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Thermal Performance Evaluation of Inserting Inserts in Evaporator Tube Analytically

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Abstract

In this thesis, the main aim is to evaluate the heat transfer performance of tube evaporator by taking inserts. Comparisons are made between the evaporator with external insert and internal insert. The inserts considered are twisted tape inside the tube and wire coils for outside the tube. The effect of varying the Reynolds number is also investigated.3D models are done in Creo 2.0. CFD analysis is done in Ansys. Analysis is performed for two models of tube evaporator twisted tape and wire coil inserts, varying Reynolds number 6000, 8000 for different refrigerants R32, R152A, R600A to determine heat transfer coefficients and heat transfer rates.

I. Introduction

The solvent removal as vapour from a slurry, solid suspension in a liquid or a solution is known as Evaporation

Thermal/ Pocess Design Considerations

Many factors should be rigorously thought-about for design of evaporators. The type of evaporator or heat exchangers, feeding arrangement, forced or natural circulation, heat transfer coefficient, boiling point elevation, tube size, fouling and tube arrangement are all vital.

Tube Details

Tube dimensions are taken from the journal: - Thermal and fluid dynamic performance Of pin fin heat transfer surfacesand calculations are according to NPTEL module#3

II. LITERATURE SURVEY

In the paper by EswaraRao.T [1], R600a as refrigerants in 2 stage vapourcompression cooling system is performed utilizing FEA to work out the rates of heat transfer, mass flow rates and pressure loss and compared for the refrigerants COPs. 3D modeling of the 2 stage vapour compression cooling system is done in CREO. CFD and Thermal Analysis are performed in ANSYS.This work done by Rajni Bunker, Ravi Vishwakarma[4], the operating fluid is nano fluid. Forced convection heat transfer analysis has been meted out in a semifluid tube heat exchanger equipped with spiral coiled inserts utilizing CuO/water as a nano fluid and base fluid as distilled water. Tests has been performed for plain tube and for tube with inserts for the determination of friction factor, heat transfer and thermal performance factor in the Reynolds no. range 4000 to ten thousand and volume concentration from 0.01%, 0.015% and 0.02% of nano fluid at room temperature. The results achieved from the employment of the CuO/water nano fluid and helical coiled inserts, are compared with plain tube with and without inserts.

III. 3D MODELING OF EVAPORATOR

All the dimensions are taken from the "**Finite element analysis to determine performance of two stage vapour**

compression refrigeration system" by EswaraRao.T, International Journal & Magazine of Engineering, Technology, Management and Research, Volume No. 3, Issue No.9 (2016) specified as [1] in References chapter.

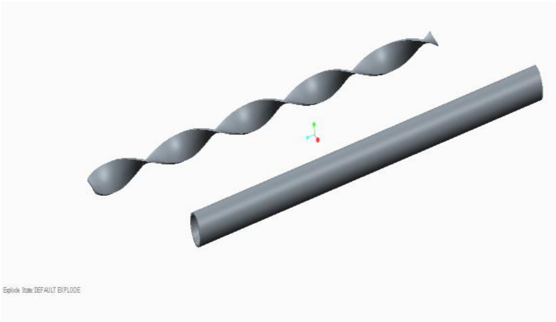

Fig.1. Twisted insert in tube assembly exploded view

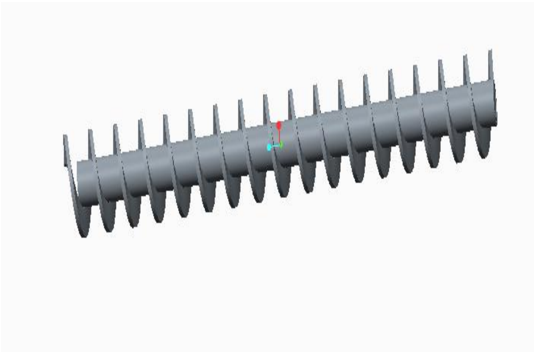

Fig.2. Final assembly of wirecoil on the tube of evaporator

Analysis of Evaporator

Boundary conditions for this work are

All the temperatures and properties are taken from the standard book-**physical properties of refrigerants**

According refrigerant cycle, the fluid enters into evaporator below its boiling temperature and it is applicable for different refrigeration and air-conditioning applications in food and cold storage

Velocity calculations

Re=$\frac{\rho v l}{\mu}$

Where,

Re=Reynolds number

ρ= density

V=velocity

L=length of tube

μ=viscocity

Note:-

These velocities are taken as input to perform CFD analysis

Fluid boundary conditions are taken based on boiling temperature

IV. CFD Analysis of Inserts In Tubes of Evaporator

Refrigerant - r32

Reynolds number – 6000

Tube with wire coil

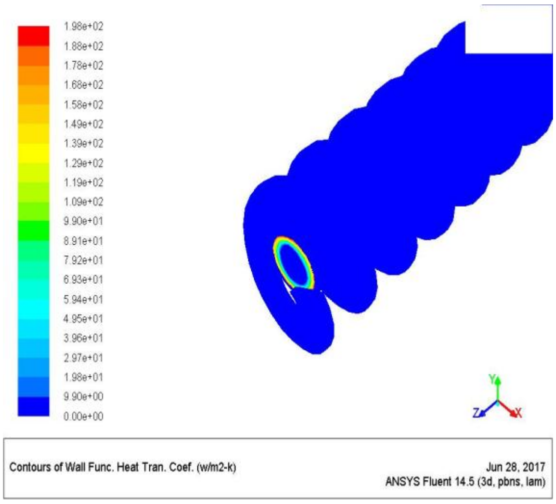

Fig.4. Wall heat transfer coefficient of tube with wire coil with R32 as refrigerant at Reynolds number 6000

Total Heat Transfer Rate	(w)
inlet	-185925.13
outlet	185887.52
wall-16	-36.1884
wall-16-shadow	36.19519
wall-7	35.622936
wall-7-shadow	-35.622955
wall-____msbr	36.166645

Net **-1.4359589**

Tube with Twisted Insert

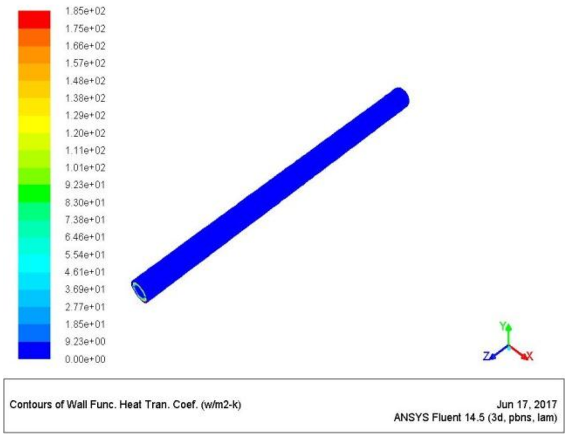

Fig.4. Wall heat transfer coefficient of tube with twisted insert with R32 as refrigerant at Reynolds number 6000

Total Heat Transfer Rate **(w)**

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-

inlet	-185925.66
outlet	185887.98
wall-13	0.48176068
wall-13-shadow	-0.48176304
wall-7	-37.093418
wall-7-shadow	37.09404
wall-____msbr	37.153511

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Net **-0.51774451**

V. Results Table

WIRE COIL

Fluids	Reynolds number	Pressure (Pa)	Velocity (m/sec)	Temperature (K)		Wall function heat transfer (W/m^{2}K)	Mass flow rate (Kg/sec)	Total heat transfer rate (W)
				max	min			
R32	6000	1.207e+5	1.215e+1	223	202	198	9.894e-6	-1.435
	8000	1.692e+5	1.585e+1	223	202.7	201	5.96e-6	-0.9894
R152a	6000	1..627e+5	1.551e+1	249	202.4	125.5	4.887e-6	-0.4698
	8000	2.283e+5	2.025e+1	249	242.9	128	2.05e-5	-1.4985
R600a	6000	1.631e+5	2.02e+1	262	242.7	1.1e+2	5.72e-6	-0.7221
	8000	2.293e+5	2.646e+1	262	242.7	1.11e+2	2.02e-5	-2.2913

TWISTED INSERT

Fluids	Reynolds number	Pressure (Pa)	Velocity (m/sec)	Temperature (K)		Wall function heat transfer (W/m^{2}K)	Mass flow rate (Kg/sec)	Total heat transfer rate (W)
				max	min			
R32	6000	1.19e+5	1.205e+1	224	202.7	1.85e+2	3.576ee-6	-1.321
	8000	1.667e+5	1.573e+1	224	202.7	1.856e+2	1.0848e-5	0.51774
R152a	6000	1.338e+6	1.575e+1	257	232.7	1.17e+2	-3.457e-6	0.3403
	8000	1.795e+6	2.094e+1	257	232.7	1.178e+2	-2.02e-6	0.55622
R600a	6000	1.612e+5	2.010e+1	262	242.5	1.01e+2	3.218e-6	-0.1607
	8000	2.225e+5	2.625e+1	262	242.8	1.012e+2	8.821e-6	-0.9247

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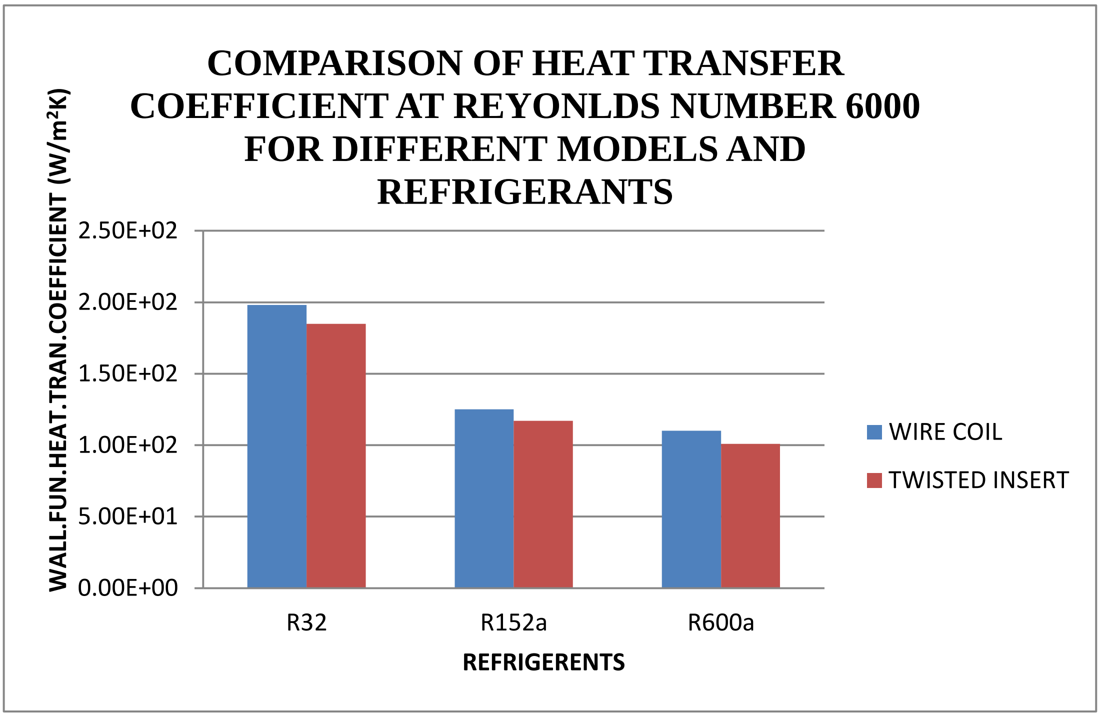

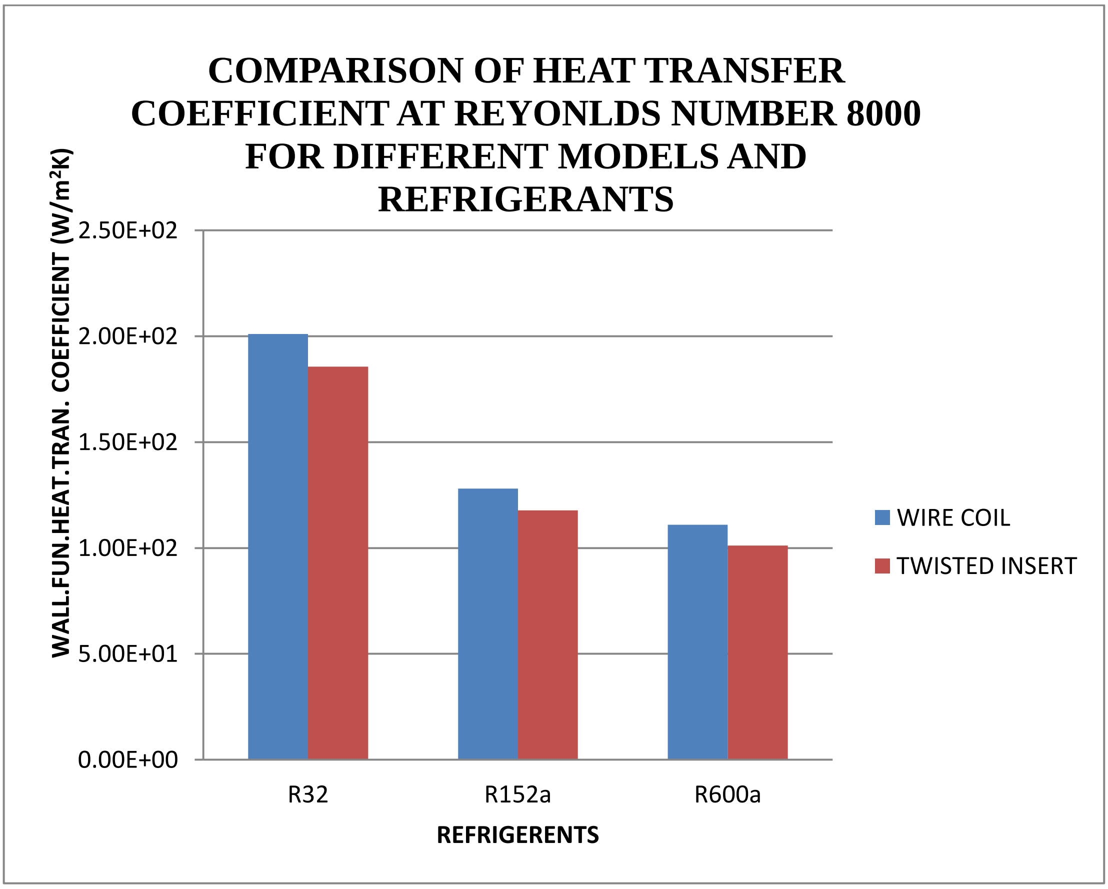

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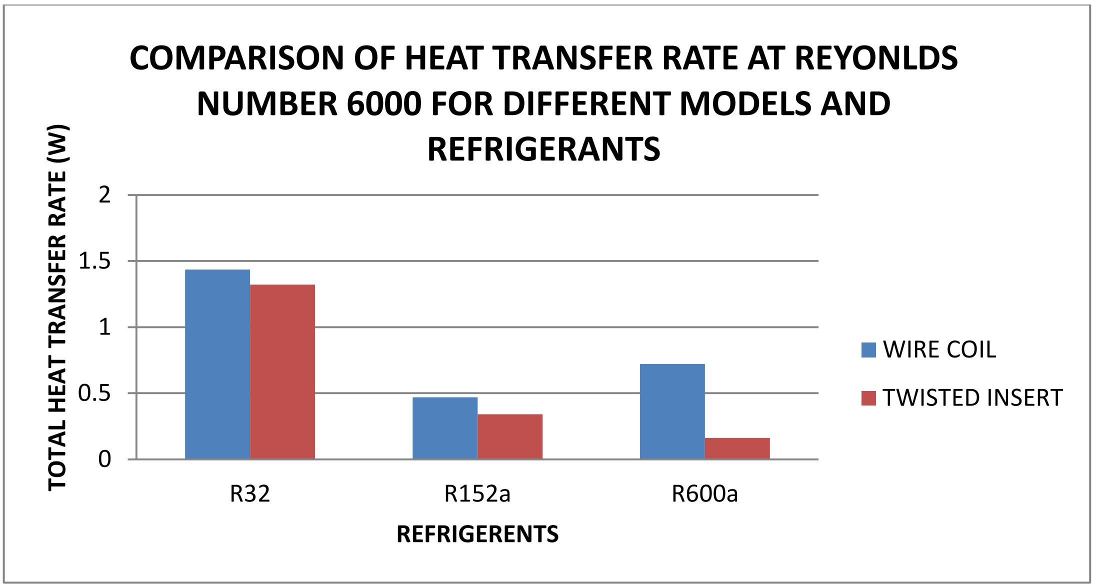

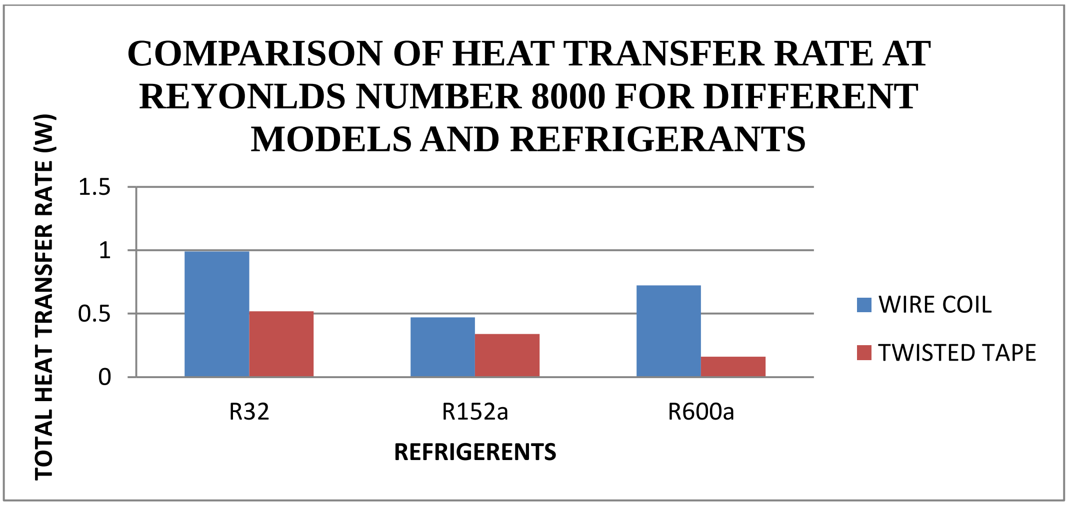

VI. Conclusion

By observing the results, the heat transfer coefficient is more when external insert (i.e) wire coil is used for tube evaporator than internal insert (i.e) twisted tape. The heat transfer coefficient values are increasing by increasing the Reynolds number. The heat transfer coefficient values are more when refrigerant R32 is used. For Reynolds number 8000 and for wire coiled tube, when R32 is used heat transfer coefficient is increasing by about 7.66%, when R152A is used heat transfer coefficient is increasing by about 7.9%, and when R600A is used heat transfer coefficient is increasing by about 8.82%.The heat transfer rate is more when external insert (i.e) wire coil is used for tube evaporator than internal insert (i.e) twisted tape. The heat transfer rate values are increasing by increasing the Reynolds number. The heat transfer rate values are more when refrigerant R32 is used. For Reynolds number 8000 and for wire coiled tube, when R32 is used heat transfer rate is increasing by about 44.6%, when R152A is used heat transfer rate is increasing by about 62.8%, and when R600A is used heat transfer rate is increasing by about 59.6%.

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