International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

IJIEMR Transactions, online available on 4th Sept 2021. Link :http://www.ijiemr.org/downloads.php?vol=Volume-10&issue=ISSUE-08

DOI: 10.48047/IJIEMR/V10/I08/58

Title **Enhanced sub-cooling attained by using moisture condensate in-unit air conditioner**

Volume 10, Issue 08, Pages: 351-361

Paper Authors
KOTA SAIBABA, ASAD HABEEB

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

Enhanced sub-cooling attained by using moisture condensate in-unit air conditioner

KOTA SAIBABA[1],ASAD HABEEB[2]

[1]M.Tech, student, Department of Mechanical Engineering, SGT UNIVERSITY (GURGAON)

[2]Assistant professor, Department of Mechanical Engineering, SGT UNIVERSITY (GURGAON)

Abstract

We live in a time of global warming. Global temperatures are rising almost every year as a result of climate change. In such a world, it is not hard to imagine that global cooling systems are more efficient than at any other time in human history. From our homes to our workplaces, from leisure centers to medical or laboratory purposes, it has become almost necessary for a person to be ventilated only for a variety of needs. We all know that air-conditioner use is very high during the summer and is followed by a small amount of reduced use during the rainy season. We also know that most air conditioning systems have an outlet for wastewater from machinery. The moisture present in the air when it comes in contact with the AC evaporator coil, turns into the water and will discharge from the system by passage. It means that AC in the coastal region, due to the high humidity in the air, will produce more polluted water than in the dry zone. It is therefore not uncommon to find people in many coastal areas reusing extruded water for other purposes such as flowering plants, washing dishes, etc. Cooling systems can work in both air conditioning and water cooling systems. Since it is very stable and has air-conditioning strategies, we often see air-conditioners installed as cooling methods unlike water cooling systems. Therefore in such 'tropical' countries, any efforts to increase AC efficiency will be welcomed. One way to achieve this goal is to provide a hybrid Cooling AC using the water it emits. In doing so, this test aims to reduce energy compensation and increase efficiency of the system. If successful, the whole project will help save energy and resources for the next generation. Global demand for Air conditioners will increase from 1.2 billion units today to 4.5 billion units by 2050. On an average, in India around six thousand trains use 7 to 15 tons of air conditioners every day. Thousands of liters of water that is being generated from the air conditioners is put to no use and let to be wasted, if we use that water to increase the efficiency of the refrigeration cycle we can reduce energy consumption. That will be for the benefit of future generations. With so much research going on around the world to make cooling systems more environmentally friendly, this small step is likely to change the future of ACs.

Introduction

Air Conditioning andEnhanced sub-cooling.

A room air-conditioner has a compressor, condenser, and evaporator. In a vapour compression refrigeration system a compressor is used to compress the refrigerant which turns it into a high-pressure-high temperature vapour. The fluid transfers to the condenser to reduce the high temperatures, the temperatures have been reduced due to this air cooling technique. After removing heat from the fluid, it will turn into a high-pressure liquid due to the phase change. The refrigerant from the condenser to the evaporator is sent with the help of a capillary pipe. The Capillary pipe is a small diameter pipe and the evaporator pipe is a large diameter pipe. Fluid flows from capillary pipe to evaporator pipe where expansion takes place and gives the desired effect of cooling because of fluid properties.

The objective of the project is to provide subcooling to the air-conditioning system. In the evaporator, the room air is treated with the evaporator coil to get the desired effect of cooling. Here the room air absorbs the cold temperature through the above process. Due to the cooling, the humidity in the air forms as moisture on the surface of the evaporator coil. The moisture droplets on the condenser coil drain out like water. This process is called condensation. The water generated from the system is totally dependent on the humidity index present in the air. The condenser is the main part of any refrigeration cycle because it removes the heat of the air conditioning system.

Water has the ability to absorb heat and, once it reaches the boiling point it gets evaporated. From the air conditioner, condensed moisture is generated with respect to the humidity index present in the air. Normally room air conditioners are designed with air-cooled condensers, these air-cooled condensers' efficiency is changed due to the atmospheric temperature. Providing additional cooling to the condenser is called sub cooling.

Sub cooling is provided to the air conditioning system to stabilize and gain proper efficiency.

The water formed due to the condensation process of the air conditioner is used back for the sub cooling process to the condenser.

LiteratureSurvey

WAHYU Budi Mursanto et.al (2014),[9]. When an automotive air conditioner connected to the main engine of a vehicle is turned on, the load will fall on the main engine, and the mileage will come down. The liquid section subcooling system is added to the automotive air conditioner and the result increases up to 6% of cop and the condenser temperature also increases to 10%. With the subcooling, the risk of compressor damage is decreased because the liquid section is absorbing the vapour section cooling, and the compressor inlet will only have the vapour. The study concludes that subcooling is very useful in the automotive system.

JieJia, W.L. Lee (2014),[10]. The heat exiting from the air-conditioner is utilized here for different useful purposes. The air-

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

conditioner compressor discharge is connected to a water tank, so the water tank acts as a sub-cooling system to the air conditioner. In return, the water tank stores the heat from the air conditioner, and the hot water is used for any suitable purposes. Normally in hotels or office spaces, they use big air conditioner systems, and they also regularly need hot water for cooking and in canteens. The subcooling increases the performance of the air conditioner and the water gets heated for many useful purposes.

Work Objective

The following points are the main objectives of our work.

- Fabricate the experimental setup.
- Compare the simulation and practical test results.

Problem

The air conditioners are used for cooling, heating, humidity management, storage of food and etc. Room air conditioners and commercial air conditioners generate more heat in summer. Due to overheating, the air-conditioning systems' life and efficiency are reduced. And this leads to global warming.

Air-cooled condensers are one of the main problems of air conditioning systems. Air conditioning system efficiency changes with respect to the changes in atmospheric conditions.

Here are the main points of our problem.

1. Air conditioners lose their efficiency due to an increase in atmospheric temperature in summer.

2. Air conditioners generate an increase in heat due to the compression process which in turn leads to global warming.

3. Overheating of condenser and compressor leads to break down in the system.

Note: Air-conditioners generate water due to humidity present in the air. Most of the time water is drained out. Water wastage is also one of the problems in this existing process.

Details of Formulated Problem

Air conditioners are working with the principle of vapor compression refrigeration. In this process, the refrigerant is compressed with the help of a compressor. And then a condenser is used to remove the heat generated from the compression process. An air-cooled condenser uses the air from the atmosphere to cool the refrigerant. Hence, the outside air temperature has directly affected the efficiency of the air conditioner.

In summers air conditioners work with less efficiency due to an increase in the atmospheric temperature. Also, the compressor performance decreases due to overheating. The following points explain the formulated problem. For simulation, we considered an open area for the experiment. The inlet air temperatures of both condenser and evaporator are the same. The experiment is placed in an open area to obtain accurate temperature differences of condenser and evaporator. The readings involve the temperatures of both the inlet and outlet of the condenser, evaporator. Amps meter is used to calculate the power consumption of the air conditioner. For checking the performance of the air conditioning system in various conditions, ice, and water are used in different stages of the experiment. We assume the remaining parameters are the same for all the stages of experiments. Other requirements and specifications are discussed in the next chapter.

Methodology

We are using quite a simple and low-cost process here. In the vapor compression process, a temperature of 90 to 110 degrees is generated. And this heat energy is absorbed by water which gets evaporated. This happened due to the transfer of heat energy from higher temperature to lower temperature. Due to this transfer of heat energy the overall temperature of the vapour compression process will be reduced.

In this vapour compression refrigeration process, the condenser reduces the generated heat. By supplying water at this stage to the heat exchanger an additional reduction in heat is observed. And this process is called sub cooling of the air conditioning system.

Here we will be experimenting with a multi-stage sub cooling to the vapour compression process.

Stage-1 - A heat exchanger is placed between the capillary and the condenser.

Stage-2 - A heat exchanger is placed between the compressor and the condenser.

This multi-stage experiment will be conducted thrice using three different elements to compare their efficiency.

1. Using ice and air to provide the sub cooling to the air conditioning system.
2. Using water and air to provide the sub cooling to the air conditioning system.
3. Using only air to provide the sub cooling to the air conditioning system.

Experimental setup→Preparing Iron frames

In this excremental producer we took the iron square type pipe with the size of 1 inch's length of 160 ft. The 20-gauge iron sheet for cover and top and base of the frame. The length of frame is 5ft and width is 50 inches and depth are 29.5 inches rectangular. The frame is prepared with arc welding.

A 20-gauge iron sheet is used for the top and bottom and middle partitions of the frame, also used the same sheet for closing sides of the frame.

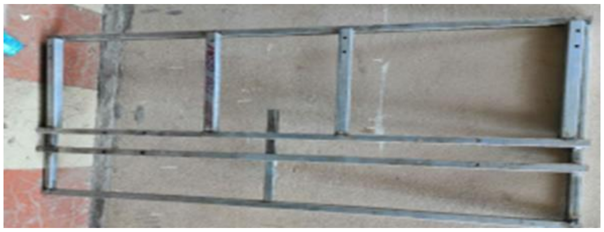

Figure: Iron frame for experimental setup

Heat Exchanger tanks preparation

The two copper tanks are prepared for heat exchangers like the 3/8 inches copper pipe length of 22 feet for each tank with the help of soldering. These tanks are prepared for storing condensed water which is generated from evaporator in the refrigeration process.

The two tanks are fixed in the down stage of the experiment, with the help of puff insulation which is very useful to hold strongly with the frame, the puff insulation is prepared with the polyurethane foam liquid 1and liquid 2.

Figure: Heat Exchanger tank with copper pipe soldering.

The polyurethane foam insulation preparation

The polyurethane foam is prepared with two liquids, the two liquids taken into one bowl, each liquid must take in the same quantity of weight like 100 grams each and mix with hard plastic stick up to 30 sec only, because the reaction starts after 1 minute. The reaction means the puff expansion is taking place. The puff insulation is used to hold the two tanks, also the thermal insulation useful to protect the equipment. The condenser and Evaporator assembly.

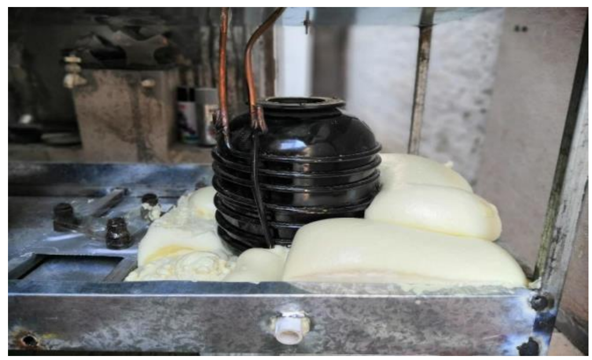

Figure: Heat Exchanger tank with puff.

Evaporator and condenser installation

The evaporator and condenser is fixed in the panel also two fans is fixed after the evaporator and condenser coils, the Evaporator fan is having draft type wing, which is taking cooling from the evaporator and pushing into outside the frame, normally the evaporator is fixed into inside of the room and the condenser is fixed outside of the room, in this experiment we have installed both evaporator and condenser in the same frame and same direction for

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

taking results and doing repeated experiments.

The evaporator is fixed with the water collector tray, the condensed moisture is collected in that tray connected with the heat Exchanger tank. The fan is installed after the Evaporator coil and the housing is fixed and insulated with foam, because the natural property of metal is absorbing the cooling and heating also.

We took 14 *14 inches 4 row copper coil for condenser and installed fan motor for taking the heat from condenser and throwing out.

We took 14 *14 inches 4 row copper coil for evaporator and installed fan motor for taking the cool from evaporator and sending to room.The condenser and evaporator also fitted in the frame and installed a fan and housing with insulation.

Figure: Condenser and fan fitting.

Figure: Evaporator and fan fitting.

Compressor installation

We took a 1.5-ton ac compressor for this experimental setup. The compressor is placed in the lower part of the frame. And connected with heat exchangers and evaporator and condenser. The power connections are fixed, and the control board is also fixed in this step.

Figure: compressor fitting.

Copper pipe connections and welding

In this experiment we have used 4 types of copper pipes, which are ½ , ¼ , 3/8, 5/16 inches pipes. The condenser and heat Exchanger tanks and compressor is connected with 3/8 pipes and the compressor discharge and heat Exchanger tank connected with 5/16 inches copper pipe length of 5 ft, and the heat Exchanger tank is rolled with the 22 ft of 3/8 inches pipe also the connection to condenser also used 3/8 inches pipe length of 3ft and the condenser is having same diameter of pipe which is 3/8 inches only. The discharge of the condenser connected with the heat Exchanger tank 2 with the same diameter of pipe which is 3/8 inches and the length is 5 ft. The heat Exchanger tank 2 discharge is connected with filter and capillary pipe.

The capillary is connected with ¼ inches of diameter copper pipe length of 6 ft, connected to evaporator coil and the evaporator is having 3/8 diameter of copper pipe and the discharge of evaporator is connected to a compressor with ½ inch diameter pipe length of 5 ft. Copper pipe welding is done by LPG using copper alloys and fillers.

Figure: Copper pipe welding.

Figure: Copper pipe welding.

Refrigerant filling into Experiment

The Experiment is ready to start the refrigerant filling process, first we need to remove the air inside the pipes and coils, so we need a vacuum pump to pump out the air from the experiment. We have used the 2-cfm vacuum pump to conduct this process. After the vacuum we connected the experiment to power and started R22 refrigerant filling. A total of 900 grams of refrigerant is filled into the experiment. The experiment switched on and the cooling process started.

Figure: Refrigerant filling.

Result

In this chapter we are going to discuss the results obtained in all the simulation tests and the experiments and compare them with each other. We conducted four tests altogether; one for simulation and three for testing sub-cooling. The results are as given below:

Simulation result

In this process, we are going to perform four tests with an interval of ten minutes. We will note down the temperatures of cold inlet and cold outlet, as well as hot inlet and hot outlet.

S.NO	Cold inlet	Cold outlet	Hot inlet	Hot outlet	Time
1	20 degrees	26 degrees	45 degrees	26 degrees	10 minutes
2	26 degrees	52 degrees	90 degrees	69 degrees	10 minutes
3	20 degrees	58 degrees	90 degrees	69 degrees	10 minutes
4	20 degrees	26 degrees	45 degrees	26 degrees	10 minutes

Table: Simulation test readings

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

From the simulation results we can understand that the cold inlet is taking the heat from hot inlet and the output of hot outlet is decreasing.

Experiment result

Here we are taking the water in to both heat exchanger tanks and preparing the equipment for test-1. We have filled 15 liters of water into each tank and then connected them to a power source. Every five minutes we take note of the atmosphere temperature, heat exchanger temperature, evaporator and condenser coil temperature. The readings of experiment are noted with the help of air temperature measuring equipment and liquid temperature measuring equipment. We took the normal room temperature of water and started to experiment the readings below.

S.NO	T1	T2	T3	H1	H2	H3	H4	A	V	T
1	33.5	27	27	33.5	40.9	33.5	14	5.7	230	00:00
2	33.5	37	37	33.5	45	33.5	14	5.7	230	05:00
3	33.5	53	44	33.5	46.5	33.5	14	5.8	230	10:00
4	33.5	61	47	33.5	49	33.5	15	5.8	230	15:00
5	34	69.4	51.1	34	52.1	34	15.8	5.8	230	20:00
6	34.3	76.5	55.2	34.3	52.6	34.3	16.7	5.8	230	25:00
7	34.2	81.1	56.8	34.2	54.2	34.2	16.6	5.8	230	30:00
8	34.6	86.1	58.7	34.6	54.9	34.6	17.1	5.8	230	35:00
9	34	90.5	60.5	34	55.9	34	17.1	5.8	230	40:00
10	33.5	95.5	63.1	33.5	57.1	33.5	17.2	5.8	230	45:00

Atmosphere temperature (T1, H1, H3)

Heat exchanger temperature (T2, T3)

Evaporator (H4)

Condenser coil temperature (H2)

Current (A)

Voltage (V)

Time (T)

Condenser readings

The test was conducted continuously up to 45 minutes and the readings were measured every 5 minutes. The readings are below.

S.NO	INLET AIR TEMPERATURE	OUTLET AIR TEMPERATURE	TIME
1	33.5	40.9	00:00
2	33.5	45	05:00
3	33.5	46.5	10:00
4	33.5	49	15:00
5	34	52.1	20:00
6	34.3	52.6	25:00
7	34.2	54.2	30:00
8	34.6	54.9	35:00
9	34	55.9	40:00
10	33.5	57.1	45:00

Table: Experiment Test 1 condenser readings.

Evaporator readings

The test was conducted continuously up to 45 minutes and the readings were measured every 5 minutes. The readings are as below.

S.NO	INLET AIR TEMPERATURE	OUTLET AIR TEMPERATURE	TIME
1	33.5	14	00:00
2	33.5	14	05:00
3	33.5	14	10:00
4	33.5	15	15:00
5	34	15.8	20:00
6	34.3	16.7	25:00
7	34.2	16.6	30:00
8	34.6	17.1	35:00
9	34	17.1	40:00
10	33.5	17.2	45:00

Heat exchanger readings

Both heat exchanger tanks have 15 liters of water in each tank and the test readings are measured every 5 minutes at the readings table.

S.NO	HEAT EXCHANGER TANK 1	HEAT EXCHANGER TANK 2	TIME
1	27	27	00:00
2	37	37	05:00
3	53	44	10:00
4	61	47	15:00
5	69.4	51.1	20:00
6	76.5	55.2	25:00
7	81.1	56.8	30:00
8	86.1	58.7	35:00
9	90.5	60.5	40:00
10	95.5	63.1	45:00

The test-1 is completed and readings are mentioned.

Test 2

In this test we are taking ice to perform the test. We filled both the heat exchanger tanks with ice upto 15 liters capacity and started the test. In this test we found large scale cooling changes in both evaporator and condenser.

We took the readings every 5 minutes, and noted down atmosphere temperature, heat exchanger temperatures, evaporator and condenser coil temperature. The readings of experiment are noted with the help of air temperature measuring equipment and liquid temperature measuring equipment.

S.NO	T1	T2	T3	H1	H2	H3	H4	A	V	T
1	33	0	0	33	33.9	33	10.1	5.7	230	00:00
2	33	0.5	0	33	42	33	10.2	5.7	230	05:00
3	33	9.5	5.4	33	42.5	33	10.5	5.7	230	10:00
4	33	15.8	12.2	33	43.1	33	12.6	5.7	230	15:00
5	33	25.2	20.1	33	43.3	33	12.7	5.7	230	20:00
6	33	36	34	33	45	33	14	5.7	230	25:00
7	32.5	53	45.4	32.5	47.6	32.5	14.6	5.8	230	30:00
8	33	63	48	33	50.1	33	15.1	5.8	230	35:00
9	32.9	68.2	50.4	32.9	51.5	32.9	15.4	5.8	230	40:00
10	34	75.6	53.8	34	52.6	34	15.9	5.8	230	45:00

Atmosphere temperature (T1, H1, H3)

Heat exchanger temperature (T2, T3)

Evaporator (H4)

Condenser coil temperature (H2)

Current (A)

Voltage (V)

Time (T)

Condenser readings

The test was conducted continuously up to 45 minutes and the readings were measured every 5 minutes. The readings are as below.

S.NO	INLET AIR TEMPERATURE	OUTLET AIR TEMPERATURE	TIME
1	33	33.9	00:00
2	33	42	05:00
3	33	42.5	10:00
4	33	43.1	15:00
5	33	43.3	20:00
6	33	45	25:00
7	32.5	47.6	30:00
8	33	50.1	35:00
9	32.9	51.5	40:00
10	34	52.6	45:00

Evaporator readings

The test was conducted continuously up to 45 minutes and the readings were measured every 5 minutes. The readings are as below.

S.NO	INLET AIR TEMPERATURE	OUTLET AIR TEMPERATURE	TIME
1	33	10.1	00:00
2	33	10.2	05:00
3	33	10.5	10:00
4	33	12.6	15:00
5	33	12.7	20:00
6	33	14	25:00
7	32.5	14.6	30:00
8	33	15.1	35:00
9	32.9	15.4	40:00
10	34	15.9	45:00

Heat exchanger readings

Both heat exchanger tanks have 15 liters of water in each and the test readings are measured every 5 minutes at the readings table.

S.NO	HEAT EXCHANGER TANK 1	HEAT EXCHANGER TANK 2	TIME
1	0	0	00:00
2	0.5	0	05:00
3	9.5	5.4	10:00
4	15.8	12.2	15:00
5	25.2	20.1	20:00
6	36	34	25:00
7	53	45.4	30:00
8	63	48	35:00
9	68.2	50.4	40:00
10	75.6	53.8	45:00

The test 2 is completed and readings are mentioned.

Test 3

In this test we took readings of ideal state, without any water or ice added. The test is performed with an ideal state air conditioner and readings are as noted below.

S.NO	T1	H1	H2	H3	H4	A	V	T
1	33	33	58.1	33	17.4	6	230	00:00
2	33	33	59	33	17.5	6	230	05:00
3	33.5	33.5	59.5	33.5	17.7	6	230	10:00
4	33	33	59.5	33	17.4	6	230	15:00
5	32.9	32.9	59.2	32.9	17.5	6	230	20:00

Atmosphere temperature (T1, H1, H3)

Evaporator (H4)

Condenser coil temperature (H2)

Current (A)

Voltage (V)

Time (T)

Condenser

S.NO	TIME	H2 IDEAL	H2 WATER	H2 ICE
1	00:00	58.1	40.9	33.9
2	05:00	59	45	42
3	10:00	59.5	46.5	42.5
4	15:00	59.5	49	43.1
5	20:00	59.2	52.1	43.3

Table: Comparing the condenser readings.

Evaporator

S.NO	TIME	H4 IDEAL	H4 WATER	H4 ICE
1	00:00	17.4	14	10.1
2	05:00	17.5	14	10.2
3	10:00	17.7	14	10.5
4	15:00	17.4	15	12.6
5	20:00	17.5	15.8	12.7

Result

Simulation test was performed first and experimental test was performed later. When both of them were compared simulation test has shown a greater efficiency. We have done three different types of test in the experimental setup. After analyzing the three test results, the test performed using ice has shown greater efficiency. Followed by ice, water has shown the next greater efficiency.

Conclusion

From this experiment we have concluded that the refrigeration cycle increases efficiency with the help of sub-cooling.

Based on the experiments we found that using Ice as the medium we have observed greater efficiency. In the same experiment the evaporator, condenser temperatures have been drastically reduced. As Ice is not affordable for regular use, it forms as the drawback for this method.

Next to Ice, water has the second greater efficiency. The water generated from the condensation process of air conditioning system can be used as a sub-cooling agent.

As water is affordable and available all the time, it is preferable as a sub-cooling element over Ice. If we use the condensed water to provide sub cooling to the air conditioner, we can decrease global warming and also get increased efficiency.

If we implement water as a sub-cooling agent to commercial air conditioner plants we can get huge difference in efficiency.

References

1. Baomin Dai, Xiaoxuan Zhao, Shengchun Liu, Qianru Yang, Dan Zhong, YunyingHao, "Energetic, Exergetic And Exergoeconomic Assessment Of Transcritical Co2 Reversible System Combined With Dedicated Mechanical Subcooling (Dms) For Residential Heating And Cooling", Elsevier Ltd. Energy Conversion and Management 209 (2020) 112594.

2. R.Karthik, A. Gokul Karthik, K. Mohan Kumar, "Subcooling Effect On Air-Conditioning System By Simulation Analysis", Elsevier Ltd. Materials Today: Proceedings, Vol. 37, Part 2, 2021, Pages 1087-1090.

3. KasniSumeru, TriajiPangriptoPramudantoro, And AndriyantoSetyawan, "A Review On Sub-Cooling In Vapor Compression Refrigeration Cycle For Energy Saving", JurnalTeknologi (Sciences & Engineering) 81:5 (2019) 155–170.

4. K.Sumeru, As Margana And S Hidayat, "Condensate Water As A Compressor Discharge Cooler To