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Evaluation of R600a blended with various quantities of CuO, Al_2O_3 and SiO_2 nanoparticles

ABSTRACT

In this work three different nanoparticle concentrations of CuO, Al_2O_3, and SiO_2 are dispersed in R600a vapour compression refrigeration system.The experiment was carried out using nanolubricant concentrations of 0g/L, 0.2g/L, and 0.4g/L having CuO, Al_2O_3, and SiO_2 nanoparticles diffused in mineral oil with refrigerant mass fractions of 30, 40, and 60g. Nano lubricant was prepared at various concentrations using CuO, Al_2O_3, and SiO_2 nanoparticles and refrigerant mass charges which were employed to perform tests. The system's performance was investigated with the variables such as coefficient of performance, refrigeration effect, compressor work, and pull down test. As a result of this study, it can be inferred that there is a significant enhancement in COP value of 2.7 by utilizing 0.4g/L SiO_2 nanolubricant concentration with 40g of refrigerant. This inclusion of nanolubricant enhanced the refrigeration effect up to180W and resulted in a reduction of compressor work to 60W.The results obtained by using nanolubricants are compared with the system without nanolubricants. The pull down test with 0.4g/L SiO_2 nanolubricant concentration quickly achieved low evaporator temperature compared to other conditions. The research was performed with various nanoparticles in R600a refrigeration system,the experiments were conducted with different nanoparticles by varying nanoparticle concentrations and refrigerant mass charges. From the experiments it is observed that SiO_2 nanolubricant results in enhanced COP and refrigerant effect,which can be used as a better alternative to a pure mineral refrigeration system.Among three nanoparticles, SiO_2 resulted in better performance and refrigerating effect with 56% less power consumption.

Keywords : *CuO, Al_2O_3 and SiO_2 nanoparticles; R600a; Performance enhancement.*

1. INTRODUCTION

The most important goal is to enhance the vapour compression refrigeration system performance while lowering the compressor's energy consumption. This is accomplished through incorporating new technology in which nanoparticles dispersed in compressor lubricating oil. The nanoparticles of particular size is employed and dispersed to make nanolubricants with certain concentrations of lubricating oil. Nanolubricants will enhance heat transfer properties of lubricating oil. A new technology was introduced by the inclusion of nanolubricants which indicates a considerable increase in the COP and reduces the energy utilized by the compressor.

Babarinde *et al*. [1,2] performed experiments in refrigerator containing R600a,dispersed with graphene nanolubricants.In the trials, different nanolubricant concentrations and refrigerant mass charges were used. Increase in COP up to 3.2 and refrigeration effect to 0.1891, 0.2054, and 0.1887 kW was achieved with the inclusion of 0.2g/L graphene nanolubricant. The use of nanolubricants led to the reduction in energy usage of 0.0653W. MWCNT nanolubricant has also been used in research. In comparison with the R134a refrigerator, *nanolubricants* concentrations of 0.4 and 0.6 g/L resulted in better performance. In this work nanolubricant concentrations of 0.4g/L and

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0.6g/L resulted in an increase in the COP of 2.8 and 2.9. The compressor used a less amount of energy value of 0.0639kW.

Olayinka S. Ohunakin et al. [3] employed TiO_2, Al_2O_3, and SiO_2 nanoparticles and conducted experiments. SiO_2 and TiO_2 nanolubricants concluded an improvement in the COP of 2.97, and the compressor utilized a minimum power of 13 and 12% in comparison with a normal LPG system not having nanoparticles. Santhana Krishnan et al. [4] fixed things in vapour compression refrigeration systems by adding Al_2O_3, SiO_2, ZrO_2, and CNT nanoparticles to the R134a refrigerator. 0.60g of silicon dioxide resulted in an enhancement in COP of 1.73.Anish.et.al. [5] utilized CuO / Al_2O_3 nanoparticles in the R22 refrigerator and carried out experiments. The refrigerator performance was evaluated by conducting an energy consumption test.The increase in COP of 0.62 resulted with dispersion of 0.05% nanoparticles.The improvement in COP of 0.62 was due to the diffusion of 0.05 percent nanoparticles, which improved the refrigeration effect and reduced the compressor's power consumption and improves refrigeration effect.

David Fernando Marcucci pico. et al. [6,7] concentrated on the refrigerator with R32 refrigrant used as a replacement for R410a refrigeration system. 0.1% and 0.5% diamond nanoparticle improve the COP and cooling effect by 0.5 and 5.0% in addition to that compressor discharge temperature dropped significantly. He also examined and evaluated the R410a refrigerator's performance. With 0.1% diamond nanolubricants the cop was increased by 4% and with 0.5% resulted in 8%. Further higher concentration of diamond nanoparticles enhances the cooling effect by 7%. Senthilkumar et al. [8] used aluminium oxide and silicon dioxide composite nanolubricants at 0.6g/L concentration; there is an increase in COP by 1.7 and refrigeration effect by 160W, and minimum work was consumed by the compressor by 60W.

Joshi et al. [9] enhanced COP to 37.2% with the addition of 0.1wt % of aluminium oxide nanoparticles in mineral oil and reduced the energy consumed by the compressor by 28.7%. He also observed lesser pull down time when compared to a normal refrigeration system. Senthilkumar *et al.* [10] observed that there is improvement in COP and cooling effect by 1.7 and 160W, respectively, and the compressor's energy consumption has been reduced by 80 watts using 0.4g/L of silicon dioxide nanolubricants and R410A refrigerant. Ali Can Yilmaz et.al. [11] Improved the COP to 20.88 percent and 14.55 percent with dispersion of 0.5vol percent of nanolubricants such as Cu/Ag alloy and CuO and this enhancement occurred due to enhancement in triobological properties of nanoparticles in the lubricant.

Choi et al. [12] COP is improved by 28.4 Percent in R134a refrigeration system obtained by investigating the power required by the compressor data and the flow boiling heat transfer coefficient of the nanolubricants. Senthilkumar *et al.* [13,14] Inferred that by utilizing 0.4g/L of CuO and SiO_2 composite nanolubricants and 40g of R600a increased the COP and cooling effect by 1.7 and 170W and minimum power utilized by the compressor of 75W.He also used zinc oxide and silicon dioxide nanolubricants and use of 60g of R600a refrigerant results in increase in COP by 1.7, cooling effect by 180W and reduction in energy used by the compressor by 78W compated to the system not having nanolubricants.

Jatinder et al. [15] performed experiment in R600a refrigerator and resulted in increase in cooling effect of 17.39 percent and COP by 62.54 percent compared to LPG refrigerator.Senthilkumar *et al*. [16] performed review, studied the effect of various nanorefrigerants and nanolubricants at various mass charges and concentrations, and clearly explained how it influences the improvement in COP and cooling effect and decrease in energy used by compressor. Jatinder gill *et al*. [17] used TiO_2 nanoparticles in the LPG refrigerator and observed that increase in COP and cooling effect by 10.15 to 61.49 percent and 18.74 to 31.72 percent in comparison with R134a refrigerator.Raghunatha reddy *et al*. [18] implemented the ANN technique and used backward back propagation and levenberg training and predicted the variables COP, cooling effect and power consumed by the compressor.

Adelekan et.al. [19-21] enhanced the COP by 2.99 to 10.94 percent by using titanium oxide nanoparticles at different concentrations and varied ambient temperatures at 19, 22 and 25^0C.and also resulted with highest COP of 4.99 with 0.1g/L of titanium oxide and 40g of R600a and enhanced cooling effect of 290.33 kJ/kg.performed experiments with varied concentrations of graphene nanolubricants and varied mass charges of R600a refrigerant. The maximum COP of 0.76 and less power utilized by the compressor by 65W was obtained.

Tae JongChoi et.al [22] proposed a model was verified, revealing that the energy usage of the nanolubricant-containing compressor might be reduced by as much as 17%. The flow boiling heat transfer coefficient of the evaporator including the nanolubricant can be enhanced by roughly 5.8% using the modified model.Furthermore, the improvement in refrigerator's coefficient of performance using R134a nanolubricant were investigated.Yogesh Joshi et.al [23] used a 0.1 wt percent R600a-MO-Al_2O_3 mixture, we were able to improve C.O.P. by 37.2 percent, reduce energy usage by 28.7%, boost compressor discharge pressure by 8.9%, reduced evaporator pressure by 24.7 percent, and reduce pull-down time by 17.6 percent when compared to a normal refrigeration system. The evaporator's flow boiling heat transfer coefficient, including the nanolubricant, can be increased by around 5.8%.

Oluseyi O.Ajayi et.al [24] performed freeze capacity testing and energy usage analyses to examine the performance of refrigerator. The results demonstrated that Al_2O_3-dispersed nano-working fluid excelled the standard working fluid mixture in terms of performance. Babarinde et al. [25] used the ANFIS model to predict MWCNT nanolubricant performance in a vapour compression refrigeration system. The data is important and essential for researchers focused on energy-efficient nanomaterials in refrigeration systems to replace MWCNT nanolubricant with base lubricant in a vapour compression refrigeration system. In compared to a refrigeration unit without nanolubricants, nanolubricants replace pure lubricants, improving the COP and refrigeration effect while lowering compressor work.

In published investigations, various types of nanolubricants and nanorefrigerants were used in vapour compression refrigeration systems, with an emphasis on the use of nanoparticles to increase COP and refrigeration effect. This nanolubricant utilises minimum energy, improves the performance of different refrigerators.With the use of nanolubricants, the heat transfer and tribological properties of compressor lubricating oil will increase, and the compressor work would be decreased, resulting in a greater COP and cooling effect. Since SiO_2 nanoparticles posses maximum thermal conductivity and specific heat value of 1.3W/m.K and 680 J/kg.K compared to CuO and Al_2O_3 results in maximimum enhancement in COP and refrigeration effect. This research primarily concentrated on the dispersion of various nanolubricants at different concentrations, which it utilized in normal refrigerator, resulted in better replacement for normal refrigerator not having nanoparticles.

2. METHODOLOGY

2.1. Nanolubricants preparation method

The nanoparticles utilized for this experimental analysis are in the form of powder that has been synthesized by appropriate methods. The three nanolubricants with CuO, Al_2O_3 and SiO_2 are prepared separately.Intially the POE oil is mixed with certain quantity of nanoparticles and followed by sonification process. The entire mixture is positioned over ultrasonic bath for proper mixing. The CuO, Al_2O_3 and SiO_2 nanoparticles utilized in this study have a size of 3 to 9nm. The Table. 1 lists the properties of the nanoparticles utilized

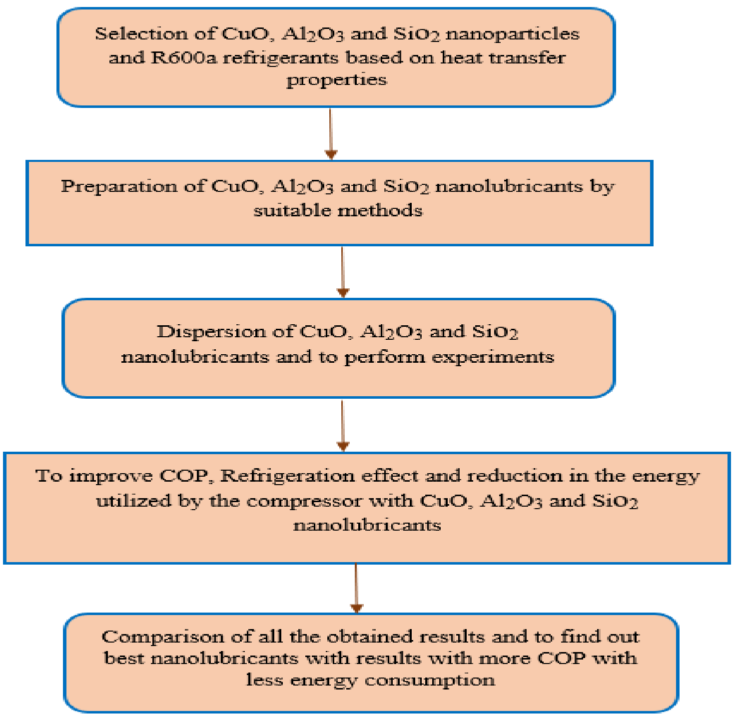


Figure 1 Research Methodology

Slika 1. Metodologija istraživanja

Table 1. Properties of Nanoparticles

Tabela 1. Osobine nanočestica

Properties	CuO	Al_2O_3	SiO_2
Melting point	1,201°C	2,072°C	1,600°C
Boiling point	2,000°C	2,977° C	2,230°C
Density	6.31g/cm^3	3.95 g/cm^3	2.53 g/cm^3

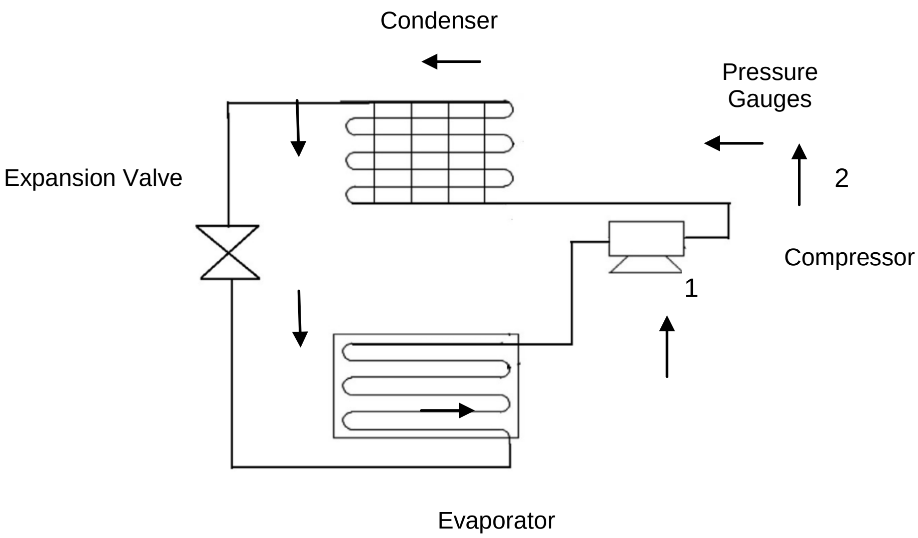
The methodology for this research to perform with various nanolubricants are explained in the flowchart as provided above Fig.1. From these three nanolubricants the outcomes obtained are compared to get the suitable nanolubricants as a consequence, the COP and refrigeration effect are improved while energy utilised is reduced.

2.2. Experimental Setup

The performance test was conducted in the R600a vapour compression refrigeration system without adding nanolubricants. The readings were noted down for calculation of COP and refrigeration effect. The pictorial representation of the experimental setup illustrated in Fig.2

Figure 2. Experimental setup

Slika 2. Eksperimentalna aparatura



1&2 – Compressor suction & Discharge pressure (Pressure gauges)

Figure 3. Experimental Test Rig.

Slika 3. Shema eksperimentalnog testa

The Figure.3 shows the experimental test setup.To achieve precise findings, the experiment was replicated more than thrice for each condition.With help of vacuum pump the mineral oil is evacuated completely and charged with CuO nanolubricant at 0.2g/l concentration and refrigerant mass charge of 30g.the experiment is repeated for various nanolubricant concentration and mass charges of refrigerant. the same procedure is followed for Al_2O_3 and SiO_2 nanolubricants.The specification of R600a refrigeration used to perform experiments are illustrated in table 2.

Tabela 2. R600a specifikacija rashladnog sistema

Table 2. R600a refrigeration system specification

Sl.No	Parameters	Values
1	Refrigerant	R600a
2	Mass Charge of Refrigerant	30,40 and 60g
3	Concentrations of Nanolubricants	0,0.2 and 0.4g/L
4	Lubricating oil used	Polyolester oil (POE)
5	Nanoparticles employed	CuO ,Al_2o_3 & SiO_2
6	Ambient temperature	35^0C

The accompanying equation used to calculate the system's performance.

Cooling Capacity is given by

$$Q_{evap} = \dot{m}(h_4 - h_1) \quad \text{(kW)}$$

The compressor power is given by

$$W_C = \dot{m}(h_2 - h_1) \quad \text{(kW)}$$

Coefficient of Performance is given by

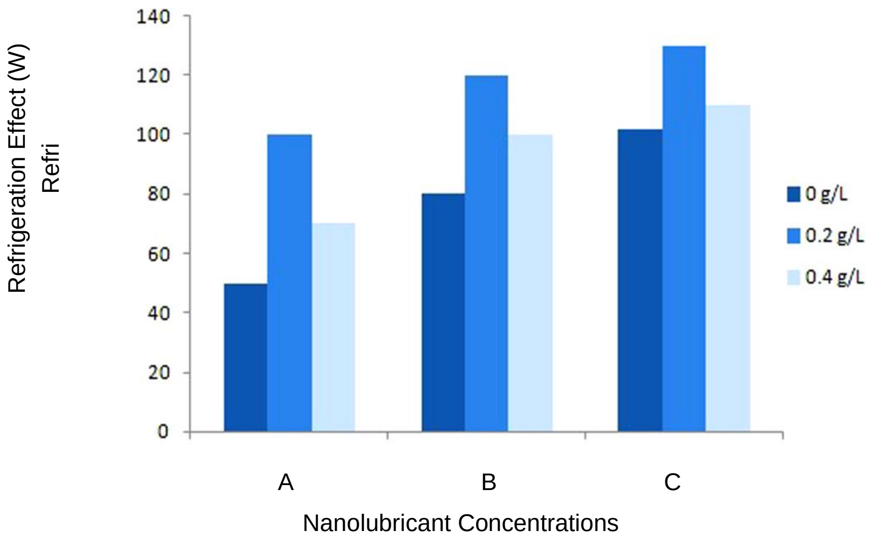
$$COP = \frac{Q_{evap}}{wc}$$

3. RESULTS AND DISCUSSION

According to Senthilkumar et.al [8,13,14] employed hybrid nanolubricants and enhanced COP and cooling effect and reduced the work involved in the compressor.This results mainly focuses on parameters that influences the R600 vapour compression refrigeration system performance and are illustrated in Figs 5-12.The impact of CuO, Al_2O_3 and SiO_2 nanolubricants on the refrigeration effect of R600a system are illustrated in Fig. 4-6.

3.1. Effect of CuO nanolubricants on Refrigeration effect

From Fig.4 it can be understood that experiment is performed with 0 g/L , 0.2 g/L & 0.4 g/L CuO nanolubricant with 30g of R600a.It is observed that refrigeration effect of 100W were obtained with 0.2g/L nanolubricant concentration. The experiment is repeated for different refrigerant mass charges of 40 and 60g. Finally the enhanced refrigeration effect of 130W resulted for 0.2g/L with 60g of R600a refrigerant.



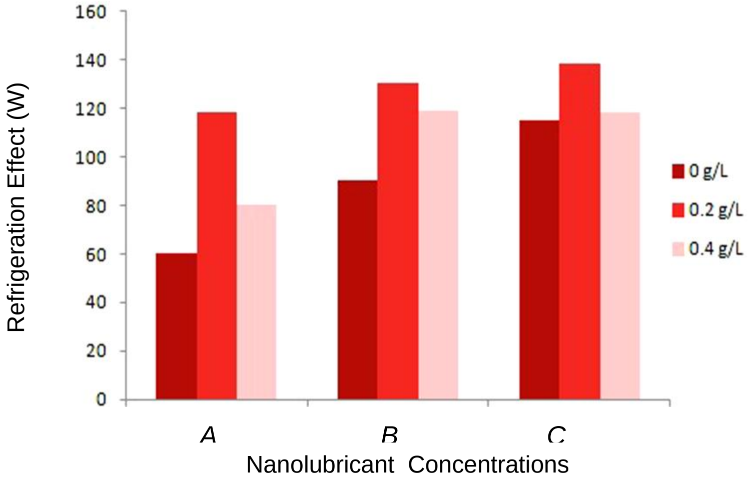
A,B &C – The concentration of CuO nanolubricants are 0,0.2 and 0.4 g/L and R600a refrigerant mass charges of 30,40 and 60g

Figure 4. Impact of CuO nanolubricants in Refrigeration effect

Slika 4. Uticaj CuO nanomaziva na efekat hlađenja

3.2. Effect of Al_2O_3 nanolubricants on Refrigeration effect

The copper oxide nanolubricants are replaced by Al_2O_3 and the impact of nanolubriants are illustrated in Fig.5. For various refrigerant mass charges and nanolubricant concentrations,the experiment is repeated.0.2 g/L with 60g of R600a results in maximum refrigeration effect of 140W compared to other cases and least effect was obtained in refrigerator without addition of nanolubricants.



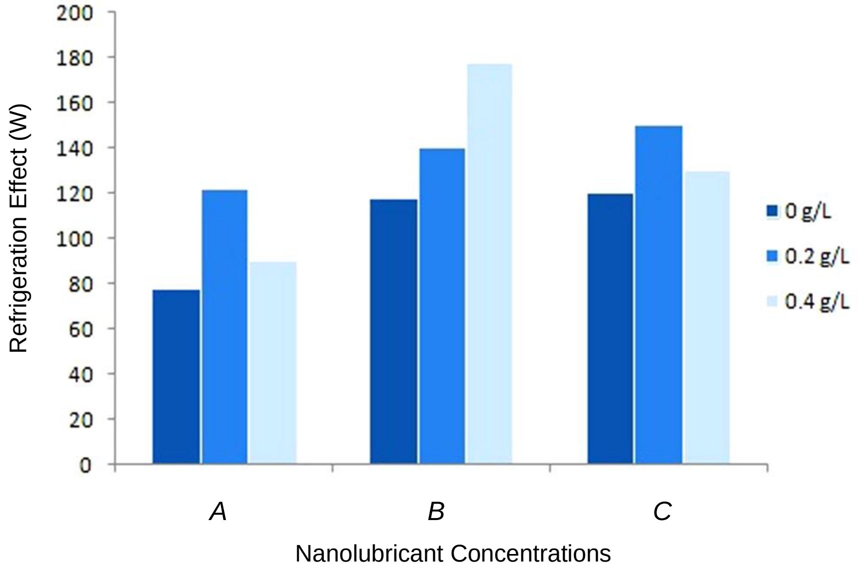
A,B &C – The concentration of Al_2O_3 nanolubricants are 0,0.2 and 0.4 g/L and R600a refrigerant mass charges of 30,40 and 60g

Figure 5. Impact of Al_2O_3 nanolubricants in Refrigeration effect

Slika 5. Uticaj Al_2O_3 nanomaziva na efekat hlađenja

3.3. Effect of SiO_2 nanolubricants on the refrigeration effect

From Fig.6. It can be observed that SiO_2 nanolubricants contribute the major impact on refrigeration effect. The maximum refrigeration effect of 180W was obtained for 0.4g/L /40g of R600a. From the above experimental results it is inferred that refrigerant effect will have major impact on system performance.



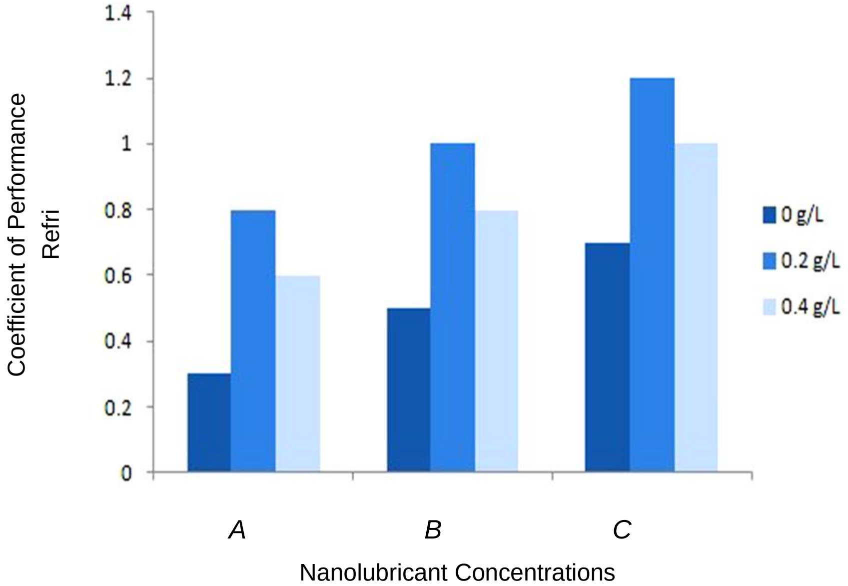
A,B &C – The concentration of SiO_2 nanolubricants are 0,0.2 and 0.4 g/L and R600a refrigerant mass charges of 30,40 and 60g

Figure 6. Effect of SiO_2 nanolubricants on Refrigeration effect

Slika 6. Uticaj SiO_2 nanomaziva na efekat hlađenja

3.4. Role of CuO nanolubricants on COP

The effect of CuO, Al_2O_3 and SiO_2 nanolubricants on Coefficient of performance are explained in Fig. 7-9. Fig.7 shows that 0.2g/L nanolubricants and 30g of R600a generates a COP of 0.8.At the same time we can see that the maximum COP of 1.2 was obtained with 0.2g/L and 60g of refrigerant. The minimum COP of 0.3 was obtained for 0g/L / 30g mass charges of refrigerant.



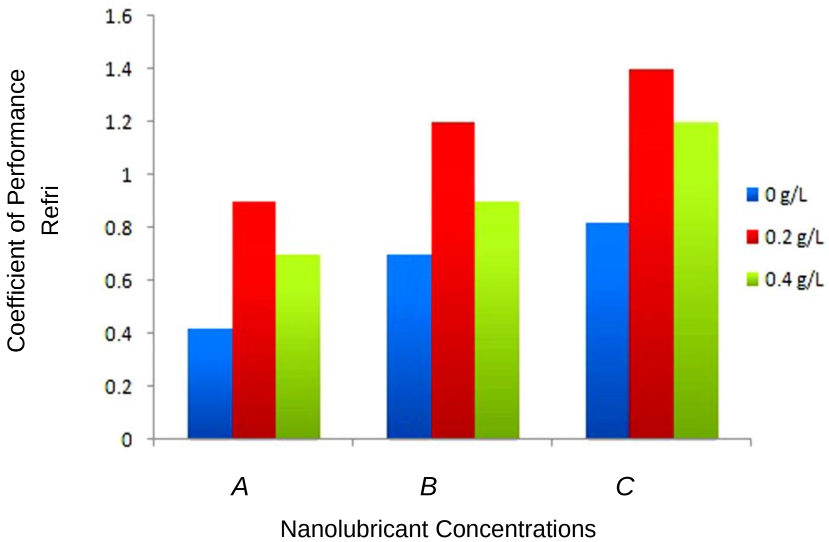
A,B &C – CuO nanolubricants with 0,0.2 and 0.4 g/L and R600a mass charges of 30,40 and 60g

Figure 7. Effects of CuO nanolubricants on COP

Slika 7. Efekti CuO nanomaziva na COP

3.5. Role of Al_2o_3 nanolubricants on COP

The Al_2O_3 nanolubricants influences more than CuO on Coefficient of performance and explained in Fig.8. As we can see that with 0.2g/L nanolubricant and 60g of refrigerant the maximum COP of 1.4 was noticed. Similarly as in the previous experiments least COP of 0.4 was resulted with the system without nanolubricants.



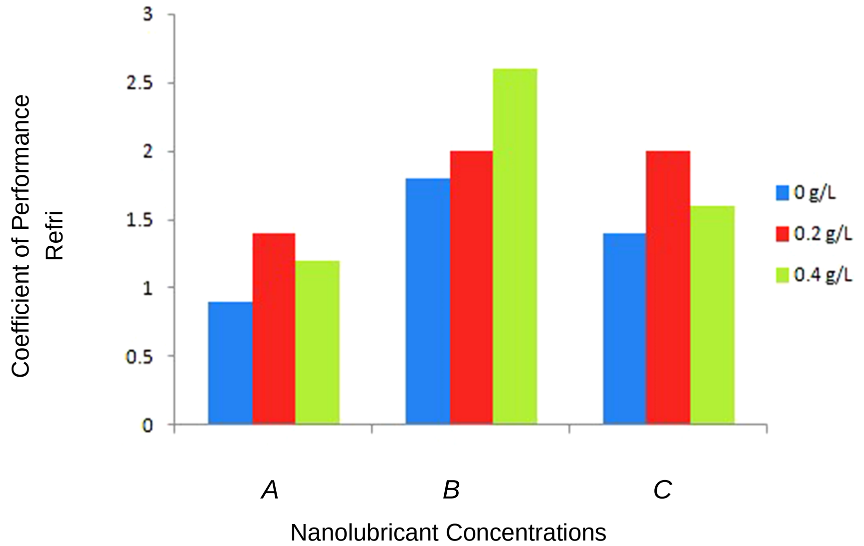
A,B &C – Al_2O_3 nanolubricants having 0,0.2 and 0.4 g/L and R600a mass charges of 30,40 and 60g

Figure 8. Effects of Al_2O_3 nanolubricants on COP

Slika 8. Efekti Al_2O_3 nanomaziva na COP

3.6. Role of SiO_2 nanolubricants on COP

From the above Fig.9. it can be noticed that 0.4g/L SiO_2 nanolubricant concentration with 40g of R600a resulting in increased COP of 2.7 in comparison with other nanolubricant and refrigerant mass charge combinations. It's also important to note that under the same circumstances the refrigerant effect was also maximum. COP value of 2 was resulted for 0.2g/L /40G and 0.2g/L / 60g.



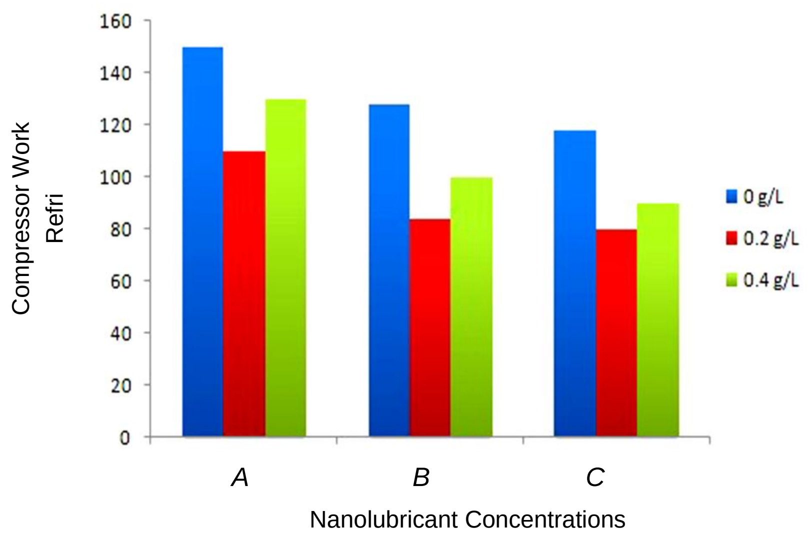
A,B &C – SiO_2 nanolubricants having 0,0.2 and 0.4 g/L and R600a mass charges of 30,40 and 60g

Figure 9. Effect of SiO_2 nanolubricants on COP

Slika 9. Efekti SiO_2 nanomaziva na COP

3.7. Inclusion of CuO Nanolubricants its consequence on Compressor Work

Fig.10. shows the impact of CuO nanolubricants on compressor work. 0.2g/L and 60g of R600a refrigerant mass charge offers minimum work utilized by the compressor of 80W.The maximum compressor work of 150W observed for the refrigerator without addition of nanolubricants. If the compressor utilizes less work, the system will work efficiently and generates more refrigeration effect and COP.



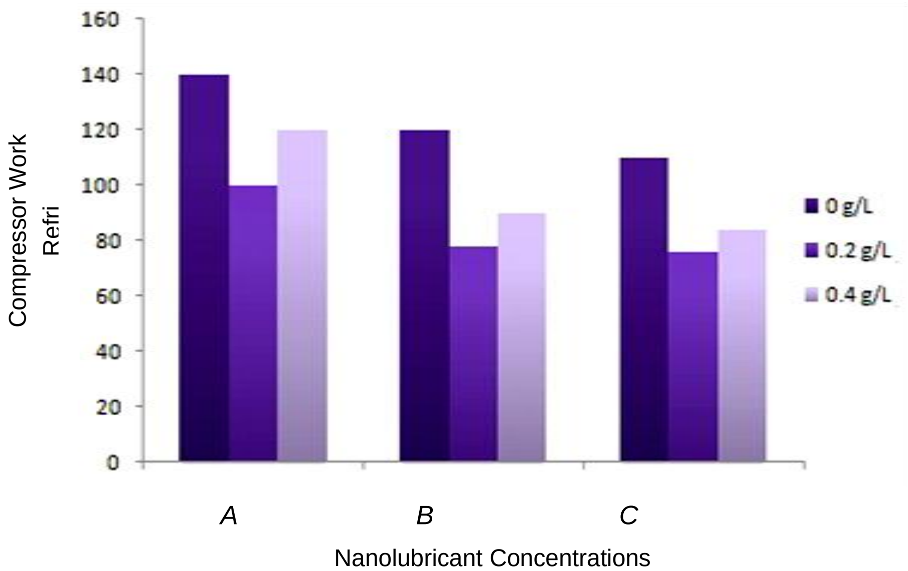
A,B &C – The concentration of CuO nanolubricants are 0,0.2 and 0.4 g/L and R600a mass charges of 30,40 and 60g

Figure 10. Effect of CuO nanolubricants on Compressor Work

Slika 10. Uticaj CuO nanomaziva na rad kompresora

3.8.Inclusion of Al_2O_3 Nanolubricants its consequence on Compressor Work

From Fig.11 it can be observed that the minimum compressor work of 78W resulted for 0.2g/L nanolubricant with 60g of refrigerant. The maximum compressor work of 140W offered by the system without nanolubricants which produces less refrigeration effect and performance of the system will be low at that conditions.



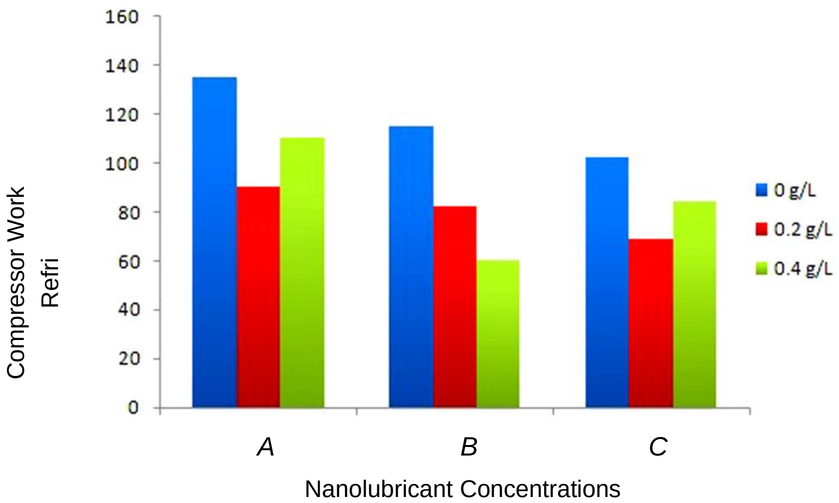
A,B &C – The concentration of Al_2O_3 nanolubricants are 0,0.2 and 0.4 g/L and R600a mass charges of 30,40 and 60g

Figure 11.Effect of Al_2O_3 nanolubricants on Compressor Work

Slika 11. Uticaj Al_2O_3 nanomaziva na rad kompresora

3.9. Inclusion of Sio_2 Nanolubricants its consequence on Compressor Work

Fig.12. shows that for 0.4g/L and 40g of refrigerant mass charge, a minimum compressor work of 60W was attained. The SiO_2 nanolubricants at that condition resulted in maximum COP and refrigeration effect. The experiment was carried out with 0.4g/L SiO_2 nanolubricant and 40g of R600a refrigerant will consume less energy and will work efficiently compared to other experimental conditions.



A,B &C – The concentration of SiO_2 nanolubricants are 0,0.2 and 0.4 g/L and R600a mass charges of 30,40 and 60g

Figure 12. Effect of SiO_2 nanolubricants on Compressor work

Slika 12. Uticaj SiO_2 nanomaziva na rad kompresora

3.10. Pull down test

The evaporator temperature is lowered from 30^{0}C to 5^{0}C and time it takes for that decrease is recorded at particular intervals. Fig.13 describes that pull down test is carried out for R600a vapour compression system without nanolubricants. It was noted that the system with 40g of R600a refrigerant takes 3500s to reach the minimum temperature.

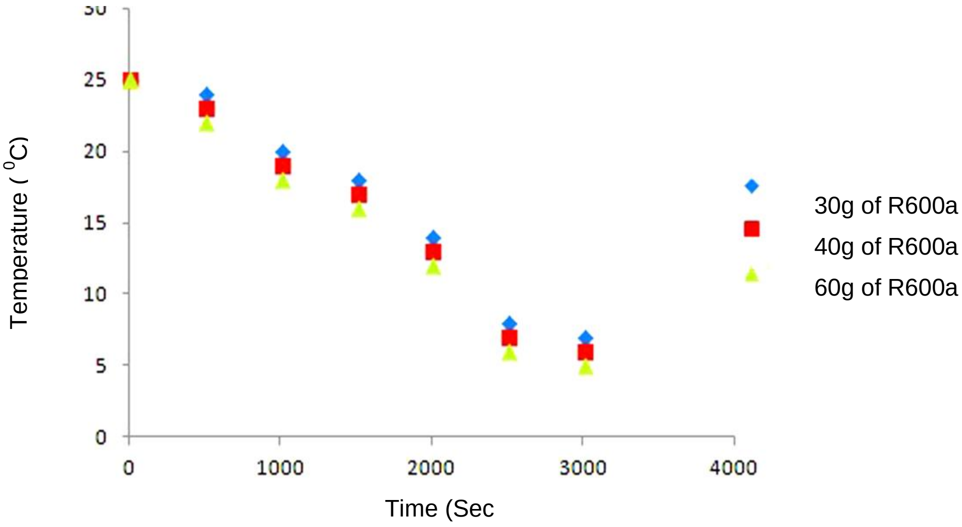


Figure 13. Pull down test for R600a without nanolubricants

Slika 13. Pull down test za R600a bez nanomaziva

Fig.14 shows the importance of nanolubricants with pull down test and conducted after dispersion of nanolubricants. The findings are compared with the results obtained of a system that does not use nanolubricants. Within 2500s, the R600a system with nanolubricants reaches the lowest temperature. If the pull down time for a system dispersed with nanolubricants is kept to a minimum, the COP and refrigeration effect are maximised with minimal compressor work.

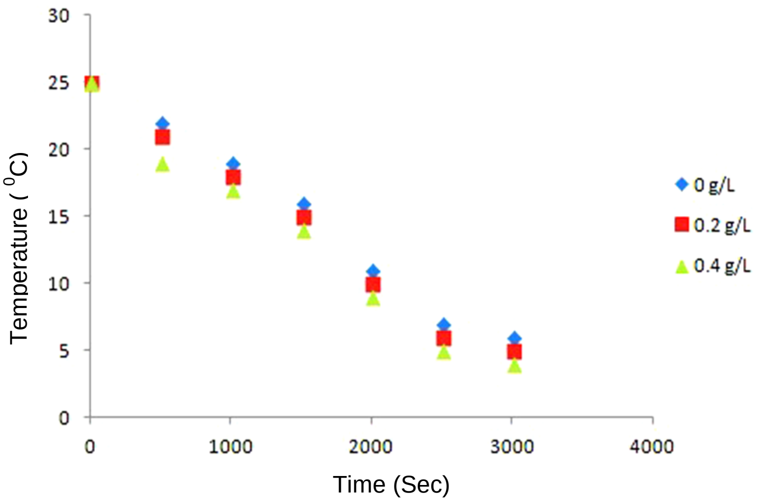


Figure14. Pull down test for R600a with nanolubricants

Slika 14. Pull down test za R600a sa nanomazivima

4. ERROR BAR CHARTS

The cooling effect for 0, 0.2, and 0.4 g/L SiO_2 nanolubricants with 30g of refrigerant resulted in a minimum value of 70W and a maximum value of 118W, as shown in the error bar chart in Fig.15. For the same concentration of nanolubricants and 40g of refrigerant, the following results were obtained with 120W and maximum of 178W. For 60g of refrigerant the results obtained was 122W and maximum of 150W.

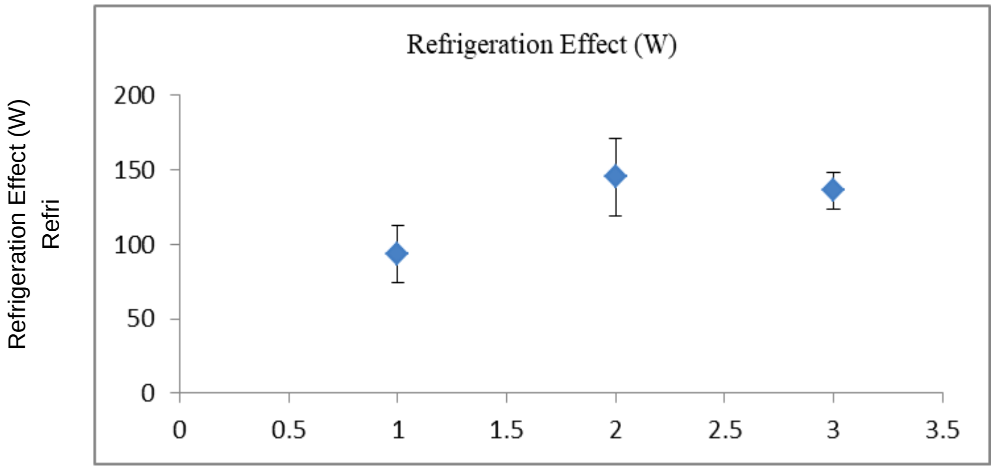
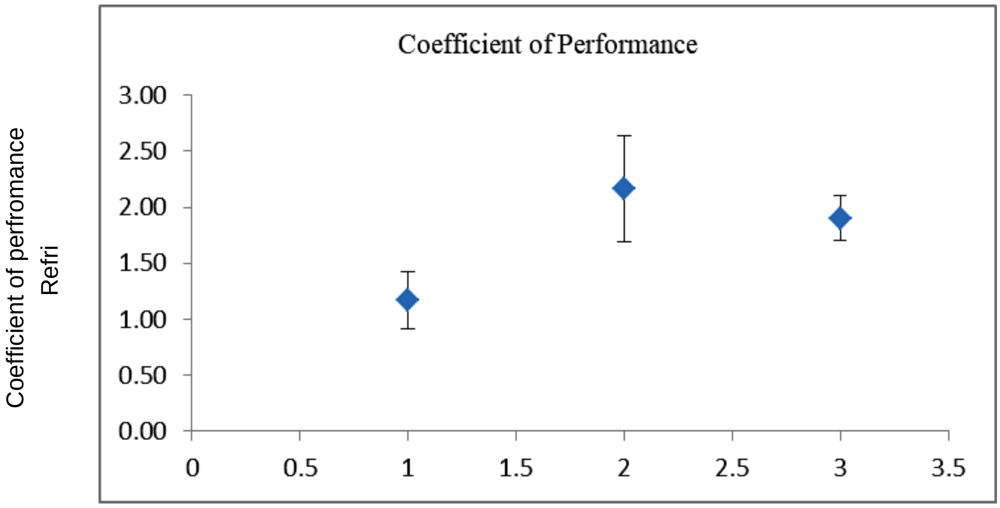


Figure 15. Error Bar for Refrigration effect

Slika 15. Traka grešaka za efekat hlađenja

Fig.16.illustrates about the error bar chart of COP and clearly explains about the results obtained for 0, 0.2 & 0.4 g/L SiO_2 and varied mass charges of refrigerant. For 30g the minimum COP resulted was 0.8 and maximum COP value of 1.48 . For refrigerant mass charge of 40g resulted with least COP value of 1.75 and maximum of 2.7. The COP value of 1.5 and maximum of 2 was obtained for 60g of refrigerant



Nanolubricant concentrations

Figure 16. Error Bar for COP

Slika 16. Traka grešaka za COP

Fig.17 describes about the compressor work error bar chart and the maximum and minimum energy utilized by the compressor. For 30g with various nanolubricants concentrations resulted with compressor work of 90W and 140W. And for 40g the minimum energy used was 58W and maximum of 120W. For the refrigerant mass charge of 60g and nanolubricants concentration compressor work resulted was 70W and 120W.

Based on the experiment conducted by the previous authors which has been explained in the introduction section.From the results and dispersion of various nanoparticles in compressor lubricating oil improves the coefficient of performance and refrigeration effect by lowering the amount of energy used by the compressor. particularly by employing SiO_2 nanoparticles compared to CuO and Al_2O_3 is shown in Table 3.

Table 3. Findings obtained by utilizing nanoparticles

Tabela 3. Nalazi dobijeni korišćenjem nanočestica

Sl. No	Nano-particles	COP	Refrigeration Effect (W)	Compressor Work (W)
1	CuO	1.3	130	90
2	Al_2O_3	1.5	140	80
3	SiO_2	2.8	190	60

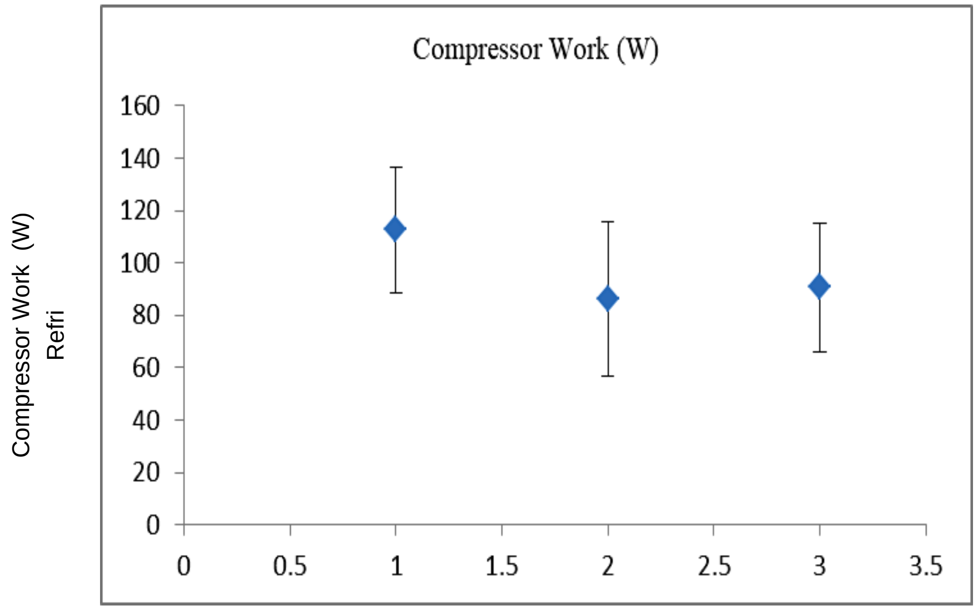


Figure 17. Error Bar for Compressor Work

Slika 17. Traka grešaka za rad kompresora

The following results were obtained:

The R600a system with CuO nanolubricants

- Increase in cooling effect of 130W obtained by 0.2g/L of nanolubricants and 60g of refrigerant mass charge
- Improved COP of 1.2 obtaind by 0.2g/L and 60g of refrigerant.
- With 0.2g/L and 60g of R600a refrigerant, minimum compressor work of 80W was achieved.

The R600a system with Al_2O_3 nanolubricants

- With a concentration of 0.2 g/L nanolubricant and 60 g of R600a, an increased cooling effect of 140W was achieved.
- COP of 1.4 was attained using 0.2g/L nanolubricant and 60g refrigerant.
- Using 60g of refrigerant and 0.2g/L nanolubricant, a minimum compressor work of 78W was attained.

The R600a system with SiO_2 nanolubricants

- Compared to other nanolubricant concentrations, mass charge resulted in a maximum cooling impact of 180W with 0.4g/L and 40g of refrigerant.
- 0.4g/L SiO_2 nanolubricant concentration with 40g of R600a refrigerant results in increase in COP of 2.7.
- Least compressor work of 60W responded for 0.4g/L with 40g of refrigerant mass charge.

Table 4. Energy saving analysis

Tabela 4. Analiza uštede energije

Sl.No	Nanolubricants Used	% Energy Savings
1.	CuO	46
2.	Al_2O_3	44
3.	SiO_2	56

From Table 4 it can be observed that energy saving analysis of vapour compression refrigeration used various nanolubricants. It is determined by the amount of energy utilized by the compressor following dispersion of nanolubricants, with SiO_2 using less energy than other nanolubricants.The above findings showed that the R600a refrigerator with a refrigerant mass charge of 40g and SiO_2 nanolubricant concentration of 0.4g/L results in enhanced COP and cooling effect and consumed minimum energy. In the future, this system can be used as energy efficient vapour compression system and a better substitute for normal household refrigerators.

5. CONCLUSION

The performance of the R600a refrigerator was evaluated using essential variables such as COP, cooling effect, compressor power consumption, and pull down test.The research was carried out with a pure R600a refrigerator and compared to the performance of the system having CuO, Al_2O_3 and

SiO_2 nanolubricants at different concentrations and refrigerant mass charges.Based on the amount of nanolubricants used in the system mass fraction or density of nanoparticles employed are varied from 0.2 and 0.4 g/L.The refrigerant mass charges also varied at the range of 30,40 and 60g to conduct the experiments. This work clearly indicates that nanolubricants system works efficiently than a normal R600a refrigerator without nanoparticles.

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IZVOD

PROCENA R600A POMEŠANOG SA RAZLIČITIM KOLIČINAMA NANOČESTICA CuO, Al_2O_3 I SiO_2

U ovom radu tri različite koncentracije nanočestica CuO, Al_2O_3 i SiO_2 su dispergovane u rashladnom sistemu R600a parom kompresije. Eksperiment je izveden korišćenjem koncentracija nanomaziva od 0g/L, 0.2g/L i 0.4g/L sa CuO, Al_2O_3 i nanočestice SiO_2, difundovane u mineralnom ulju sa masenim udelom rashladnog sredstva od 30, 40 i 60 g. Nanomazivo je pripremljeno u različitim koncentracijama korišćenjem nanočestica CuO, Al_2O_3 i SiO_2 i rashladnog masenog punjenja koji su korišćeni za izvođenje testova. Performanse sistema su ispitivane pomoću varijabli kao što su koeficijent performansi, efekat hlađenja, rad kompresora i test spuštanja. Kao rezultat ove studije, može se zaključiti da postoji značajno povećanje vrednosti COP od 2,7 korišćenjem koncentracije nanomaziva od 0,4 g/L SiO_2 sa 40 g rashladnog sredstva. Ovo uključivanje nanomaziva povećalo je efekat hlađenja do 180W i rezultiralo smanjenjem rada kompresora na 60W. Rezultati dobijeni korišćenjem nanomaziva upoređuju se sa sistemom bez nanomaziva. Pul-down test sa koncentracijom nanomaziva od 0,4 g/L SiO_2 brzo je postigao nisku temperaturu isparivača u poređenju sa drugim uslovima. Istraživanje je sprovedeno sa različitim nanočesticama u rashladnom sistemu R600a; eksperimenti su sprovedeni sa različitim nanočesticama različitim koncentracijama nanočestica i masenim punjenjem rashladnog sredstva.

Iz eksperimenata je primećeno da SiO_2 nanolubrikant dovodi do poboljšanog COP i efekta rashladnog sredstva, koji se može koristiti kao bolja alternativa čistom mineralnom sistemu za hlađenje. Među tri nanočestice, SiO_2 je rezultirao boljim performansama i efektom hlađenja sa 56% manjom potrošnjom energije.

Ključne reči: *nanočestice CuO, Al_2O_3 i SiO_2, R600a, Poboljšanje performansi.*

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