1.2.1 Capillary Tube

A slim tube is a long, tight container of steady breadth. "Capillary" is a misnomer since surface strain isn't critical in refrigeration utilization of slim tubes. Normal tube breadths of refrigerant fine tubes

extend from 0.5 mm to 3 mm and the length ranges from 1.0 m to 6 m. The weight diminishment in a slim tube happens because of the accompanying two elements:

1. The refrigerant has to stunner the frictional resistance presented via tube walls. This primes to nearly pressure drop, secondly
2. The liquid refrigerant flashes i.e. evaporate with mixture of liquid as well as vapour so its Pressure reduces. The density of vapour is no more than that of the liquid. Thus, the normal density of refrigerant declines as it streams in the tube. The mass flow rate as well as tube diameter being constant, the velocity of refrigerant upsurges since $= \rho VA$. The growth in velocity and acceleration of the refrigerant too needs more pressure drop.

Truth be told, the course through slim tube is really adiabatic not an isenthalpic. As the Name proposes the adiabatic narrow tubes are one in which there is no warmth exchange with the environment or the dividers of the fine tube are thermally protected. Based on Geometrical shape, the narrow tubes can be named under:

1. Straight capillary tube
2. Coiled capillary tube

1.2.1.1 Straight Capillary Tube:

In adiabatic slender tube, the refrigerant extends from high weight side to low weight favor no warmth trade with the environment. The refrigerant frequently enters the slender in a sub cooled fluid state. As the fluid refrigerant courses through the capillary, the weight drops straightly because of rubbing while the temperature stays steady. As the weight of refrigerant falls underneath the immersion weight a small amount of fluid refrigerant flashes into vapor. The liquid speed expands in view of the fall in thickness of the refrigerant because of vaporization. Along these lines, the whole narrow tube length is by all accounts partitioned into two unmistakable locales. The area close to the passage is involved by the fluid stage and alternate as the two-stage fluid vapor locale.

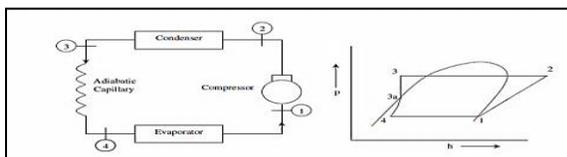


Figure 1.4 Adiabatic capillary tube (a) block diagram (b) P-h diagram

The stream inside the hair like container of a refrigeration framework can be separated into a sub cooled fluid locale from the passageway to the point in which the liquid achieves soaked conditions, and a two-stage stream area after that point until the finish of the narrow tube. In Figure 1.5, the variety of refrigerant temperature and weight has been plotted against the slim tube length.

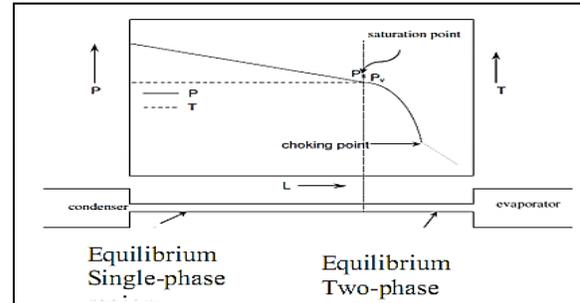


Figure 1.5 Temperature and pressure variation along the adiabatic capillary tube

Diabatic capillary tube goes about as warmth exchanger. In a diabatic stream plan, the capillary tube is fortified with the chilly blower suction line in a counter stream course of action as appeared in Fig. 1.6 a. As consequence of this refrigerating limit increments, additionally cause change in productivity of cycle.

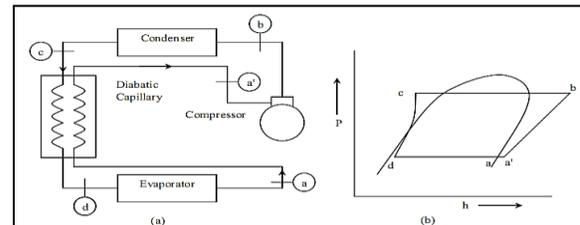


Fig.1.6 Diabatic capillary tube (a) block diagram (b) P-h diagram

1.2.1.2 Coiled Capillary Tubes

The helical slender tubes in a residential fridge or in a window ventilation system are no more another thing. The distinction between the back to back turns of the curled capillary tube is named as loop pitch, meant by 'p'. In helical fine tubes there are two looping parameters one is curl pitch and another is curl breadth. Figure 1.7 demonstrates the helical and winding tubes portraying the geometric parameters, viz. loop pitch, curl distance across and tube width.

The course through curled tubes is muddled contrasting with straight tubes. The frictional powers causes', weight drop of a solitary stage liquid course through a bended.

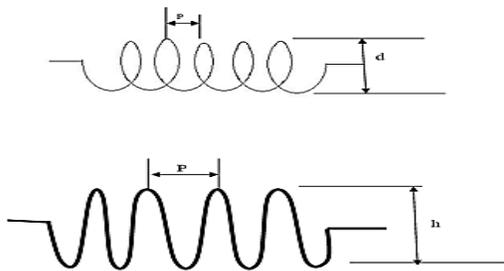


Figure 1.7 Helical coiled capillary tubes tube is larger than that for a flow through a straight tube under similar conditions. The liquid streaming in tube experiences a radiating power, which brings about the auxiliary stream, as appeared in Figure 1.8. The auxiliary stream forced on the principle stream shapes a counter-pivoting helical vortex match. The presence of auxiliary stream is known as the Dean effect.[3]. Dean has proposed a dimensionless number called Dean Number given by the following equation:

$$De = Re\sqrt{d/D} \quad \dots\dots\dots (1.1)$$

The stream design by Dean's examination is appeared in Figure 1.4. The auxiliary stream in the curled capillary tube has the balancing out impact on laminar liquid stream, bringing about higher basic Reynolds number. The basic Reynolds number increments with the expansion in proportion, d/D , and is Expressed by the accompanying connection

$$Re_{crit} = 2000 \left(\frac{d}{D}\right)^{0.32} \quad (1.2)$$

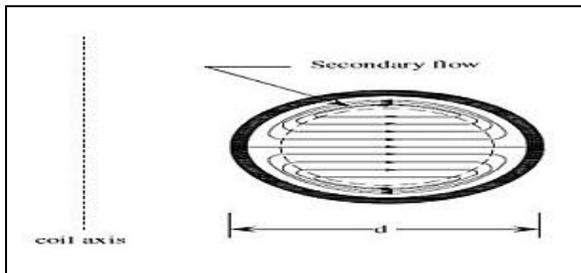


Figure 1.8 Secondaryflows in the cross-section of the coiled capillary tube

1.3 Refrigerants

The most recent decade has seen radical changes in the choice and utilization of refrigerants, chiefly in

light of the natural issues of 'gaps in the ozone layer' and 'a dangerous atmospheric deviation or nursery impact'. Beforehand there had not been much talk about the decision of refrigerant, as the larger part of uses could be met by the outstanding and all around tried liquids, R11, R12, R22, R502 and smelling salts (R717).

Nano Fluids as Refrigerants

In 1995, Stephen Choi presented the term nanofluid as a promising warmth exchange liquid. Nanofluid is a strong fluid blend that comprises of nanoparticles and a base fluid. Because of little sizes and vast particular surface regions of the nanoparticles, nanofluids have unrivaled properties like high warm conductivity, negligible obstructing in stream sections, long haul strength, and homogeneity.

II-LITERATURE REVIEW

2.1 Investigation of various geometries of capillary tube

The impacts of different geometries of fine tubes had been explored by numerous specialists. Their investigations depended on the curl measurements and lengths alone, no specific consideration had been put on the impact of loop pitch.

At introduce no data is accessible about the impacts of serpentine-wound narrow tubes on icebox execution. Mutalubi Aremu Akintunde et al reviewed the influences of fields of both helical as well as serpentine-snaked slim tubes on the implementation of a vapor pressure refrigeration outline. He originates the consequences that, on justification of helical-curled geometries the pitch has no enormous influence on the outline implementation yet the circlet distance crossways as of now expected by frequent scientists. On justification of winding geometries both pitch as well as physique impact the framework execution. Execution increments with both increment in the pitch and the tallness.

In little refrigeration and aerating and cooling frameworks, one of the generally utilized development gadgets to control the stream rate of refrigerants is the slender tube. This is a straightforward container of few millimeter inward widths, normally running between 0.5 to 2 mm (Stoecker and Jones 1982). In spite of the fact that the gadget needs dynamic capacity (mechanical or

electrical) to effectively conform to any sudden change in the heap conditions, it is still being used because of its straightforwardness, ease and prerequisite of low blower beginning torque (Kim et al. 2002).

The required length of slender tube depends generally on the measure of the framework. The required length has detailed by Wei et al. (2001) for little refrigeration frameworks, ranges from 400 to 2,500 mm. In the event that this length is to be kept straight in any application (that is establishment), a ton of room would be required. Subsequently, the capillary tubes are regularly collapsed in different designs, in order to lessen the required space. There are broad information for adiabatic slim tubes and solid graphs. A portion of these can be found underway of Bittle et al. (1998), ASHRAE (1994), Akintunde (2004a) and Kim et al. (2002). Since the narrow tube is to be collapsed so as to diminish the required space, there is the need to consider the impact of capillary tube geometry on the execution of refrigeration frameworks. Wei et al. (2001) examined the AUJ.T. 11(1): 14-22 (Jul. 2007) execution of fine tubes for R-407C refrigerant. In their examination a sum of nine slender tubes were tried.

The fine tubes comprised of straight and curled setups. Their outcome was contrasted and the relationships proposed by Bittle et al. (1998) and ASHRAE (1994). The geometry of the fine tubes utilized by Wei et al. (2001) are: length (1,000 mm), inside width (1.0 mm) and two snaked measurements of 52 and 130 mm. Looking at the stream rate of the wound arrangement with that of straight capillary tube, for a similar gulf and out let weights, tube distance across and length, the mass stream rate diminishes with diminish in looped measurement.

Akintunde (2004b) revealed the execution of R-12 and R-134a in slender tubes for refrigeration frameworks. In his work, fifty-eight (58) slender containers of various geometries (50 straights and 8 snaked) made of copper-tubes were utilized. The straight tubes were frequently unique lengths (ranges from 1.53 to 2.63 m) and five diverse inward distances across (ranges from 0.72 to 1.62 mm), while the snaked ones were of two straight lengths (1.53 and 2.03 m) with four distinctive looped measurements (50, 100, 150 and 200 mm) yet of the same inner breadth of 1.62 mm. It was appeared in his outcomes that a narrow container of length 2.03

m with tube width at the very least 1.1 mm and wound distance across of no less than 1000 mm could be utilized for little refrigeration frameworks of limits extending between 8 to 12 kW. His outcomes likewise demonstrated that mass stream rate diminishes with curl distance across.

From the above writing audit it is reasoned that on account of helical-curved geometries the pitch has no critical impact on the framework execution yet the loop breadth has. In light of the stream rate of the looped setup with that of straight fine tube, for a similar delta and out let weights, tube width and length, the mass stream rate diminishes with diminish in curled distance across

2.2 Selection of refrigerant:

S. M. Sami et al. (2003) tentatively explored the execution of new elective refrigerant blends, for example, R-410A, R-507, R-407C, and R-404A under different states of attractive field. The test outcomes were acquired utilizing an air-source warm direct set-up with upgraded surface tubing under different attractive field conditions. Execution tests were led by the ARI/ASHRAE Standards.

The test outcomes showed that as attractive field constrain builds, blower head weight and release temperature marginally increment and also less fluid refrigerant is bubbling in the blower shell. This has a constructive outcome in securing the blower. The impact of attractive field on blend conduct shifts starting with one blend then onto the next relying on the blend's structure and its breaking point. Besides, the utilization of attractive field seems to affect the framework COP and in addition warm limits of condenser and evaporator.

Hiralal Sachdev et al. (2004) completed test examination alongside vitality investigation of vapor pressure refrigeration cycle for R-22 and its substitute refrigerant R407C, R410A and R417A has been done by differing evaporator temperature between - 38 °C to 7°C and condenser temperature between 35 °C to 60°C, with the assistance of Engineering Equation Solver (EES). The parametric examination, for example, coefficient of execution, volumetric cooling limit, weight proportion, exergy decimation proportion, exergetic proficiency, and productivity imperfection in singular segments for R-22, R-407C, R-410A and R-417A have been completed

hypothetically and have been contrasted and the trial accessible information.

The outcomes show that dissipating and gathering temperatures have articulated impact on exergy devastation noticeable all around conditioner parts, for example, blower, condenser, and throttle valve where as in the evaporator it is unimportant. The exergetic productivity and COP of the cycle change to vast degree with the variety in evaporator and condenser temperatures. The computational investigation has permitted the assurance of the best vivacious and exergetic exhibitions of R-22 and its substitute refrigerant R-407C, R410A and R417A.

Bansal and Rupasinghe has likewise built up an experimental model for measuring slender tubes. This paper introduces an exact model that has been created to estimate adiabatic and non-adiabatic fine tubes for little vapor pressure refrigeration frameworks, specifically, family iceboxes and coolers. The model depends on the supposition that the length of a narrow tube is reliant on five essential factors, to be specific the capillary tube internal distance across, the mass stream rate of the refrigerant in the fine tube, the weight distinction between high side and low side, the refrigerant sub cooling at slender channel and the relative harshness of the fine tube material. The model is approved with past investigations over a scope of working conditions and is found to concur sensibly well with the exploratory information for HFC I34a.

Bansal and Rupasinghe have displayed a homogeneous two-stage stream show, CAPIL, which is intended to ponder the execution of adiabatic slim tubes in little vapor pressure refrigeration frameworks, specifically family unit iceboxes and coolers. The model depends on the principal conditions of preservation of mass, vitality and force that are explained at the same time through iterative methodology and Simpson's run the show. The model uses exact relationships for single-stage and two-stage erosion factors and furthermore represents the passage impacts. The model incorporates the impact of different plan parameters, to be specific the tube distance across, tube relative unpleasantness, tube length, level of subcooling and the refrigerant stream rate. The model is approved with before models over a scope of working conditions and is found to concur sensibly well with the accessible test information for HFC-134a.

Wongwises et al. introduced hypothetical examination of the stream attributes of numerous sets of Refrigerants coursing through adiabatic fine tubes. The two-stage stream display created depended on homogeneous stream suspicion. Two-stage grinding factor was resolved from Colebrook connection. The consistency demonstrate was likewise in view of the suggestions from the past writing. For all sets, numerical outcomes demonstrated that the customary refrigerants reliably gave bring down weight drops for both single-stage and two-stage stream than the ecologically satisfactory elective refrigerants which brought about longer tube lengths.

Wongwises and Pirompak have contemplated the stream attributes of unadulterated refrigerants and refrigerant blends in adiabatic capillary tubes and this paper gives the aftereffects of reenactments utilizing an adiabatic fine tube as a refrigerant control gadget in refrigerating frameworks. The created model can be considered as a successful apparatus of slender tubes' plan and streamlining for frameworks utilizing more up to date elective refrigerants.

The model is approved by contrasting and the trial information of Li et al. what's more, Mikol for R12 and Melo et al. for R134a. Specifically, it has been conceivable to look at different sets of refrigerants. It is discovered that the regular refrigerants reliably give longer slender lengths than the elective refrigerants. For all combines, the ordinary refrigerant reliably gives bring down weight drops for both single-stage and two-stage stream which brought about longer tube lengths. Also, a case of slender tube choice diagram created from the present numerical reproduction is appeared. The diagram can be for all intents and purposes used to choose the fine tube estimate from the stream rate and stream condition or to decide mass stream rate straightforwardly from a given fine tube size and stream condition. The aftereffects of this investigation are of mechanical significance for the effective plan when frameworks are allocated to use different elective refrigerants.

In the writing Sami et al, clarified the trial information acquired on narrow tube conduct, utilizing different new choices under various geometrical parameters will be displayed and broke down. Slim geometrical parameters will incorporate length, distance across, and additionally entrance conditions. The outcomes obviously demonstrated

that the weight drop over the slim tube is essentially affected by the breadth of the fine tube, channel conditions to the capillary and refrigerant compose. The information exhibited that the capillary weight drop diminishes with the expansion of the narrow distance across and that options when all is said in done experience higher weight drop than that of R-22.

Zhang and Ding in light of estimated logical arrangements of adiabatic fine tube is important for hypothetical examination and designing figuring. In this work, two sorts of inexact expository arrangements of adiabatic slim tube have been created. One is the express capacity of fine tube length. Another is the express capacity of refrigerant mass stream rate. In these arrangements, the stifled stream condition is considered without iterative counts. The inexact expectations are found to concur sensibly well with exploratory information in open literary works.

Akure et al. has talked about the impacts of different geometries of narrow tubes had been explored by numerous analysts. Their investigations depended on the loop distances across and lengths alone, no specific consideration had been set on the impact of curl pitch. At show no data is accessible about the impacts of serpentine-curved slender tubes on icebox execution. This examination inspected the impacts of pitches of both helical and serpentine-curved slim tubes on the execution of a vapor pressure refrigeration framework. A few slim containers of equivalent lengths (2.03 m) and changing pitches, snaked breadths and serpentine statures were utilized. Both bay and outlet weight and temperature of the test area (slender tube) were estimated and used to assess the coefficient of execution (COP) of the framework. The outcomes demonstrate that, on account of helical-wound geometries the pitch has no noteworthy impact on the framework execution yet the loop width as of now anticipated by numerous scientists. On account of serpentine geometries both pitch and stature influence the framework execution. Execution increments with both increment in the pitch and the tallness. Connections were proposed to portray connections amongst straight and looped narrow tube and between helical-snaked and serpentine-curved capillary tubes. The coefficient of connections is: 0.9841 for mass stream rates of helical and serpentine with straight tubes; 0.9864 for

comparing COPs and 0.9996 for mass stream rates of serpentine and helical-snaked tube.

Khan et al. have likewise built up a numerical model course through an adiabatic winding narrow tube. An expository model has been created to anticipate the length of adiabatic fine tubes utilized as a part of household iceboxes and low-limit private aeration and cooling systems. The model predicts the length of two kinds of tubes—straight and winding adiabatic capillary tubes. The proposed display depends on the homogenous two-stage stream demonstrate, which predicts the length of the adiabatic capillary tubes as an element of refrigerant mass stream rate, narrow tube distance across, level of sub cooling at slim delta, inner surface harshness, and the pitch of the Archimedean winding. The presence of sub cooled fluid at the section of the slim tube requires the calculation of single-stage and afterward two-stage lengths of the tube.

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