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Modelling of vapour compression refrigeration system (VCRS) by using alternative refrigerants with TiO_2 and without nano materials

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Abstract

Application of Nano particles in refrigerants has been identified as a better way of enhancing the thermal performance of the vapour compression refrigeration system (VCRS) without modification the system design. When nano particles are dispersed in a refrigerant, they are regarded as nano refrigerants. The improvement in evaporator and condenser heat transfer coefficient are responsible for the enhancement of VCRS performance.
In this paper, the effect of TiO_2 (nano particles) on the first law efficiency in terms of coefficient of performance (COP), exergetic efficiency (second law efficiency0 and system exergy destruction ratio (EDR) based on exergy of fuel / exergy of product) using alternative refrigerants are discussed. It is shown that the application of Nano particles as additives in refrigerant and lubricant in VCRS is favorable and promising. Therefore, Nano refrigerants are expected to be the future refrigerants for improving thermal performances of vapour compression refrigeration systems.

Keywords: Thermodynamic performance improvements, Mixing Nano materials, Vapour Compression Refrigeration System

1. Introduction

Refrigeration systems have become one of the most important utilities for people's daily lives. With the advancement and technological developments in the field of refrigeration new methods are developed to increase the COP of the systems. Traditional methods for exchanging heat from the system involves increment in the surface area but this leads to the increase in the size of the system, so there was need of some efficient way that can enhance the heat transfer. The inventive idea of using nanofluids, fluids which consist of suspended nanoparticles are used to remove such kind of barriers. The nano refrigerant is used to improve system performance, and it is decreased energy consumption of the system (viz. enhance heat transfer rate in cooling coil). Nano particles of Al_2O_3, TiO_2 and CuO are used due to their higher thermal conductivity to achieve better efficiency. Mishra et al. [1] experimentally evaluated the performance of a vapour compression refrigeration system by using Cu, Al_2O_3,CuO and TiO_2 based nano refrigerants in the primary circuit. The experimental results showed that the C.O.P of the system using Al_2O_3/R134a nano refrigerant was enhanced by 35% which was highest among all other nanorefrigerant. Sabareesh et al. [2] experimentally investigated 17% increase in COP by using 0.01% by volume concentration TiO2 nano fluid in VCRS as a lubricant additive.. Shengshan Bi et al. [3] found performance improvement reduction in power consumption upto 25% by mixed mineral oil TiO2 as the lubricant with refrigerant R600a
Subramani & Prakash [4] found improvement in performance by using Al_2O_3 at 0.06% weight in the mineral oil. Kumar et al. [5] found improvement in COP by 19.6% and reduction in power consumption by 11.5%. Due to enhancement in heat transfer coefficient using nanofluid Al_2O_3 & R600a/mineral oil as working fluid in a domestic refrigerator. Abbas et al. [6] performed the analysis of an air conditioning system by using a concentration of 0.01-0.1wt% of CNT Polyester oil with refrigerant R134a and found 4.2% enhancement in the COP was enhanced by using CNT particles concentration of 0.1% by weight. Hussen [7] showed the conventional

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refrigeration system performance improved with nano refrigerant. Compressor work decreases by about 13.3% and system C.O.P. increases by about 12%.

2. Results and Discussion

The numerical computation was carried out for finding thermal performance of vapour compression refrigeration from developed model, the following input data have been assumed.

Condenser temperature=48^{0}C, Evaporator temperature-5^{0}C, mixing of nano particles =5% by volume.

2.1 Effect of refrigerants with mixing TiO_2 nano particles

Table-1 shows the variation of thermal performances with titanium di oxide in the different ecofriendly refrigerants and it was found that by using nano in the R410a gives worst thermal performance in terms of first law efficiency, second law efficiency and exergetic efficiency. The best thermal performance in terms of first law efficiency is found by using R152a. By using hydrocarbons mixed TiO_2 nano the thermal performance of R600a hydrocarbon is lower than by using TiO_2 in the R290a. By comparing R134a and R407C, R404a, R507a and R125, it is observed that R407c gives better performance when TiO_2 is used in these refrigerants. With comparing thermal performances from Table-1, without nano by using R134a, the first law performance (COP) and second law performance (exergetic efficiency) increased significantly. Two types of EDR were computed. EDR computed based on exergy of product i.e. in terms of exergy of fuel in terms of total power utilized for running compressor for finding the components defects (Exergy losses) in the system as shown in Table-1 and effective utilization of cooling load (Q_Eva*(1-(T_Dead_State/T_eva)) in Table-1 respectively.

Table-1: Variation of thermal performances (First law efficiency (COP) and Exergetic efficiency) with ecofriendly refrigerants using TiO_2 nano material mixing

Refrigerants	First law COP	EDR	Exergetic Efficiency
R134a	4.36	1.659	0.3761
R404a	4.303	1.704	0.3698
R407c	4.634	1.458	0.4068
R125	4.044	1.935	0.3407
R507a	4.328	1.685	0.3725
R290	4.826	1.335	0.4282
R600a	4.009	1.969	0.3368
R152a	5.169	1.143	0.4666
R410a	2.138	6.847	0.1274
R502	4.671	1.433	0.4110
R134a without nano	2.978	2.44	0.2904

2.2 Effect of Thermal performances first law Performance (COP) on VCRS using TiO_2 Nano Material

The variation of evaporator temperature with variation of first law thermal performances in terms of COP and second law efficiency (exergetic efficiency) for different ecofriendly refrigerants withTiO_2 nano particles and without nano by using R134a is shown in Table-2 (a) and table-3(a) respectively. It was found that by increasing evaporator temperature the first law performance (COP) increases. And best first law performance (COP) was found by using R152a since R152a and hydrocarbon are flammable, therefore R134a gives better first law performance (COP). Similarly by increasing condenser temperature, the first law thermal performance (COP) decreases as shown in table-2(b) and table-3(b) respectively.

Table-2(a) Variation of COP with Evaporator temperature of Vapour compression using TiO_2 nano materials

T_Evaporator (K)	R134a	R404a	R125	R290	R600a	R410a	R507a	R152a	R502
283	7.932	7.12	6.715	7.802	6.866	2.557	7.09	9.273	7.645
278	6.595	5.942	5.595	6.548	5.751	2.416	5.945	7.734	6.396
273	5.517	5.048	4.746	5.599	4.873	2.282	5.06	6.493	5.448
268	4.36	4.303	4.044	4.826	4.009	2.138	4.328	5.166	4.671
263	2,182	3.525	3.327	4.086	2.588	1.932	3.58	2.70	3.908
258	--------	2.242	2.192	3.043	---------	1.466	2.399	-------	2.769

Table-2(b) Variation of COP with condenser temperature of Vapour compression using TiO_2 nano materials

T_Condenser (K)	R134a	R404a	R125	R290	R600	R410a	R507a	R152a	R502
329	1.992	3.591	3.025	3.768	1.484	1.99	3.249	2.434	3.591
325	3.342	4.118	3.532	4.281	2.323	2.087	3.785	3.99	4.118
321	4.36	4.671	4.044	4.826	3.605	2.138	4.328	5.169	4.671
317	5.229	5.294	4.605	5.444	4.578	2.166	4.924	6.185	5.294
313	6.096	6.035	5.26	6.18	5.446	2.183	5.62	7.207	6.035

Table-3(a) Variation of Exergetic Efficiency with evaporator temperature of Vapour compression using TiO_2 nano materials

T_EVA (K)	R134a	R404a	R125	R290	R600a	R410a	R507c	R152a	R502
283	0.3674	0.3556	0.3029	0.3605	0.3639	0.08253	0.3557	0.4385	0.3522
278	0.4025	0.3707	0.3306	0.3991	0.4137	0.1019	0.3718	0.4845	0.3882
273	0.4136	0.3698	0.3430	0.4211	0.4462	0.1174	0.3725	0.497	0.4073
268	0.3761	0.3360	0.3407	0.4282	0.4488	0.1274	0.3434	0.4666	0.4110
263	0.1573	0.1926	0.3049	0.4107	0.3444	0.124	0.2169	0.2262	0.4387

Table-3(b) Variation of COP with condenser temperature of Vapour compression using TiO_2 nano materials

T_EVA (K)	R134a	R404a	R125	R290	R600a	R410a	R507c	R152a	R502
329	0.1111	0.2469	0.2267	0.3099	0.1593	0.2228	0.2517	0.1606	0.290
325	0.2622	0.3083	0.2834	0.3673	0.2571	0.2337	0.3117	0.3348	0.3491
321	0.3761	0.3648	0.3407	0.4282	0.3368	0.2394	0.3725	0.4666	0.5890
317	0.4734	0.4369	0.4036	0.4975	0.4110	0.2425	0.4392	0.5804	0.4807
313	0.5704	0.5152	0.4769	0.5798	0.490	0.2443	0.4828	0.6948	0.5634

3. Conclusion

Following conclusions were drawn from present investigation.

(i) By using nano in the R410a gives worst thermal performance in terms of first law efficiency, second law efficiency and exergetic efficiency.

(ii) The best thermal performance in terms of first law efficiency is found by using R152a.

(iii) By increasing evaporator temperature the first law performance (COP) increases and best first law performance (COP) was found by using R152a

(iv) R152a and hydrocarbon are flammable, therefore R134a gives better first law performance (COP) and second law performances.

(v) By increasing condenser temperature, the first law thermal performance (COP) decreases.

References

[1] Mishra R S and Jaiswal Rahul Kumar [2015] Thermal Performance Improvements of Vapour Compression Refrigeration System Using Eco-Friendly Based Nanorefrigerants in Primary Circuit, International Journal of Advance Research and Innovation **3,** page-524-535.

[2] Sabareesh R K, Gobinath N, Sajith V, Das S and Sobhan C B 2012 Application of TiO 2 nanoparticles as a lubricant-additive _ for vapor compression refrigeration systems–An experimental investigation International journal of refrigeration 35, page-1989-1996.

[3] Bi Shengshan, [2011] Performance of a domestic refrigerator using TiO 2-R600a nano-refrigerant as working fluid Energy Conversion and Management **52** 733-737

[4] Bandgar M S, Ragit S S, Kolhe K P and Biradar N S 2016 Effect of Nano Lubricant on the Performance of Vapour Compression Refrigeration System: A Review JETIR **3,** page- 2349-5162.

[5] Subramani N and Prakash M J 2011 Experimental studies on a vapour compression system using nanorefrigerants International Journal of Engineering, Scie-nce and Technology ,3, page- 95-102.

[6] Kumar R R, Sridhar K and Narasimha M 2013 Heat transfer enhancement in the domestic refrigerator using *R600a/mineral* oil/nano-Al_2O_3 as working fluid International Journal of Computational Engineering Research **3,** page-42-50.

[7] Abbas M, [2013] Efficient Air—Condition Unit By Using Nano—Refrigerant 1st Engineering undergraduate research catalyst conference.

[8] H.A. Hussen [2014] Experimental investigation for TiO2 nanoparticles as a lubricant- Additive for a compressor of window type air-conditioner system **J.** Eng., 20 (2014), pp. 61-72