



INFLUENCE OF NANO EFFECT ON VAPOUR COMPRESSION REFRIGERATION SYSTEM (VCRS) IN U TYPE SERPENTINE TUBE CONDENSER

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Abstract:

Nano fluids are a new class of fluids engineered by dispersing nanometre –sized materials (nanoparticles, nano fibers, nano tube, nano wire, nano rods, nano sheet, or droplets) in base fluids. Flow condensing experiments for refrigerant R-134a and R-404a mixed with nano fluid in serpentine small diameter U-tube will be calculated. In this work Refrigerant properties like Co efficient of Performances, Refrigerant Effect, Overall heat transfer co efficient will calculate for air cooled condenser and the result is going to compared with serpentine tube condenser. Nano fluids normally enrich the heat transfer and pressure drop characteristics of a refrigeration system. In serpentine tube condenser refrigerant is flowing inside tube and outside the tube Nano fluid passing to improve the Co-efficient of Performances (COP), Refrigerant Effect (RE), Heat Transfer Co-efficient and Pressure Drop Characteristics. Based on the data's obtained the characteristic curves will be drawn which show the efficiency of refrigeration System. Different Refrigerant test will be carried out based on the mass fraction and the will be compared to the existing setup.

Key Words: Nano Fluids, Co Efficient of Performances & Refrigerant Effect

1. Introduction:

The distinction between refrigerator and heat pump is one of purpose more than technique. The refrigeration unit transfers energy (heat) from cold to hot regions for the purpose of cooling the cold region while the heat pump does the same thing with the intent of heating the hot region. The following will focus on refrigeration and make the distinction between refrigeration and heat pumps only when it is essential to the discussion. It should be pointed out that any heat engine cycle, when reversed, becomes a refrigeration cycle, because the cyclic integral of the heat transfer, and thus the net work, becomes negative. This implies heat rejection at higher than the lowest cycle temperature. The vapor compression refrigeration system is the mainstay of the refrigeration and air conditioning industry. Absorption refrigeration provides an alternative to the vapor compression approach, particularly in applications where a heat source is economical and readily available. This chapter considers both of these system types in turn, and closes with a discussion of moist air behavior and its influence on air conditioning system design

Refrigeration: Refrigeration can be defined as the process of removing heat from a substance under controlled conditions. It is also defined as the process of reducing and maintaining the temperature of a body below the general temperature of its surroundings.

Kelvin –Planck 'S Statement: It is impossible to construct an engine working in a cyclic process, whose sole purpose is to convert heat energy from a single thermal reservoir into an equal amount of work.

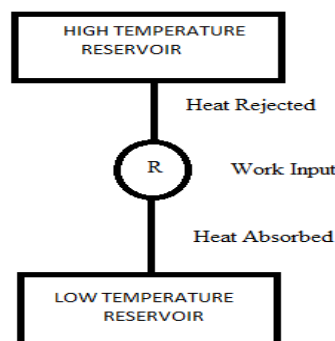


Figure 1: Schematic Representation of Kelvin Planck Statement

Clausius Statement: It is impossible for a self-acting machine working in cyclic process, to transfer heat from a body at lower temperature to a body at a higher temperature. A cyclic refrigeration plant according to second Law of Thermodynamics is shown above.

Nanofluid: Nanofluids are a new class of fluids engineered by dispersing nanometre –sized materials

(nanoparticles, nanofibers, nanotube, nanowire, nanorods, nanosheet, or droplets) in base fluids. In other words, nanofluids are nanoscale colloidal suspensions containing conducted considered nonmaterials. They are two phase systems with one phase (solid phase) in another (liquid phase). Nanofluids have been found to possess enhanced thermo physical prosperities such as thermal conductivity, thermal diffusivity, viscosity, and convective heat transfer coefficients compared to those of base fluids like oil or water. It has demonstrated great potential applications in many fields.

Preparation Methods for Nano Fluid: Two step methods is the most widely used method for preparing nanopfluids. Nanoparticles, nanofibers, nanotubes, or other nonmaterials used in this method are first produced as dry powers by chemical or physical methods. Then, the nanosized powder will be dispersed into a fluid in the second processing step with the help of intensive magnetic force agitation, ultrasonic agitation, high-shear mixing, homogenizing, and ball milling.

2. Related Works:

Arijit Kundu, Ravi Kumar [1] The experimental investigation on two phase flow evaporative heat transfer of refrigerants R134a and R407C in a smooth copper tube inclined at five different angles between 0 and 90 was conducted. The experimental heat transfer coefficients were also compared with some existing correlations. Bartosz Dawidowicz, Janusz T. Cieslin ski [2] the experimental stand and procedure for flow boiling investigations are described. Experimental data for pure R22, R134a, R407C and their mixtures with polyester oil FUCHS Reniso/Triton SEZ 32 in a tube with porous coating and smooth, stainless steel reference tube are presented. Correlation equation for heat transfer coefficient calculation during the flow boiling of pure refrigerants inside a tube with porous coating has been proposed. Boissieux.X, M.R. Heikal [3] This paper presents experimental heat transfer results obtained during the evaporation of, R407C and R404A in a horizontal tube. The results have been compared with existing correlations which characterise the evaporative heat transfer coefficient to assess the validity of these models for refrigerant mixtures. The modified Kattan model over a good prediction of the heat transfer results, with a standard deviation of 6.1%. Chang.Y.S, M.S. Kim [4] Performance of a heat pump system using hydrocarbon refrigerants has been investigated experimentally. Single component hydrocarbon refrigerants (propane, isobutane, butane and propylene) and binary mixtures of propane/ isobutane and propane/butane are considered as working fluids in a heat pump system. Some hydrocarbon refrigerants have better performance characteristics than R22.

Problem Definition: Global warming and ozone depletion has now become the major concerns in selecting refrigerants for refrigeration and air conditioning equipments. Chlorine containing fluorinated alkalises have a successful association with refrigeration industries. These fluorinated alkalise lead to the damage of ozone layer. Power consumption is found to be high for the existing refrigerant mixtures, which is also a major concern. Heat transfer in the air cooled condenser tube is less and this adversely affects the heat transfer coefficient, refrigeration effect and COP of refrigeration system.

Experimental Method: The experimental apparatus consisted of compressor, condenser, expansion valve and evaporator. The system also consists of two main flow loops: a refrigerant loop and heat source water for condensing loop. The heat exchanger (test section) is shown in the outer and inner diameter of the inner tube (copper) is 6.35 mm, 8 mm, and outer and inner diameters of the outer tube (copper) are 12.7 mm and 14 mm respectively. The experiment was performed on steady state after conditions control, temperature at the evaporator is the only parameter varied with respect to time. All the observations are taken for the corresponding temperature drop rate at the evaporator. In this paper, we used R-134a (tetrafluoro ethane) and R-404a (Pentafluoroethane/1, 1, 1-Trifluoroethane/1, 1, 1-Tetrafluoroethane (44/52/4% by weight)) as working fluids. To examine the condensation heat transfer characteristics, the data (temperature of refrigerant, heat source water and outer wall) are measured at the heat exchanger. In addition the pressure between inlet and outlet of heat exchanger are measured as well. Validating parameters are shown below.

Compressor: Different types of compressors used for compression of refrigerants are mainly classified into two groups

- ✓ Positive displacement compressor (Reversible of flow within the machine will be obtained by valves etc.)
- ✓ Non positive displacement compressor (No reversible of flow of fluid)

Condenser: The heat of the refrigerants is rejected in the condenser in the vapour compression refrigeration machine. The vapour at discharge from the compressor is superheated. Re-superheating of the vapour place in the discharge line and in the first few coils of condenser.

Evaporator: Evaporator is an important device used in the low pressure side of the refrigeration system in the evaporator heat removed from air, water or any other body required to be cooled by the evaporating refrigerants. The liquid refrigerant from the expansion valve enters into evaporator where it changes into vapour.

Type of Refrigerants Used In Vapour Compression Systems: A variety of refrigerants are used in vapour compression systems. The required cooling temperature largely determines the choice of fluid. Commonly used refrigerants are in the family of chlorinated fluorocarbons (CFCs, also called Freon's): R-11, R-12, R-21, R-22 and R-502.

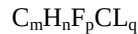
Table 1: Properties of Commonly Used Refrigerants

Refrigerant	Boiling point** (°C)	Freezing point (°C)	Vapour pressure* (m ³ /kg)	Vapour volume* (m ³ /kg)	Enthalpy*	
					Liquid (kJ/Kg)	Vapour (kJ/Kg)
R-11	-23.82	-111.0	25.73	0.61170	191.40	385.43
R-12	-29.79	-158.0	219.28	0.07702	190.72	347.96
R-22	-40.76	-160.0	354.74	0.06513	188.55	400.83
R-502	-45.40	----	414.30	0.04234	188.87	342.31
R-7 (ammonia)	-33.30	-77.7	289.93	0.41949	808.71	487.76

*At -10°C

*At standard atmospheric pressure (101.325 Kpa)

Designation of Refrigerants: The international designation of the refrigerants, uses R (or alternately HC's, HFC's, HCFC's and CFC's as the case) as the designation followed by certain numerals. Thus for a compound derived from a saturated hydrocarbon denoted by the chemical formula.



In which (n+p+q) = 2m+2 and the complete designation is given by, R (m-1) (n+1) (p)

Where,

M – No of carbon atoms

N – No of hydrogen atoms

P – No of fluorine atoms

Q – No of chlorine atoms

Classification of Refrigerants: The refrigerants may broadly classified into two types

- ✓ Primary refrigerants
- ✓ Secondary refrigerants

The refrigerant which directly takes part in the refrigeration system is called primary refrigerants whereas the refrigerant which cooled by the primary refrigerants and then used for cooling purpose is known as secondary refrigerants.

Data Reduction:

Condensation Heat Transfer Coefficient:

$$h = \frac{q}{(T_s - T_w)} \text{ W/m}^2\text{°C}$$

Where,

q- Average heat flux at test section calculated from temperature difference across the test section & flow rate of water.

T_s- Saturation temperature of refrigerants.

T_w- Wall temp.

$$\text{Heat flux, } q = Q_w / \pi D L \text{ W/m}^2$$

Where,

D- Inner diameter of water tube in metres

L- Length of test section in metres

$$Q_w = m_w c_{pw} (T_{w,out} - T_{w,in}) \text{ W}$$

Where,

m_w- flow rate of water Kg/s

T_{w,in} & T_{w,out}- Inlet and Outlet temperatures of water in double tube condenser.

c_{pw}- Specific heat of water KJ/Kg°C

Co-Efficient of Performance:

$$COP = \frac{R_n}{W}$$

Where,

R_n – Net refrigeration effect in KW

W – Work required (or) work done in KW

Compressor Work Required:

$$\frac{E_f - E_o}{t} \text{ KW}$$

Where,

E_f - Final energy meter reading in KWh

E_o - Initial energy meter reading in KWh

t - Time in hours

Results:

Result of R134a

Table 2: Result R134a

Temp p	Condenser Outlet (bar)	Evaporator outlet (bar)	Time in Sec	Power Consumed (KW/hr)	Refrigeration Effect (KW)	Energy Input (KW)	CO P
17	15.6	2.6	36	6.71	1.39	1.00	1.39
15	16.2	2.7	199	6.75	0.38	0.91	0.42
13	16.8	2.75	148	6.78	0.68	1.98	0.34
11	17.1	2.78	182	6.81	0.69	2.18	0.32
9	16.3	2.5	423	6.90	0.36	1.70	0.21
7	16.8	2.3	435	6.98	0.40	2.32	0.17
5	16.9	2.2	385	7.05	0.52	3.27	0.16
3	17	2.1	502	7.13	0.45	3.08	0.15
1	17.05	2.1	571	7.17	0.44	2.96	0.15
-1	15.8	2.1	2400	7.41	0.11	1.07	0.11

Table 3: Result of R404a

Temp °C	Condenser Outlet (bar)	Evaporator outlet (bar)	Time in Sec	Power Consumed (KW/hr)	Refrigeration Effect (KW)	Energy Input (kw)	CO P
27	10.09	1.8	52	7.08	0.48	1.80	0.27
25	11.1	1.86	78	7.09	0.64	1.85	0.35
23	11.18	1.9	70	7.10	1.08	2.74	0.39
21	11.35	2	68	7.12	1.47	3.79	0.39
19	12	2.05	83	7.14	1.51	3.91	0.39
17	12.1	2.1	88	7.15	1.71	4.24	0.40
15	12.2	2.1	80	7.17	2.20	5.59	0.39
13	12.9	2.1	75	7.19	2.68	6.72	0.40
11	13	2.1	79	7.21	2.84	7.25	0.39
9	13.1	2.1	92	7.23	2.73	7.14	0.38

Table 4: Result of R404a/Al₂O₃

Temp °C	Condenser Outlet (bar)	Evaporator outlet (bar)	Time in Sec	Power Consumed (KW/hr)	Refrigeration Effect (KW)	Energy Input (kw)	CO P
28	19.95	1.55	185	8.49	0.14	0.68	0.20
26	20.1	1.62	199	8.52	0.25	1.32	0.19
24	20.85	1.68	212	8.57	0.35	1.97	0.18
22	21	1.95	208	8.61	0.48	2.70	0.18
20	21.15	2	268	8.66	0.47	2.81	0.17
18	21.9	2.05	269	8.71	0.56	3.53	0.16
16	22.1	2.1	326	8.78	0.54	3.64	0.15
14	22.93	2.15	367	8.85	0.55	3.95	0.14
12	23.2	2.45	422	8.94	0.53	4.16	0.13
10	24	2.5	448	9.04	0.56	4.71	0.12

Model Calculations:

Table 5: Result of R134a

Operating Conditions:	
Evaporator outlet/evaporator inlet	2.6 bar
Compressor outlet/condenser inlet	15.6 bar
Water inlet temperature (T _o)	30 °C
Final temperature of water (T _f)	28°C
Amount of water taken (W)	3 kg
Time taken t	9 sec
Energy meter initial reading (E _o)	6.7 KWh/hr
Energy meter final reading (E _f)	6.71 KWh/hr
Refrigeration effect	$W \cdot 4.18(T_o - T_f) / (t \cdot 60) = 1.39 \text{ KW}$
Energy Input	$E_f - E_o / t = 1 \text{ KW}$
Actual COP	Refrigeration effect/Energy Input = 1.39/1
COP	1.39

Table 6: Result of R404a

Operating Conditions:	
Evaporator outlet/evaporator inlet	2.6 bar
Compressor outlet/condenser inlet	15.6 bar
Water inlet temperature (T_o)	30 °C
Final temperature of water (T_f)	28°C
Amount of water taken (W)	3 kg
Time taken t	9 sec
Energy meter initial reading (E_o)	6.7 KWh/hr
Energy meter final reading (E_f)	6.71 KWh/hr
Refrigeration effect	$W*4.18(T_o-T_f)/(t*60) = 1.39KW$
Energy Input	$E_f-E_o/t = 1KW$
Actual COP	Refrigeration effect/Energy Input = 1.39/1
COP	1.39

Table 7: Result of R404a/ Al_2O_3

Operating Conditions:	
Evaporator outlet/evaporator inlet	1.55 bar
Compressor outlet/condenser inlet	19.95 bar
Water inlet temperature (T_o)	30°C
Final temperature of water (T_f)	28°C
Amount of water taken (W)	3 kg
Time taken t	185 sec
Energy meter initial reading (E_o)	8.45 KWh/hr
Energy meter final reading (E_f)	8.49 KWh/hr
Refrigeration effect	$W*4.18(T_o-T_f)/(t*60) = 0.14KW$
Energy Input	$E_f-E_o/t = 0.68KW$
Actual COP	Refrigeration effect/Energy Input = 0.14/0.68
COP	0.20

Comparison of Refrigeration Effect & Co-Efficient of Performance:

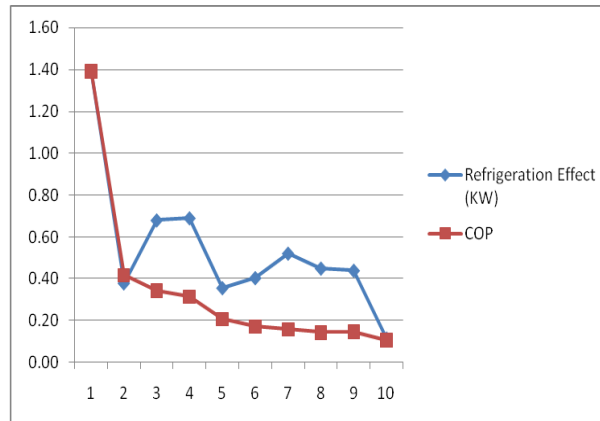


Figure 2: Comparison of refrigeration effect and COP of R134a

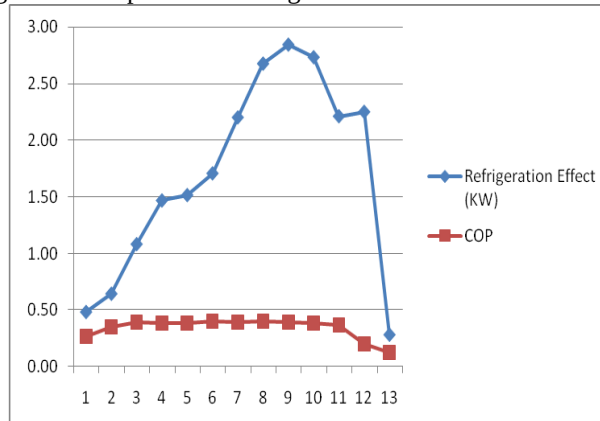


Figure 2: Comparison of Refrigeration Effect and COP of R404a

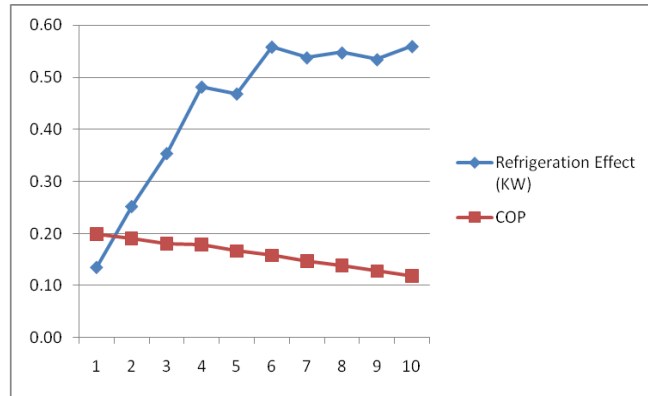


Figure 3: Comparison of refrigeration effect and COP of 404a/AL₂O₃

Comparison of Co-Efficient Of Performance & Time:

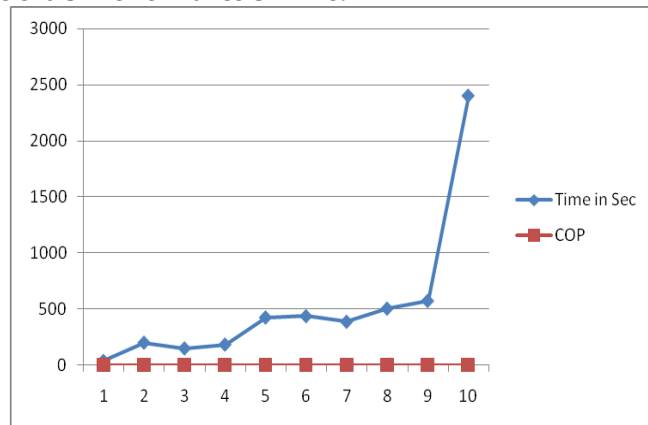


Figure 4: Comparison of time and COP of R134a

Comparison of Time and COP R404a:

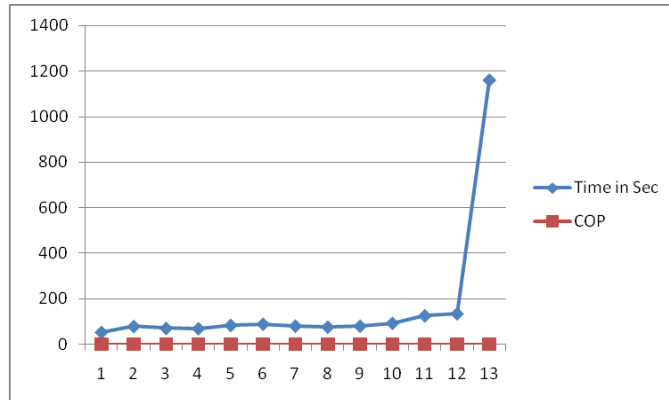


Figure 5: Comparison of time and COP R404a

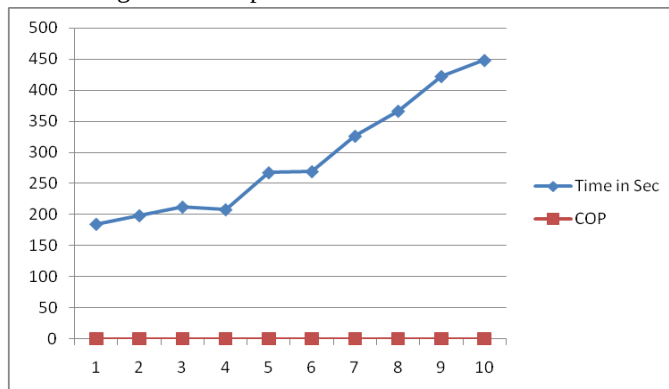


Figure 6: Comparison of time and COP of R404a/AL₂O₃

Comparison of Energy Input & Co-Efficient Of Performance:

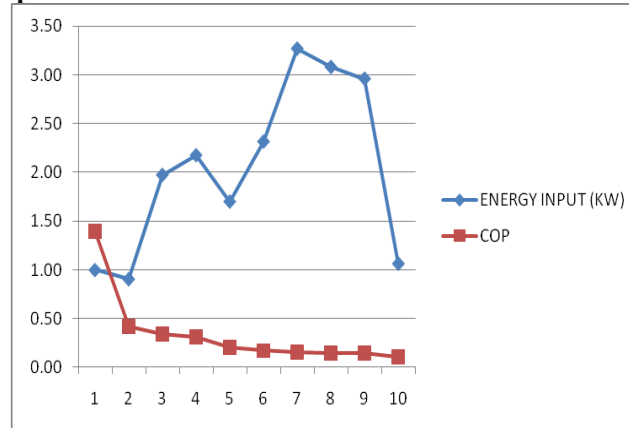


Figure 7: Comparison of energy input and COP of R134a

Comparison of energy input and COP R404a:

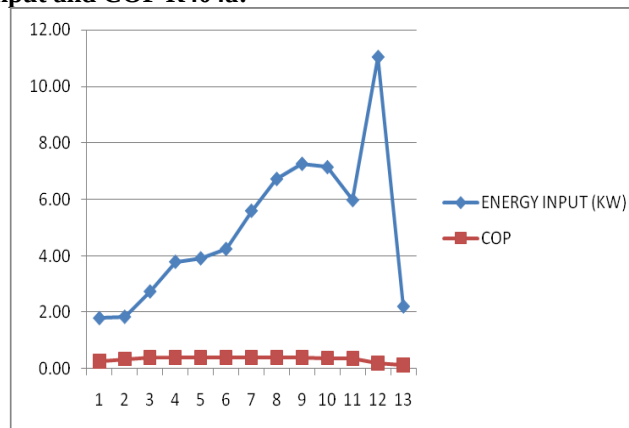


Figure 8: Comparison of energy input and COP R404a

Comparison of energy input and COP of R404a/AL2O3:

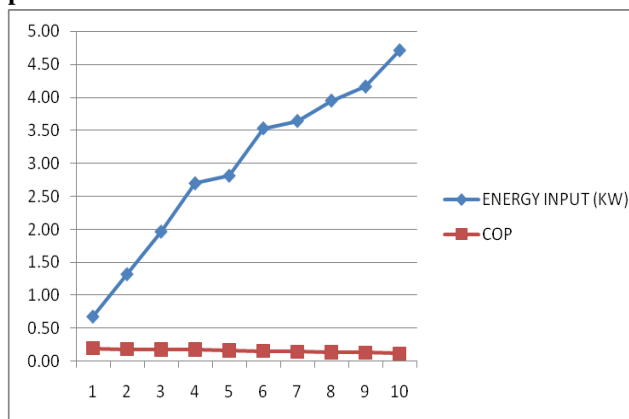


Figure 9: Comparison of energy input and COP of R404a/AL2O3

Specifications of Refrigeration System (Existing):

Compressor	-	1/8 HP reciprocating compressor
Condenser	-	Fin type condenser
Expansion devices-		Capillary tube diameter (0.036 inches)
Expansion devices-		Capillary tube Length-10 feet
Evaporator	-	Coil diameter- ¼ inch length
Evaporator	-	Length 11 feet
Evaporator	-	4 litres flask capacity
Heat exchanger	-	2 feet
Refrigerant used	-	R134a (80 gm)

Experimental Readings in Double Tube Condenser

Working fluid	R134a, R404a
Evaporating temperature (K)	30°C to -3°C
Inner tube diameter (mm)	6.35mm
Mass of refrigerant used	80gms
Chilled water	
Inlet temperature (K)	30°C
Mass flow rate (kg/h)	164-170kg/h
Nano Fluid	Al ₂ O ₃ , SiO ₂

5. Conclusion:

In this work water cooled condenser is used instead of air cooled condenser with nano fluids to enrich the process parameter of a Refrigeration system. To conduct the experiments setup will be fabricated with required parameters, based on the design fabrication work started. In the future work different Nano fluids is used as a coolant instead of water and analyzed then will be obtained results will compare with existing setup. Characteristics curves plotted based on the obtained values. The performance of the refrigeration system will be calculated. The optimum weight percentages of nano fluid concentration will be finalized.

6. References:

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