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IJIEMR Transactions, online available on 26th Aug 2021. Link :http://www.ijiemr.org/downloads.php?vol=Volume-10&issue=ISSUE-08

DOI: 10.48047/IJIEMR/V10/I08/14

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Volume 10, Issue 08, Pages: 85-93

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

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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.

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Introduction

Air Conditioning and Enhanced 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.

Literature Survey

Air Conditioners are used for domestic and commercial purposes, also they consume high electrical energy. Also, the heat coming out from air conditioning systems is high and leads to global warming. Some researchers are done already also still continues to obtain good efficiency and Eco-Friendly systems and less electricity consumption.

To obtain good efficiency few researchers are took sub cooling to the air conditioning system. For sub cooling researchers used water, mechanical, LSHX, etc.

Ying Hao et.al (2020), [1]. In this research, Co2, reversible heat pump, and dedicated

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subcooling are used. The Co2 is a refrigerant and the cycle is reversible also provided sub-cooling to this process. With this process, global warming could be decreased. It will also increase the efficiency of the cycle while decreasing the cost of the refrigerant and air-conditioner unit.

The Co2 is having global warming potential is only one, ozone depression potential is zero also non-flammable & non-toxic. So the Co2 based heat pump air conditioner with a dedicated sub-cooling system is very useful for better efficiency while it also decreases the global warming rate.

R. Karthik et.al (2020), [2]. The air-conditioner efficiency and the effect of subcooling on the air conditioner is analyzed by simulation analysis. The subcooling is provided to the air conditioner system and measuring the changes with the help of simulation software is very easy instated of fabrication and the result we can get in different stages also. In this process, the air conditioner has increased efficiency and the temperature change is around 10 degrees. So the subcooling is one of the better ways to obtain the efficiency of air-conditioner.

Work Objective

The following points are the main objectives of our work.

- Design an outline with the help of a drawing.
- Prepare the CAD drawings with the help of Solid works.

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

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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.

Solid works

Solid works is used for drawing the project on the computer before going to fabrication. In this, we are going to design the required experimental setup beforehand. Heat-exchanger tanks and coils were designed using solid works initially. Each tank's capacity is 20 liters. The length of the coil is 6 feet. This coil works as a heat exchanger. The module designed in the solid works will be explained below

Solid Works Step by Step Process

- After selecting solid works now select the part and create a circle with the below-mentioned dimensions

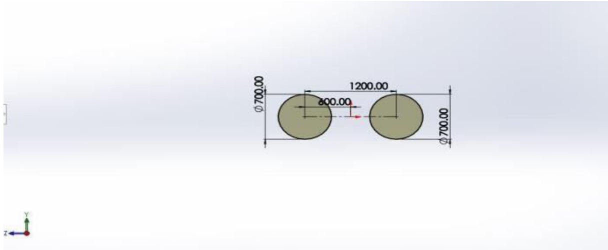

Figure 1 : Heat Exchanger Tank's diameter. Here tank was created by using the line option with mentioned dimensions in the above image, and, after following these rules now exit 2d sketcher window, and then select extrude option

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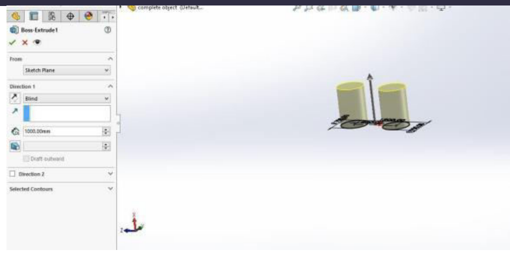

Figure 2: Heat Exchanger Tank's Height.

Now select extrude length enter 1000mm

Figure 3: Heat Exchanger Tank's.

To create coil here helix option was used and this helix has a height 500 mm and the pitch values 100mm

Figure 4: Heat Exchanger Tank's.

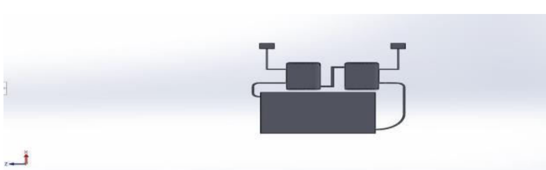

Figure 5: Heat Exchanger Tank's side view.

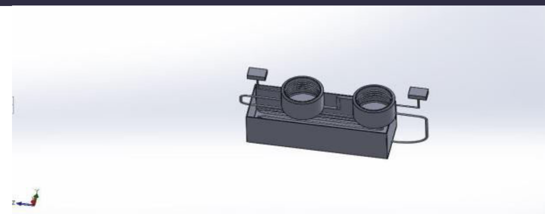

Figure 6: Heat Exchanger Tank's top view.

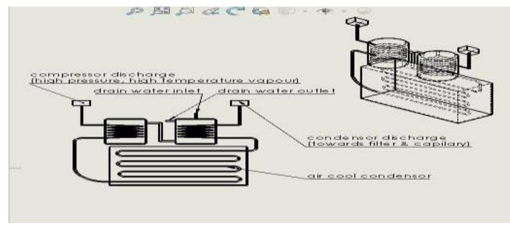

Figure 7: Heat Exchanger Tank's detailed view.

With the help of solid works, we have designed the heat exchanger tanks. The coils which were designed in the tanks will work as the heat exchanger. As the heat transmission is good with copper metal, we have considered copper as the suitable metal for the tanks to be made of. The designed tanks top view can be seen from the above-given figures. So to analyses these designs we will be using the ANSYS process.

ANSYS Process

ANSYS process is used to analyses the designs made in Solid Works, CAD, etc. Through a real-time kind of setup. So now we will be analyzing the real-time results of our design in the ANSYS process.

Material Properties

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Copper

Density: 8970 kg/m^3

Specific heat: 381 j/kg-k

Thermal conductivity: 387.1w/m-k

R22

Density: 3660 kg/m^3

Specific heat: 1183 j/kg-k

Thermal conductivity: 0.0837 w/m-k

Viscosity: 0.0001658 kg/m-s

Water

Density: 998.2 kg/m^3

Specific heat: 4182 j/kg-k

Thermal conductivity: 0.6 w/m-k

Viscosity: 0.001003 kg/m-s

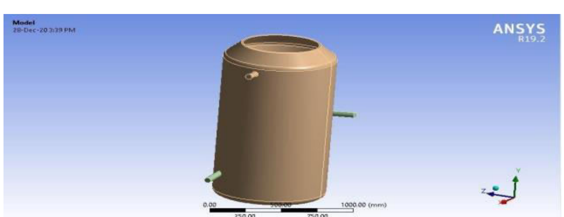

Figure 9: Heat Exchanger Tank model.

Meshing

With the help of meshing, the object is divided into a number of parts like elements and nodes. These elements and nodes are connected with each other by their bonding loads which will transfer from one end to another end. Here tetra element is used, and the element size is taken as 1mm, and the reason behind choosing this element is because this object is nonlinear. So that hex element cannot generate nodes.

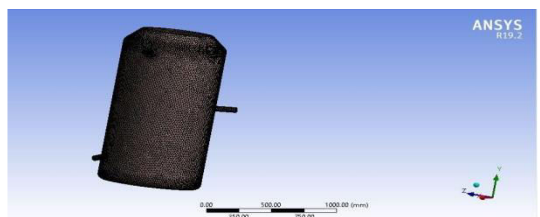

Figure 10: Heat Exchanger Tank's meshing view.

Case 1 boundary conditions

Tank inlet temperature 20*C

Coil inlet temperature 45*C

Coil inlet velocity 0.001m/s

Tank inlet velocity 0.002m/s

Coil fluid R22

Tank fluid water

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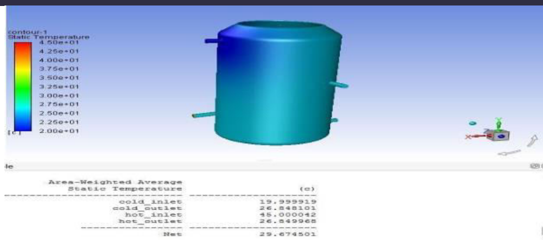

Figure 11: Heat Exchanger Tank with simulation result.

Case 2 boundary conditions

Tank inlet temperature 20*C

Coil inlet temperature 45*C

Coil inlet velocity 0.001m/s

Tank inlet velocity 0.002m/s

Coil fluid R22

Tank fluid water

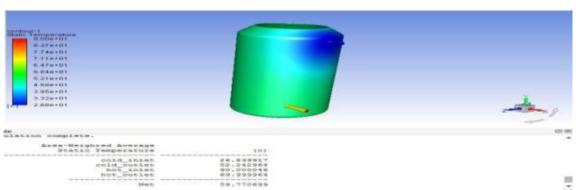

Figure 12: Heat Exchanger Tank with simulation result.

Case 3 boundary conditions

Tank inlet temperature 20*C

Coil inlet temperature 45*C

Coil inlet velocity 0.001m/s

Tank inlet velocity 0.002m/s

Coil fluid R22

Tank fluid water

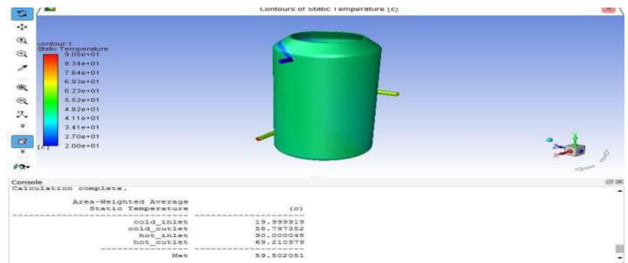

Figure 13: Heat Exchanger Tank with simulation result.

Case 4 boundary conditions

Tank inlet temperature 20*C

Coil inlet temperature 45*C

Coil inlet velocity 0.001m/s

Tank inlet velocity 0.002m/s

Coil fluid R22

Tank fluid water

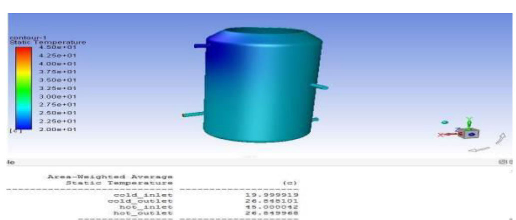

Figure 14: Heat Exchanger Tank with simulation result.

Simulation result

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

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.

Table 1: Simulation test readings

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

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.

Conclusion

In this paper air conditioner setup modelling were developed with the help of solid works tool, and then analyzing temperature and heat transfer rate values with the help of Ansys cfd tool. In this thesis R22 used as a refrigerant in different cases and compared results with water. 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.

Future scope:

- Right now here completing simulation results with the help of cad/cae tools, and now we can also check experimental analysis results with same properties.
- After completing experimental analysis results here results were compared with simulation and experimental.

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