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CFDANALYSISOFEVAPORATORUSEDINDOMESTICREFRIGERATIONWITHR30-R160MIXTURE

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ABSTRACT

An evaporator is a device in a process used to transform the liquid form of a chemical material such as water into its gaseous-form/vapor. During this procedure, the liquid is vaporized, or evaporated, into a gaseous form of the target ingredient.In this study, an evaporator model created in CATIA software and analyzed in ANSYS software using an AZEOTROPIC combination of R30 and R160 is employed in a refrigeration unit with varying flow rates, with R160 concentrations of 0, 20, 40%, 60%, 80%, and 100% in R30.

Higher flow rates of the refrigerant mixture increase heat transfer rates in this thesis' analysis, but at the expense of increased work consumption, which will affect the performance coefficient of the refrigerant unit. This is not recommended because the work utilization of a good refrigeration unit should be lower for a refrigeration unit. Heat transfer coefficient, mass flow rate, heat transfer rate, pressure drop and velocity at varied mass flow rates (1, 1.5 and 2kg/s).

Keywords: Refrigerants, evaporator, and CFD analysis are all included.

INTRODUCTION

Dehumidification and heat extraction are the primary functions of an Air Conditioner (also known as an AC), a common household device. Simple refrigeration cycles are used for cooling. The term "HVAC" refers to a system or unit that includes heating, ventilation, and air conditioning. When it comes to a structure or an automobile, it serves to keep the occupants cool or warm, depending on the season.

Evaporators are where refrigeration and air conditioning systems get their cooling power. The evaporator is commonly regarded as the most important component of a refrigerator's cooling system, with the other components receiving less attention.

Evaporators are heat exchange surfaces that convey the cooling effect of the refrigerant to the material or space to be cooled, thus eliminating the heat from the space or substance. Many different evaporators can be found because they are employed in so many different operations, such as air conditioning and refrigeration.

Other factors include how air flows around an evaporator's evaporator, how it is constructed, how refrigerant is fed into an evaporator and how it is controlled.

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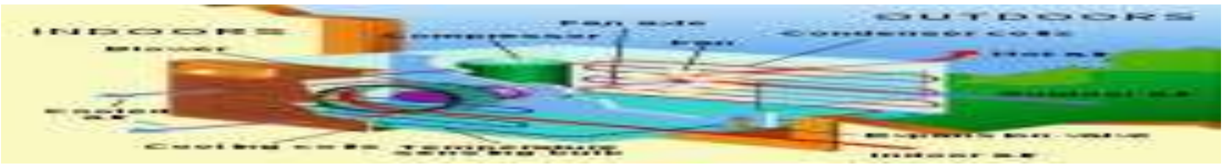


Fig.1.Airconditioningunit

The classification of evaporators or the types of evaporators:

Refrigeration and air conditioning plants employ evaporators to cool water. In such instances shell and tube type of heat exchangers are employed as the evaporators. In such plants the evaporators or the chillers are classified as:

Dry expansion evaporators are the most common form of evaporator.

2) Flooded type of the evaporators

LITERATURESURVEY

1.Effectongeometryofevaporatorcoilforrefrigeratorenhancingefficiencyofheattransfer Professors JH Bhangale and DD Palande have contributed to this article in the following ways: Refrigerant cooling and air conditioning systems use an evaporator as a primary component, which is used in a wide range of refrigeration applications in a variety of industries. A liquid is evaporated and converted to vapor in an air conditioning system's evaporator. The design specifications of the refrigeration cycle's essential components play a critical role in absorbing heat during the operation. The goal of this study is to determine how the shape of the evaporator coil affects the performance of the refrigerator. Methodology is typically used to investigate the evaporator's cross section and the fitting method, such as grooved construction. A typical miniature prototype will be used to demonstrate the improvement of the findings obtained by the application of CFD methodology.

2.CFDanalysisoftube-fin'no-frost'evaporatorsBYJaderR.Barbosa,Jr.I;ChristianJ.L.HermesII;CláudioMeloIIIThepurposeofthispaperistoassesssomeaspectsofthedesignofevaporatorsforhouseholdrefrigeration appliancesusing ComputationalFluid Dynamics(CFD). The evaporators under study are tube-fin 'no-frost' heatexchangerswithforcedconvectionon theair-sideanda staggeredtube configuration. The calculationmethodology was verified against experimental data for the heat transfer rate, thermal conductance and pressure dropobtainedfortwoevaporatorswithdifferent geometries.Theaverageerrorsoftheheattransferrate,thermalconductanceand pressuredropwere10%,3%and 11%,respectively.

3.CFD Analysis of VARS Component (Evaporator) on ANSYS FluentBY Ajay Pawar , Ajay Ekka, AnmolPagariaArjunParmar,BhupeshChouhanThe exhaust from an internal combustion engine is used as a power source to develop and analyze an ammonia water absorption refrigeration system. An AC system that can handle up to 1 tonne of refrigeration capacity will replace the current system in automobiles. Fundamental thermodynamic principles inform the design. The enthalpy parameters at various locations in the system are used in the design of the evaporator. Analyses of the data are made utilizing the thermodynamic rules of first and second order. Solid Edge cad software is used to model the system, while ansys fluent is used for analysis. There is a 10.7 bar difference between the condenser and evaporator pressures in this system. The physic-chemical process uses ammonia as the refrigerant and water as an absorbent.

EVAPORATORDIMENSIONS

Tubelength=500mm,Tubeinside=9.2mm

Fig.2.2Dmodel

Refrigerant BlendCalculationsFLUIDPROPERTIES

Fluids	Density(kg/m3)	Thermal conductivity(w/m-k)	Specific heat(j/kg-k)	Viscosity (kg/m-s)
R-30	**1326.6 kg/m^3**	**0.0042 w/m-k**	**1043.0 j/kg/k**	**0.000279kg/m-s**
R-160	**921.0 kg/m^3**	**0.0337 w/m-k**	**1023.0 j/kg/k**	**0.00043kg/m-s**
Water	998.2 kg/m^3	0.6W/m-k	4182 J/kg-k	0.001003kg/m-s

NOMENCLATURE

the kg/m3 density of water in kilograms per cubic meter is R30
Density in kilograms per cubic meter of mixture kg/m3 kg/m3 R30-R160 kg/m3
CpR30 = R30j/kg-k / kg-k a particular type of heat It is calculated as follows: CpR30 R160 j/kg-k a certain degree of warmth

In kilograms per square meter per second (kg/m-s), the viscosity of R30 is measured.
fig.3.3Dmodel
A viscosity of R160 kg/ms = R160 mix = Viscosity kg/m-s of the mixture Radiant heat capacity (KR30) of R3
W/m-k
KR160 = R160 W/m-k Thermal conductivity Temperature coefficients of R30 to R160, expressed as W/m-k
FORMULAS

PROPERTIES	FORMULA
DENSITY	$\rho_{mix}=\phi\times\rho_{R160}+[(1-\phi)\times\rho_{R30}]$
SPECIFICHEAT	$C_{pmix} = \phi\times\rho R160\times CpR160+(1-\phi)(\rho R30\times CpR30)\phi\times\rho R160+(1-\phi)\times\rho R30$

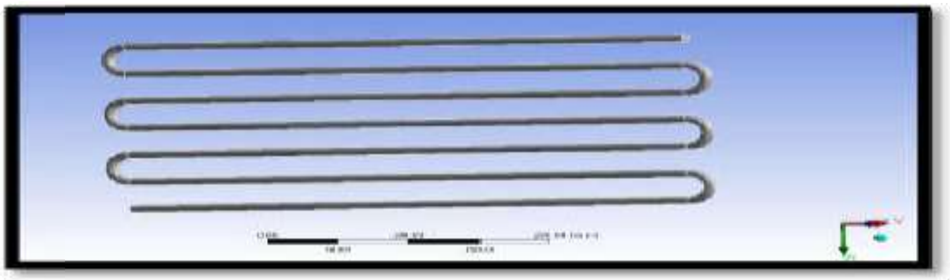
THERMALCONDUCTIVITY	$K_{mix} = \frac{K1+2K2+2(K1-K2)(1+\beta)^3\times\phi}{K1+2K2-(K1-K2)(1+\beta)^3\times\phi} \times k_2$
VISCOSITY	$\mu_{mix}=\mu_{R160}(1+2.5\phi)$

Azeotropicproperties

Volume fraction (ϕ)	Density (kg/m^3)	Specific heat (j/kg-k)	Thermal conductivity (w/m-k)	Viscosity (kg/m-s)
0.2	1245.48	1040.042	0.0076	0.0004185
0.4	1164.36	1036.67206	0.0111808	0.000558
0.6	1083.24	1.32.7972	0.019106	0.0006975
0.8	1002.12	1028.2951	0.038677	0.000837

ModelforMassflowinlet1kg/min

fig.4.Importedmodel



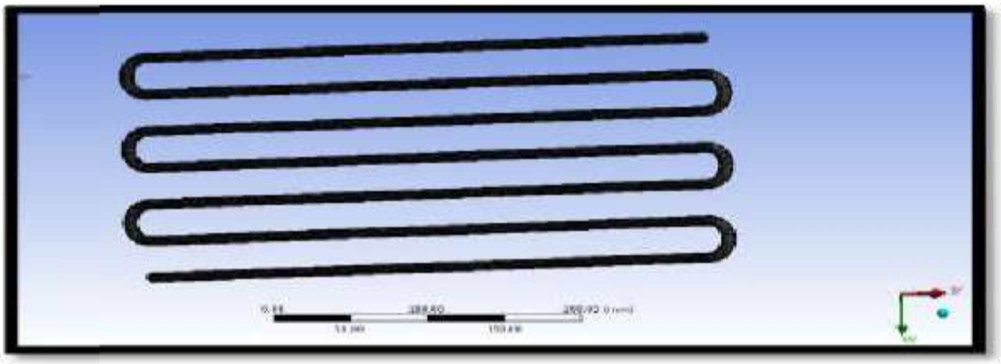
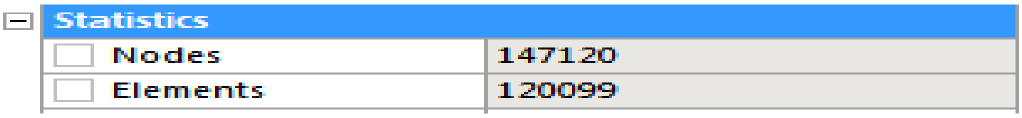


Fig.5.Meshedmodel

No'ofnodesandelements

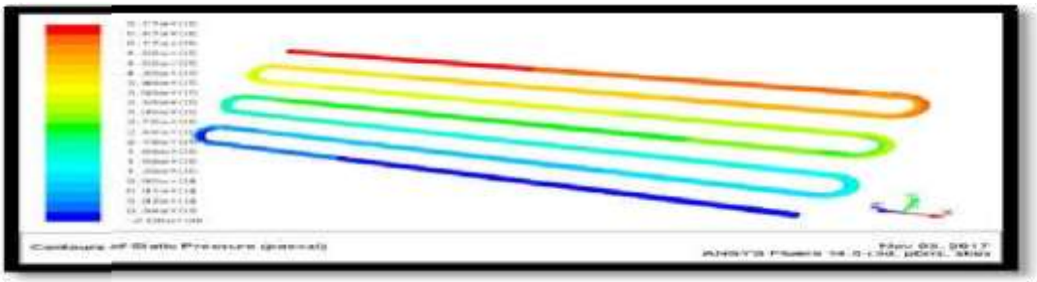
FLUIDR-30



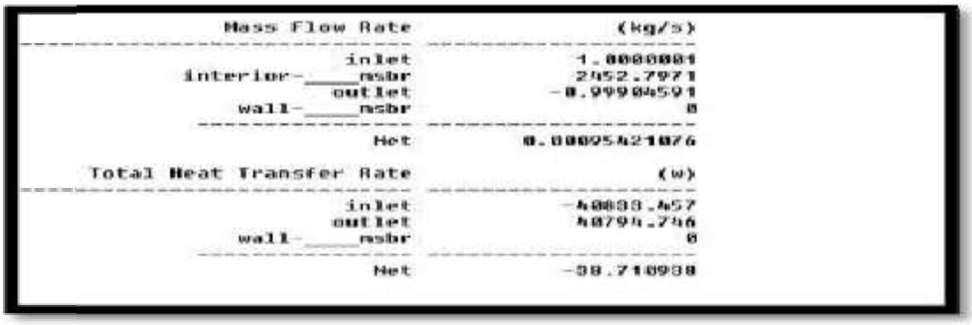
Statistics	
☐ Nodes	147120
☐ Elements	120099

Fig.6.pressure

MassFlowRate&HeatTransferRate



RESULTTABLE:AnalyticalInvestigationMassflowrate1kg/min



```
                  Mass Flow Rate                 (kg/s)
-------------------------------- --------------------
                           inlet              1.0000001
             interior-_____msbr              2452.7971
                          outlet            -0.99904591
                 wall-_____msbr                      0
               ----------------- --------------------
                             Net         0.00095421076

        Total Heat Transfer Rate                    (w)
-------------------------------- --------------------
                           inlet             -40833.457
                          outlet              40794.746
                 wall-_____msbr                      0
               ----------------- --------------------
                             Net             -38.710938
```

Fluid	Pressure (Pa)	Velocity (m/s)	Heat transfer coefficient (w/m^2-k)	Mass flow rate (kg/s)	Heat transfer rate(W)
R-30	5.77e+05	1.43e+01	2.65e+03	0.00095421	38.710938
(Φ= 0.2)	6.61e+05	1.52e+01	3.12e+03	0.0018023252	73.214844
(Φ= 0.4)	7.16e+05	1.63e+01	3.43e+03	0.004491	182.23047
(Φ= 0.6)	8.89e+05	1.75e+01	4.31e+03	0.001823	73.769531
(Φ= 0.8)	9.66e+05	1.88e+01	6.24e+03	0.002842	114.39844
R-160	1.12e+06	2.06e+01	8.19e+03	0.004652	185.85547

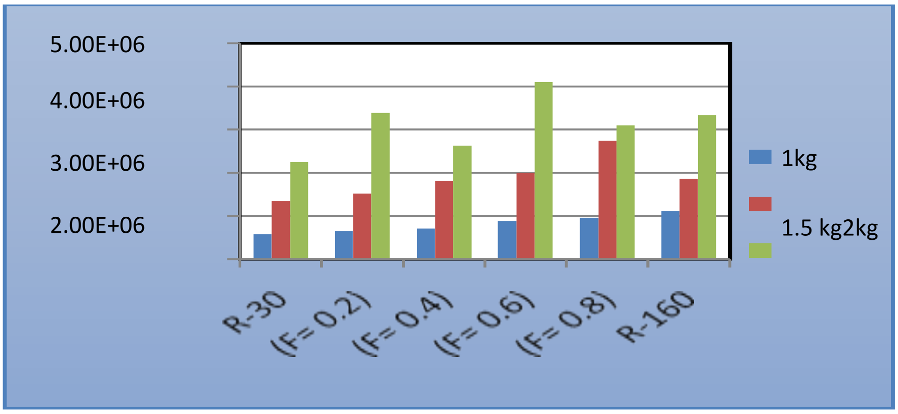
Massflowrate1.5kg/min

Massflowrate2kg/min

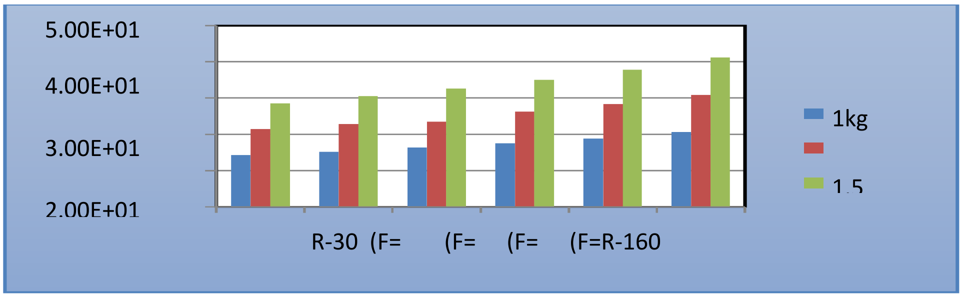
Fluid	Pressure (Pa)	Velocity (m/s)	Heat transfer coefficient (w/m^2-k)	Mass flow rate (kg/s)	Heat transfer rate(W)
R-30	1.34e+06	2.15e+01	3.83e+03	0.0047117	192.57813
(Φ= 0.2)	1.52e+06	2.28e+01	4.49e+03	0.00090575218	36.8984
(Φ= 0.4)	1.81e+06	2.344e+01	4.92e+03	0.0032984	133.6132
(Φ= 0.6)	2.00e+06	2.63e+01	6.19e+03	0.003185482	134.1289
(Φ= 0.8)	2.74e+06	2.84e+01	8.93e+03	0.006955	279.98043
R-160	1.86e+06	3.09e+01	1.17e+04	0.00254344	101.82031

GRAPHS:

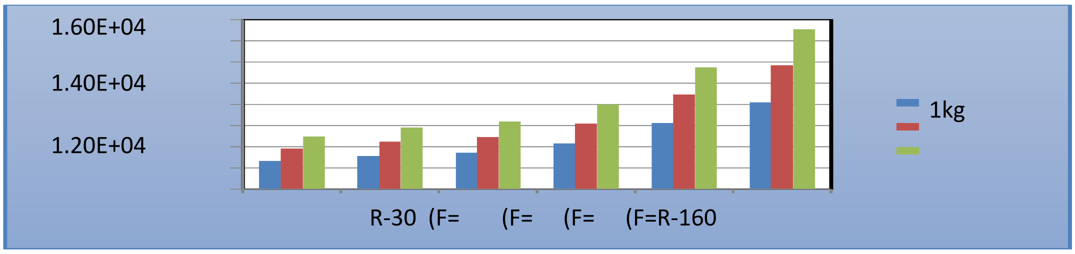
Fluid	Pressure (Pa)	Velocity (m/s)	Heat transfer coefficient (w/m^2-k)	Mass flow rate (kg/s)	Heat transfer rate(W)
R-30	2.25e+06	2.86e+01	4.97e+03	0.0035150051	144.34375
(Φ= 0.2)	3.39e+06	3.05e+01	5.83e+03	0.012027264	489.45313
(Φ= 0.4)	2.63e+06	3.26e+01	6.38e+03	0.00502657	204.19531
(Φ= 0.6)	4.10e+06	3.50e+01	7.99e+03	0.0093023	376.00781
(Φ= 0.8)	3.10e+06	3.78e+01	1.15e+04	0.007047	283.2812
R-160	3.33e+06	4.12e+01	1.51e+04	0.0077912	311.95313



1. **Pressurevsfluids**



2. **Velocityvsfluids**



3. **Heattransfercoefficientvsfluids**

CONCLUSION

Assuming that the other input parameters are held constant, the azeotropic mixture of refrigerant 30 and refrigerant 160 is formed by varying the concentrations of R160 by 0 percent, 20%, 40%, 60%, 80%, and 100% in R30.

With our refrigerant blend, a flow rate of 1.5 kg/min is appropriate and suggested for the refrigeration unit.

A higher R30 concentration mixture consumes more pumping and flow work due to its denser nature, which again decreases the COP of the refrigeration unit, despite the fact that the concentration of R160 in R30 doesn't follow a particular pattern in the heat transfer rates at various flow rates. Corrosion of the evaporator and condenser tubing is also seen at greater R30 concentrations.

Greater doses of R160 appear to be more beneficial than higher amounts of R30. As a result, 20% R30 and 80% R160 is used, which provides higher heat transfer rates and lower work consumption.

Results show that a 20% R30–80% R160 combination at a flow rate of 1.5 kg/min is ideal for the refrigeration unit without compromising the COP of that unit.

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