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EFFECT OF EVAPORATIVE CONDENSER BY CAPILLARY ACTION ON VCR SYSTEM USING R600a AND CuO NANO MIXED WITH POE OIL AS LUBRICANT

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Abstract—The concept of effect of evaporative condenser on the coefficient of performance of vapor compression system mainly carried out to improve the coefficient of performance of system by using R600a and 0.5%V of CuOnano mixed with Polyolester oil as lubricant. To improve the COP, it is required that decreases the compressor work and refrigerating effect should increases. The aim of increasing the COP of refrigeration system by using evaporative condenser instead of the air cooled condenser. In the evaporative condenser (wick from the basin wet the condenser tubes by capillary action) is used to decrease the condensing temperature which results in decrease the energy consumption by compressor and then coefficient of performance (COP) will increased. The cloth should be super absorbent fabric, which is absorbs high amount of water. Wick suck the water by capillary action from the basin and wet the condenser tubes, then the condenser rejects the heat by evaporation which results low condensing temperature compared to air cooled condenser. In additional fan or blower fixed at the end of the condenser, then heat transfer rate increases due to forced convection. Hence COP should improve and also getting better performance compared with earlier observations.

Keywords—Refrigeration,polyolester oil, evaporative condenser, fan, capillary action.

I. INTRODUCTION

Decreasing energy consumption by renewable energy is an important task for decreasing global warming. Residential vapor compression units are widely spread all over the world. Any trials to decrease the energy consumption of these units will decrease the dependence on fossil fuel. The energy consumption of these units depends on the COP, which is improved by decreasing the condensing temperature. There are three types of condensers of refrigerating systems: air-cooled, water-cooled, and evaporative-cooled. The COP of the refrigerating systems with air cooled condenser drops down when the ambient air temperature increases especially in hot regions in summer. The condensers of residential refrigerators and air conditioners are mainly air cooled. Meanwhile, evaporative cooled condensers are widely used in large units. Little attention was given to the application of evaporative condensers for small residential refrigerating systemsinnovative evaporative condenser and compared it with that of a conventional air-cooled condenser for a split heat pump system. In their design, the condenser tubes are immersed in a water bath. Disks, which are partially submerged in the water bath, are rotated by a motor while air is blown across them. The disks carry a thin water film from the bath to the air system, and water from the film is evaporated into the air stream. The condenser tubes reject heat to the water bath and the evaporation from the film rejects heat to the air stream. Their experimental results showed that the evaporative condenser has a higher capacity than the air-cooled condenser by 1.8 to 8.1 %, a higher COP by 11.1 to 21.6%.In the present study the refrigerant selected is R600a and the nanoparticle is copper. Isobutene (R600a) is more widely adopted in domestic refrigerator because of its better environmental and energy performances. A new refrigerator test system was built up according to the requirement of this study. 0.5% V and 50nm-200nm size of CuOnano particles mixed with POE oil used as lubricant and R600a is used as refrigerant in 168L capacity refrigerator. Also evaporative condenser used as a regenerative heat exchanger. To allow for evaporative cooling, sheets of cloth were wrapped around the condenser to suck the water from a water basin by capillary action. Experiments are conducted to analyze the performance. CuO nanoparticles mixed with POE oil lubricant was prepared and used as lubricating oil.In additional fan or blower fixed at the end of the condenser, then heat transfer rate increases due to forced convection.

LITERATURE REVIEW

M.M. Nasr and M. Salah, et.al Experimental and theoretical investigation of an innovative evaporative condenser for residential refrigerator. In this study evaporative condenser has introduced and working effectively. The condenser temperature increases 0.45^0C for each degree increases in evaporative condenser temperature when the air velocity 2.5 m/s. The condensing temperature 20^0C lower than the air cooled condenser

Jwo, et.al . Conducted studies on a refrigeration system replacing R-134a refrigerant and polyester lubricant with a hydrocarbon refrigerant and mineral lubricant. The mineral lubricant mixed with Al2O3 nanoparticles to improve the lubrication and heat-transfer performance. Their studies show that the 60% R-134a and 0.3 wt % Al2O3 nanoparticles were optimal. Under these conditions, the power consumption was reduced by about 2.4%, and the coefficient of performance was increased by 4.4%.

A.Senthikumar, R.Praveen, et.al. Conducted an experimental investigation on VCR system using CuO-R600a as alternate refrigerant to R134a. In this paper, CuO-R600a was used as a working fluid of domestic refrigerators. The results indicated that CuO-R600a can work normally and efficiently in refrigerator. 0.1 & 0.5g/L concentrations of CuO-R600a can save 11.83% and 17.88% energy consumption respectively and the cooling capacity of the domestic refrigerator is increased by 10 - 20% by using nano – refrigerant. The freezing velocity of CuO-R600a was more quickly than the pure R600a system. So the above works have demonstrated that CuO-R600a can improve the performance of the domestic refrigerator.

II. SYSTEM DESIGN AND EXPERIMENTAL SET-UP

The layout of the tested refrigeration cycle is shown in Fig. 1. The main components are R600a compressor, the proposed evaporative condenser, capillary tube expansion valve, and U-shape aluminum plate evaporator. The details of the condenser, are shown in Fig 2. A thin sheet of cloth was immersed in the water from one side and wrapped over each tube of serpentine from the other side. These components were inserted inside a rectangular duct. The cloth sheets suck the water from the basin by capillary action and wet the tubes. In this experiment the condenser is open to atmosphere for sub cooling and the evaporator coil is immersed into the condenser instead of compressor for superheating. In this work R-600a with CuOnano mixed with Polyolester oil as lubricant instead of R600a with mineral oil and used here. And in evaporative condenser water is used. In the evaporative condenser, to allow for evaporative cooling sheets of cloth were wrapped around the condenser to stuck the water from the water basin (shell and tube condenser) by capillary effect to the system.Blower or fan is fixed additionally at the end of the evaporative condenser for the better performances. The heat transfer rate is increases with help of blower or fan and check the performance of the domestic refrigerator. Power consumption takes very low with maximum efficiency. The air velocity from the fan is 1.2 m/s.

Fig 1: Experimental setup

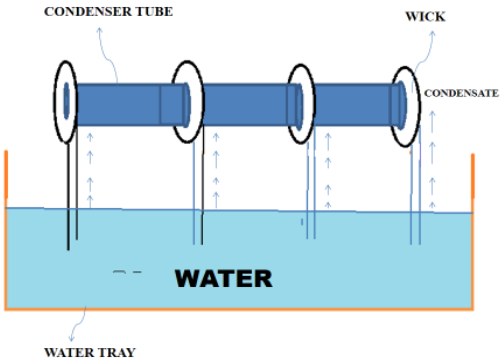

Fig 2. Working of evaporative condenser

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III. WORKING OF EVAPORATIVE CONDENSER

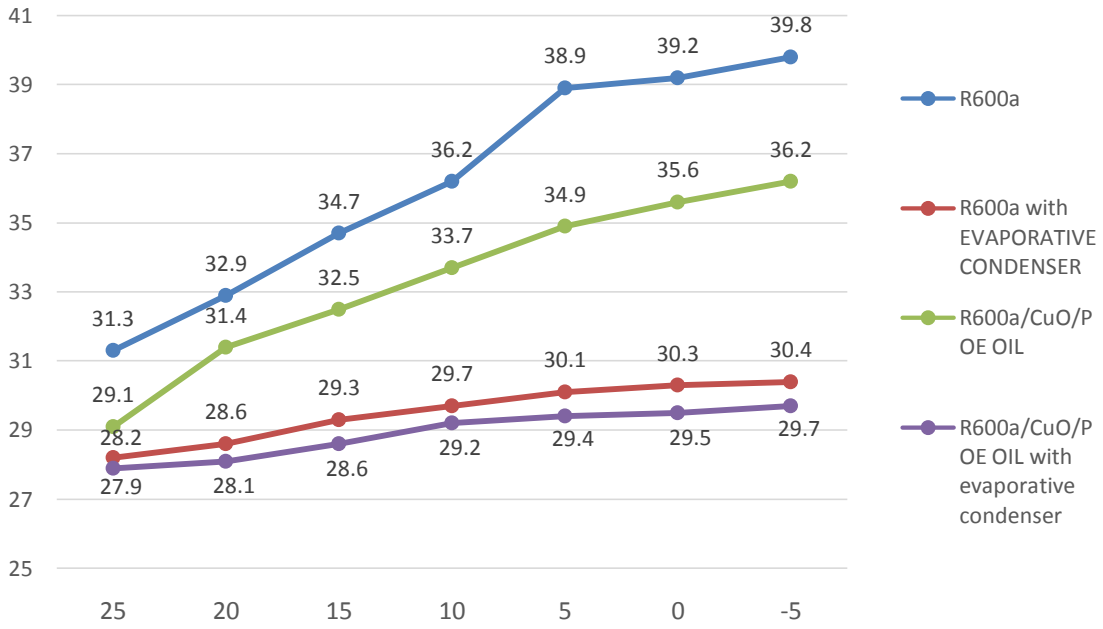
Fig 2 shows the working of evaporative condenser. Evaporative condenser consist of series of tubes. One set of these tubes contains the fluid that must be either heated or cooled. The second fluid runs over the tubes that are being heated or cooled so that it can either provide the heat or absorb the heat required. The condenser is a material of copper laid longitudinally on a water tray with a shallow of water. A thin sheet of cloth was super absorbent fabric immersed in the water from one side and wrapped over each tube of serpentine from other side. These components were inserted inside a rectangular duct. The cloth sheets suck the water from the basin and wet the tubes by capillary action. At a certain height the amount of water sucked by the cloth.A blower or fan was used to deliver air through the condenser duct. The fan is fixed at the end of the condenser and adjusting fan to ensure uniform flow distribution. The condenser rejects heat to the air by evaporation of some water from the cloth sheets surrounding the tubes, and the air is evaporative cooled by the basin water and the vertical cloth.

IV. EXPERIMENTAL RESULTS

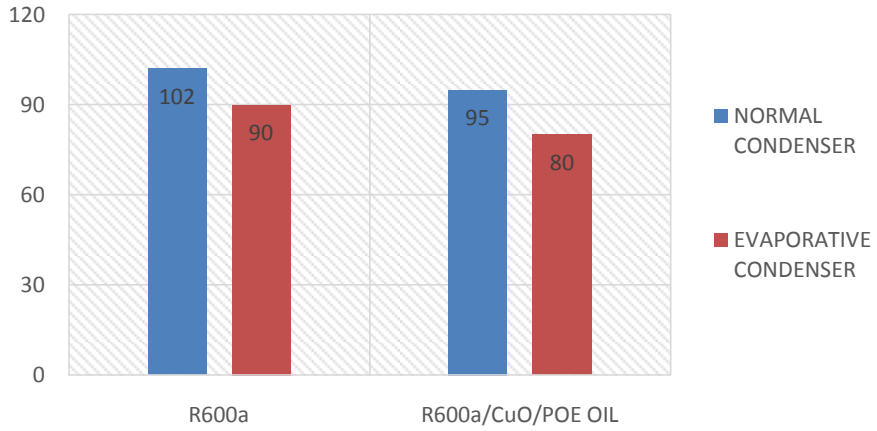
EFFECT OF EVAPORATIVE CONDENSER ON CONDENSING TEMPERATURE:

The condensing temperatures for R600a and R600a/CuO/POE oil with evaporative condenser has decreased and lower than normal condenser for both the processes. With help of the evaporative condenser subcooling has placed and more

temperature of condenser decreases enormously.. The condensing temperature of R600a/CuO/POE oil refrigerant is lower than the R600a because of CuOnano particles has more heat transfer rate than normal lubricant oil. In both refrigerants with evaporative condenser the condensing temperature very low than the normal condenser because of wet wick and water is used as cooling medium. Fan or blower is used as additional low condensing temperatures. Therefore R600a and R600a/CuO/POE oil with evaporative condenser has low condensing temperature than the normal R600a and R600a/CuO/POE oil.



Comparison of Compressor work throughout the Experiment:

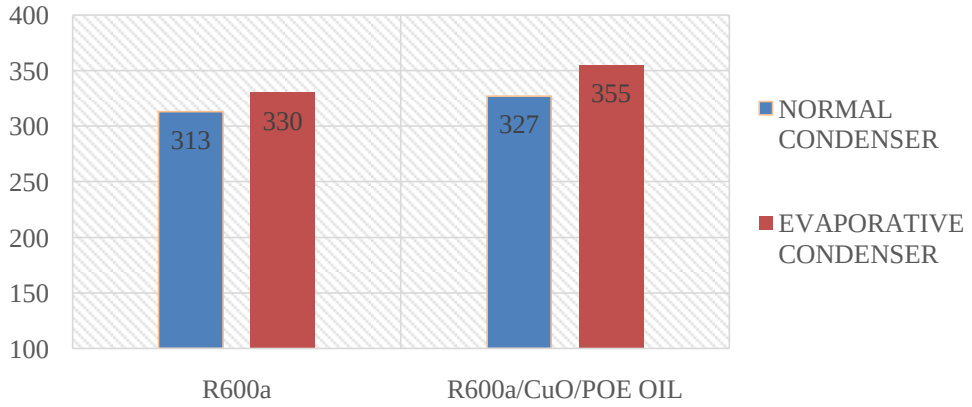


The above graph shows that the comparison of compressor work for R-600a and R600a/Cuo/POE oil refrigerants with and without evaporative condenser. From the graph it concludes that the compressor work for using R-600a with evaporative condenser is less than the before regeneration in domestic refrigerator because of the water is used as cooling medium in the condenser. With help of the cloth suck the water from the basin by capillary action and cool the condenser duct and additionally fan act as a forced convection. Also the R600a/CuO/POE oil lubricant has low compressor work compared to the R600a refrigerant. Also the graph shows that the compressor work of

R600a/CuO/POE oil with evaporative condenser is less than the R600a/CuO/POE of without evaporative condenser. Therefore in both processes with evaporative condenser has low compressor work than the normal condenser.

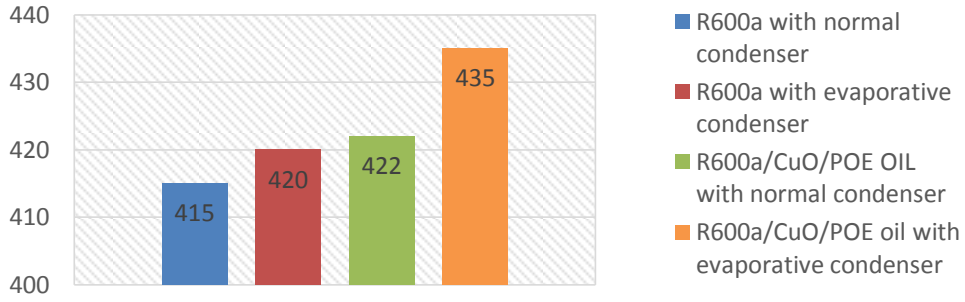
Comparison of Refrigeration effect throughout the Experiment:

The graph shows that the comparison of refrigeration effect of both R600a and R600a/CuO/POE oil refrigerants with and without evaporative condenser. It shows that the refrigeration effect of R600a with evaporative condenser is better than all the variables. The graph also shows that the refrigeration effect of R600a/CuO/POE oil is more compared to the R600a. Andalso we have observed that the refrigeration effect of both R600a and R600a/CuO/POE oil with evaporative condenser has more than the normal condenser.

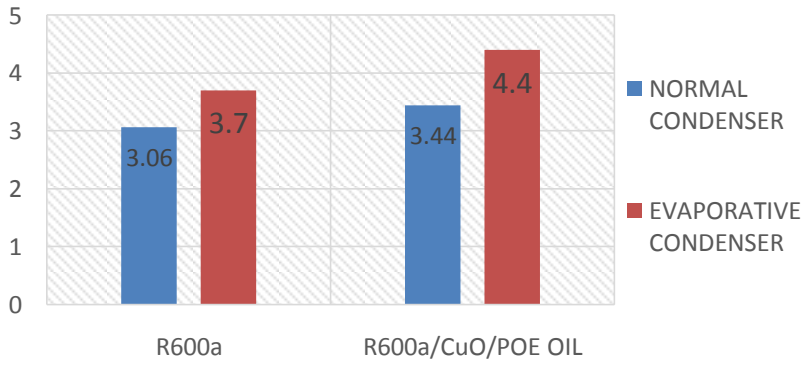


Comparison of Heat rejection in Condenser throughout the Experiment:

The graph 6.3 shows that the comparison of heat rejection in condenser for both R600a and R600a/CuO/POE oil refrigerants with and without evaporative condenser. From the graph it reveals that the heat rejection in condenser is higher for R600a/CuO/POE oil with evaporative condenser than R600a with and without evaporative condenser. In the R600a/CuO/POE oil refrigerant CuOnano particles has mixed with POE oil and CuO has the more heat transfer rate so heat rejection is high than normal lubricant oil. In the evaporative condenser water is used as cooling medium and water sucked by cloth, it keeps always rejection the heat. Fan or blower is used for additional cooling medium. Therefore R600a/CuO/POE oil with evaporative condenser has more heat rejection than R600a.



Comparison of COP throughout the Experiment:



The graph shows that the comparison of coefficient of performance for both refrigerants R600a and R600a/CuO/POE oil refrigerants and also comparing with and without evaporative condenser on COP using R600a and R600a/CuO/POE oil as refrigerant. It reveals that the COP of R600a/CuO/POE oil with evaporative condenser is higher than the R600a with evaporative condenser because of the refrigeration effect is increased by the cooling medium water in basin and also fan is used for extra COP increase parameter. With evaporative condenser of both refrigerants has more COP than normal condenser. And also R600a/CuO/POE oil has more COP than the R600a.

V. **CONCLUSIONS**

S.NO	PERFORMANCE CHARACTERISTIC	R600a	R600a WITH EVAPORATIVE CONDENSER	R600a/CuO/POE OIL	R600a/CuO/POE OIL WITH EVAPORATIVE CONDENSER
1	Net refrigerating effect KJ/Kg	313	330	327	355
2	Coefficient of performance (COP)	3.06	3.7	3.44	4.4
3	Mass flow rate to obtain 1TR Kg/min	0.67	0.64	0.64	0.6
4	Work of compression KJ/Kg	102	90	95	80
5	Heat equivalent of work of compression per TR KJ/min	68.44	57.6	64	47.3
6	Compressor power KW	1.14	0.96	1.06	0.78
7	Heat to be rejected in condenser KJ/Kg	415	420	422	435

Table 1 comparison of theoretical model with experimental data

Experimental investigations were made on the domestic refrigerator of 165 liters capacity with evaporative condenser system using R-600a and R600a/CuO/POE oil as refrigerant and the water is used as heat transfer medium with help of wet wick..

- Compressor work for R600a with evaporative condenser 11.76% lower than the R600a with normal condenser and also R600a/CuO/POE oil with evaporative condenser 15.78% lower than the R600a/CuO/POE oil normal condenser.

- With evaporative condenser the condenser temperature 23.61% and 17.95% lower than the normal condenser in both R600a and R600a/CuO/POE oil. Condenser respectively.

- Refrigeration effect for R600a with evaporative condenser 5.43% higher than the R600a with normal condenser and also R600a/CuO/POE oil with evaporative condenser 8.56% higher than the R600a/CuO/POE oil normal condenser.

Table 2 represents the percentage of energy saving

Different oil/Condenser	Energy Consumption (kwh)	Percentage of energy saving (%)
R600a	0.9567	-
R600a with evaporative condenser	0.8435	11.83
R600a/CuO/POE oil	0.7856	17.88
R600a/CuO/POE OIL with evaporative condenser	0.7018	26.64

Percentage of energy savings of R600a with evaporative condenser, R600a/CuO/POE oil and R600a/CuO/POE oil with evaporative condenser is 11.83%, 17.88% and 26.64% respectively

The COP of the domestic refrigerator R600a with evaporative condenser is 20.91% more than the R600a normal condenser and also R600a/CuO/POE oil with evaporative condenser is 27.90 more than R600a/CuO/POE oil normal condenser

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