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Performance Evaluation of Water Cooled Condenser of Air Conditioner Working on VCRS

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Abstract :

VCRS commonly known as (Vapour Compression Refrigeration System) is widely adopted method for air conditioning of buildings, in pharmaceutical industry for storage of medicine, in hospitals, automobiles etc. There are several methods for increasing the efficiency% (COP) of an VCRS cycle. Some of the modification can be done in Compressor, Condenser, Evaporator, and in Refrigerant . In this experiment, we adopted method of Subcooling to reduce Compressor work. This study investigates the implementation of subcooling in the condenser of a Vapour Compression Refrigeration System (VCRS) to enhance its efficiency and reduce power consumption. The traditional condenser design is modified by submerging it in a water tank, allowing for subcooling of the refrigerant. The subcooling process involves lowering the temperature of the refrigerant below its saturation temperature, which improves the system's Coefficient of Performance (COP) by increasing the density of the refrigerant entering the expansion valve. This modification aims to optimize the heat rejection process and enhance the overall performance of the refrigeration system .Experimental result demonstrate a significant reduction in power consumption and an improvement in COP, highlighting the effectiveness of the condenser subcooling method in enhancing the efficiency of VCRS.

Keywords : Compressor, Condenser, Expansion Valve, Evaporator.

Introduction :

"Refrigeration systems play a pivotal role in our daily lives, quietly ensuring food preservation, comfort, and medical advancements. From keeping groceries fresh to cooling our homes and enabling the safe storage of vaccines, these systems are indispensable. By extracting heat from enclosed spaces, refrigeration prevents spoilage, extends shelf life, and maintains optimal temperatures for various applications. In households, supermarkets, restaurants, and pharmaceutical industries, refrigeration is not just a convenience but a necessity for public health and safety. Its importance lies in safeguarding our well-being, reducing waste, and facilitating technological advancements in various sectors."Refrigeration systems are ubiquitous in our daily lives, playing a vital role in preserving food, facilitating medical advancements, and enhancing comfort in various environments. These systems operate on the principle of removing heat from a confined space, typically by circulating a refrigerant through a cycle of compression, condensation, expansion, and evaporation. The result is the creation of a cooler environment, crucial for storing perishable goods, maintaining optimal temperatures in homes and workplaces, and sustaining critical processes in industries such as pharmaceuticals and manufacturing.
In households, refrigeration systems ensure the freshness and safety of food by slowing down bacterial growth and enzymatic reactions that cause spoilage. From keeping fruits and vegetables crisp to preserving dairy and meat products, refrigerators and freezers are indispensable appliances in modern kitchens. Moreover, in commercial settings like supermarkets and restaurants, refrigeration units enable the storage and display of large quantities of perishable items, ensuring a constant supply of fresh produce to consumers. Beyond food preservation, refrigeration technology supports medical advancements by storing vaccines, medications, and biological samples at precise temperatures, safeguarding their efficacy and integrity.

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In addition to preserving perishable goods and supporting medical advancements, refrigeration systems also play a crucial role in enhancing comfort and productivity in various environments. Air conditioning units, which rely on refrigeration technology, are integral to maintaining comfortable indoor temperatures in homes, offices, vehicles, and public spaces, particularly during hot and humid weather conditions. By regulating indoor climates, these systems improve air quality, reduce humidity levels, and create a conducive environment for relaxation, work, and leisure activities.

Experimental setup of VCRS Cycle :

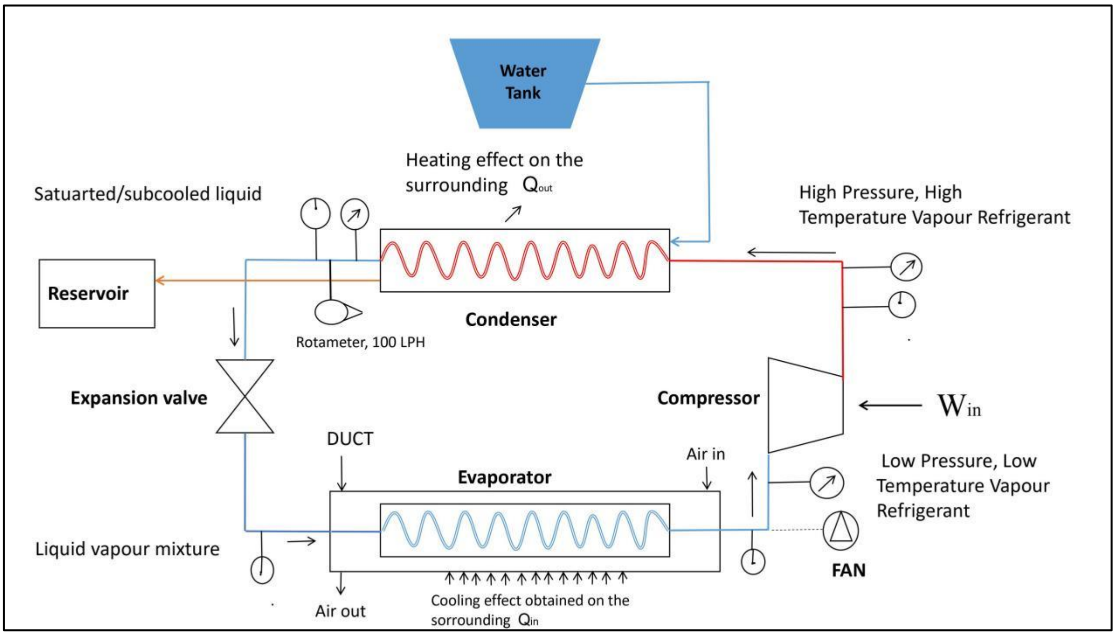

Fig1: Schematic diagram of VCRS Cycle with impelmentation of subcooling

Experimental setup :
The traditional fan is replaced by water tank to dissipate heat of the refrigerant before it leaves to the expansion device, further the condenser coil is submerged into water tank as large amount of produced heat is absorbed by water (coolant) to low down the refrigerant temperature. As necessary accessories has been installed to note down readings for the experiment. Components used : Compressor, Condenser, Expansion valve, Evaporator, water pump, Pressure guage, Ammeter, Anamometer, Electronic temperature sensors, Energy meter, Rotameter (100) lph.

Methodology :

In this experiment split-type air conditioners were used to investigate the influence of cooling of the condenser. Air conditioner were operated with R22 refrigerant.
The working of a water-cooled condenser in an air conditioning system operating on a Vapor Compression Refrigeration System (VCRS) can be described in the following steps:

1.Compression:
The compressor in an air conditioning system plays a crucial role, often referred to as the “heart” of the system. Here’s what it does:

Compression: It compresses the refrigerant vapor (R-22), raising its pressure and temperature, which is essential for the heat transfer process.
Heat Transfer: By pushing the hot, high-pressure gas to the condenser coil, it facilitates the release of heat to the outside air, helping in cooling the refrigerant.
Circulation: The compressor moves the refrigerant through the air conditioning system, enabling the continuous cycle of heat absorption from the indoor air and its release to the outdoor environment.

2.Condensation:
The high-pressure, high-temperature vapor refrigerant then flows into the water-cooled condenser. The role of a water-cooled condenser in an AC system is to condense the refrigerant vapors back into a liquid state by transferring the heat from the refrigerant to water. Here's how it functions:
Heat Transfer: The hot refrigerant vapor from the compressor enters the water-cooled condenser. Here, water circulates around the coils or tubes containing the refrigerant R-22.
Condensation: The heat from the refrigerant is absorbed by the water, causing the refrigerant to cool down and change from a vapor to a liquid state.
Efficiency: Water has a higher heat capacity than air, which makes water- cooled condensers more efficient in heat removal, especially in environments where air temperatures are high.
System Stability: By efficiently removing heat, water-cooled condensers help maintain the desired temperature and pressure levels within the AC system, ensuring stable operation.

3.Expansion:
The expansion device in an AC system, often referred to as an expansion valve, has several key functions:
Pressure Reduction: It reduces the pressure of the liquid refrigerant coming from the condenser, which is essential for the subsequent evaporation process.
Temperature Control: By controlling the flow of refrigerant, the expansion device helps maintain the desired temperature within the evaporator, contributing to the overall cooling effect.
Flow Regulation: It regulates the flow of refrigerant according to the variation of load on the evaporator, ensuring efficient operation under different conditions.
Phase Change Initiation: The expansion device facilitates the phase change of the refrigerant from a high-pressure liquid to a low-pressure gas, which absorbs heat from the environment and provides the cooling effect.

4.Evaporation:
The R22 refrigerant in a Vapor Compression Refrigeration System (VCRS) absorbs heat from the environment primarily through the process of evaporation in the evaporator. Here's how it works:
Evaporator Entry: The refrigerant enters the evaporator as a low-pressure, low-temperature mixture of liquid and vapor after passing through the expansion valve.
Heat Absorption: Inside the evaporator, the refrigerant circulates through coils that are exposed to the air of the space being cooled.
Phase Change: As the warmer air passes over the cold coils, the refrigerant absorbs the heat from the air. This heat transfer causes the liquid part of the refrigerant to evaporate and turn into a gas, a process which is endothermic, meaning it absorbs heat.
Return to Compressor: The now vaporized refrigerant, carrying the absorbed heat, is then drawn back into the compressor to repeat the cycle.
Return to Compressor: The low-pressure vapor is then drawn back into the compressor, and the cycle repeats. This cycle is continuous and provides a consistent cooling effect as long as the system is operating. The water-cooled condenser is particularly effective in systems where a large amount of heat needs to be dissipated or where air- cooled condensers might be less efficient due to high ambient temperatures.

Experimental procedure used can be described as follows:

1. Setup Preparation:
- Set up an air conditioning system with a air-cooled condenser and take measurable readings.
- Now replace condenser with water cooled condenser.
- Ensure the air conditioning system is properly connected to power and water sources.
- Install rota meters to accurately measure the water flow rates for the water-cooled condenser.

2. Water Flow Conditions:
- Set the water flow rate for the water-cooled condenser to 100 liters per hour (lph) and run the air conditioning system.
- Repeat the experiment for water flow rates of 300 lph and 200 lph.
- Ensure that the subcooling remains at 100% for each water flow condition.

3. Baseline Measurements:
-Run the air conditioning system with both the water air-cooled condensers under standard conditions (e.g., room temperature, humidity).

4. Data Collection:
- Continuously monitor and record parameters such as inlet and outlet water temperatures; inlet and outlet temperature and pressure of compressor, condenser and evaporator; temperature and relative humidity of atmospheric air; energy meter reading during each experiment.

5. Analysis:
- Calculate COP, compressor work, pressure ratio, refrigeration effect for each experimental condition.
- Compare the performance of the water-cooled system under different water flow conditions with the traditional air-cooled system.
- Analyze the data to determine the impact of varying water flow rates on the performance of the water cooled condenser.

RESULT

We took project readings on different days. On the first day, we recorded readings for the air-cooled condenser. After that, we recorded readings for the water-cooled condenser at different water flow rates. The comparison between them is as follows :

21-02-2024	Conventional VCRS based Air Conditioner						
Time	04:00	04:05	04:10	04:15	04:20	04:25	04:30
Cond. Inlet (T2)	38.9	62.1	78.9	90	99	105	110
Cond. Outlet (T3)	34.1	36.7	38.3	39.3	40.3	40.9	41.2
Eva Inlet (T4)		0.9	0.1	1.2	1	1.3	1.2
Comp Inlet/Eva Outlet (T1)	30.1	30.9	31.2	31.4	31.1	30.9	30.9
Air Inlet (Duct) (Ti)	29.7	29.7	29.7	29.7	29.7	29.7	29.7
RH Inlet of Duct (%)	32	32	32	32	32	32	32
Air Outlet (duct) (To)	22.5	21.7	21.7	22.1	19.8	19.3	19
RH outlet of Duct (%)	37	37	37	37	38	39	40
Ambient (T11)	29.7	29.7	29.7	29.7	29.7	29.7	29.7
Comp. Outlet Pressure (P1)	14	14.6	15.2	15.3	16.1	16.4	16.5
Comp. Inlet Pressure (P2)	2	2.5	2.7	2.8	2.9	2.9	3
Evaporator Inlet Pressure (P4)	2.2	2.6	2.8	3.1	3.2	3.2	3.2
Flow rate of Refrigerant (lph)	50	56	50	60	70	60	60
time/10 pulse (t) (sec)	7.6	7.5	7.32	6.95	6.5	6.7	6.05
Pressure Ratio	5.00	4.46	4.38	4.29	4.38	**4.46**	4.38
h1		430	430	430	429	429	429
h2		479	474	474	474	471	473
h3=h4		242	246	248	252	252	252
h2-h1 =Wc		49	44	44	45	42	44
h1-h4=R.E		188	184	182	177	177	177
Theoretical COP		3.84	4.18	4.14	3.93	**4.21**	4.02
Duct							
Vair	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Duct Area	0.071	0.071	0.071	0.071	0.071	0.071	0.071
air Density inlet	1.12	1.12	1.12	1.12	1.12	1.12	1.12
H1 (Kj/kg)	52.4	52.4	52.4	52.4	52.4	52.4	52.4
Hi	10.42	10.42	10.42	10.42	10.42	10.42	10.42
Air Density outlet	1.15	1.15	1.15	1.15	1.16	1.16	1.16
H2 (kJ/kg)	39.13	37.53	37.53	37.52	34.24	33.65	33.45
Ho	7.99	7.66	7.66	7.66	7.05	6.93	6.89
Hi-Ho(kW) Heat Rejected	2.43	2.76	2.76	2.76	3.37	3.49	3.53
Compressor Work	1.48	1.50	1.54	1.62	1.73	1.68	1.86
Actual COP	1.64	1.84	1.79	1.70	1.95	**2.08**	1.90

Date:24/02/24	Condition	Water Flow from tank to outside					
Time	03:40	03:45	03:50	03:55	04:00	04:05	04:10
Compressor outlet Temp	27.9	60.2	76.1	86.6	95.3	102.8	108
Condenser Outlet Temp	30.8	34.3	37.2	39.3	41.2	42.7	43.9
Evaporator Inlet Temp	19.6	2	-0.3	-1	0.8	-0.4	-0.2
Evaporator Outlet Temp	27.9	27.8	27.4	27.2	27.1	27.2	27.3
Pressure Ratio	4.33	4.41	**4.71**	4.30	4.50	4.52	4.36
h1	428	427	427	426	426	426	425
h2	470	471	470	468	469	468	470
h3=h4	238	242	243	248	252	254	256
h2-h1 =Wc	42	44	43	42	43	42	45
h1-h4=R.E	190	185	184	178	174	172	169
Theoretical COP	4.52	4.20	**4.28**	4.24	4.05	4.10	3.76
Duct Inlet Air Temp	28	28	28	28	28	28	28
Inlet RH %	39	39	39	39	39	39	39
Duct Outlet Temp	24.3	23.2	23	22.5	22.5	23.3	22.3
Outlet RH	46	44	45	48	52	54	56
Vair	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Duct Area	0.071	0.071	0.071	0.071	0.071	0.071	0.071
Air Density inlet	1.12	1.12	1.12	1.12	1.12	1.12	1.12
H1 (Kj/kg)	52.52	52.52	52.52	52.52	52.52	52.52	52.52
Hi	10.44	10.44	10.44	10.44	10.44	10.44	10.44
Air Density outlet	1.14	1.14	1.14	1.14	1.14	1.14	1.14
H2 (kJ/kg)	47.45	43.87	43.91	44.13	45.93	48.9	47.23
Ho	9.60	8.88	8.89	8.93	9.29	9.89	9.56
Hi-Ho(kW) Heat Rejected	0.84	1.56	1.56	1.51	1.15	0.55	0.88
Compressor Outlet Pressure (P1)	12	14	15	16.2	17	18	18.2
Compressor Inlet Pressure(P2)	2	2.4	2.4	3	3	3.2	3.4
Condenser outlet Pressure(P3)	2.2	3	3	3.2	3.4	3.4	3.8
Energy Meter Reading	8.23	8.25	8.89	8.9	8.4	8.7	8.9
Rotameter Reading Refrigerant	50	50	60	60	60	60	60
Compressor Work	1.37	1.36	1.27	1.26	1.34	1.29	1.26
Actual COP	0.61	1.15	**1.23**	1.20	0.86	0.42	0.70
Water Flow rate	70	70	70	70	70	70	70
Water Temperature in tank	30	32.5	35	37.5	39.7	41.5	42.9
Inlet Water Temperature	30	30	30	30	30	30	30
		203.1944444	406.3888889	609.5833333	788.3944444	934.6944444	1048.483333
			203.1944444	203.1944444	178.8111111	146.3	113.7888889

Room Temperature	27.9	27.9	27.9	27.9	27.9	27.9	27.9
Room RH	41	41	41	41	41	41	41

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Date:4/03/24	Condition	Water Flow from tank to outside				
Time	03:31	03:38	03:46	03:53	03:59	04:06
Compressor outlet Temp	40	70.6	89.4	97.7	104.6	113
Condenser Outlet Temp	30.2	35.9	36.9	36.1	38.7	38.1
Evaporator Inlet Temp	8.5	-1.6	-2.1	-0.1	-0.2	-1.9
Evaporator Outlet Temp	30.2	29.6	29.1	29.1	29.1	29.1
h1	430	429	428	428	429	427
h2	477	475	472	472	479	472
h3=h4	240	242	246	246	248	246
h2-h1 =Wc	47	46	44	44	50	45
h1-h4=R.E	190	187	182	182	181	181
Theoretical COP	4.04	4.07	4.14	4.14	3.62	4.02
Duct Inlet Air Temp	31	31	31	31	31	31
Inlet RH %	35	35	35	35	35	35
Duct Outlet Temp	29.3	28.2	26.1	25.8	25.3	24.9
D(Duct Outlet Temp)	27	25.2	23.1	22.8	22.3	21.9
Outlet RH	41	42	44	49	51	52
Vair	2.5	2.5	2.5	2.5	2.5	2.5
Duct Area	0.071	0.071	0.071	0.071	0.071	0.071
Air Density inlet	1.11	1.11	1.11	1.11	1.11	1.11
H1 (Kj/kg)	57.25	57.25	57.25	57.25	57.25	57.25
Hi	11.28	11.28	11.28	11.28	11.28	11.28
Air Density outlet	1.13	1.13	1.14	1.14	1.15	1.15
H2 (kJ/kg)	51.29	47.52	43.64	45.3	44.98	44.46
Ho	10.29	9.53	8.83	9.17	9.18	9.08
Hi-Ho(kW) Heat Rejected	0.99	1.75	2.45	2.11	2.10	2.20
Compressor Outlet Pressure (P1)	13	14.6	14.7	14.9	15	15.1
Compressor Inlet Pressure(P2)	1.9	2.6	2.6	2.6	2.9	2.7
Condenser outlet Pressure(P3)	2	2.8	2.9	2.8	3.4	3.3
Pressure Ratio	4.83	4.33	4.36	4.42	4.10	4.35
Energy Meter Reading	9.23	7.85	8.63	9.07	7.87	7.76
D (Energy Meter Reading)	9.23	7.85	7.25	9.07	7.87	7.76
Rotameter Reading Refrigerant	50	60	60	60	60	60
Compressor Work	1.22	1.43	1.55	1.24	1.43	1.45
Actual COP	0.81	1.22	1.58	1.70	1.47	1.52
Water Flow rate litre/hr	275	275	275	275	275	275
Water Temperature in tank	31	32.5	32.5	33.6	34	34.7
Inlet Water Temperature	31	31	31	31	31	31
		478.9583333	478.9583333	830.1944444	957.9166667	1181.430556
			0	351.2361111	127.7222222	223.5138889
Room Temperature	31	31	31	31	31	31
Room RH	35	35	35	35	35	35

Date:11/03/24	Condition	Water Flow from tank to outside 100% sub				
Time	02:50	02:56	03:02	03:08	03:14	03:20
Compressor outlet Temp	36.3	68.9	84	95.8	104.6	113
Condenser Outlet Temp	33.3	37.8	39.3	42.3	44.3	43.6
Evaporator Inlet Temp	1	0.6	1.1	2.1	1.8	2.1
Evaporator Outlet Temp	31.9	31.8	31.5	31	31.1	31.3
h1	431	430	430	429	429	429
h2	480	472	471	473	474	473
h3=h4	240	249	250	254	254	254
h2-h1 =Wc	49	42	41	44	45	44
h1-h4=R.E	191	181	180	175	175	175
Theoretical COP	3.90	4.31	**4.39**	3.98	3.89	3.98
Duct Inlet Air Temp	33.2	33.2	33.2	33.2	33.2	33.2
Inlet RH %	37	37	37	37	37	37
Duct Outlet Temp	33.1	28	27.6	27.2	27.3	27.2
Outlet RH%	36	37	37	38	40	41
Vair	2.5	2.5	2.5	2.5	2.5	2.5
Duct Area	0.071	0.071	0.071	0.071	0.071	0.071
Air Density inlet	1.1	1.1	1.1	1.1	1.1	1.1
H1 (Kj/kg)	65.21	65.21	65.21	65.21	65.21	65.21
Hi	12.73	12.73	12.73	12.73	12.73	12.73
Air Density outlet	1.1	1.12	1.13	1.13	1.13	1.13
H2 (kJ/kg)	63.6	51.26	50.3	49.97	51.44	51.79
Ho	12.42	10.19	10.09	10.02	10.32	10.39
Hi-Ho(kW) Heat Rejected	0.31	2.54	2.64	2.71	2.41	2.34
Compressor Outlet Pressure (P1)	13.1	15	15.6	17	18	17.8
Compressor Inlet Pressure(P2)	1.9	2.4	2.5	3	3.2	3.2
Condenser outlet Pressure(P3)	2.2	2.8	3	3.2	3.8	3.8
Pressure Ratio	4.86	4.71	**4.74**	4.50	4.52	4.48
Energy Meter Reading	9.61	9.19	9.1	8.54	7.43	8.05
Rotameter Reading Refrigerant	60	60	60	60	60	60
Compressor Work	1.17	1.22	1.24	1.32	1.51	1.40
Actual COP	0.27	2.08	**2.14**	2.06	1.59	1.68
Water Flow rate litre/hr	180	180	180	180	180	180
Water Temperature in tank	31	34.6	37.6	40.3	42.1	41.9
Inlet Water Temperature	31					
		7231.4	7858.4	8422.7	8798.9	8757.1
			627	564.3	376.2	-41.8
Room Temperature	33.2	33.2	33.2	33.2	33.2	33.2
Room RH	37	37	37	37	37	37

The graph (fig-2) illustrates the Actual Coefficient of Performance (COP) of an air conditioning (AC) system under normal testing conditions. The test compares three variations of flow rates: 100 lph, 200 lph, and 300 lph, alongside a traditional air-cooled AC system.

Each data point represents the actual COP achieved by the AC system at different flow rates (100 lph, 200 lph, and 300 lph) with respect to time for the water-cooled condenser. Additionally, a data point is included for the COP of the traditional air-cooled AC system for comparison. The graph suggests that the actual COP of the AC system tends to be higher at a flow rate of 200 lph compared to 100 lph and 300 lph.

This implies that, under normal testing conditions, the AC system may achieve better efficiency (as indicated by the COP) when the water-cooled condenser operates at a flow rate of 200 lph. Additionally, the graph allows for a comparison between the COP of the water-cooled AC system and the traditional air-cooled AC system, providing insights into the potential benefits of water-cooled condensers in terms of efficiency.

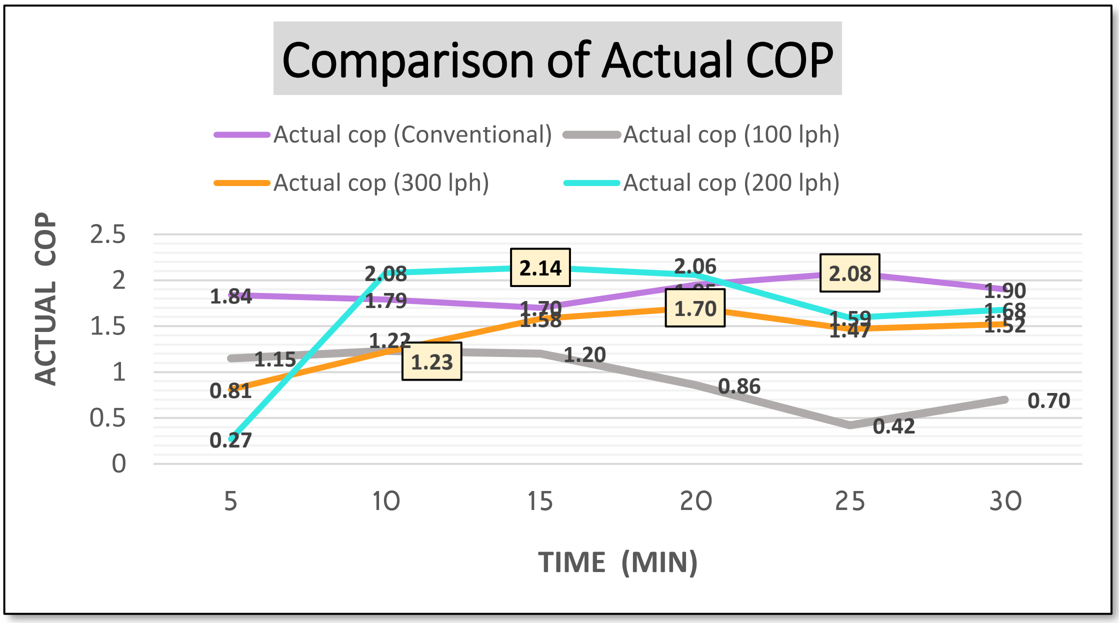

Figure-2 comparison of actual COP

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	Actual cop			
Time	(Conventional)	(100 lph)	(300 lph)	(200 lph)
5	1.84	1.15	0.81	0.27
10	1.79	1.23	1.22	2.08
15	1.70	1.20	1.58	2.14
20	1.95	0.86	1.70	2.06
25	2.08	0.42	1.47	1.59
30	1.90	0.70	1.52	1.68

The graph (fig-3) illustrates the theoretical COP values obtained during testing under normal conditions for different flow rates (100 lph, 300 lph, and 200 lph) of the water-cooled condenser. Additionally, it includes the theoretical COP value for the traditional air-cooled air conditioning system.From the graph, we observe that the theoretical COP value at the end of data retrieval for the 200 lph flow rate is higher compared to the other flow rates and the traditional air-cooled system.

This indicates that under normal testing conditions, the air conditioning system with a water-cooled condenser operating at a flow rate of 200 lph has a higher theoretical efficiency in cooling compared to other flow rates and the traditional air-cooled system.

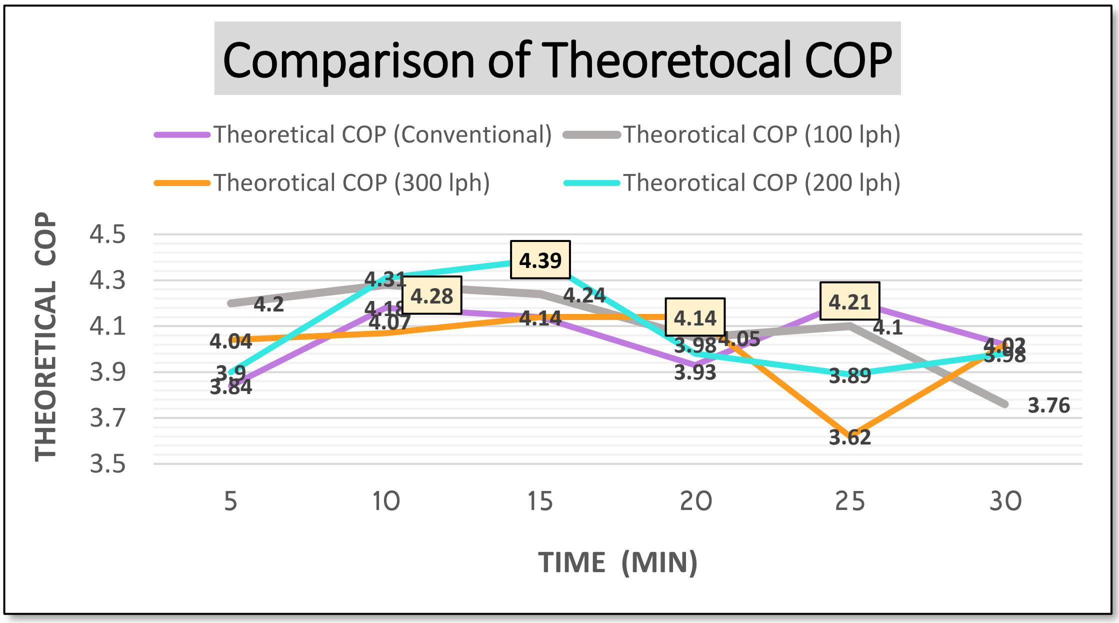

Figure 3

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	Theoretical COP			
Time	(Conventional)	(100 lph)	(300 lph)	(200 lph)
5	3.84	4.2	4.04	3.9
10	4.18	4.28	4.07	4.31
15	4.14	4.24	4.14	4.39
20	3.93	4.05	4.14	3.98
25	4.21	4.1	3.62	3.89
30	4.02	3.76	4.02	3.98

As we examine the graph, you'll observe that the data points for the 100 lph, 200 lph water flow rate are consistently lower than those for 300 lph and traditional air conditioning system.

In simpler terms, this means that under these testing conditions, the AC system with a water flow rate of 100lph and 200 lph requires the less compressor compared to the other flow rates (300 lph) and the air-cooled system.

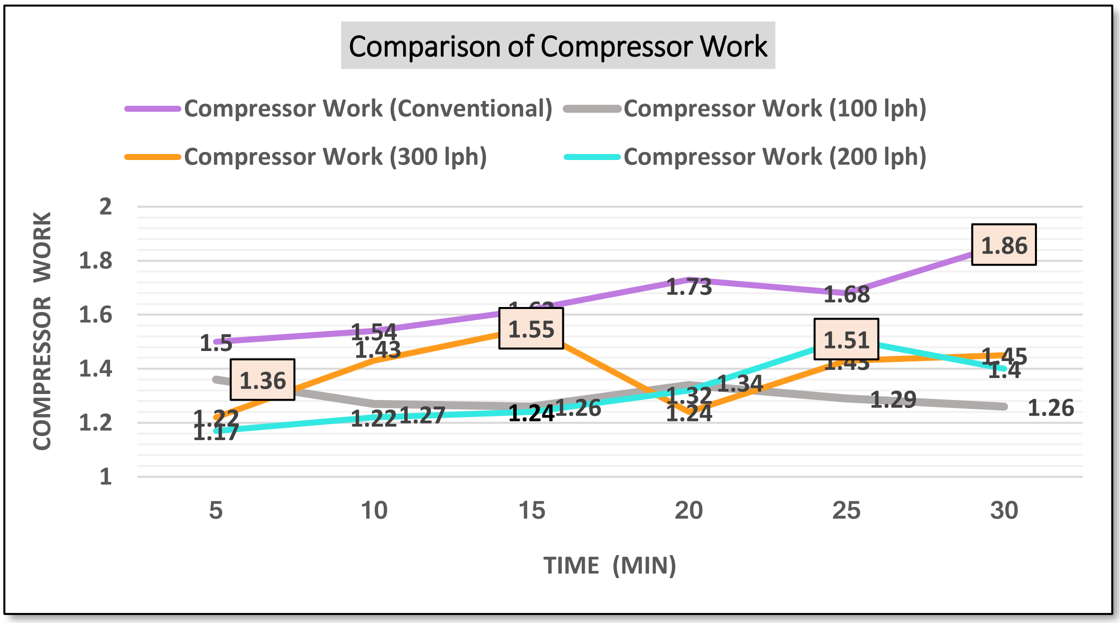

Figure 4

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	Compressor Work			
Time	(Conventional)	(100 lph)	(300 lph)	(200 lph)
5	1.5	1.36	1.22	1.17
10	1.54	1.27	1.43	1.22
15	1.62	1.26	1.55	1.24
20	1.73	1.34	1.24	1.32
25	1.68	1.29	1.43	1.51
30	1.86	1.26	1.45	1.4

The graph demonstrates that under normal testing conditions, the theoretical compressor work for the AC system tends to be higher when the water flow rate is set at 200 lph compared to other flow rates (100 lph and 300 lph) and the traditional air-cooled AC system.

This observation suggests that adjusting the water flow rate to 200 lph may potentially optimize the theoretical compressor work of the AC system, indicating improved efficiency or performance compared to other flow rates and traditional air-cooled systems.

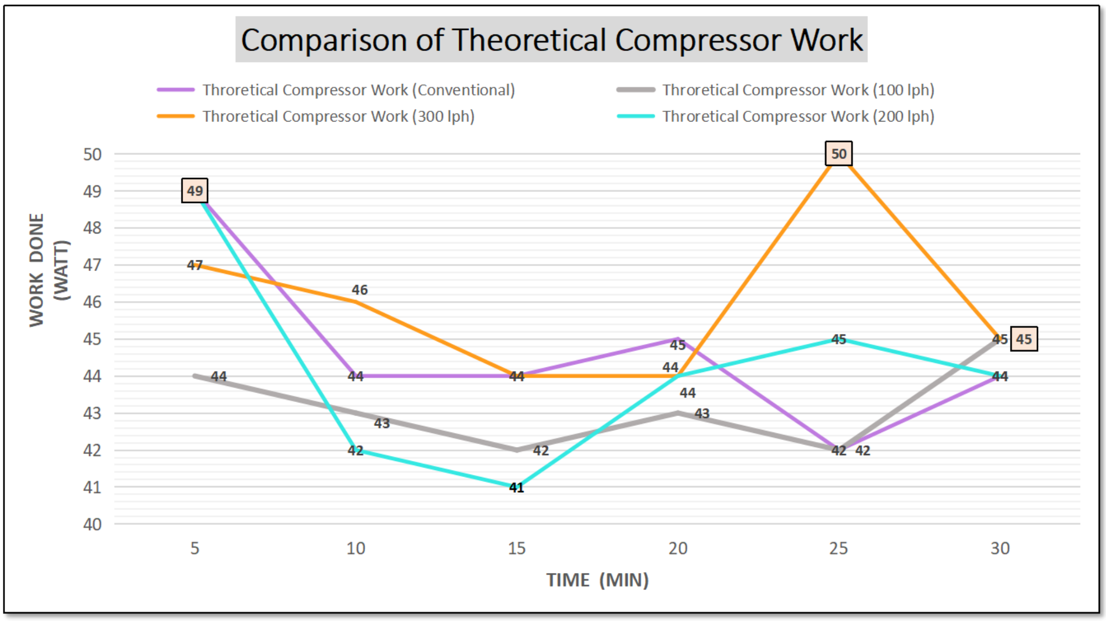

Figure 5

	Theoretical Compressor Work			
Time	(Conventional)	(100 lph)	(300 lph)	(200 lph)
5	49	44	47	49
10	44	43	46	42
15	44	42	44	41
20	45	43	44	44
25	42	42	50	45
30	44	45	45	44

"Overall, the data indicates that increasing the water flow rate improves the refrigeration effect of the water-cooled AC system. At 200lph, and 300lph the system performs the best among the tested variations, outperforming both lower as well as the traditional air-cooled AC system."

By following these steps, we create a simple yet detailed graph explanation that effectively communicates the comparison of refrigeration effects between water-cooled and air-cooled AC systems under normal testing conditions.

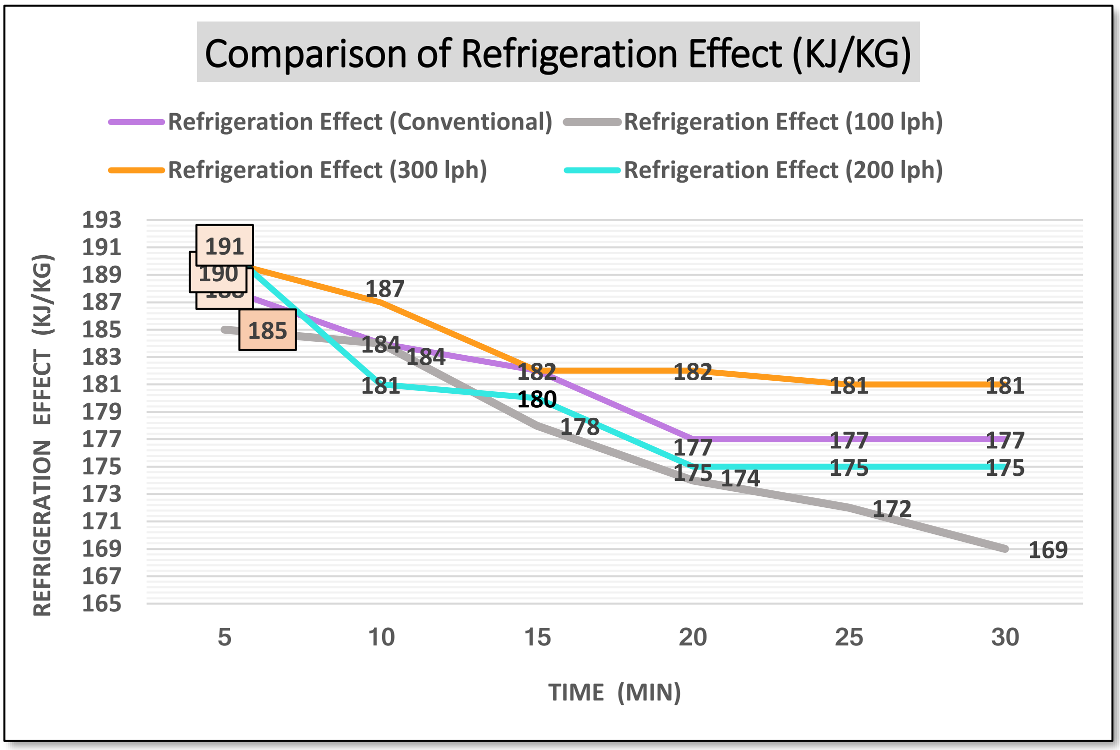

Figure 6

	Refrigeration Effect			
Time	(Conventional)	(100 lph)	(300 lph)	(200 lph)
5	188	185	190	191
10	184	184	187	181
15	182	178	182	180
20	177	174	182	175
25	177	172	181	175
30	177	169	181	175

In an air conditioning system, the pressure ratio refers to the ratio between the pressure on the high-pressure side of the system (often referred to as the discharge or condenser side) and the pressure on the low-pressure side (often referred to as the suction or evaporator side).

This ratio is significant because it helps determine the efficiency and effectiveness of the air conditioning system. A higher pressure ratio typically indicates higher compression, which can lead to better cooling efficiency but may also require more energy to operate. Conversely, a lower pressure ratio may result in less efficient cooling but may require less energy.

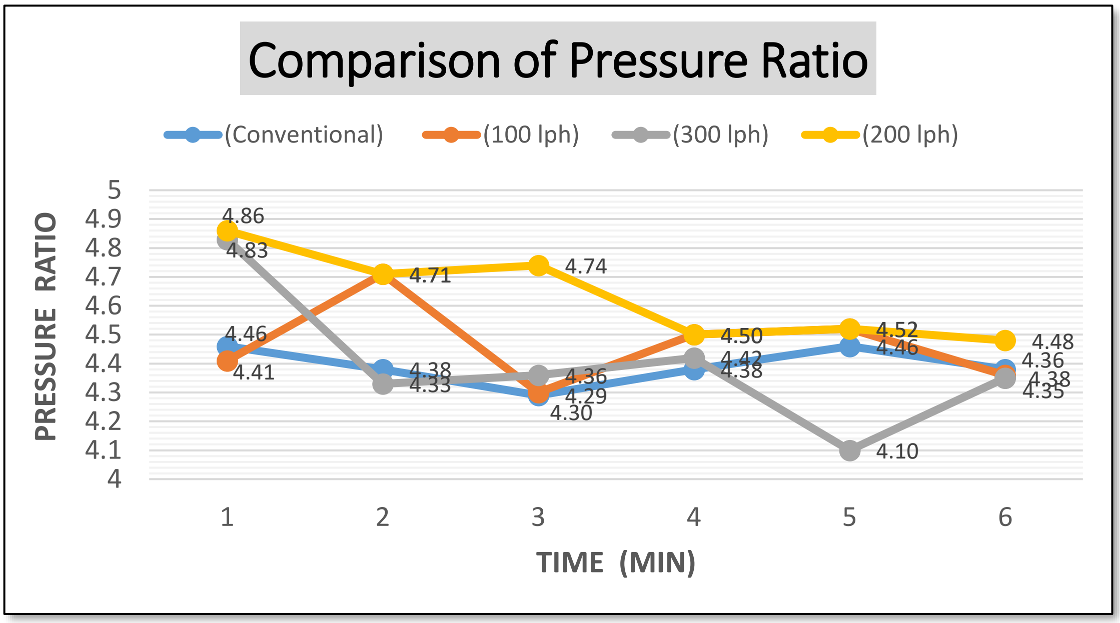

Figure 7

	Pressure Ratio			
Time	(Conventional)	(100 lph)	(300 lph)	(200 lph)
5	4.46	4.41	4.83	4.86
10	4.38	4.71	4.33	4.71
15	4.29	4.30	4.36	4.74
20	4.38	4.50	4.42	4.50
25	4.46	4.52	4.10	4.52
30	4.38	4.36	4.35	4.48

CONCLUSION

The conclusion drawn from comparing a water-cooled condenser with different flow rates and an air-cooled condenser suggests that the water-cooled condenser with a water flow rate of 200 liters per hour (lph) exhibits a higher coefficient of performance (COP) and requires less compressor work. This finding indicates that the water-cooled condenser with this specific flow rate is optimal for reducing energy consumption in the air conditioning system.

This conclusion underscores the efficiency advantage of water-cooled condensers over air-cooled ones, particularly when operated at the specified flow rate. By efficiently removing heat from the refrigerant, the water-cooled condenser allows the compressor to operate more effectively, resulting in lower energy consumption. This highlights the importance of selecting appropriate equipment and operating parameters to achieve optimal energy efficiency in air conditioning systems.

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