iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 Issue: VI Month of publication: June 2023

DOI: https://doi.org/10.22214/ijraset.2023.54242

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VI Jun 2023- Available at www.ijraset.com

Enhancement of Cooling Capacity of Refrigerant R-134a through the Addition of CuO and Silica Nanoparticles

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Abstract: This study investigates the cooling capacity enhancement of refrigerant R-134a by dispersing copper oxide (CuO) and silica (SiO2) nanoparticles in the base fluid. The nanoparticles were mixed at different concentrations, and their effects on the thermophysical properties and heat transfer characteristics of R-134a were evaluated. Experimental results demonstrated that the addition of CuO and SiO2 nanoparticles significantly improved the cooling capacity of R-134a, highlighting the potential of nanofluids in enhancing refrigeration systems.

The demand for efficient and environmentally friendly refrigeration systems has led to extensive research in the field of nanofluids. This study investigates the cooling capacity enhancement of refrigerant R-134a by dispersing copper oxide (CuO) and silica (SiO2) nanoparticles in the base fluid. The nanoparticles were mixed at different concentrations, and their effects on the thermophysical properties and heat transfer characteristics of R-134a were evaluated. Experimental results demonstrated that the addition of CuO and SiO2 nanoparticles significantly improved the cooling capacity of R-134a, highlighting the potential of nanofluids in enhancing refrigeration systems.

Keywords: Refrigerant, R-134a, Cooling capacity, CuO nanoparticles, Silica nanoparticles.

I. INTRODUCTION

Refrigeration is a vital process used in various industries, including HVAC, automotive air conditioning, and food preservation. The efficiency and performance of refrigeration systems greatly depend on the choice of refrigerant. Traditional refrigerants like R-134a, though widely used, have certain limitations, including lower heat transfer coefficients and lower cooling capacities. Therefore, the integration of nanotechnology into refrigeration systems has gained attention as a promising approach to enhance their efficiency. This research aims to investigate the impact of CuO and SiO2 nanoparticles on the cooling capacity of R-134a.

II. METHODOLOGY

Nanofluid Preparation Copper oxide (CuO) and silica (SiO2) nanoparticles were selected due to their thermal conductivity and stability. The nanoparticles were synthesized through a suitable method and characterized using techniques such as X-ray diffraction (XRD) and scanning electron microscopy (SEM). The nanoparticles were dispersed in R-134a using a two-step mixing method to ensure homogeneity. This portion of the paper describes the testing and condenser quality experiments I conducted. I served as the foundation for the choice utilizing information from the Performance Enhancement of Refrigeration System by utilizing Copper Oxide Nano Particles equipment that was used. According to their requirements, the industry may select testing of nano-particles refrigerant (R134a+CuO+Silca) into the system machine data, which is beneficial. The machine's use and functionality are the basis for this certification. They employed the Taguchi Method to finalize the machine's specification in line with their demands after choosing a decent machine. Any experiment may be carried out using a number of techniques, and the outcomes can also vary widely.

There are several ways to approach this issue. a range of strategies. The procedures listed below can be used to carry out experiments and determine their results.

1) Made the decision to run the experiment using the given parameters.
2) Based on the literature review investigation, pick the basic metal (R134a+CuO+Silca) first.
3) The experiment looks for effects of the process parameter on the result. - Minitab Software optimizes the process parameter using experiment data. - The findings of the testing of the experiment's required item were documented for a later study and scope.
4) The outcomes of the two comparisons ultimately identify the ideal process parameter.

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A. Pareto Low

The concept was developed by an economist from Italy named Vilfredo Pareto. Pareto noted that in Italy in 1906, 20% of the population had control over 80% of the country's property. He hypothesised that this ratio may be indicative of a natural norm and said that it might be observable across the physical cosmos.H

$$H = G \quad \ldots\ldots\ldots\ldots \qquad .(1)$$

$$\{H = 2A\text{-}1 = 1\text{-}2B\}$$

Dr. Joseph Juran, an American electrical engineer widely regarded as the pioneer of quality control, created Pareto's idea in the 1940s. The 80/20 rule is referred to as "The Pareto Principle" by Dr. Juran. The Pareto Principle may be used to business measurements to distinguish between the "essential few" (the 20% with the greatest impact) and the "useful many" (the remaining 80%).

$$A:B = [1+H/2]:[1-H/2] \quad \ldots\ldots\ldots \qquad . (2)$$

The Pareto principle has several applications.

1) A Pareto chart depicts frequency under the premise that the more often something occurs, the greater the influence it has on the result.
2) In a Pareto efficient resource allocation equilibrium, one person's condition cannot be bettered without making another person's situation worse.

The following are a few examples of the Pareto principle in action:

a) Only 20% of a company's employees are in charge of producing 80% of its product.
b) When an employee spends 20% of their time working, their output rises by 80%.
c) Twenty percent of software flaws cause eighty percent of software failures.
d) A company realises 80% of the profits from its investments 20% of its investment portfolio.

Table 1 Using pareto law for selecting Refrigerator

Given preference 80 % of these criteria	Given preference 20% of these criteria
Capacity	Part warranty
Cost	Scrap & Rework
Cooling Capacity	Service warranty
Reliability	Product Conformance
Safety	Number of machines breakdown
	Professional skill
	Flexibility in mass production
	Variety and Flexibility of
	Easy to operate
	Easy to move
	Operation
	Performance
	System control and automation
	Utilization

B. Constructing the Experimental setup

The same or, more precisely, identical methodology is used for this topic as well, where the VCRS setup is built first, followed by the nanorefrigerant setup, based on the requirements for carrying out the task, and the testing is carried out in it, and the findings are acquired.

Figure 1: Constructing the Experimental setup

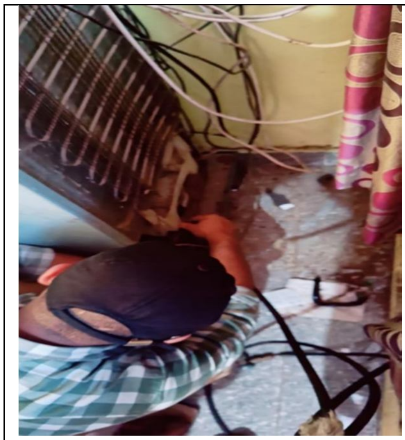
C. Developing or Trying a Commercial Model

A commercial model that is widely used globally may go through the same testing. This method is employed by several researchers to track the immediate impacts of the experiment and determine its long-term sustainability. The investigation into this topic had already been conducted using the same techniques.

D. VCRS System Construction

The approach used was to build up the experimental setup for performing on this specific issue, i.e., Experimental Investigation of Vapour Compression Refrigeration System by contrasting the outcomes obtained after employing pure refrigerant R134a with and without Titanium Oxide Nanoparticle. Therefore, the following actions were followed to create a setup:

1) Before building begins, a complete working plan is created. The working plan is created as a schematic diagram. Yes, a schematic design of the VCRS has been created, demonstrating the system's many operations as well as the locations of key equipment needed for the system to function.
2) Next, a list of every element that will be needed to build the VCRS configuration is created. The following elements were needed:

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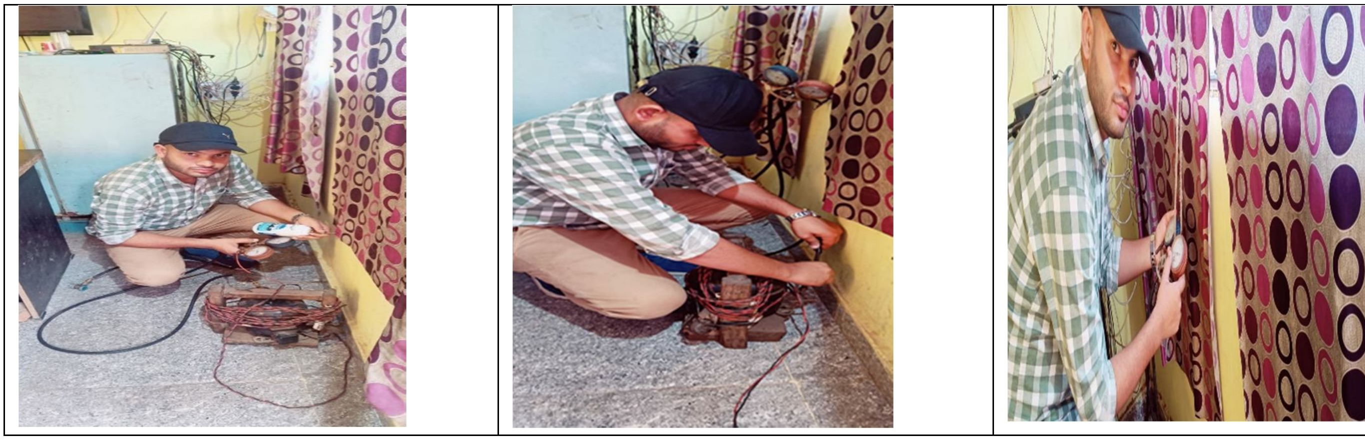


Figure 2: Experimental VCRS working setup

E. Permanent Components in Setup

1) Copper tubes (25 foot, quarter inch)
2) Compressor (hermetically sealed)
3) Condenser
4) Expansion valve (quarter inch)
5) Thermal Insulation
6) Energy meters (2 for heater and compressor)
7) Refrigerant gas R134a
8) Heater (to be applied in evaporator for maintaining temperature)
9) Bucket, Electrical wires for connection
10) High and Low Pressure gauges
11) Temperature sensors
12) CuO+silica Nanoparticles
13) Shut off valve
14) Copper filter
15) Relay overload and electrical condenser for compressor
16) Flair Nut

F. Equipment& Accessories Required During Construction of Setup

1) Brazing Rod
2) Brazing Gun
3) Flux for preventing oxidation
4) Can tap valve
5) Gas charging wire
6) Brazing Gas
7) Dead nut
8) Pin valve
9) Teflon tape

a) Wire insulation insulation tape The true construction begins when the parts are listed and bought, and it begins with building the basis or foundation on which all the parts will be attached. After being divided into 4 equal halves, iron bars are first welded to form the frame's leg. The iron frame is next fitted with hardwood planks that are the proper sizes, and the foundation is complete.
b) The compressor, condenser, evaporator, expansion valve, and energy metres are now all installed on the foundation of the VCRS.
c) All copper tube connections are now formed to complete the VCRS cycle by brazing, and the copper coiling in the evaporator is finished.
d) Next, using T joints, the pressure gauges, both high and low, are carefully inserted into the compressor's input and output.

e) At this point, electrical connections are completed, including the connection of energy metres to the heater and compressor, respectively, and the connection of switches to complete the circuit.

f) The setup is now prepared for testing by placing all temperature sensors at all of the measuring sites.

G. System after Construction and Basic cycle of VCRS

Figure 3: VCRS Experimental setup.

The formula above will be used for comparing the results obtained firstly, by testing only with R134a and then testing with nano-refrigerants i.e. R134a+CuO+Silca.

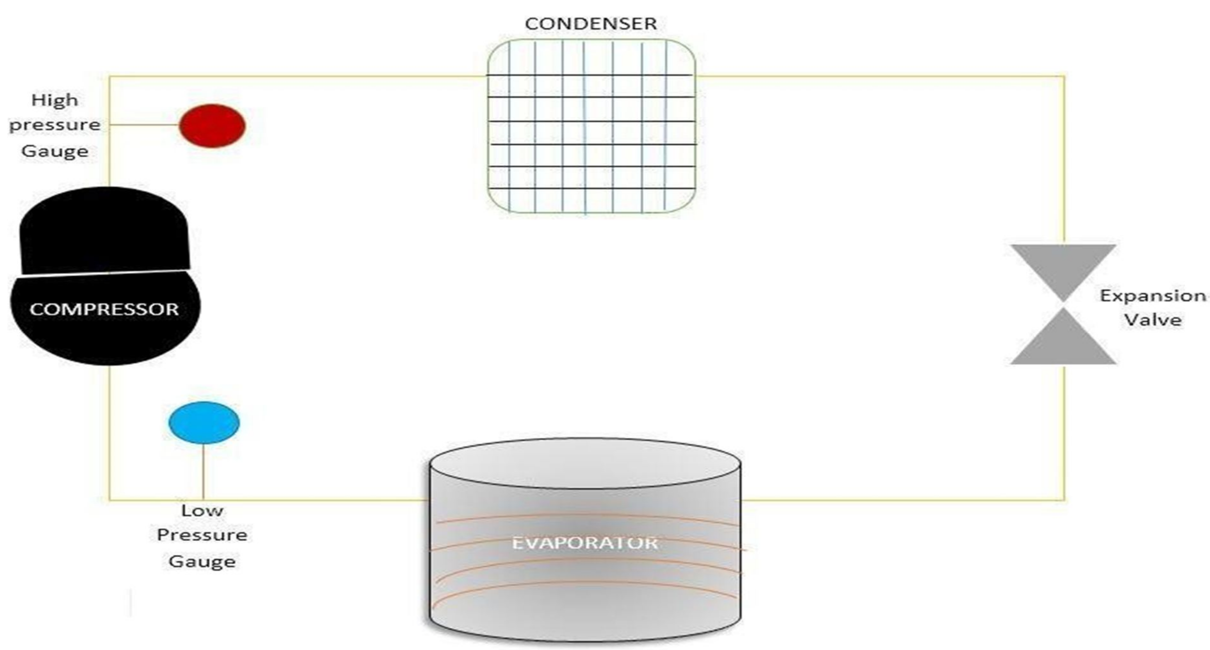


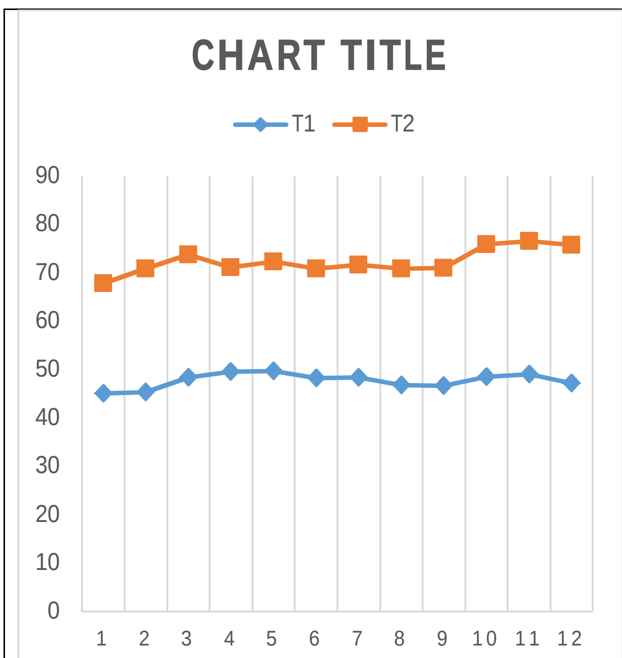
Figure 4 : Components of Vapour Compression system

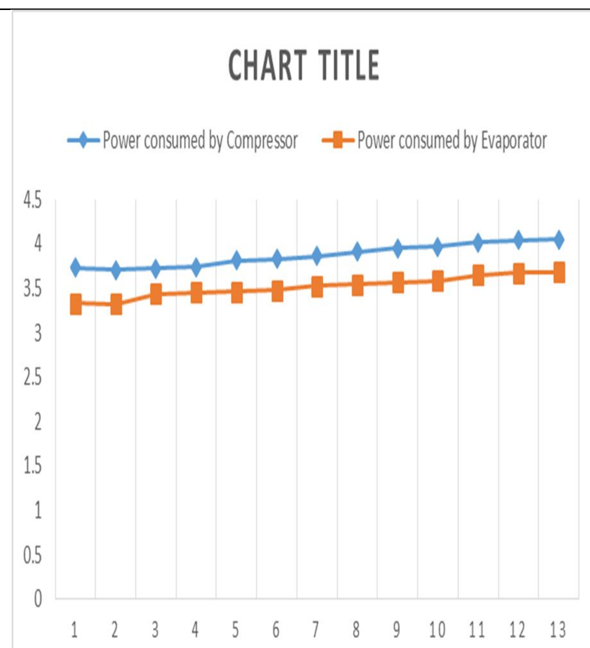
III. RESULTS & DISCUSSION

Results Procured After Performing Experiment the construction and execution of the experiment using the VCRS experimental setup, we obtained the following results.

Table no.1 At 13 Dec.2022									
Atmospheric Temperature = 20°C							Refrigerant R134a = 100 gm		
T1 (°C)	T2 (°C)	Condenser Temperature Drop(T1-T2)	T3 (°C)	T4 (°C)	P1 (psi)	P2 (psi)	Power consumed by Compressor	Power consumedby Evaporator	Time(min)
44.8	29.0	15.8	-2.0	20	210	13	3.73	3.33	00
45.2	29.3	15.9	-2.1	20	215	11	3.71	3.32	20
45.4	29.5	15.9	-2.2	20	215	12	3.72	3.44	40
45.7	29.2	16.5	-2.2	20	225	14	3.74	3.45	60
46.4	28.3	18.1	-2.4	20	230	12	3.81	3.46	80
45.6	28.1	17.5	-3.5	20	225	11	3.83	3.48	100
46.2	28.5	17.7	-2.3	20	230	11	3.86	3.53	120
47.5	30.1	17.4	-3.6	20	225	11	3.91	3.54	140
48.4	31.4	17.0	-3.9	20	230	13	3.95	3.57	160
46.3	28.6	17.7	-2.8	20	220	13	3.97	3.58	180
47.2	31.2	16.0	-3.2	20	230	09	4.02	3.65	200
48.2	30.4	17.8	-2.8	20	230	11	4.04	3.67	220
46.7	30.6	16.1	-2.8	20	230	12	4.05	3.68	240
Difference in final and initial power consumption							4.05-3.73 = 0.32	3.68-3.33 = 0.35	

COP = Heat Consumed by Evaporator / Power consumed by Compressor
= **0.35 / 0.32 = 1.093**





Graph 1: Comparison Graph of Temperature and Power consumed by R134a

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
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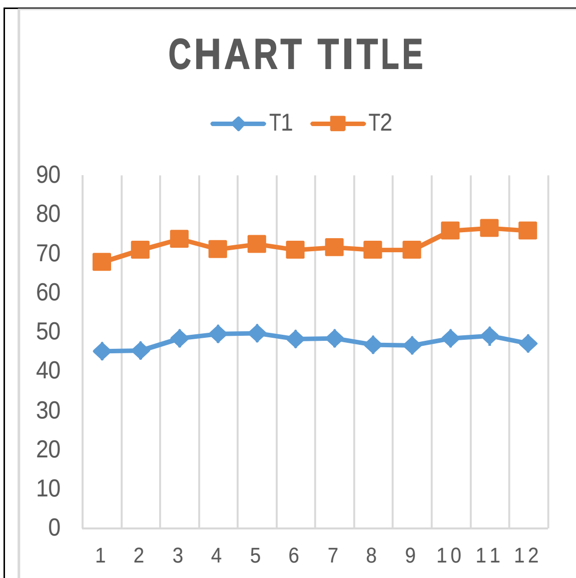
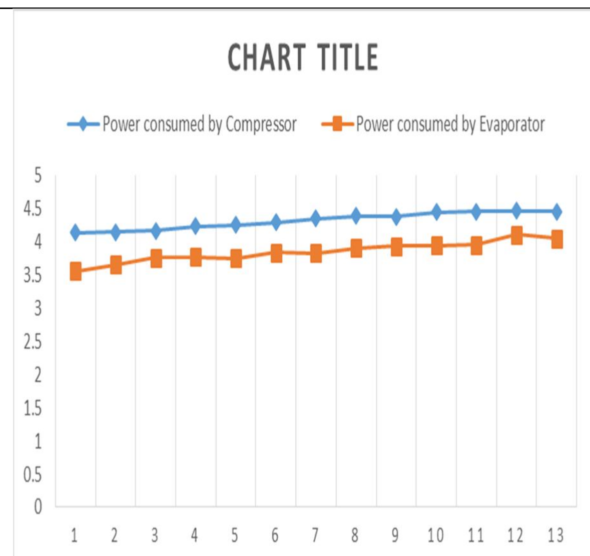
Table no. 2 at 13 dec. 2022									
Atmospheric Temperature =20.5°C				Refrigerant R134a = 100 gm					
T1 (ºC)	T2 (ºC)	Condenser Temperature Drop(T1-T2)	T3 (ºC)	T4 (ºC)	P1 (psi)	P2 (psi)	Power consumed by Compressor	Power consumedby Evaporator	Time(min)
47.0	31.6	15.4	-2.2	28	215	12	4.14	3.66	00
48.3	31.8	16.5	-2.3	28	225	10	4.15	3.66	15
48.5	28.7	19.8	-2.3	28	230	12	4.17	3.76	30
46.7	28.5	18.2	-2.5	28	230	10	4.24	3.77	45
46.8	28.1	18.7	-2.8	28	225	10	4.26	3.75	60
45.9	27.2	18.7	-3.4	28	225	10	4.29	3.84	75
47.4	31.3	16.1	-2.7	28	230	10	4.35	3.83	90
45.6	27.7	17.9	-3.4	28	225	10	4.39	3.91	105
46.2	28.5	17.7	-2.4	28	230	14	4.38	3.94	120
46.1	27.4	18.7	-2.2	28	220	10	4.45	3.95	135
45.5	26.6	18.9	-2.3	28	230	8	4.46	3.96	150
48.7	27.8	20.9	-2.2	28	230	12	4.47	3.97	165
47.4	28.9	18.5	-2.3	28	230	12	4.46	3.99	180
Difference in final and initial powerconsumption							4.46-4.14 = 0.32	3.99-3.66= 0.33	

COP = Heat Consumed by Evaporator/Power consumed by Compressor
= 0.49 / 0.32 = 1.031





Graph 2: Comparison Graph of Temperature and Power consumed by R134a

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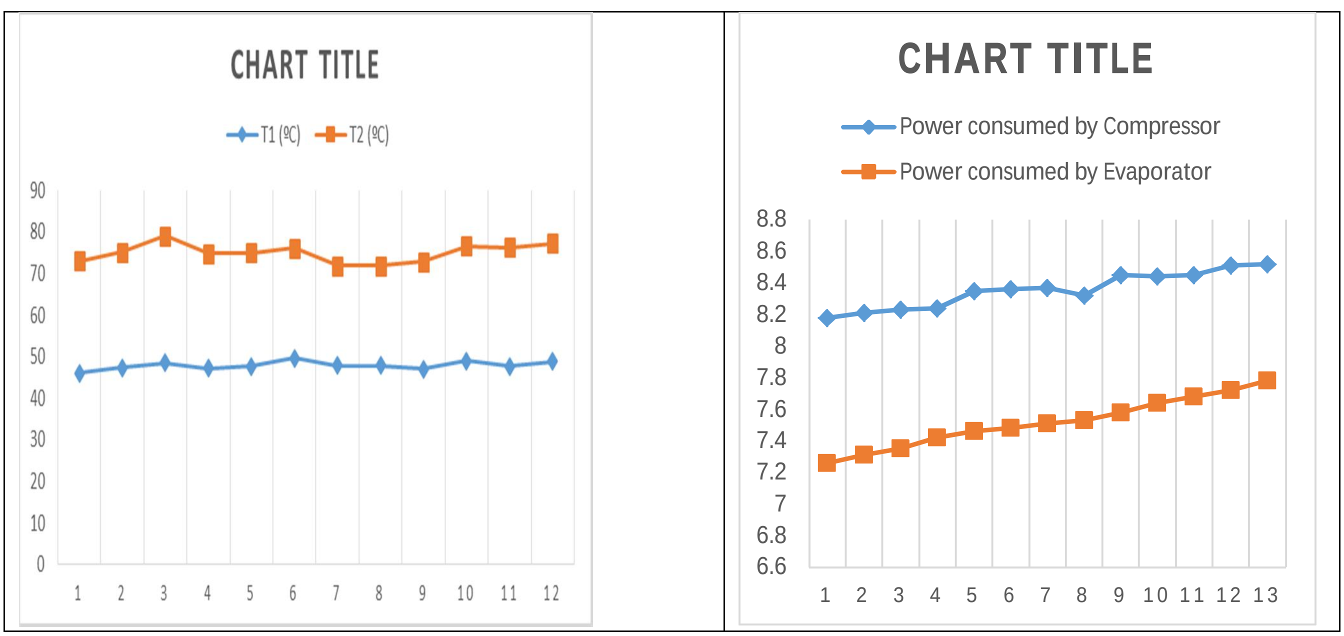
Table no. 3 at 13dec. 2022									
Atmospheric Temperature = 21°C					Refrigerant R134a = 100 gm				
T1 (°C)	T2 (°C)	Condenser Temperature Drop (T1-T2)	T3 (°C)	T4 (°C)	P1 (psi)	P2 (psi)	Power consumed by Compressor	Power consumedby Evaporator	Time min)
46.1	26.9	19.2	0.8	30	195	18	4.62	4.08	00
47.3	27.8	19.5	0.7	30	200	20	4.64	4.06	20
48.4	30.7	17.7	0.3	30	210	20	4.62	4.11	40
47.2	27.6	19.6	-0.8	30	210	18	4.78	4.14	60
47.6	27.4	20.2	-1.2	30	210	18	4.73	4.11	80
49.7	26.3	23.4	-1.7	30	215	16	4.74	4.26	100
47.8	24.1	23.7	-2.2	30	215	17	4.77	4.27	120
47.9	24.0	23.9	-2.6	30	215	16	4.85	4.30	140
47.0	25.8	21.2	-2.5	30	210	18	4.83	4.31	160
48.9	27.7	21.2	-2.7	30	215	16	4.84	4.36	180
47.7	28.5	19.2	-2.3	30	215	18	4.91	4.41	200
48.8	28.4	20.4	-2.4	30	215	18	4.93	4.42	220
47.5	29.3.	18.2	-2.5	30	215	17	4.94	4.42	240
Difference in final and initial power consumption							4.94-4.62 = 0.32	4.42-4.08= 0.34	

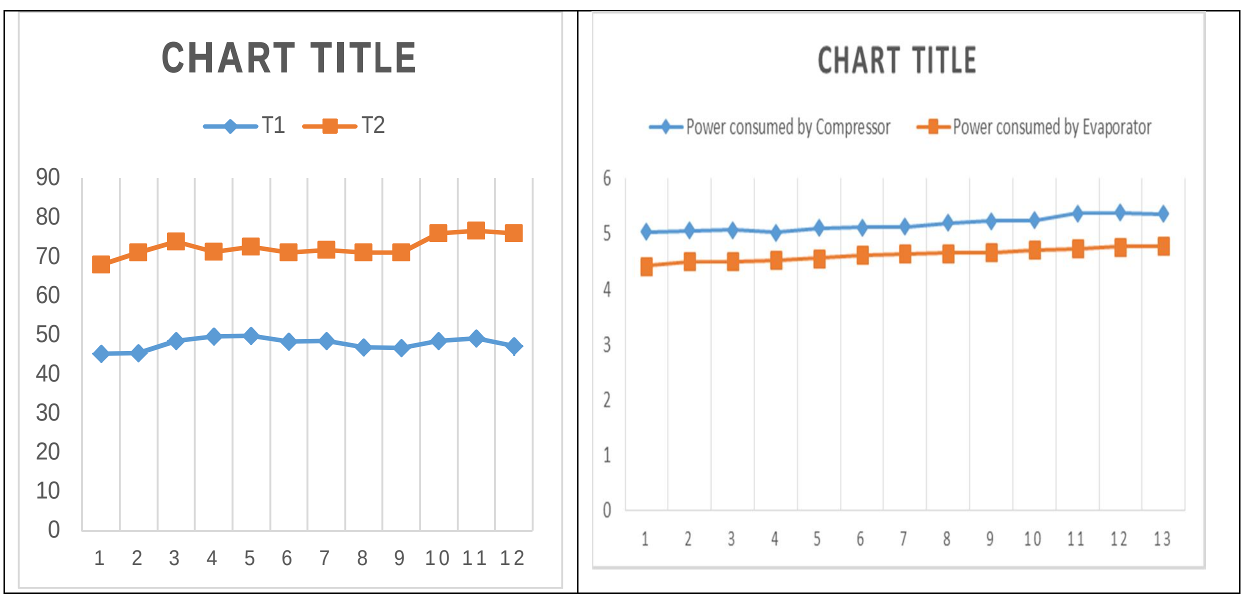
COP = Heat Consumed by Evaporator/Power consumed by Compressor
= 0.45 /0.32 = 1.0625



Graph 3: Comparison Graph of Temperature and Power consumed by R134a

Table no. 4at 14dec.2022									
Atmospheric Temperature = 23°C					Nanoparticle Weight CuO+Silca (0.4gm) + Refrigerant R134a(100 gm)				
T1 (ºC)	T2 (ºC)	Condenser Temperature Drop(T1- T2)	T3 (ºC)	T4 (ºC)	P1 (psi)	P2 (psi)	Power consumedby Compressor	Power consumedby Evaporator	Time (min)
47.1	29.7	17.4	-1.8	20	240	16	5.04	4.42	00
48.5	29.4	19.1	-2.3	20	240	14	5.06	4.51	20
48.4	29.9	18.5	-1.8	20	230	14	5.07	4.50	40
49.3	29.8	19.5	-1.7	20	230	16	5.02	4.53	60
49.7	29.7	20	-2.1	20	235	12	5.11	4.56	80
48.8	28.6	20.2	-2.2	20	235	14	5.12	4.62	100
47.5	29.4	18.1	-2.2	20	235	14	5.13	4.64	120
47.2	29.0	18.2	-2.3	20	235	14	5.20	4.66	140
48.3	28.1	20.2	-2.1	20	230	12	5.23	4.67	160
48.5	28.3	20.2	-2.3	20	230	12	5.24	4.71	180
49.4	28.4	21	-2.4	20	230	14	5.37	4.74	200
48.5	28.6	19.9	-2.5	20	225	14	5.38	4.77	220
48.2	28.7	19.5	-2.4	20	230	14	5.36	4.78	240
Difference in final and initial power consumption							5.36-5.04 = 32	4.78-4.42 = 36	

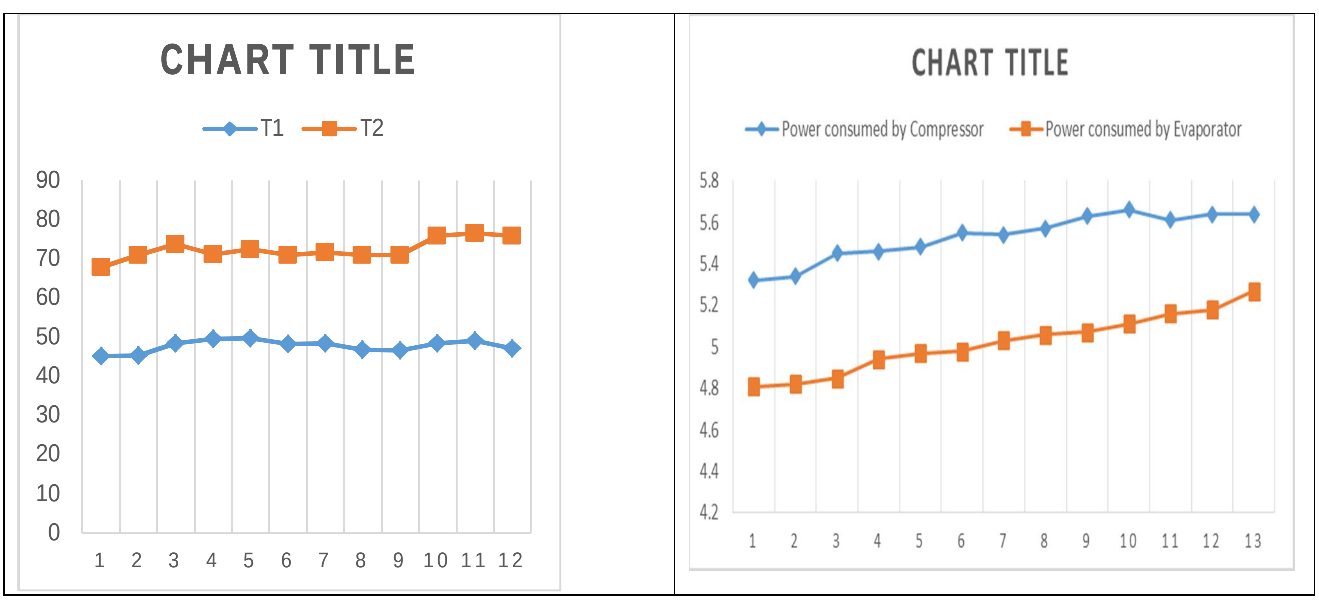
COP = Heat Consumed by Evaporator/Power consumed by Compressor
= 0.36 / 0.32 = 1.125



Graph 4: Comparison Graph of Temperature and Power consumed by Nanoparticle CuO+ Silica (0.4 gm) +Refrigerant R134a(100 gm)

Table no. 5 at14dec.2022									
Atmospheric Temperature =23.5°C				Nanoparticle Weight CuO+Silca (0.4 gm) + Refrigerant R134a(100 gm)					
T1 (ºC)	T2 (ºC)	Condenser Temperature Drop(T1-T2)	T3 (ºC)	T4 (ºC)	P1 (psi)	P2 (psi)	Power consumed by Compressor	Power consumedby Evaporator	Time (min)
45.0	26.5	18.5	-2.2	28	210	11	5.32	4.81	00
45.1	26.8	18.3	-1.8	28	215	10	5.34	4.82	20
46.3	26.8	19.5	-2.3	28	220	13	5.45	4.85	40
46.5	24.2	22.3	-2.4	28	225	13	5.46	4.94	60
46.7	25.3	21.4	-2.5	28	220	15	5.48	4.97	80
47.9	26.4	21.5	-2.2	28	215	15	5.55	4.98	100
47.7	25.8	21.9	-2.2	28	220	16	5.54	5.03	120
49.6	26.5	23.1	-2.3	28	220	16	5.57	5.06	140
49.8	27.7	22.1	-2.3	28	220	17	5.63	5.07	160
49.2	27.9	21.3	-2.5	28	225	17	5.66	5.11	180
48.3	27.8	20.5	-2.5	28	225	18	5.61	5.16	200
48.4	28.5	19.9	-2.3	28	220	18	5.64	5.18	220
48.5	28.1	20.4	-2.3	28	220	148	5.64	5.27	240
Difference in final and21.1 initial power consumption							5.64-5.32 = 0.32	5.27-4.81 =0.46	

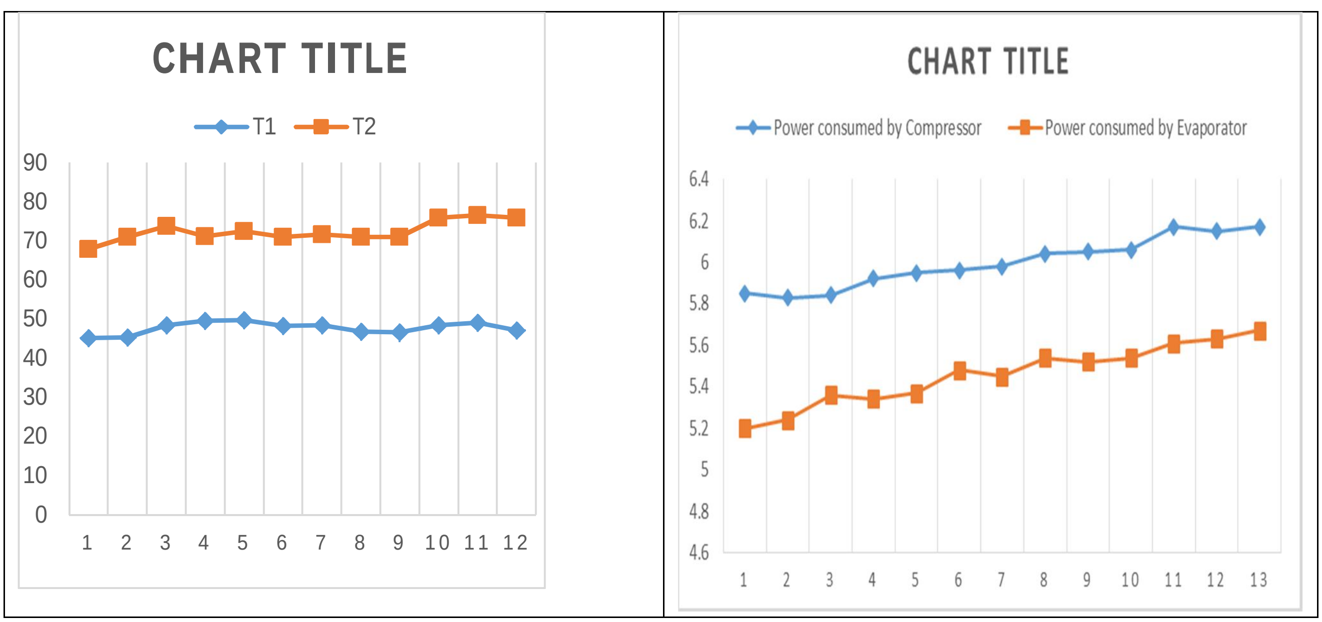
COP = Heat Consumed by Evaporator / Power consumed by Compressor
= (5.25-4.80) / (5.70-5.36)
= 0.46 / 0.32 = 1.437



Graph 5: Comparison Graph of Temperature and Power consumed by Nanoparticle CuO+ Silica (0.4 gm) +Refrigerant R134a(100 gm)

Table no. 6 at 14dec.2022									
Atmospheric Temperature =24°C				Nanoparticle Weight CuO+Silca (0.4 gm +RefrigerantR134a (100 gm)					
T1 (ºC)	T2 (ºC)	Condenser Temperature Drop(T1-T2)	T3 (ºC)	T4 (ºC)	P1 (psi)	P2 (psi)	Power consumed by Compressor	Power consumedby Evaporator	Time (min)
47.0	28.2	18.8	- 1.4	30	210	11	5.85	5.20	00
47.2	28.3	18.9	- 2.0	30	210	13	5.83	5.24	20
47.4	28.4	19	- 2.1	30	215	13	5.84	5.36	40
47.7	28.6	19.1	- 2.0	30	215	13	5.92	5.34	60
47.9	28.5	19.4	- 2.0	30	215	14	5.95	5.37	80
47.8	28.4	19.4	- 2.2	30	220	14	5.96	5.48	100
47.6	28.1	19.5	- 2.3	30	220	15	5.98	5.45	120
47.7	28.6	19.1	- 2.4	30	225	15	6.04	5.54	140
47.5	28.7	18.8	- 2.2	30	225	17	6.05	5.52	160
48.4	28.8	19.6	- 2.1	30	231	17	6.06	5.54	180
48.3	28.9	19.4	- 2.2	30	228	15	6.17	5.61	200
47.2	28.5	18.7	- 2.3	30	227	12	6.15	5.63	220
47.1	28.7	18.4	- 2.2	30	228	11	6.17	5.67	240
Difference in final and initial power consumption							6.17-5.85 = 0.32	5.67-5.20 =0.47	

COP = Heat Consumed by Evaporator/Power consumed by Co mpressor
= 0.47 / 0.32 = 1.468



Graph 6: Comparison Graph of Temperature and Power consumed by Nanoparticle CuO+ Silica (0.4 gm) +Refrigerant R134a(100 gm)

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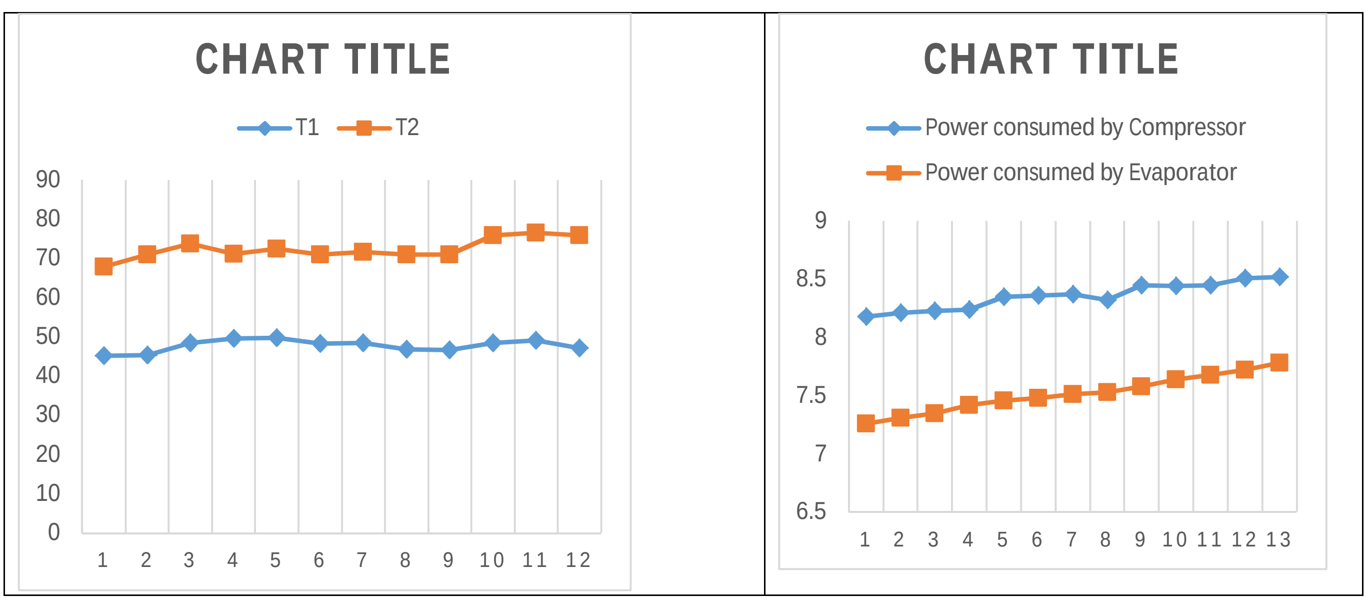
Table no. 7 at 15dec.2022									
Atmospheric Temperature = 24.5 °C			Nanoparticle Weight CuO+ Silica (0.6 gm) + Refrigerant R134a (100gm)						
T1 (ºC)	T2 (ºC)	Condenser TemperatureDrop (T1-T2)	T3 (ºC)	T4 (ºC)	P1 (psi)	P2 (psi)	Power consumed by Compressor	Power consumedby Evaporator	Time (min)
45.7	26.1	19.6	-1.2	20	210	20	6.36	5.66	00
46.2	26.3	19.9	-1.4	20	215	11	6.37	5.72	20
46.3	26.4	19.9	-2.1	20	210	13	6.39	5.75	40
46.4	27.6	18.8	-2.2	20	215	11	6.43	5.77	60
48.5	28.7	19.8	-2.1	20	216	13	6.44	5.78	80
48.7	28.8	19.9	-2.3	20	220	15	6.46	5.83	100
48.8	29.1	19.7	-2.4	20	220	15	6.47	5.85	120
49.2	29.2	20	-2.5	20	225	17	6.55	5.88	140
49.8	29.3	20.5	-2.6	20	225	17	6.54	5.92	160
49.6	29.4	20.2	-2.2	20	230	18	6.52	5.94	180
48.2	29.5	18.7	-2.3	20	230	15	6.61	5.97	200
47.3	29.4	17.9	-2.5	20	235	18	6.64	5.98	220
46.7	29.3	17.4	-2.0	20	235	17	6.68	6.06	240
Difference in final and initial power consumption							6.68-6.36 = 0.32	6.06-5.66 =0.42	

COP = Heat Consumed by Evaporator/Power consumed by Compressor
= 0.42 / 0.32 = 1.321



Graph 7: Comparison Graph of Temperature and Power consumed by Nanoparticle CuO+Silica (0.6 gm) +Refrigerant R134a(100 gm)

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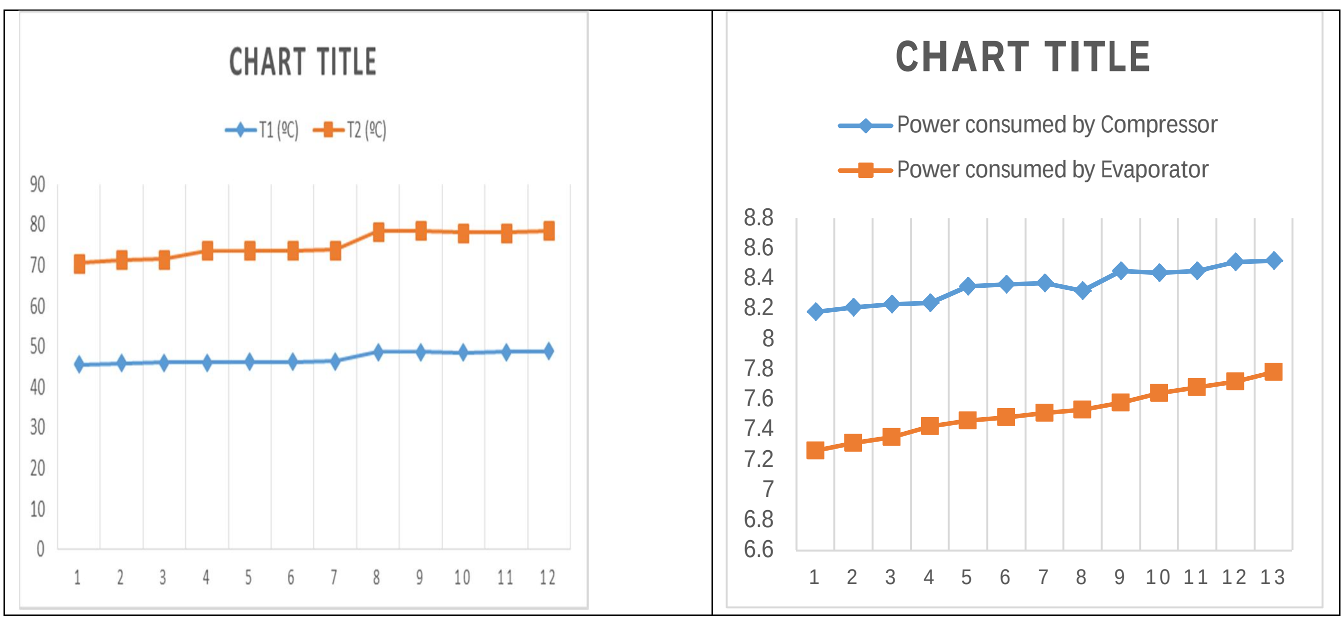
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VI Jun 2023- Available at www.ijraset.com

Table no.8 at 15dec.2022									
Atmospheric Temperature = 25°C				Nanoparticle Weight CuO+ Silica (0.6 gm) +Refrigerant R134a(100 gm)					
T1 (ºC)	T2 (ºC)	Condenser Temperature Drop(T1-T2)	T3 (ºC)	T4 (ºC)	P1 (psi)	P2 (psi)	Power consumed by Compressor	Power consumedby Evaporator	Time (min)
45.5	25.1	20.4	-1.0	28	200	11	6.79	6.04	00
45.8	25.5	20.3	-1.3	28	205	11	6.84	6.01	20
46.0	25.5	20.5	-1.5	28	210	13	6.85	6.11	40
46.1	27.5	18.6	-1.7	28	210	13	6.87	6.15	60
46.2	27.4	18.8	-1.9	28	210	13	6.91	6.14	80
46.2	27.5	18.7	-2.0	28	215	14	6.94	6.24	100
46.3	27.5	18.8	-2.1	28	220	14	6.97	6.25	120
48.6	29.7	18.9	-2.3	28	220	15	7.00	6.27	140
48.7	29.8	18.9	-2.4	28	220	15	7.01	6.31	160
48.5	29.5	19	-2.6	28	220	16	7.04	6.33	180
48.6	29.4	19.2	-2.7	28	215	16	7.06	6.36	200
48.8	29.7	19.1	-2.8	28	215	18	7.10	6.44	220
48.9	29.7	19.2	-2.9	28	220	18	7.11	6.48	240
Difference in final and initial power consumption							7.11-6.79 = 0.32 kw	6.48-6.04 =0.44 kw	

COP = Heat Consumed by Evaporator/Power consumed by Co mpressor
= 0.44 / 0.32 = 1.375



Graph 8: Comparison Graph of Temperature and Power consumed by Nanoparticle CuO+ Silica (0.6 gm) +Refrigerant R134a(100 gm)

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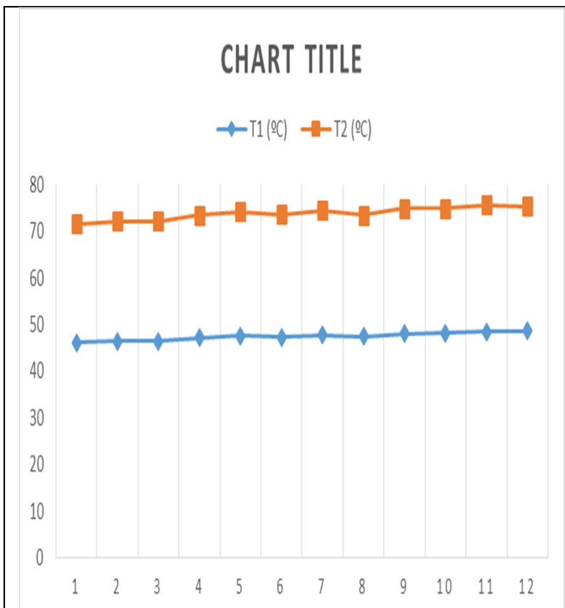
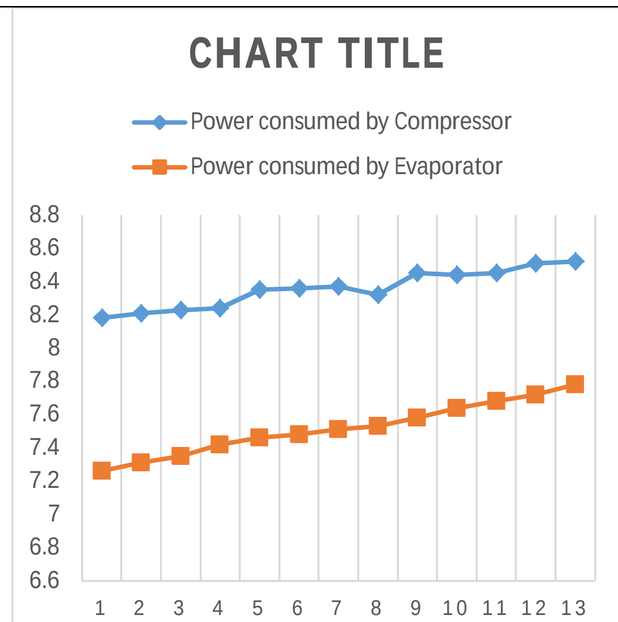
Volume 11 Issue VI Jun 2023- Available at www.ijraset.com

Table no.9 at 15dec.2022									
Atmospheric Temperature = 25.5 °C			Nanoparticle Weight CuO+ Silica (0.6 gm) + Refrigerant R134a (100gm)						
T1 (ºC)	T2 (ºC)	Condenser Temperature Drop(T1-T2)	T3 (ºC)	T4 (ºC)	P1 (psi)	P2 (psi)	Power consumed by Compressor	Power consumedby Evaporator	Time (min)
46.2	25.4	20.8	-0.8	30	200	15	7.29	6.45	00
46.5	25.6	20.9	-1.1	30	205	15	7.26	6.50	20
46.4	25.7	20.7	-1.3	30	205	13	7.32	6.54	40
47.2	26.3	20.9	-1.5	30	210	13	7.34	6.58	60
47.6	26.5	21.1	-1.5	30	215	11	7.37	6.62	80
47.3	26.3	21	-1.6	30	215	11	7.41	6.66	100
47.8	26.6	21.2	-1.7	30	220	15	7.44	6.70	120
47.4	26.1	21.3	-1.8	30	220	14	7.47	6.74	140
48.1	26.8	21.3	-2.1	30	225	17	7.50	6.78	160
48.2	26.7	21.5	-2.2	30	230	16	7.52	6.81	180
48.4	27.2	21.2	-2.4	30	235	17	7.53	6.85	200
48.6	26.7	21.9	-2.3	30	230	16	7.55	6.89	220
48.7	26.6	22.1	-2.4	30	220	16	7.61	6.91	240
Difference in final and initial power consumption							7.61-7.29 = 0.32	6.93-6.52 =0.41	

COP = Heat Consumed by Evaporator/Power consumed by Compressor
= 0.41 / 0.32 = 1.281





Graph 9: Comparison Graph of Temperature and Power consumed by Nanoparticle CuO+ Silica (0.6 gm) +Refrigerant R134a(100 gm)

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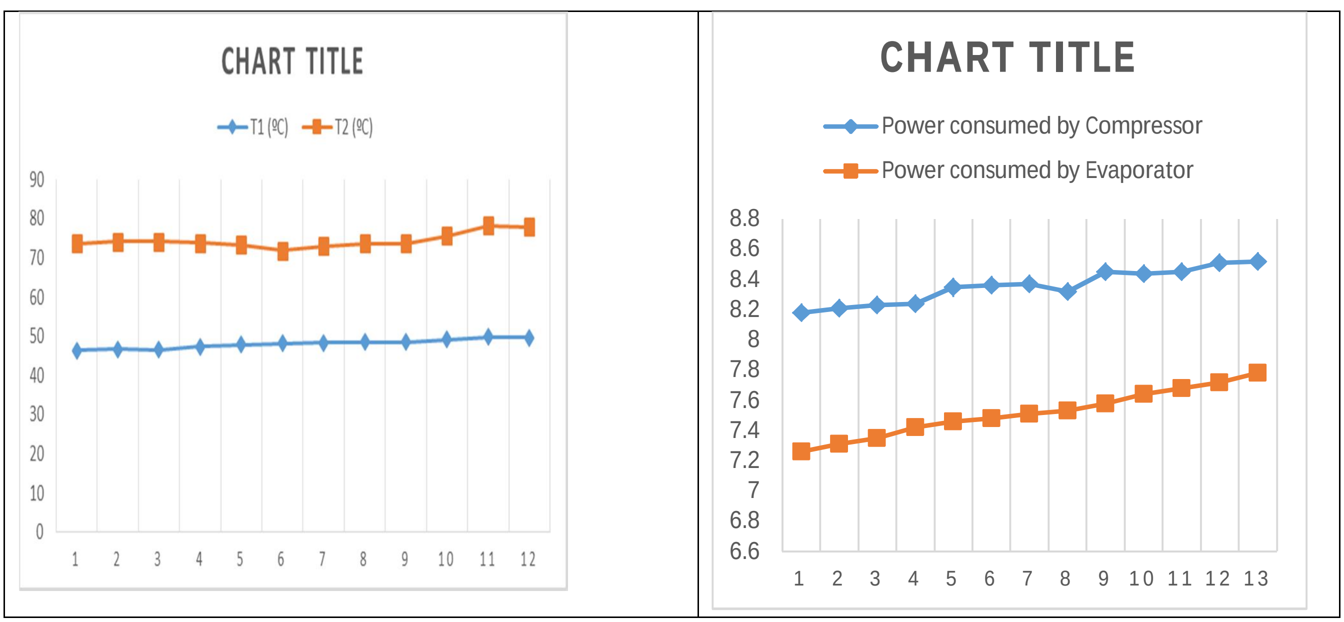
Volume 11 Issue VI Jun 2023- Available at www.ijraset.com

Table no. 10 at 16dec.2022										
Atmospheric Temperature =20°C			Nanoparticle Weight CuO+ Silica (0.8 gm) + Refrigerant R134a (100 gm)							
T1 (ºC)	T2 (ºC)	Condenser Temperature Drop(T1-T2)	T3 (ºC)	T4 (ºC)	P1 (psi)	P2 (psi)	Power consumed by Compressor	Power consumedby Evaporator	Time (min)
46.4	27.2	19.2	-1.7	20	221	12	7.72	6.86	00
46.7	27.4	19.3	-1.9	20	223	13	7.74	6.93	20
46.6	27.6	19	-2.1	20	225	14	7.78	6.97	40
47.4	26.4	21	-2.4	20	227	14	7.81	7.02	60
47.8	25.5	22.3	-2.5	20	229	17	7.86	7.01	80
48.1	23.7	24.4	-2.6	20	229	16	7.87	7.06	100
48.3	24.6	23.7	-2.6	20	230	15	7.90	7.15	120
48.5	25.1	23.4	-2.7	20	235	11	7.97	7.14	140
48.4	25.3	23.1	-2.8	20	238	14	7.98	7.17	160
49.1	26.5	22.6	-2.9	20	239	15	8.01	7.25	180
49.8	28.4	21.4	-2.5	20	240	13	8.02	7.24	200
49.6	28.2	21.4	-2.3	20	242	14	8.05	7.27	220
49.4	28.7	20.7	-2.2	20	244	14	8.04	7.26	240
Difference in final and initial power consumption							8.04-7.72 = 0.32	7.26-6.86 =0.40	

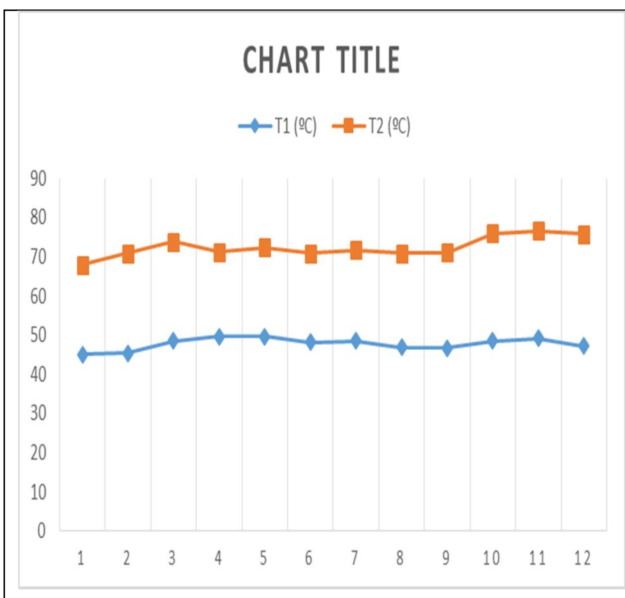
COP = Heat Consumed by Evaporator/Power consumed by Compressor
= 0.40 / 0.32 = 1.250

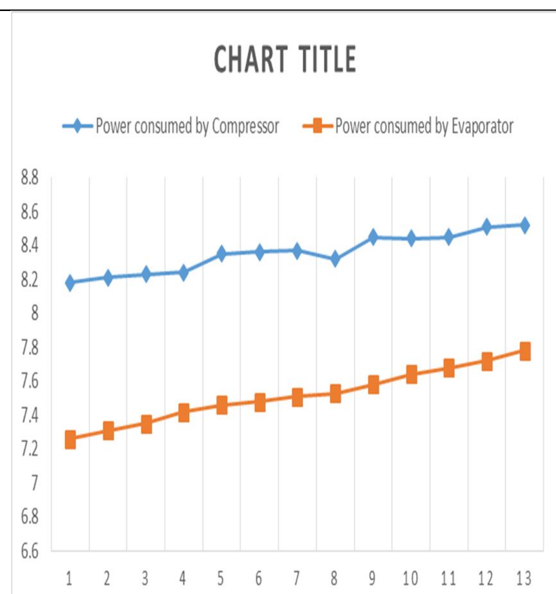


Graph 10: Comparison Graph of Temperature and Power consumed by Nanoparticle CuO +Silica (0.8 gm) +Refrigerant R134a (100 gm)

Table no. 11 at 16dec.2022										
Atmospheric Temperature = 25 °C			Nanoparticle Weight CuO+ Silica (0.8 gm) + Refrigerant R134a (100gm)							
T1 (°C)	T2 (°C)	Condenser Temperature Drop(T1-T2)	T3 (°C)	T4 (°C)	P1 (psi)	P2 (psi)	Power consumed by Compressor	Power consumedby Evaporator	Time (min)
45.1	22.8	22.3	-1.1	28	190	9	8.18	7.26	00
45.3	25.6	19.7	-1.4	28	200	12	8.21	7.31	20
48.4	25.4	23	-1.5	28	210	15	8.23	7.35	40
49.6	21.5	28.1	-1.7	28	212	17	8.24	7.42	60
49.7	22.7	27	-1.8	28	216	18	8.35	7.46	80
48.2	22.7	25.5	-1.8	28	216	16	8.36	7.48	100
48.4	23.3	25.1	-1.9	28	215	14	8.37	7.51	120
46.8	24.1	22.7	-1.8	28	220	13	8.32	7.53	140
46.7	24.3	22.4	-1.9	28	225	10	8.45	7.58	160
48.5	27.4	21.1	-1.7	28	225	12	8.44	7.64	180
49.1	27.5	21.6	-1.4	28	230	17	8.45	7.68	200
47.2	28.6	18.6	-1.5	28	235	15	8.51	7.72	220
48.4	25.1	23.3	-1.7	28	220	12	8.52	7.78	240
Difference in final and initial power consumption							8.50-8.18 = 0.32 kw	7.78-7.27 = 0.51 kw	

COP = Heat Consumed by Evaporator / Power consumed by Compressor
= 0.51 / 0.32 = 1.594





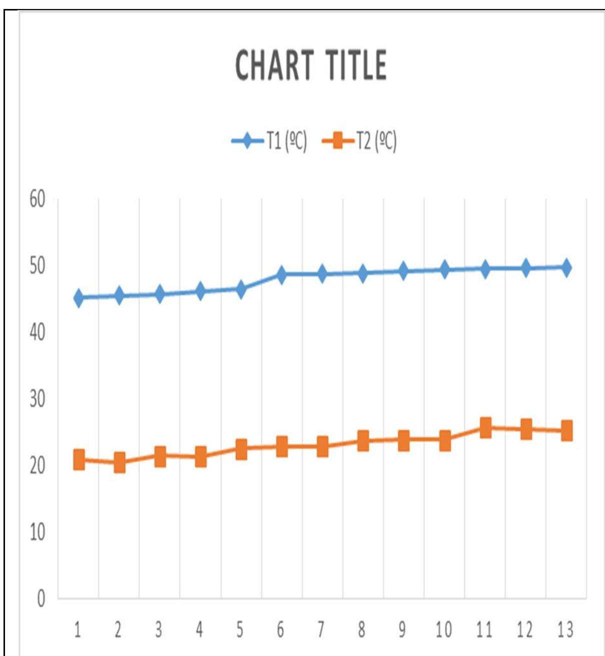
Graph 11: Comparison Graph of Temperature and Power consumed by Nanoparticle CuO+Silica (0.8 gm) +Refrigerant R134a(100 gm)

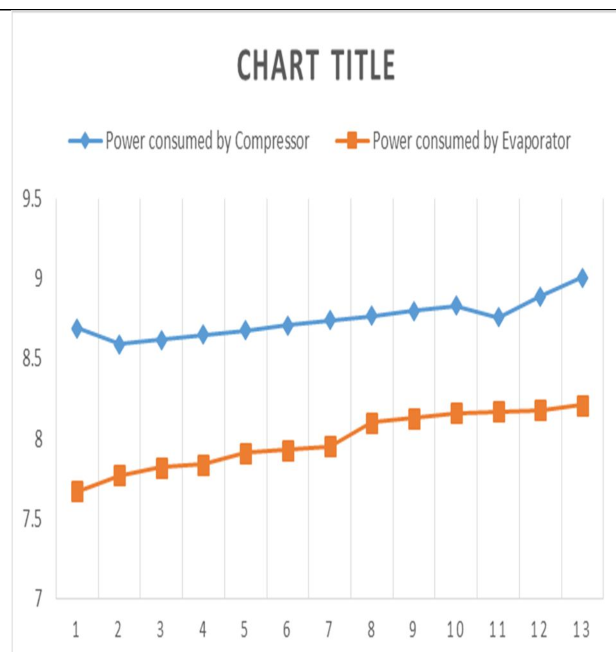
Table no. 12 At 16 Dec.2022

Atmospheric Temperature = 30 °C			Nanoparticle Weight CuO+ Silica (0.8 gm) + Refrigerant R134a(100gm)						
T1 (ºC)	T2 (ºC)	Condenser Temperature Drop(T1-T2)	T3 (ºC)	T4 (ºC)	P1 (psi)	P2 (psi)	Power consumed by Compressor	Power consumed by Evaporator	Time (min)
45.2	20.9	24.3	-0.6	30	212	09	8.69	7.67	00
45.5	20.5	25	-1.0	30	220	13	8.59	7.77	20
45.7	21.4	24.3	-1.1	30	220	12	8.62	7.82	40
46.1	21.3	24.8	-1.2	30	225	12	8.65	7.84	60
46.5	22.5	24	-1.4	30	230	14	8.68	7.91	80
48.6	22.8	25.8	-1.5	30	235	14	8.71	7.93	100
48.8	22.9	25.9	-1.8	30	235	16	8.74	7.95	120
48.9	23.7	25.2	-1.9	30	235	16	8.77	8.10	140
49.2	23.8	25.4	-2.1	30	235	18	8.80	8.13	160
49.4	23.8	25.6	-2.3	30	240	18	8.83	8.16	180
49.5	25.7	23.8	-2.4	30	240	15	8.76	8.17	200
49.6	25.5	24.1	-2.7	30	235	15	8.89	8.18	220
49.7	25.2	24.5	-2.8	30	235	18	9.01	8.21	240
							9.01- 8.69 = 0.32	8.21 - 7.65 = 0.54	

COP = Heat Consumed by Evaporator/Power consumed by Compressor

= 0.54/ 0.32= 1.687





Graph 12: Comparison Graph of Temperature and Power consumed by Nanoparticle CuO+ Silica (0.8 gm) + Refrigerant R134a(100 gm).

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Volume 11 Issue VI Jun 2023- Available at www.ijraset.com

IV. RESULTS COMPARISON

Following the execution of the experimental investigation and the collection of the data, we will now compare the outcomes using graphs and tables:

A. Comparison of COP in Various Temperature

Table 13 : Comparison of COP in Various Temperature

T4 (°C)	COP I	COP II	Percentage Improvementin COP (%)	COP III	Percentage Improvementin COP (%)	COP IV	Percentage Improvementin COP (%)
20	1.093	1.125	2.92 %	1.321	20.86 %	1.250	14.36 %
25	1.031	1.437	39.37%	1.375	33.36 %	1.594	54.60 %
30	1.062	1.468	38.22 %	1.281	21.90 %	1.687	62.50 %

Where
T4 = Temperature Maintained at Evaporator Section (°C)
COP I = COP when R134a (100 gm) is inserted
COP II = COP when R134a (100 gm) + 0.4gm CuO+ Silica inserted
COP III = COP when R134a (100 gm) + 0.6 gm CuO+ Silica inserted
COP IV = COP when R134a (100 gm) + 0.8 gm CuO+ Silica inserted

Table 14 : COP and Cost analysis of R134a

COP	COST ₹
1.093	₹128
1.031	₹128
1.062	₹128

TABLE 15 : COP and Cost analysis of R134a + 0.2 gm CuO + Silica Nanoparticles

COP	COST ₹
1.125	₹170
1.437	₹170
1.468	₹170

TABLE 16 : COP and Cost analysis of R134a+ 0.4 gm CuO+ Silica Nanoparticles

COP	COST ₹
1.321	₹191
1.375	₹191
1.281	₹191

TABLE 17 : COP and Cost analysis of R134a+ 0.8 gm CuO+Silica Nanoparticles

COP	COST ₹
1.250	₹212
1.594	₹212
1.687	₹212

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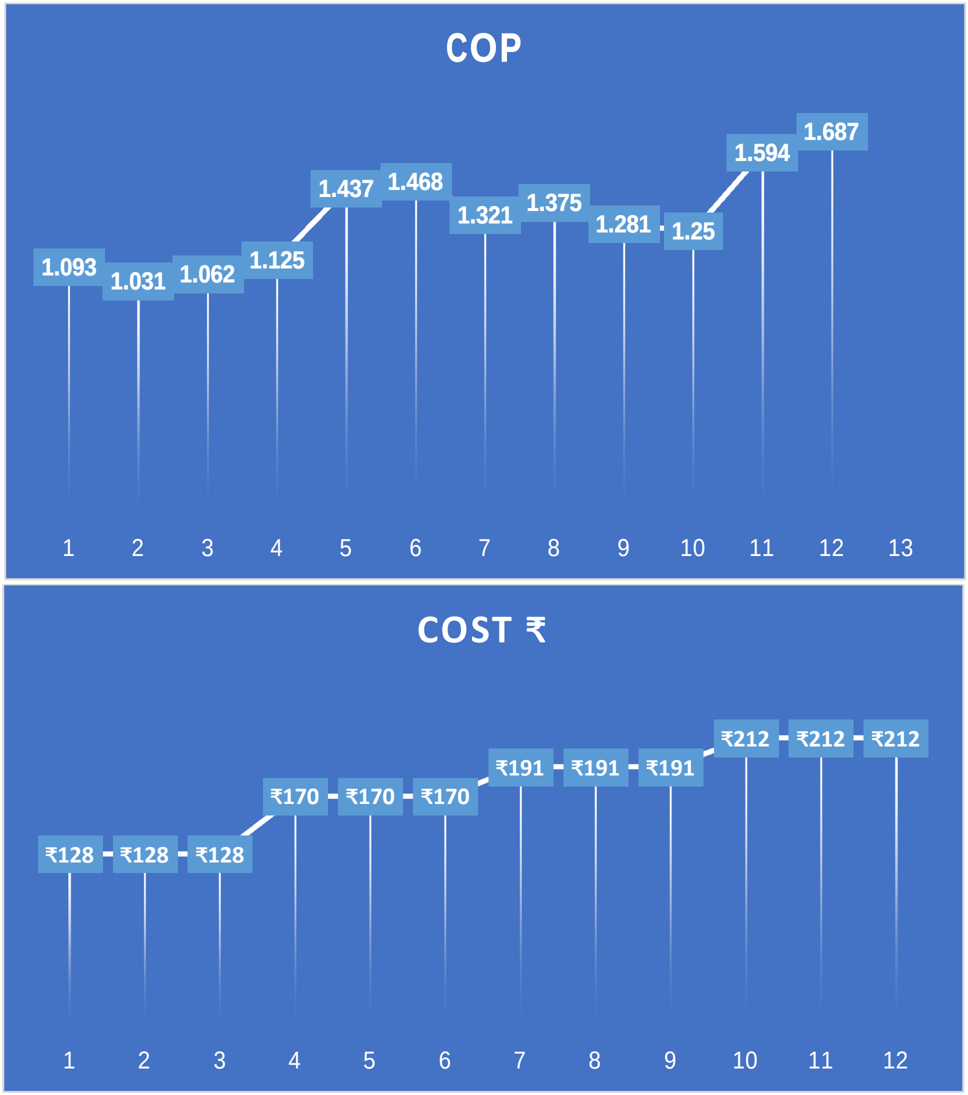

Graph 13 Comparison COP and Cost.

Table 18: Comparison of cost analysis			
Cost of R134a	Cost of R134a+ 0.4 gm CuO+silica Nanoparticles	Cast of R134a+ 0.6 gm CuO+silica Nanoparticles	Cast of R134a+ 0.8 gm CuO +silica Nanoparticles
128	₹ 170	₹ 191	₹ 212
Cost Differences ₹	₹ 42	₹ 63	₹ 84

After increasing COP of refrigerant also Increase its loading capacity. If COP will increase upto 62.50 % that means loading capacity of 200 litre refrigerator is increase upto 210 litre.

V. CONCLUSION

This trial study utilised another performance enhancement of refrigeration system using copper oxide nanoparticles arrangement, and despite having exceptional details regarding its blower type, evaporator shape, size, length of copper tubes used in it, measurement of copper tubes, type of condenser, number of turns in it, length of cylinder and limit of that particular condenser, and type of extension valve used, it was still obvious that the results were also exceptional.

In order to finish the postulation and the try to make it successful, my main obligation was to build up Performance Enhancement of Refrigeration System utilizing Copper Oxide Nano Particles as perfectly as feasible, which I did with exceptional sincerity and care. After everything was ready, the test was started by including the COP and R134a refrigerant into the framework before being released. The showdown taguchi technique and graphing table give a very clear explanation of how we arrived at the outcomes. The framework was created utilizing cost analysis or energy use experiments. A similar method was applied when micro refrigerants were utilized in the Taguchi framework, and the outcomes were then reviewed. After concentrating on, the theory's commitments and outcomes declaration are compacted.

1) COP rose when nano-refrigerants were used in the copper or silica base nano particles' experimental setting rather than just R134a refrigerants.
2) Compared to employing 0.6 gramme and 0.8 gramme, which had a decent multiplication rate, using 0.4 gramme CuO+silica nanoparticles caused a sudden rise in COP.
3) When nano-refrigerant was employed, an exact improvement of 19.1 percent was seen. At 20, 25, and 30 degrees Celsius in the evaporator, R134a was mixed with 0.8 gramme of CuO + Silica.
4) The condenser temperature reduction increased as a result of the usage of nano-refrigerants, and it continued to rise as a result of nanoparticle fixation. To get the greatest results, the refrigerant R134a was enclosed in a 0.8 gramme nanoparticle.
5) R134a will function more effectively as a compressor for the typical refrigeration system if the minimum price rises. If adjusted appropriately for heavier load refrigeration systems, the COP approaches increase 24.28% with only 84 rupees in additions. If COP rises by 62.50%, the loading capacity of a refrigerator with a 200-liter capacity will increase to 210 litres.

This research study investigated the cooling capacity enhancement of refrigerant R-134a by incorporating CuO and SiO_2 nanoparticles. The experimental results demonstrated that the addition of nanoparticles significantly improved the cooling capacity and heat transfer performance of R-134a. The findings suggest that nanofluids have the potential to enhance the efficiency and performance of refrigeration systems. Further research is warranted to optimize the nanoparticle concentrations and explore long-term stability and compatibility with system components.

VI. FUTURE SCOPES

Nanotechnology will be crucial to the refrigeration sector in the near future. There are several nanorefrigerants, nanolubricants, and perhaps even new nano-based technologies as a result. Future work in the refrigeration business should still be achievable using nanotechnology:

1) Different refrigerants and their mixes can be combined with special nanoparticles to create new kinds of nanorefrigerants.
2) The usage of nanoparticles with environmentally friendly refrigerants that are less likely to contribute to ozone depletion and global warming should be especially investigated.
3) There is a need for a full explanation because there hasn't been much study done regarding the differences in characteristics when nanoparticles are employed with any major refrigerant.

A. Future Scope

1) *Optimization of Nanoparticle Concentrations:* Further research can focus on identifying the optimal concentrations of CuO and SiO_2 nanoparticles that provide the maximum cooling capacity enhancement without significantly increasing viscosity or causing issues related to nanoparticle agglomeration.
2) *Long-Term Stability and Compatibility:* Investigating the long-term stability of the nanofluid and assessing its compatibility with various system components, such as pipes, heat exchangers, and compressor materials, is crucial for the practical implementation of nanofluid-based refrigeration systems.
3) *Cost Analysis:* Conducting a comprehensive cost analysis to evaluate the economic feasibility of incorporating CuO and SiO_2 nanoparticles in refrigerant systems is essential for commercial viability.

VII. ACKNOWLEDGMENTS

The authors would like to acknowledge SRCEM BANMORE GWALIOR for providing the necessary resources and support for this research project

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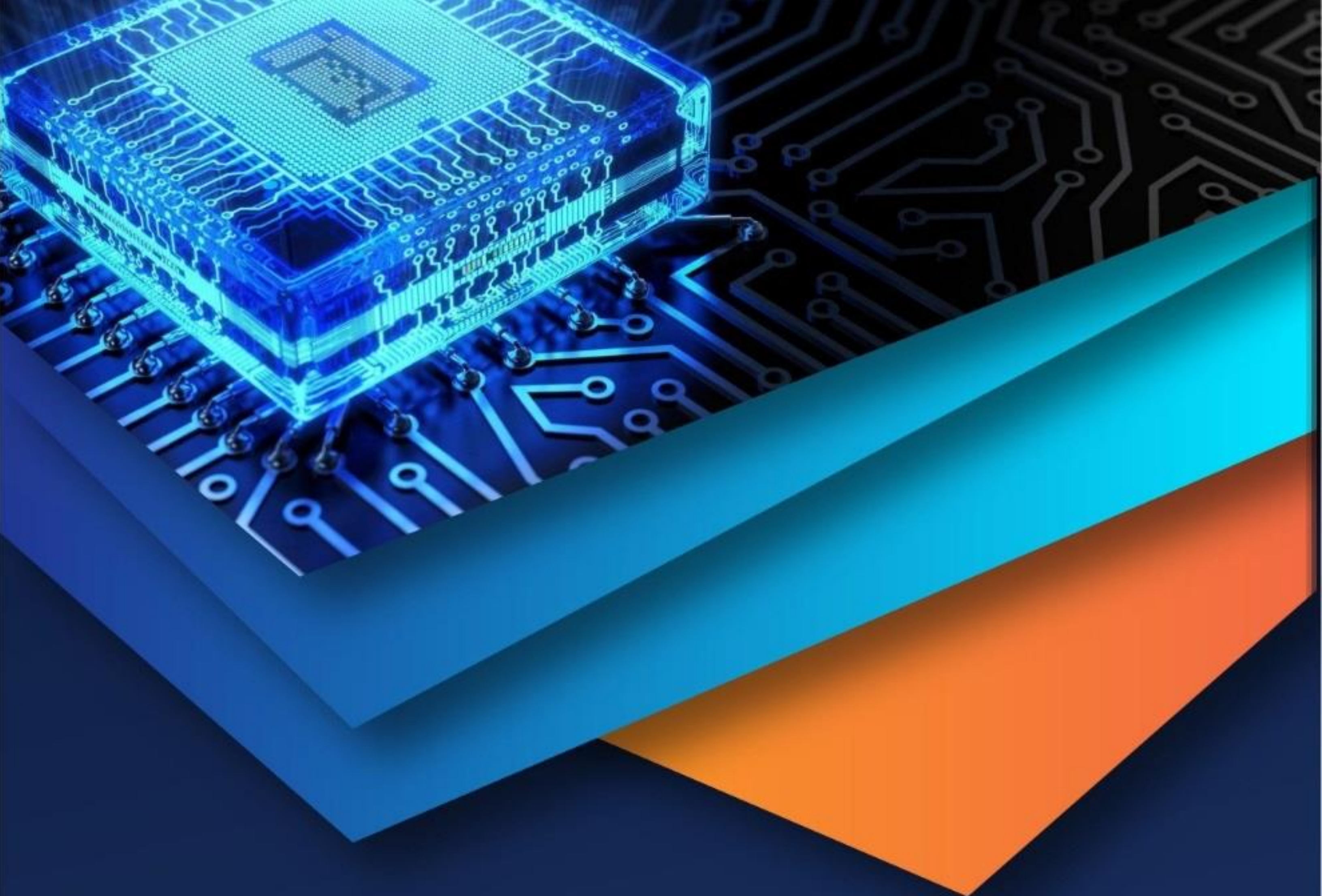

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