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Experimental investigation for enhancing thermal performance of vapour compression refrigeration system using nano fluids

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Abstract

For increasing first law efficiency in terms of COP and Second law efficiency (Exergetic Efficiency) of VCR systems.the experiment is performed on VCR system to study the effect of silver oxide Nano particle(50nm) in base fluid of ethyl glycol (50:50 ratio with water) with concentration factor 0.02 to 0.06g by volume % on hot side of system (condenser side). For high efficiency out-put, the plate type heat exchanger has been taken in the VCR system. Test results show that the performance parameters such as exergetic efficiency of the system improved in the range of 1.9-5.96% and heating capacity was improved by 26-82% respectively by using 0.06 Vol% silver Nano fluid compared to water as cold based fluid for considerable range of cold base fluid flow rate. It was observed that the exergy destruction is decreasing in the range of 29-31.28%, 65.77-70.01%, 14.31-16.03%, 17-23% in compressor, condenser, evaporator and expansion valve respectively. High volume ratio (0.015 Vol%) of silver Nano fluid shows a very less effect on thermal performance parameters of system for different base fluid mass flow rates.

.Keywords: VCR, Nano Materials, Performance Evaluation , Experimentation

1. Introduction

The increasing demand of energy leads to global warming and environmental imbalance in the society. In order to satisfy the needs, utilization of energy available at the systems should be in best way. The primary function of system based on vapour compression refrigeration technology is to reject heat at higher temperature and absorb at lower temperature. Heat rejected by condenser generally not utilized for constructive applications instead of this heat is wasted either to the surrounding or to the water circulating from cooling tower. Like milk plant, vapour compression refrigeration system is used for cooling of milk for the purpose of preserving the same for long time and heat rejected by condenser is wasted to water circulating from cooling tower. In same plant large amount heat is also required for heating of milk to kill bacteria. This much amount of heat is taken either from burning of diesel or other non-renewable resources. It is very important to increase coefficient of performance, exergy efficiency, and sustainability index on the other hand reduction of exergy destruction in the components of vapour compression refrigeration system. Along with above mentioned parameters, it is also important to utilization of energy available at vapour compression refrigeration system. In view of above factors experimental test rig was fabricated which is used for both cooling and heating of water. Cooling is done by evaporator and utilizes the waste heat from condenser is for heating of water. Silver nanofluid with 0.01% and 0.05% volume concentration ratio used as cooling base fluid for enhancing of heating. The purpose of using of nanofluid to improve the performance parameters like effectiveness, exergy efficiency, sustainability index and decrease the irreversibility in components of VCR. The leakage test of developed test rig was done by filling of nitrogen gas. After successful completion of leakage test, test rig has been evacuated by using of vacuum pump. The vacuum was held for 30 hr and after that the correct amount of R22 was charged in refrigerant circuit. After completion of leakage testing and charging of refrigerant, cooling base fluid pump, cooling secondary fluid pump, chilled water pump and chilled secondary fluid pump was switched on. Chilled water mass flow rate (300 kg/hr) remain constant for considered number of experiments. Thermostat attached with heating coil used to maintain constant inlet

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temperature (T_7 =26^0C) of chilled secondary fluid and thermostat of same configuration attached with cooling coil for constant inlet condition (T_{11} =22^0C) of cooling secondary fluid. Then compressor of refrigerant circuit was switched on. Before collection of experimental data, system was allowed to run until the steady state condition was reached. Experimental data were recorded six times during one hour. Experiments were done with water followed by 0.01 and 0.05 vol% silver nanofluid as cooling base fluid with same above described procedure. It should be noted that any fluid to be heated or cooled can be used as cooling or chilled secondary fluid. In the present study water is used in both cooling and secondary fluid circuit.

2. Literature Review

S.No	Author	Journal	Year	Findings	Conclusions
1	Elcock et al.	Argonne National Laboratory	2007	They found that TiO_2 nanoparticles can be used as additives to enhance the solubility of the mineral oil with the hydro fluorocarbon (HFC) refrigerant. Author also reported that refrigeration systems using a mixture of HFC134a and mineral oil with TiO_2 nanoparticles appear to give better performance by returning more lubricant oil to the compressor	TiO_2 nanoparticles can be potentially used in refrigeration system.
2	Hindawi	Hindawi	2009	It has been carried out by experimental study on boiling heat transfer characteristics of R22 refrigerant with Al_2O_3 nanoparticles and found that the nanoparticles enhanced the refrigerant heat transfer characteristics by reducing bubble sizes	Nanoparticles can be used to enhance heat transfer capabilities
3	Eastman et al.	Mater Res Soc Symp Proc	1996	They investigated the pool boiling heat transfer characteristics of R11 refrigerant with TiO_2 nanoparticles and showed that the heat transfer enhancement reached by 20% at a particle loading of 0.01 g/L.	TiO_2 nano particles can be used to enhance the heat transfer capability of R11 refrigerants.
4	Liu et al.	Chemical Engineering and Technology	2006	They investigated the effects of carbon nanotubes (CNTs) on the nucleate boiling heat transfer of R123 and HFC134a refrigerants. Authors reported that CNTs increase the nucleate boiling heat transfer coefficients for these refrigerants.	CNT have a potential to increase the nucleate boiling heat transfer coefficient of the refrigerants.
5	Jiang et al.	International Journal of Thermal Sciences	2009	The experimental results showed that the thermal conductivity of carbon nanotubes (CNT) Nano refrigerants are much higher than those of CNT–water Nano fluids or spherical nanoparticle–R113 Nano refrigerants. Authors reported that the smaller the diameter of CNT larger the thermal conductivity enhancement of CNT Nano refrigerant.	CNT with smaller diameter can be used to enhance the thermal conductivity of the refrigerants
6	Hwang et al.	Current applied Physics	2006	They suggested that thermal conductivity enhancement of Nano fluids is greatly influenced by thermal conductivity of nanoparticles and base fluid. For instance, thermal conductivity of water based Nano fluid with multiwall carbon nanotubes has noticeably higher thermal conductivity compared to SiO_2 nanoparticles in the same base fluid.	Multiwall carbon nanotubes has the higher thermal conductivity among the other Nano particles.
7	Yoo et al.	Thermochimica Acta	2007	They argued that surface to volume ratio of nanoparticles is a dominant factor. Surface to volume ratio is increased with smaller sizes of nanoparticles. 150% thermal conductivity enhancement was observed in poly (a-olefin) oil by addition of multiwall carbon nanotubes (MWCNT)	Surface to volume ratio is an dominant factor to enhance the thermal properties of Nano fluid.

8	Yang.Y	University of Kentucky	2006	He reported, a 200% thermal conductivity enhancement for poly (a-olefin) oil containing 0.35% (v/v) MWCNT. It is important to note that this thermal conductivity enhancement was accompanied by a three order of magnitude increase in viscosity.	MWCNT nanoparticles can increase the thermal conductivity as well as viscosity
9	Eastman	Applied Physics Letters	2001	He observed 40% thermal conductivity enhancement for ethylene glycol with 0.3% (v/v) copper nanoparticles (10 nm diameter), although the authors also added that about 1% (v/v) thioglycolic acid helpful for dispersion of nanoparticles in base fluid. The addition of this dispersant yielded a greater thermal conductivity than the same concentration of nanoparticles in the ethylene glycol without the dispersant.	Dispersant can be used to enhance the conductivity.
10	Kang et al.	Experimental Heat Transfer	2006	They reported a 75% thermal conductivity enhancement for ethylene glycol with 1.2% (v/v) diamond nanoparticles between 30 and 50 nm diameter. Despite of these remarkable results, some researchers also measured the thermal conductivity of Nano fluids and found no anomalous results.	Diamond nanoparticles can be used to enhance the thermal conductivity of ethylene glycol.
11	Lee et al.	International Journal of Heat and Mass Transfer	2008	They revealed that optimum combination of pH level and surfactant leads to 10.7% thermal conductivity enhancement of 0.1% Cu/H2O Nano fluid. They also concluded that during Nano fluid preparation stage thermal conductivity of Nano fluid is affected by pH level and addition of surfactant.	PH level and surfactant potentially used to enhance the thermos-physical properties.
12	Jiang et al.	International Journal of Thermal Sciences	2009	They added that thermal conductivity of Nano fluids also depend on the nanoparticles size and temperature	Size and temperature can be affected to the thermal properties of Nano-particles.
13	Wu et al.	Journal of Engineering Thermophysics	2008	They observed that the pool boiling heat transfer was enhanced at low TiO_2 nanoparticles concentration in R11 but deteriorated under high nanoparticles concentration.	Low concentration of TiO_2 in R11 can affectively enhanced the pool boiling heat transfer.
14	Trisaksri et al	International Journal of Heat and Mass Transfer	2009	They investigated TiO_2 in HCFC 141b in a cylindrical copper tube and found that the nucleate pool boiling heat transfer deteriorated with increasing nanoparticle concentrations especially at higher heat fluxes.	Increasing concentration and heat flux can badly affect to the thermal properties of Nano particles.
15	Hao et al.	International Journal of Refrigeration	2009	They investigated flow boiling inside a smooth tube at different nanoparticles concentration, mass fluxes, heat fluxes, and inlet vapor qualities in order to analyze the influence of nanoparticles on the heat transfer characteristics of refrigerant-based nanofluid. Authors observed that the heat transfer coefficient of refrigerant-based nanofluid in flow boiling is larger than that of pure refrigerant and the maximum enhancement is about 29.7% when observed with a mass fraction of 0–0.5 wt%.	Nanoparticle can enhance the heat exchange capability of refrigerants.

16	Hao et al.	International Journal of refrigeration	2010	They studied experimentally the nucleate pool boiling heat transfer characteristics of refrigerant/oil mixture with diamond nanoparticles. The results indicate that the nucleate pool boiling heat transfer coefficient of R113/VG68 oil mixture with diamond nanoparticles is larger than that of R113/oil mixture by 63.4%. Enhancement in same factor increases with the increase of nanoparticles concentration in the nanoparticles/oil suspension and decreases with the increase of lubricating oil concentration.	Refrigerant/oil mixture with diamond nanoparticles can be used to enhance the thermal conductivity.
17	Wang et al.	Proceedings of the 4th symposium on refrigeration and air condition	2006	They carried out an experimental study of boiling heat transfer characteristics of R22 with Al_2O_3 nanoparticles and found that nanoparticles enhanced the refrigerant heat transfer characteristics by reduction of bubble sizes that moved quickly near the heat transfer surface.	R22 with Al_2O_3 nanoparticles showed the better thermal properties
18	Li et al.	Proceedings of the 12th symposium on engineering thermo physics	2006	They investigated the pool boiling heat transfer characteristics of R-11 with TiO_2 nanoparticles and showed that the heat transfer enhancement reached by 20% at a particle loading of 0.01 g/L.	R-11 with TiO_2 nanoparticles and showed the pool boiling heat transfer characteristics.
19	Peng et al.	International Journal of Refrigeration	2009	They investigated the influence of CuO nanoparticles on the heat transfer characteristics of R-113 refrigerant-based nanofluids and presented a correlation for prediction of heat transfer performance of refrigerant based nanofluids. Authors reported that the heat transfer coefficient of refrigerant-based nanofluids is higher than that of pure refrigerant.	CuO in 113 refrigerant-based nanofluids can enhanced the heat transfer characteristics
20	Kumar and Elansezhian	J Front Mech Engg	2014	They experimentally investigated the effect of varying concentration of ZnO nanoparticles on various performance parameters like COP, suction temperature, input power and pressure ratio with 152a as working fluid in vapour compression refrigeration system. They found that 0.5% v ZnO nanoparticles with R152a gives maximum COP of 3.56 and 21% reduction in power input. Pressure ratio decreases with increase in ZnO concentration.	
21	Mahbubul et al.	International Journal of Heat and Mass Transfer	2013	They measured thermo physical properties, pressure drop and heat transfer performance of Al_2O_3 nanoparticles and R-134a mixture. Thermal conductivity of Al_2O_3/R-134a nano refrigerant increased with temperature and augmentation of particle concentration. It was also observed that pumping power, viscosity, pressure drop, and heat transfer coefficients of the nanorefrigerants show significant increment with the increase of volume fractions. The frictional pressure drop also shows rapid increment with 3 vol. % particle fraction.	The pumping power, viscosity, pressure drop, and heat transfer coefficients of the nano refrigerants shows significant increment with the increase of volume fractions.

3. Description of experimental test rig and instrumentation

As shown in Fig.1 experimental test rig comprising of refrigerant, chilled water, chilled secondary fluid, cooling base fluid and cooling secondary fluid circuits. Refrigerant circuit used R22 as working fluid consists of single cylinder hermetically sealed reciprocating compressor, plate type condenser, thermal expansion valve, plate type evaporator and accessories like filter, drier, power meter used for measurement of electricity consumed by compressor and sight glass.

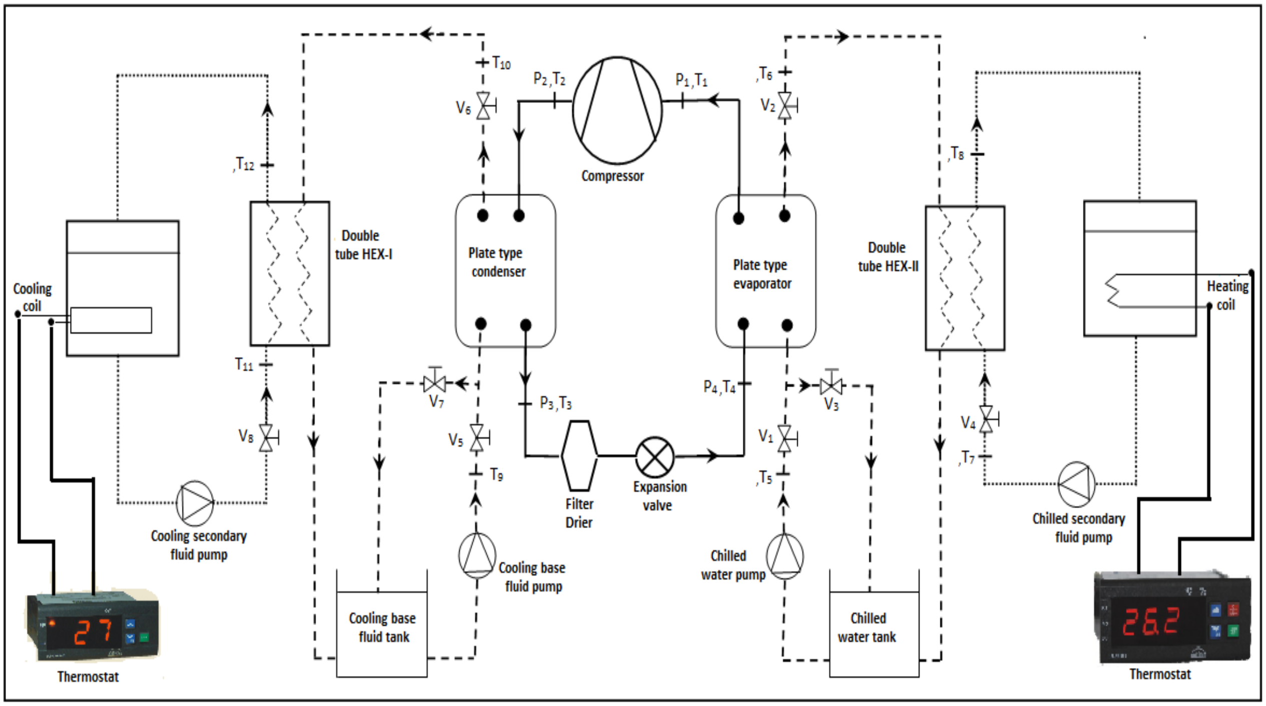

Figure: 1 Experiment test rig of vapour compression refrigeration system

Due to high heat transfer coefficient and compact design, plate type heat exchangers were used as evaporator and condenser. For convenient and easy installation valves were mounted at various desired locations. The whole system is placed in well insulated chamber within 0.03°C control to the surrounding conditions.

Cooling base fluid may be supplied with either water or nanofluid .Chilled water circuit consist of plate type evaporator, double tube heat exchanger for heat transfer between chilled water & chilled secondary fluid and chilled water pump for circulation of chilled base fluid throughout the circuit. Cooling base fluid circuit consist of plate type condenser, tube in tube heat exchanger for exchange of heat between cooling base fluid & cooling secondary fluid and cooling base fluid pump for circulation of cooling base fluid. Water is supplied to both chilled and cooling secondary circuit. Chilled secondary circuit comprised of chilled secondary fluid pump, double tube HEX-I and thermostat for maintaining the temperature of chilled secondary fluid. Cooling secondary circuit consists of double tube HEX-II, cooling secondary fluid pump and thermostat for maintaining the temperature of cooling secondary fluid. Piping network of discussed circuits is well insulated with respect to environmental conditions.

In order to gauge the various operating parameters such as refrigerant pressure, temperatures at desired points of discussed circuits, flow rate and electricity consumption, a requisite instrumentation system is installed in the experimental test rig. RTD type thermocouples were positioned for measurement of temperatures at desired locations of experimental test rig. Pressures at compressor suction, condenser inlet, inlet of expansion valve and evaporator's inlet were measured using calibrated bourdon tube type pressure manifold.

Electricity consumed by compressor is measured by digital watt meter. Water flow rates through secondary circuits were measured by using a digital balance capable of reading 0.001 g and a stopwatch capable of reading 0.01 s.

4. Energy and Exergy Analysis

The idea of energy efficiency was given first law of thermodynamic. Energy efficiency or cooling effectiveness is the ratio of output in the form cooling effect to input in the form of energy consumed by compressor. First law analysis limited to evaluate only cooling effectiveness of the system as mentioned below.

4.1 Cooling effectiveness in terms of COP

$$\varepsilon_{cooling} = \frac{\dot{Q}^{+}_{evap}}{\dot{W}^{+}_{comp}}$$

Second law of thermodynamics gives the idea of exergy generation in work producing as well as work consuming systems. Exergy generation also gives the concept of amount of constructive or destructive energy for the systems and impact on surrounding Exergy destruction in each component of considered system is calculated as per following equations

Exergy Balance in Compressor

$$\dot{E}_{1-2} = T_a \left[\frac{\dot{m}_f\left(k_{f2} - k_{f1}\right) + \dot{W}^{+}_{comp} - \dot{m}_f\left(j_{f2} - j_{f1}\right)}{T_a} \right]$$

Exergy Balance in Evaporator

$$\dot{E}_{4-1} = \left(\begin{matrix} T_a \begin{pmatrix} \dot{m}_f\left(j_{f1} - j_{f4}\right) - \\ \dot{m}_f\left(k_{f1} - k_{f4}\right) \end{pmatrix} + \\ \sum \dot{Q}^{+}_{evap}\left(1 - \frac{T_a}{T_L}\right) \end{matrix} \right)$$

Exergy Balance in Condenser

$$\dot{E}_{2-3} = \left(\begin{matrix} T_a \begin{pmatrix} \dot{m}_f\left(j_{f3} - j_{f2}\right) - \\ \dot{m}_f\left(k_{f3} - k_{f2}\right) \end{pmatrix} - \\ \sum \dot{Q}^{-}_{cond}\left(1 - \frac{T_a}{T_H}\right) \end{matrix} \right)$$

Exergy Balance in Expansion valve

$$\dot{E}_{3-4} = \dot{m}_f \begin{pmatrix} \left(j_{f4} - j_{f3}\right) - \\ T_a\left(k_{f4} - k_{f3}\right) \end{pmatrix}$$

Exeretic efficiency

$$\xi = \frac{\dot{EP}}{\dot{W}^{+}_{comp}} = \frac{\left|\dot{Q}^{+}_{evap}\left(1 - \frac{T_a}{T_L}\right)\right|}{\dot{W}^{+}_{comp}}$$

Exergy destruction ratio based on exergy output

$$EDR = \frac{\sum \dot{E}_{\alpha}}{\dot{EP}} = \frac{1}{\xi} - 1$$

4.2 Sustainability index

$$£ = \frac{1}{1 - \xi}$$

Cooling base fluid mass flow rate and its temperature rise will leads to evaluation of heating capacity ($\dot{Q}^{-}_{cond}$) of condenser as follow:

$$\dot{Q}^{-}_{cond} = \dot{m}_{cbf} c_{P,cbf}\left(T_{cbf,o} - T_{cbf,i}\right)$$

Similarly chilled water mass flow rate and its temperature fall will leads to evaluation of cooling capacity ($\dot{Q}^{+}_{evap}$) of evaporator as given below:

$$\dot{Q}^{+}_{evap} = m_{chw} c_{P,chw}\left(T_{chw,i} - T_{chw,o}\right)$$

4.3 Specific heat of nano fluid

In order to evaluate the heating capacity of Nano fluid, effective specific heat should be determined. Mass fraction mixture rule is used for calculation of effective specific heat, which is as follow:

$$C_{P,nf} = \frac{(1 - \phi_v)\rho_{bf} C_{P,bf} + \phi_v \rho_P C_{P,p}}{\rho_{nf}}$$

5. Preparation of Nano fluid

In literature one-step and two-step methods are commonly used for preparation of nanofluid. Eastman et al. developed one-step procedure for preparation of nanofluid. In this method problem of agglomeration was reduced by great extent and preparation and dispersion of solid nanoparticles in base fluid concurrently occurred. This method leads to uniform and stable distribution of nanoparticles in the base fluid. In order to produce nanofluids in large scale one step procedure is not economical. Zhu et al. developed another method for preparation of nanofluids called two-step method. In this process nanoparticles directly dispersed in base fluid. Dispersion is done by either bath type or probe type ultrasonicator.

In this manuscript two-step method is adopted for preparation of silver nanoparticles and water mixture. Silver nanoparticles of spherical morphology with average particle size 50 nm size and bulk density 0.312 g/cm^3. The TEM image, UV spectrophotometer analysis and raman analysis of silver nanoparticles presented in Fig. 2-4 respectively. As per 0.01 and 0.05% volume concentration ratio silver nanoparticles were measured by digital balance and mixed with water. Probe type ultrasonicator as shown in Fig.6 was used for stable and uniform distribution of nanoparticles in base fluid for 30 min. As shown in Fig 7-13 shows no settlement of nanoparticles and water mixture were observed after 2, 4, 6, 8, 10, 12 and 14 h respectively. As a result 0.01 and 0.05% volume solution has selected for solubility test. Fig 14-16 shows test plate type heat exchanger used in test rig and setup of VCR respectively.

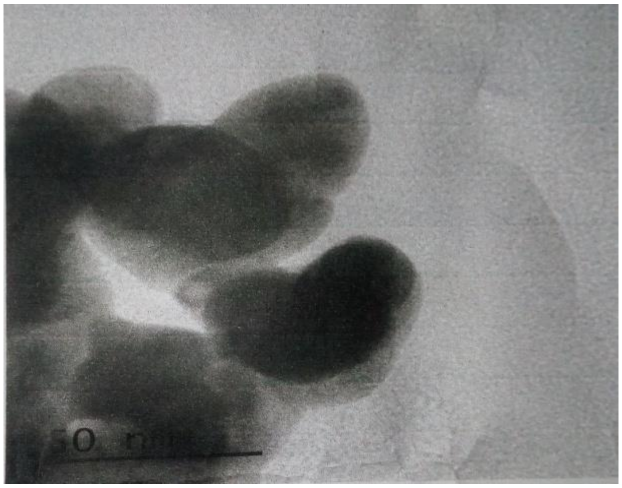

Figure: 2 TEM image of nano particle

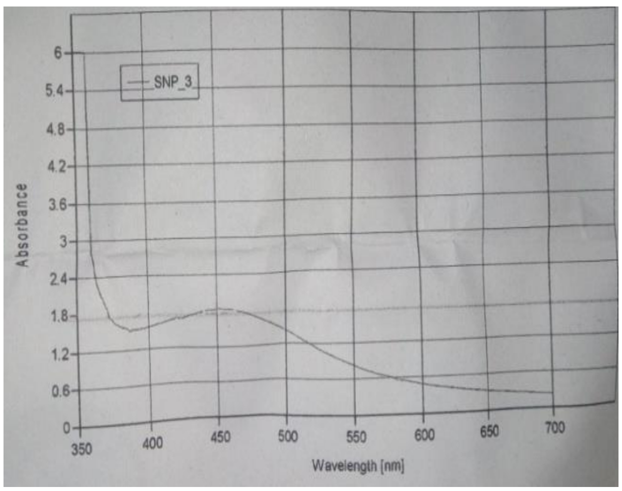

Figure: 3 UV spectrophotometer of silver

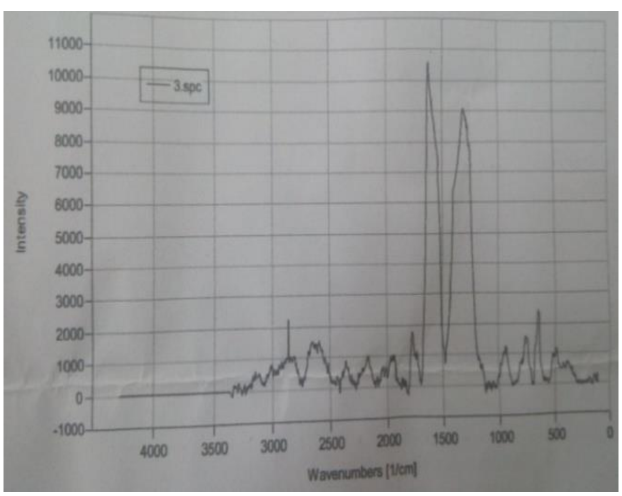

Figure: 4 Raman analysis of silver nanoparticles

Figure: 5 volume concentration ratio silver nanoparticles were measured by digital balance

Figure: 6 Probe type ultrasonicator

Figure: 7 Nano particle settlement after (2 hours)

Figure: 8 Nano particle settlement after 4 hours

Figure: 9 Nano particle settlement after 6 hours

Figure: 10 (Nano particle settlement after 8 hours

Figure: 11 Nano particle settlement after 10 hours

Figure: 12 Nano particle settlement after12 hours

Figure: 13 Nano particle settlement after 14 hours

Figure: 14 Plate type Heat Exchanger

Figure: 15 Plate type Heat Exchanger

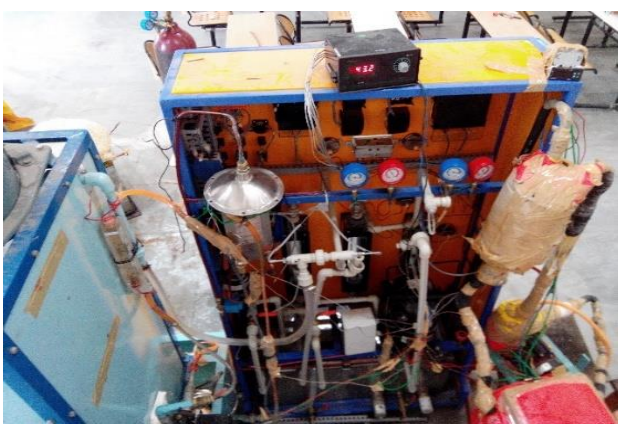

Figure: 16 Plate type heat exchanger with cooling tower in VCR assembly

6. Results and Discussions

Fig.17-18 represents the effect of variation of mass flow rate of cooling base fluid on working pressures of refrigerant circuit. The variation of condensing pressure and evaporating pressure with mass flow rate of cooling base fluid as shown in fig 17-18 respectively. It was observed that with increase of mass flow rate of cooling base fluid, operating pressures decreases due to enhancement of heat exchange between refrigerant and cooling base fluid. Both of these figures also revealed that variation of mass flow rate give a more prominent effect on condensing pressure rather than evaporating pressure.

Deviation of evaporation and condensation pressures with various working parameters were studied with water, 0.01 and 0.05 vol. % silver nanofluid as cooling base fluid. Pertaining to evaporation pressure, reveals that water gives highest while 0.05 vol. % silver nanofluids gives lowest evaporating pressure. The average values of condensation pressure for water, 0.01 and 0.05 vol. % silver nanofluid as cooling base fluids are 1417.06, 1393.57 and 1230.73 kpa while their evaporation pressures are 196.13, 192.26 and 169.16 kpa respectively over wide range of cooling base fluid mass flow rate (Fig.17-18). Mean condensation pressure of water and 0.01 vol. % silver nanofluid are greater than 0.005 vol% silver nanofluid by 15.13% and 13.23% respectively. On the other hand average evaporation pressure of water and 0.001 vol. % silver nanofluids are higher than 0.001 vol. % silver nanofluid by 15.94% and 13.65% respectively.

Variation of cooling effectiveness verses mass flow rate of cooling base fluid is shown in Fig.19. It is evident that higher mass flow rate of cooling base fluid responsible for lower compressor work due to decreasing of compressor to evaporator ratio and increases cooling & heating effectiveness. Increases cooling & heating capacity and decrement in compressor work increases the cooling and heating effectiveness of the system. Average cooling effectiveness of system using 0.05 vol. % silver nanofluid as cooling base fluid is higher than that of water by 14.98% as cooling base fluid over considered range of mass flow rate of cooling base fluid. Fig. 20-21 show the impact of mass flow rate of cooling base fluid on exergy efficiency and exergy destruction ratio respectively. Since exergy efficiency is the ratio of useful output in term of cooling capacity $\left[\dot{Q}_f^+\left(1-\frac{T_a}{T_L}\right)\right]$ to the input energy given to the system. As discussed input energy given in term of compressor work gets lower down with increase of mass flow rate of cooling base fluid. Like compressor work numerator of exergy efficiency also follow the same trend. Combined effect of both discussed terms increase the exergy efficiency .It is clear that behavior of curve of Fig.20 is almost opposite to the Fig.21.The behavior of trends is due to fact that exergy destruction ratio and exergy efficiency are inversely proportional to each other. Behavior of Sustainability index with change of mass flow rate of cooling base fluid was also analyzed through Fig.22. The sustainability index is the function of exergy efficiency. Trend of sustainability index with mass flow rate of cooling base fluid is almost same as of exergy efficiency with same variable. It is concluded that increase of cooling base fluid mass flow rate put less adverse effect on the environmental conditions. The sustainability index is the function of exergy efficiency. Sustainability index determines the impact on environmental or surrounding conditions. Lower sustainability index of the system put adverse effect on the environmental conditions. Average value of sustainability index of the system using water, 0.01 vol% and 0.05 vol% nanofluid as cooling base fluid are 1.147, 1.148., and 1.152 respectively.

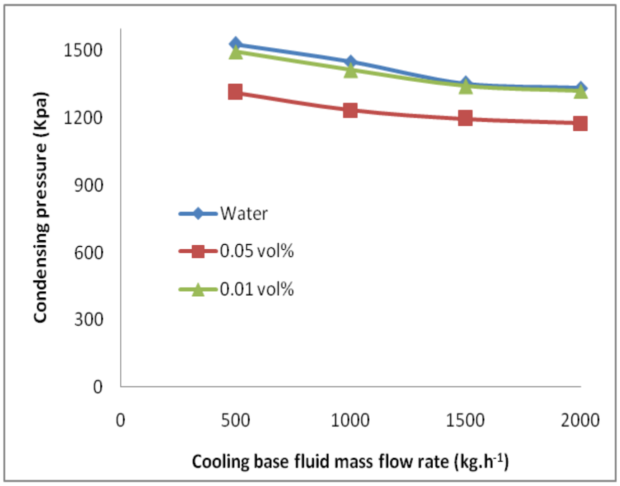

Figure: 17 Condensing pressure versus cooling based fluid mass flow rate

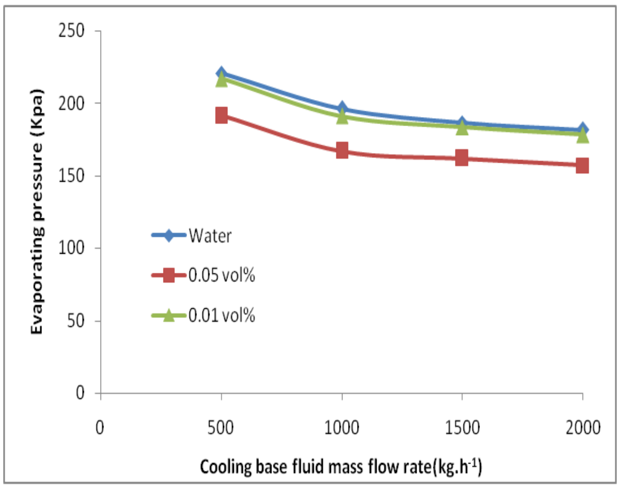

Figure: 18 Evaporating pressure versus cooling based fluid mass flow rate

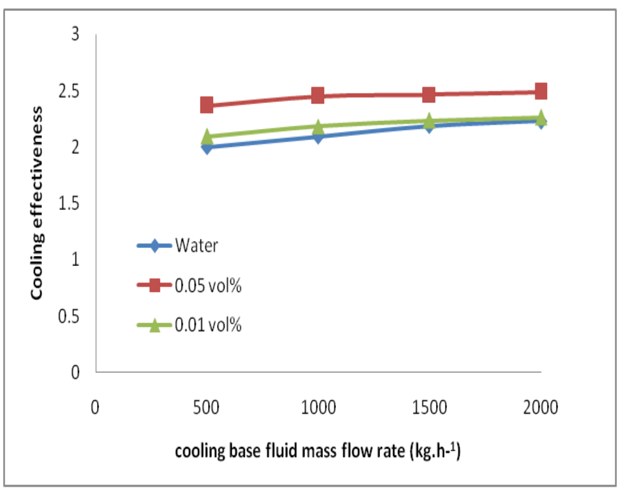

Figure: 19 Cooling effectiveness vs cooling mass flow rate

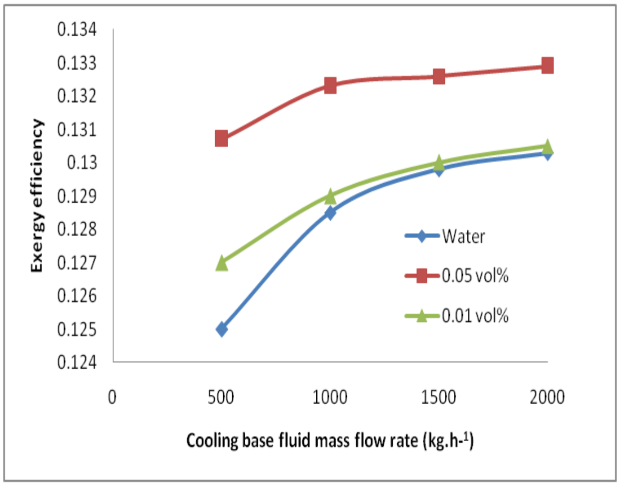

Figure: 20 Exergy efficiency versus versus cooling based fluid mass flow rate

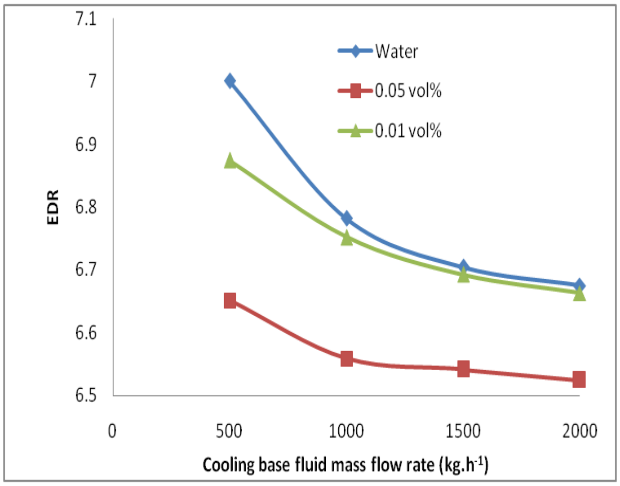

Figure: 21 Exergy destruction ratio versus cooling based fluid mass flow rate

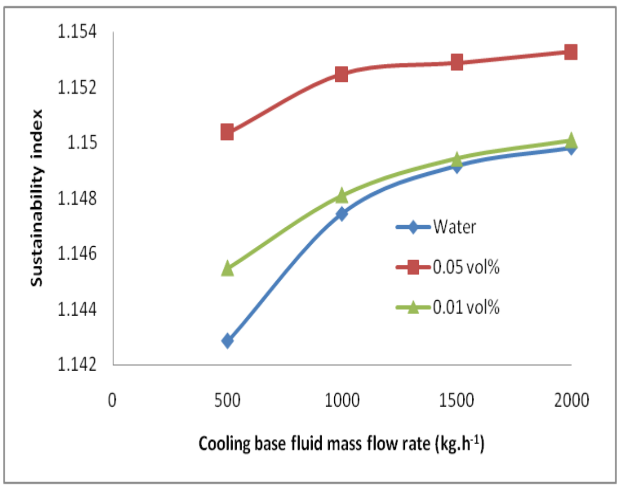

Figure: 22 Sustainability index versus cooling based fluid mass flow rate

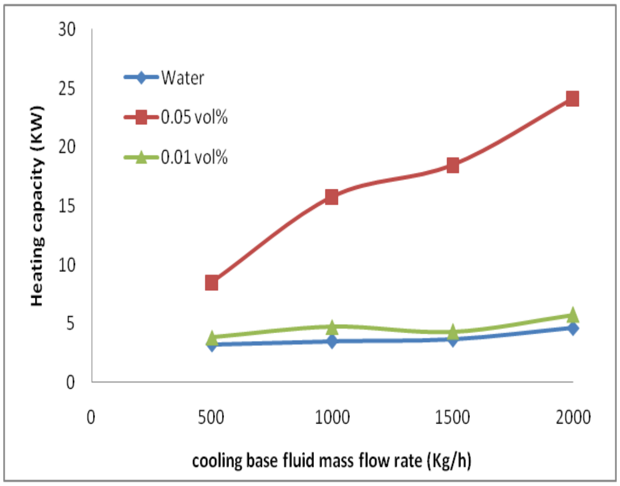

Figure: 23 Heat capacity versus cooling based fluid mass flow rate

Heating capacity is the product of mass flow rate, specific heat and temperature rise of cooling base fluid. By keeping constant mass flow rate of water and discussed percentage of nanofluid remaining two factors i.e specific heat and temperature difference of cooling base fluid responsible for increase of heat transfer between refrigerant through condenser and cooling base fluid. Average specific heat of 0.05 and 0.01 vol% nanofluid is higher than water; also temperature rise of 0.05 vol% of nanofluid is much higher than water and 0.01 vol% nanofluid over entire range of cooling base fluid mass flow rate. This increase in heat transfer termed as heating capacity of condenser, maximum 80% heat capacity higher when 0.05 vol% nanofluids is used instead of water at 2000 Kg/h cooling base fluid mass flow rate. Table-1 illustrates the variation of exergy destruction in compressor, condenser, expansion valve & evaporator with variation in mass flow rate of cooling base fluid. Exergy destruction in component is due to depletion of input energy in particular component. It also gives idea about best and worst component of the system. It was observed that expansion valve and compressor are the best and worst component of the system respectively for entire range of mass flow rate of cooling base fluid. It is clear that average exergy destruction. Experiment is done to give valuable suggestion for increasing efficiency of cryogenics systems.Experiment is performed on VCR system to study the effect of Silver oxide Nano particle (50nm) in base fluid of ethyl glycol (50:50 ratio with water) with concentration factor 0.02g to 0.06g by volume % on hot side of system (Condenser side).For high efficiency out-put Plate Type heat exchanger are taken in the system. Test results show that The parameters such as exergy efficiency, heating capacity of the considered system improved in the range of 1.9-5.96% and 26-82% respectively by using 0.06 Vol% silver Nano fluid compared to water as cold based fluid for considerable range of cold base fluid flow rate. Exergy destruction decreases in the range of 29-31.28%, 65.77-70.01%, 14.31-16.03%, 17-23% in compressor, condenser, evaporator and expansion valve respectively. whereas 0.015 Vol% silver Nano fluid shows very less effect on performance parameters of system for different base fluid mass flow rates.

Over wide range of mass flow rate of cooling base fluid in compressor, condenser, expansion valve and evaporator is lowest by 29.92, 67.16, 20.11 and 14.8% respectively when 0.05 vol. % silver nanofluid compared to water used as cooling base fluid. Mean exergy destruction in compressor, condenser, capillary tube & evaporator ***is*** 873.18, 180.65, 22.50 and 97.36 W respectively which ishighest in case of water used as secondary fluid through evaporator. 7.13, 18.88,3.68 and 1.57 % reduction of exergy destruction in compressor, condenser, expansion valve & evaporator respectively by using of 0.01 vol. % silver nanofluid used as cooling base fluid compared to water

Table .1. Variation of exergy destruction in compressor, condenser, expansion valve & evaporator with variation in mass flow rate of cooling base fluid

Cooling base fluid mass flow rate (Kg/h)	**Water**				**0.01 vol%**				**0.05 vol%**			
	$\dot{E}_{1-2}$ (W)	**$\dot{E}_{2-3}$ (W)**	**$\dot{E}_{3-4}$ (W)**	**$\dot{E}_{4-1}$ (W)**	**$\dot{E}_{1-2}$ (W)**	**$\dot{E}_{2-3}$ (W)**	**$\dot{E}_{3-4}$ (W)**	**$\dot{E}_{4-1}$ (W)**	**$\dot{E}_{1-2}$ (W)**	**$\dot{E}_{2-3}$ (W)**	**$\dot{E}_{3-4}$ (W)**	**$\dot{E}_{4-1}$ (W)**
500	918.2	206.2	23.83	99.13	856.3	173.4	22.81	97.82	708.9	123.4	19.5	86.72
1000	869.6	185.9	22.47	98.44	814.4	155.5	21.62	96.73	677.8	109.6	18.61	85.35
1500	867.5	169.1	22.28	96	807.4	142.6	21.52	94.62	666.6	101.9	18.61	83.77
2000	837.4	161.4	21.41	95.85	781.84	136.19	20.85	94.22	648.1	97.36	18.2	83.16

7. Conclusion

(1) Test results show that the parameters such as exergy efficiency, heating capacity of the considered system improved in the range of 1.9-5.96% and 26-82% respectively by using 0.06 Vol% silver Nano fluid compared to water as cold based fluid for considerable range of cold base fluid flow rate.
(2) Exergy destruction decreases in the range of 29-31.28%, 65.77-70.01%, 14.31-16.03%, 17-23% in compressor, condenser, evaporator and expansion valve respectively. whereas 0.015 Vol% silver Nano fluid shows very less effect on performance parameters of system for different base fluid mass flow rates.
(3) Experiments performed on compressor to improve the performance of system using different mineral oil. Because different Nano particle are helpful for achieving high output of system and performance of system enhanced up to 6%.

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