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Performance Enhancement of Vapour Compression System Using Nanofluids: A Review

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Abstract

Performance enhancement of refrigeration and heat pump systems is an emerging research topic recent technological developments in the fields of electronics, transportation, medical and HVAC systems have resulted in a pressing need for a performance enhanced cooling system. Now days, refrigeration and heat pump systems have become one of the most important systems for people's daily lives. Based from some research, the use of refrigeration & air conditioning systems consumes 30 to 40% of total electricity consumed. The traditional method for increasing heat dissipation is to increase the area available for exchanging heat, However, this approach involves an undesirable increase in the size of a thermal management system; therefore, there is an urgent need for new and novel coolants with improved performance. The innovative concept of 'nanofluids' heat transfer fluids consisting of suspended of nanoparticles has been proposed as a prospect for these challenges. In this review, we summarized the Performance enhance Of Vapour Compression System Using Nanofluids reported by different Investigators. Moreover, challenges and future directions of Performance enhance of VCRs and to try finding some challenging issues that need to be solved for future research.

1. Introduction

Now days, refrigeration and heat pump systems have become one of the most important systems for people's daily lives. Based from some research, the use of refrigeration & air conditioning systems consumes 30 to 40% of total electricity consumed. Also downscaling or miniaturization has been a recent major trend in modern science and technology. Confronted with limited energy and material resources and undesirable manmade climate changes, science is searching for new and innovative strategies to save, transfer and store thermal energy. In the face of imminent energy resource crunch there is need for developing thermal systems which are energy efficient. Thermal systems like refrigerators and air conditioners consume large amount of electric power. So avenues of developing

energy efficient refrigeration and air conditioning systems with nature friendly refrigerants need to be explored The rapid advances in nanotechnology have lead to emerging of new generation heat transfer fluids called nanofluids. Nanofluids are prepared by suspending nano sized particles (1-100nm) in conventional fluids and have higher thermal conductivity & Convective Heat Transfer Coefficient than the base fluids. Also recently different researchers tried performance enhancement of refrigeration & air Conditioning system using Nanofluids.

2. Literature review

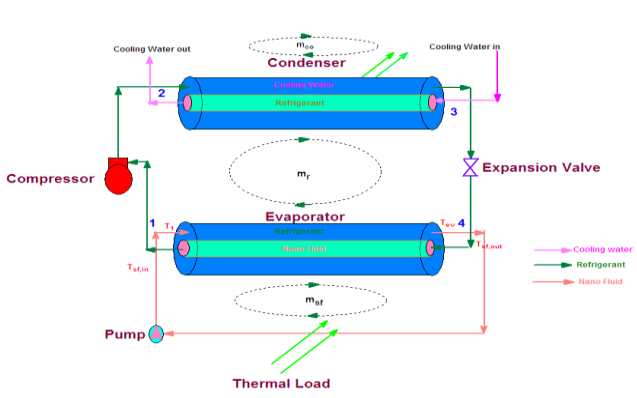
Most of the refrigeration & air-conditioning systems work on the vapour compression cycle, the expansion in most practical real vapour compression cycles occurring in an expansion valve is an irreversible throttling process. This causes a reduced cooling capacity and an increased work requirement in comparison with the Carnot cycle. Many Researchers tried performance enhancement of Simple Vapour compression system By using the Following different way such as by using the Different Types Compressors/Expanders, flash chamber, accumulator or pre-cooler, Economizer, Ejector or Diffuser Different Types Refrigerants etc, by using the Subcooling Methods such as a) By sub cooling the liquid Refrigerant by using vapour refrigerant or using liquid refrigerant that is using Liquid line suction heat exchanger (LLS-HX). b) By sub cooling the liquid Refrigerant by external cooling source such as Condenser subcooling by supplying more amount coolant water in a condenser, using sub cooler, IHX between Condenser and expansion device, mechanical Subcooling, using Auxiliary Cooling system etc, By Using Multistage compression, By Using the Nanofluids such as Nanorefrigerant and Nano lubricants etc. In this paper performance enhancement of Vapour compression refrigeration system only using Nanofluids Reviewed.

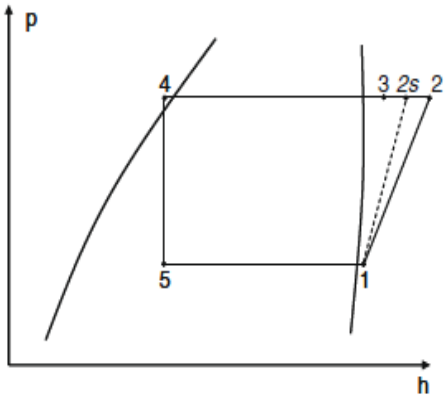
Recently, some investigators have conducted studies on vapour compression refrigeration systems, to study the effect of nanoparticles in the refrigerant/lubricant on its performance. Wang et al. (2003) they studied a refrigeration system working with R134a & mineral oil added with TiO2 nanoparticles; better performances than using Polyolester (POE) oil. Wang et al. (2003), Shengshan et.al (2007), Bi et al. (2008) conducted studies on a domestic refrigerator using mixture of mineral oil TiO2 was used as the lubricant with R134a They found that the refrigeration system with the nanorefrigerant worked normally & efficiently & the energy consumption reduced & refrigerator performance improved when compared with R134a/POE oil system. Similar results were found by Subramani & Prakash (2011). They employed Al_2O_3 nanoparticles at 0.06% by weight in mineral oil instead of POE in the cycle compressor & they found about 25% reduction of power consumption. Jwo et.al (2009) conducted studies on a refrigeration system replacing R-134a refrigerant & polyester lubricant with a hydrocarbon refrigerant & Al_2O_3 mineral lubricant. Their studies show that the 60% R-134a & 0.1 wt % Al_2O_3 nanoparticles were optimal. & the power consumption was reduced by about 2.4%, & the COP was increased by 4.4%. Kristen Henderson et.al (2010) conducted an experimental analysis on the flow boiling heat transfer of R134a based nanofluids in a horizontal tube. They found excellent

dispersion of CuO nanoparticles with R134a and POE oil & the heat transfer coefficient increases more than 100% over baseline R134a/POE oil results. Dr. Nimai Mukhopadhyay et.al (2013) they summarized the nanofluid preparation methods reported by different investigators in an attempt to find a suitable method for preparing stable nanofluids. Moreover, challenges and future directions of applications of nanofluids have been reviewed. R. Reji Kumar et.al (2013) Investigated heat transfer enhancement numerically using Al2O3 Nanolubricant & R600a/mineral oil/nano-Al2O3 as working fluid in domestic refrigerator they found that Freezing capacity higher & the power consumption reduces by 11.5 % & the COP increases by 19.6 %. Subramani et al. (2013) investigated performance of a VCRs using nano-lubricant with mineral oil and mineral oil with different nanoparticles added to it. They concluded nanolubricant works normally and safely. It is found that power consumption reduces by 15.4% & the COP increases by 20% when TiO2 nanolubricant is used instead of SUNISO 3GS. Rashmi G. Walvekar et.al (2013) carried out Experimental analysis of Air conditioning Unit with a concentration of 0.01-0.1wt% of CNT Polyester Oil along with suitability and environmental friendly refrigerant R134a. Results show that CNT nanoparticles concentration of 0.1wt% is optimal and gives highest heat transfer enhancement and improve the COP by 4.2%. R. Reji Kumar et.al (2014) investigated numerically heat transfer enhancement on the surface of a refrigerator by using Al2O3 nano-refrigerants. It is found that the freezing capacity is higher and the power consumption reduces by 11.5 % when POE oil is replaced by a mixture of mineral oil and Al2O3 nanoparticles. T. Coumaressin and K. Palaniradja (2014) carried out Performance Analysis Using CuO-R134a Nanofluids in the VCRs with concentrations ranged from 0.05 to 1% with using FLUENT Heat transfer coefficients were evaluated for heat flux ranged from 10 to 40 KW/m^2. & found evaporator heat transfer coefficient increases with the usage of nano CuO. Laura et.al (2014) Several Nanolubricants, formed by Polyolester (POE) or mineral oil as base fluid, & TiO_2 or SWCNH as nanoparticles, were studied in a dedicated test rig. In contrast with the published literature, no improvement was detected using nanofluids instead of commercial oil. Fatou Toutie Ndoye et.al (2014) studied numerically energy performance secondary loops of refrigeration Systems using nanofluids for various types of nanoparticles (Al2O3, Co, CuO, Fe, SiO2 and TiO2) and a wide range of volume fraction they found that heat transfer coefficients significantly & pumping power also increased with the increase of nanoparticles concentration whatever the flow regime. K.P. Kumar et.al [2013] studied the heat transfer Properties of Nano fluids (volume fraction 0.1 % to 0.5%), sisal & silicon Nano particles in Shell & coil Heat Exchanger & concluded that Heat Transfer Rate Enhanced by Using Nano fluids as Compared to base Fluid. Rohit S. Khedkar, et.al (2013) Carried Out experimental study on concentric tube heat exchanger for water to nanofluids heat transfer with various concentrations of nanoparticles in to base fluids and application of nanofluids as working fluid. Overall heat transfer coefficient was experimentally determined for a fixed heat transfer surface area

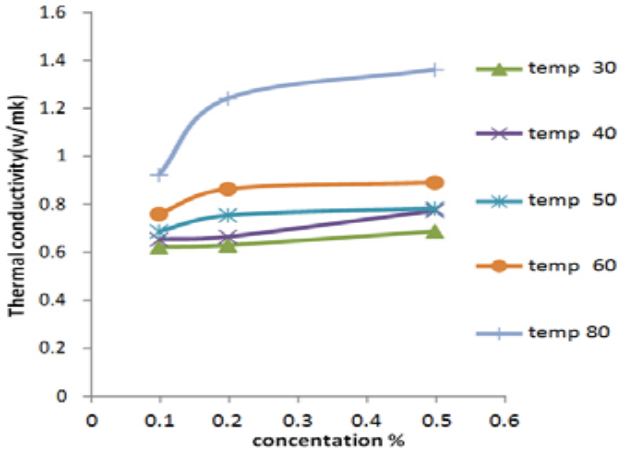
with different volume fraction of nanoparticles in to base fluids and results were compared with pure water. It observed that, 3 % nanofluids shown optimum performance with overall heat transfer coefficient 16% higher than water.

Case study: Prof (Dr) R S Mishra (2014) described thermal modeling of VCRs using R134a in primary circuit & Al2O3-Water based nanofluids in secondary circuit. The model uses information of the secondary fluids input conditions geometric characteristics of the system, size of nanoparticles and the compressor speed to predict the secondary fluids output temperatures, the operating pressures, the compressor power consumption and the system overall energy performance. Simulation results have shown that for the same geometric characteristics of the system performance increased from 17% to 20% by application of nanofluid as a secondary fluid in VCS.





Kama deep Singh (2013) The experimental work has been done at different temperature range (30 to 80°C) with varying different volume concentration (0.1%, 0.2%, 0.5%), 20nm size of Al2O3 nanoparticles in base fluid water to study the behaviour of thermo physical properties of nanofluid and compare with the base fluid. it can be conclude that thermal conductivity of nanofluids increases with increase in temperature. As well as with increase in concentrations of particles.



Fig; Thermal Conductivity V/s Concentration

3. Conclusions

Many Researchers tried performance enhancement of Simple Vapour compression system by using Nanofluids either in the form Nanorefrigerant or Nanolubricant. Refrigeration system with the nanorefrigerant works normally & efficiently & the energy consumption reduced & System performance improved. Use of the Nanofluids such as Nanorefrigerant or a Nano lubricant in refrigeration system is the recent trend.

4. Future work

Many researchers tried performance enhancement of refrigeration system above mentioned different methods but no one tried it by using the nanofluid as cooling medium in water cooled condenser refrigeration system so it is decided to experimentally investigate the performance vapour compression system using the nanofluid as cooling medium in water cooled condenser refrigeration system.

References

1. Khan, J. R., Zubair, S. M., Design and Rating of a Dedicated Mechanical Subcooling Vapour Compression Refrigeration Systems, Proc. Instn Mech. Engrs, vol. 214, part. A: p. 455-471, (2000a)
2. Khan, J. R., Zubair, S. M., "Design and Rating of an Integrated Mechanical Subcooling Vapour Compression Refrigeration System", Energy Convers. Mgmt., vol. 41: p. 1201-1222, (2000b).
3. Klein, S. A., Reindl, D. T., Brownell, K., "Refrigeration System Performance Using Liquid-Suction Heat Exchangers", Int. J. Refrigeration., and vol. 23: (2000), pp. 588-596.
4. Klein, S. A., Reindl, D. T., Brownell, K., "A Review on Refrigeration System Performance Using Liquid-Suction Heat Exchangers", Int. J. Refrigeration., (2000).

5. B.O. Bolaji, M.A. Akint unde, and T.O. Falade "A theoretical investigation of the performance of some environment-friendly refrigerants in sub-cooling heat exchanger refrigeration system" (2001)
6. Ciro Aprea and Angelo Maiorino "An experimental evaluation of the transcritical CO2 refrigerator performances using an internal heat exchanger" international journal of refrigeration (2006) 1-6.
7. Nguyen Q. MINH Neil J. HEWITT1, Philip C. EAMES "improved vapour compression refrigeration cycles: literature review and their application to heat pumps" International Refrigeration and Air Conditioning Conference at Purdue, July 17-20, 2006.
8. Hoon Kang, Kwangmin Choi, Chasik Park, Yongchan Kim Effects of accumulator heat exchangers on the performance of a refrigeration system International Journal of Refrigeration 30 (2007) 282-289
9. J. K. Dabas, A.K.Dodeja, Sudhir Kumar, K. S. Kasana Performance Characteristics of "Vapour Compression Refrigeration System" Under Real Transient Conditions IJAT, Vol. 2 No. 4 (October 2011)
10. Ramón Cabello a,*, Daniel Sánchez a, Jorge Patiño a, Rodrigo Llopis a, Enrique Torrella "Experimental analysis of energy performance of modified single-stage CO2 transcritical vapour compression cycles based on vapour injection in the suction line" Applied Thermal Engineering 47 (2012) 86-94
11. Bilal Ahmed Qureshi, Syed M. Zubair* Mechanical sub-cooling vapor compression systems: Current status and future directions" international journal of refrigeration 36 (2013)
12. Xiaohui She, Yonggao Yin, Xiaosong Zhang. "A proposed subcooling method for vapor compression refrigeration cycle based on expansion power recovery" international journal of refrigeration 43 (2013)
13. Christian J. L. Hermes "A New perspective on the internal heat exchange in the vapor compression cycle" 22nd International Congress of Mechanical Engineering 3-7 Nov 2013.
14. Amit Prakash "Improving the performance of Vapor compression refrigeration system by using sub- cooling and diffuser" IJEBEA 13-129; 2013, IJEBEA All Rights Reserved Page 88.
15. Neeraj Upadhyay "To study the effect of Sub-cooling and Diffuser on the Coefficient of Performance of Vapour Compression Refrigeration System" IJARAME volume 2 issue 6 June 2014 page 4-44
16. K.P. Kumar, j saibabu, K.V.N.S. Rao, srikanth. "Experimental Analysis of sisal Nano fluids in shell coil Heat Exchanger" Indian journal of Heat and mass transfer, volume3 July December 2013
17. Jaafar Albadr, Satinder Tayal a, Mushtaq Alasadi "Heat transfer through heat exchanger using Al2O3 nanofluid at different concentrations" Case Studies in Thermal Engineering 1 (2013) 38–44
18. Joaquín Navarro-Esbrí, Francisco Molés, Ángel Barragán-Cervera "Experimental analysis of the IHX influence on a vapour compression system performance working with R1234yf as a drop-in replacement for R134a" Applied Thermal Engineering 59 (2013) 153-161
19. M. Krishna Prasanna & P. S. Kishore "Enhancement of COP in Vapour Compression Refrigeration System" (IJERT) ISSN: 2278-0181 Vol. 3 Issue 11, November-2014

20. Reddy et al. "Analytical study of Study of Effect of effect of evap. temp., degree of sub cooling on performance of refrigeration System Applied Thermal Engineering 59 (2013) 156-164
21. B.O. Bolaji "Influence of sub-cooling on the energy performance of two eco-friendly R-22 Alternative refrigerants" Journal of Science and Technology, Vol. 34, No. 2 (2014), pp 73-83 73
22. V. M. Jamadar and A. M. Patil "Investigation of performance analysis of compressor cooling in vapour compression system" International Refrigeration and Air Conditioning Conference at 17-20, 2014.
23. Ashish Kumar Paharia & R. C. Gupta "Effect of sub cooling and superheating on vapour compression refrigeration systems using R-22 alternative refrigerants" International journal of emerging trends in Engineering and Development Issue 3, Vol.1 (January 2013) ISSN 2249-6149
24. D. P. Patil, J. H. Bhang ale, K. S. Deshmukh "Experimental Analysis of Refrigeration system using Micro channel condenser & Round Tube condenser" (IJIRAE) ISSN: 2349-2163 Volume 1 Issue 5 (June 2014).
25. Daehui Lee, Kyoung , Jinho Lee "Performance investigation of vapor and liquid injection on a refrigeration system operating at high compression ratio" International Journals of Refrigeration 53 (2015)15-2 5
26. Rodrigo Llopis, Ramon Cabello, Daniel Sanchez, Enrique Torrella "Energy improvements of CO2 transcritical refrigeration cycles using dedicated mechanical subcooling." IJR (2015) Vol 50 pp 12- 141.
27. Gustavo Pottker and Pega Hrnjak "Effect of the condenser subcooling on the performance of vapor compression systems" International journals of refrigeration Vol 50 (2015) 15-164.
28. Wang RX, Xie HB. "A refrigerating system using HFC134a and mineral lubricant appended with N-TiO2(R) as working fluids". In: Proceedings of the 4th international symposium on HAVC, (2003)
29. Shengshan, Lin Shi & Lili Zhang, "Performance study of a domestic refrigerator using R134a/mineral oil/nano-TiO2 as working fluid", IJR 07-B2-346, (2007).
30. Bi S., Shi L. and Zhang L., "Application of nanoparticles in domestic refrigerators. Applied Thermal Engineering" International journals of refrigeration (2008),
31. Jwo et.al, "Effect of nano lubricant on the performance of Hydrocarbon refrigerant system", J. Vac. Sci. Techno. B, (2009) Vol.27, No. 3, pp. 1473- 1477.
32. Henderson et al. "Experimental analysis on the flow boiling heat transfer of R134a based nanofluids in a horizontal tube". IJHMT , (2010) Vol. 53, pp. 944-951
33. Dr. Nimai Mukhopadhyay et.al A review on Nanofluid Preparation Methods" Applied thermal engineering Elsevier (2013)
34. N. Subramani & M. J. Prakash "Experimental studies on a vapour compression system using nanorefrigerant" International Journal of Engineering, Science & Technology Vol. 3, No. 9, 2011, pp. 95-102
35. Subramani, Mohan, Dr. Prakash. "Performance studies on a vapour compression refrigeration system nanorefrigerants" IJIRSET Proceedings – Of ICEE 2013.
36. Rohit S. Khedkar, Shriram S. Sonawane*,Kailas L Wasewar "Water to Nanofluids heat transfer in concentric tube heat exchanger: Experimental study" Elsevier Procedia Engineering 51 (2013) 318 – 323

37. R. Kumar, K. Sridhar, M.Narasimha "Heat transfer enhancement in domestic refrigerator using R600a/mineral oil/nano-Al2O3 as working fluid." Int. Journal of Computational Engg Research Vol, 032014.
38. T. Coumaressin and K. Palaniradja "Performance Analysis of a Refrigeration System Using Nano Fluid" IJAME. ISSN 2250-3234 Volume 4, Number 4 (2014), pp. 459-470.
39. Laura Fedele, Laura Colla, Mauro Scattolini, Filippo Bello mare, Sergio. "Nanofluids Application as Nanolubricants in Heat Pumps System" International Refrigeration and Air Conditioning Conference (2014)
40. Krishna Kant Dwivedi & R.C.Gupta "Experimental Analysis For Performance Enhancement of House hold Refrigerator With Cooling of Compressor" IJETDE Issue4, Vol.5 (Aug.-Sep. 2014)
41. Fatou Toutie Ndoye et.al "numerically energy performance secondary loops of refrigeration" Elsevier Procedia Engineering 51 (2014)
42. Thornton, J. W,, Klein, S. A., Mithchell, J. W., "Dedicated Mechanical Subcooling Design Strategies for Supermarket Applications", Int. J. Refrig., vol. 17, no. 8: p. 508-515, (1994).
43. Prof (Dr) R S Mishra1 Methods for Improving Thermodynamic Performance of Vapour Compression Refrigeration System Using Twelve EcoFriendly Refrigerants in Primary Circuit And Nanofluid (Water- Nano Particles Based) in Secondary Circuit IJET&AE Volume 4, Issue 6, June 2014)
44. Sendil Kumar, Dr. R. Elansezhian, "Experimental Study on Al2O3-R134a Nano Refrigerant in Refrigeration System", "International Journal of Modern Engineering Research", Vol. 2, Issue. 5, 2012, pp. 3927-3929.
45. Kamaldeep Singh, 2Sumeet Sharma, 3D. Gangacharyulu Experimental Study of Thermophysical Properties of Al2O3/Water Nanofluid IJRMET Vol. 3, Issue 2, May - Oct 2013