A
Project Report
On
ENHANCING EFFICIENCY OF SPLIT AIR CONDITIONER WITH CONDENSATE ASSISTED EVAPORATIVE COOLING

Project submitted in partial fulfilment of the degree

BACHELOR OF TECHNOLOGY

IN

MECHANICAL ENGINEERING

Submitted by

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CERTIFICATE

This is to certify that the project report entitled "**ENHANCING EFFICIENCY OF SPLIT AIR CONDITIONER WITH CONDENSATE ASSISTED EVAPORATIVE COOLING**" submitted by E. Adharsha, Roll No:O180645, Y. Sai Mahesh, Roll No: O180846, M. Immaniyelu, Roll No: O180036, K. Dhana Lakshmi, Roll No: O180429, K. Ayyappa Swamy, Roll No: O180587, to the Department of Mechanical Engineering, Rajiv Gandhi University of Knowledge Technologies, Ongole Campus, during the academic year 2023-2024 is a partial fulfilment for the award of Undergraduate degree of Bachelor of Technology in Mechanical Engineering, is a bonafide record carried out by them under my supervision. The project has fulfilled all the requirements as per the regulations of this institute and in my opinion reached the standard for submission.

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APPROVAL SHEET

This report entitled "**ENHANCING EFFICIENCY OF SPLIT AIR CONDITIONER WITH CONDENSATE ASSISTED EVAPORATIVE COOLING**" submitted by E. Aadharsha, Roll No: O180645, Y. Sai Mahesh, Roll No: O180846, M. Immaniyelu, Roll No: O180036, K. Dhana Lakshmi Roll No: O180429, K. Ayyappa Swamy, Roll No: O180587 and it is approved by Mr. R. Sanjay Kumar for the degree of Bachelor of Technology in MECHANICAL ENGINEERING.

Examiner(s)

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DECLARATION

We declare that this written submission represents our ideas in our own words. We have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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At the outset, I would like to thank Rajiv Gandhi University of Knowledge Technologies, Ongole for providing all the necessary resources for the successful completion of my course work. At last, but not least I thank my team members and other students for their physical and moral support.

I also wish to register my feelings towards my family members who have been much more encouraging and understanding.

With Sincere Regards,

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ABSTRACT

The overwhelming evidence of global warming caused by human activities documents both contemporary impacts on human life but also extraordinary future risks are also assisted with it. Accretion of global temperatures engenders the extensive use of air conditioning devices to make the surrounding liable in the summer season. Energy consumption for air conditioning is also palpable by the evidence that this industry is the 2nd largest power-consuming sector in the consumer field. High temperatures also affect the performance of the air conditioning system by decreasing their energy efficiency ratio and cooling capacity. Modifications are made in such a way to lower down the temperature of the surrounding by the use of a honeycomb wet pad which uses evaporative cooling with condensate of the indoor side. We designed and analyzed the evaporator part to reduce the refrigerant temperature comes from the environment temperature of split air conditioner and improve the efficiency of the split air conditioner.

CHAPTER 1

INTRODUCTION

1.1 Introduction of Air Conditioning

Life seems indispensable without air conditioning nowadays. Ever increasing temperatures and congested space make the usage of air conditioners mandatory to work or live in a comfortable place. Due to small size and easy installation, split type air conditioners are mostly installed in residential homes, cooperate offices, restaurants, and hotels for cooling, heating, and air conditioning of the air. Improving life standards create an impact on energy consumption. International Energy Agency (IEA) data statistics shows that 10% of world power consumption is due to air conditioning devices. The air conditioning industry will be the 2nd biggest power consumer by the mid of the 21st century lagging only behind the manufacturing industry. It is also estimated that around 2/3rd of the world's homes will have air conditioning facilities by 2050 with 50% of that will come from three countries China, India, and Indonesia. This is because of largescale urbanization. Urbanization becomes more critical for the rising economies of countries where skyscrapers construction is soaring.

Fig-1.1: SPLIT AIR CONDITIONER

1.2. REFRIGERATION:

The term refrigeration denotes cooling of a space, substance or system to lower and/or maintain its temperature below the ambient one (while the removed heat is rejected at a higher temperature). Refrigeration is considered an artificial, or human-made, cooling method.

Refrigeration refers to the process by which energy, in the form of heat, is removed from a low-temperature medium and transferred to a high-temperature medium. This work of energy transfer is traditionally driven by mechanical means, but can also be driven by heat, magnetism, electricity, laser, or other means. Refrigeration has many applications, including household refrigerators, industrial freezers, cryogenics, and air conditioning. Heat pumps may use the heat output of the refrigeration process, and also may be designed to be reversible, but are otherwise similar to air conditioning units.

1.3. AIR CONDITIONING

Air-conditioning is that process used to create and maintain certain temperature, relative humidity and air purity conditions in indoor spaces. This process is typically applied to maintain a level of personal comfort.

It's also used in industrial applications to ensure correct operation of equipment or machinery that need to operate in specific environmental conditions or alternatively to be able to carry out certain industrial processes, such as welding, which produce considerable amounts of heat that needs to be disposed of in some manner.

An air-conditioning system must be effective regardless of outside climatic conditions and involves control over four fundamental variables: air temperature, humidity, movement and quality.

1.4. TYPES OF AIR CONDITIONING

1.4.1. CENTRAL AIR CONDITIONING

Central air conditioner unit is an energy moving or converted machines that are designed to cool or heat the entire house. It does not create heat or cool. It just removes heat from one area, where it is undesirable, to an area where it is less significant. Central air conditioner has a centralize duct system. The duct system (air distribution system) has an air handler, air supply system, air return duct and the grilles and register that circulates warm air from a furnace or cooled air from central air conditioning units to our room. It returns that air back to the system and starts again. It uses Ac refrigerant (we may know it as Freon) as a substance to absorb the heat from indoor evaporator coils and rejects that heat to outdoor condenser coils or vice-versa.

Central Air Conditioning working Diagram:

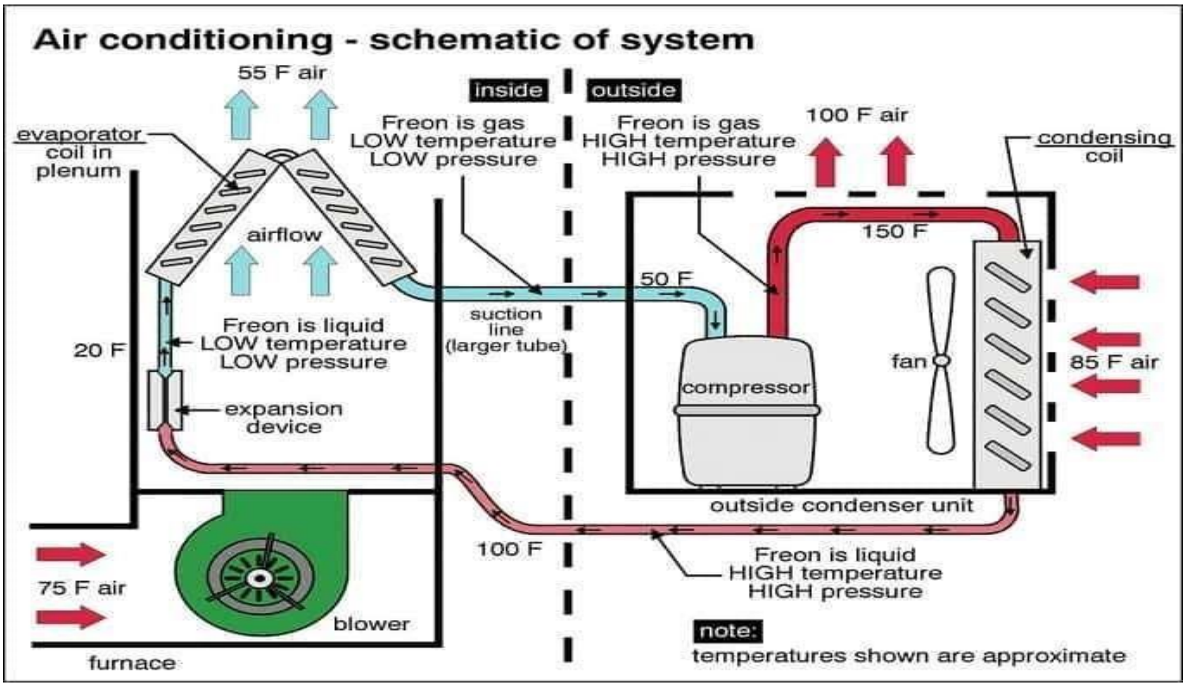

FIG 1.2: SCHEMATIC OF THE SYSTEM

1.4.2. SPLIT AIR CONDITIONING SYSTEM

Split air conditioner is the modified version of window air conditioner. The idea of split units came from the fact that, 'in window air conditioner, it is sometimes not possible to minimize the noise problem, as it is installed on the wall of conditioned room'. In order to overcome the difficulty noise, split air conditioner is developed, in which, compressor and condenser are located at a remote location and only evaporator coil and a fan are located near the application. This division or splitting of air conditioning unit gave the equipment its name as "Split air conditioner". Split air conditioner is basically an air conditioning system, which is built into two separate or distinct units, named as 'indoor unit' and 'outdoor unit'.

Indoor unit

It is located in the space to be conditioned. It is well insulated on inside housing. It consists of evaporator (cooling coil), a fan coupled with motor, electronic controls and provisions for condensate drain.

Outdoor unit

Outdoor section consists of compressor, capillary tube, condenser and condenser cooling fan with motor. Outdoor unit can be erected away from the room to be conditioned. The outdoor unit is connected to in- door unit by extended pipelines covered with insulating material provided. Therefore, split air conditioner is also known as "Remote mounted air conditioner". With the help of insulated piping, the low pressure and low temperature liquid refrigerant comes in the evaporator. Fan fitted in indoor unit sucks the air over the evaporator coil and delivers it back to room. Thus, the operation of split air conditioner is similar to the window air conditioner using the basic cycle of operation as vapour compression refrigeration. The refrigerant is compressed, condensed, expanded at remote site and gets evaporated only in the room.

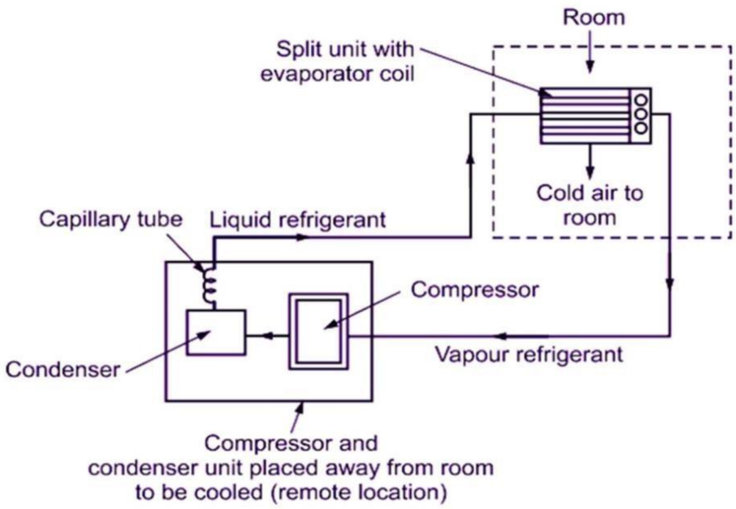

FIG 1.3: OUTDOOR UNIT

COMPONENTS OF AIR CONDITIONING SYSTEM:

• compressor

• condenser

• evaporator

• expansion valve

• refrigerant

Compressor:

The compressor is the pump that enables the flow of the refrigerant. The compressor works by increasing the pressure and temperature of the vaporized refrigerant.

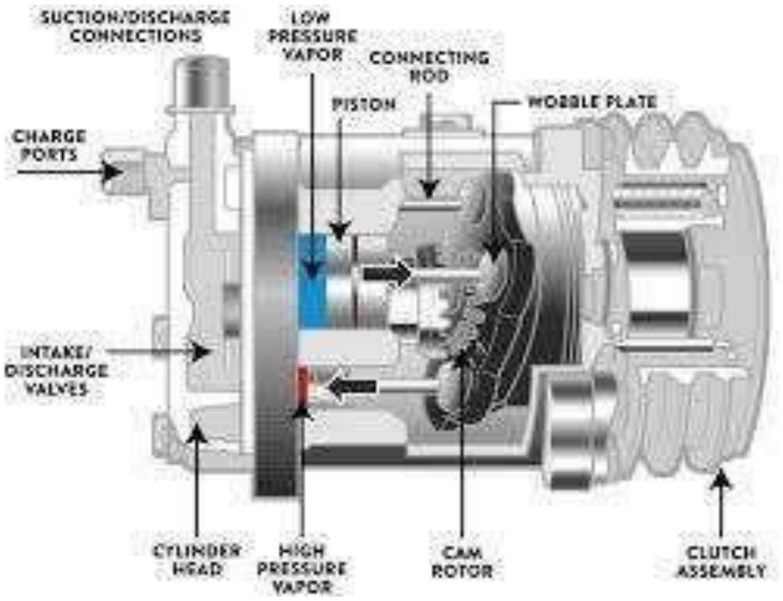

FIG 1.4: COMPRESSOR

Function of compressor:

The purpose of the compressor is to circulate the refrigerant in the system under pressure, this concentrates the heat it contains. At the compressor, the low pressure gas is changed to high pressure gas.

Condenser:

A condenser (or AC condenser) is the outdoor portion of an air conditioner or heat pump that either releases or collects heat, depending on the time of the year.

FIG 1.5: CONDENSOR

Function of condenser:

The function of the condenser in a refrigeration system is to transfer heat from the refrigerant to another medium, such as air and/or water. By rejecting heat, the gaseous refrigerant condenses to liquid inside the condenser. The major types of condensers used are (1) water-cooled, (2) air-cooled, and (3) evaporative.

Evaporator:

In refrigeration, an evaporator is the heat exchanger where the refrigerant circulating inside the refrigeration circuit absorbs the thermal energy from the environment, which is then cooled.

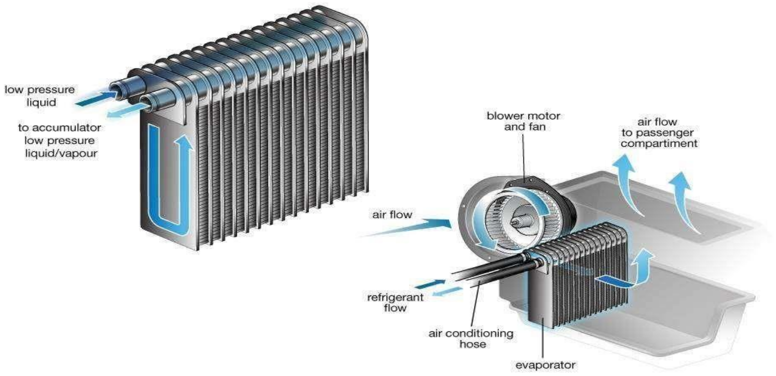

FIG 1.6: EVAPORATOR

Function of evaporator:

The evaporator is located inside a refrigerator and is the part that makes the items in the refrigerator cold. As the refrigerant turns from a liquid into a gas through evaporation, it cools the area around it, producing the proper environment for storing food.

Expansion valve:

Expansion valves serve two purposes: Controlling the amount of refrigerant entering the evaporator: As much of the evaporator surface as possible should be covered with liquid refrigerant without liquid being carried over to the compressor.

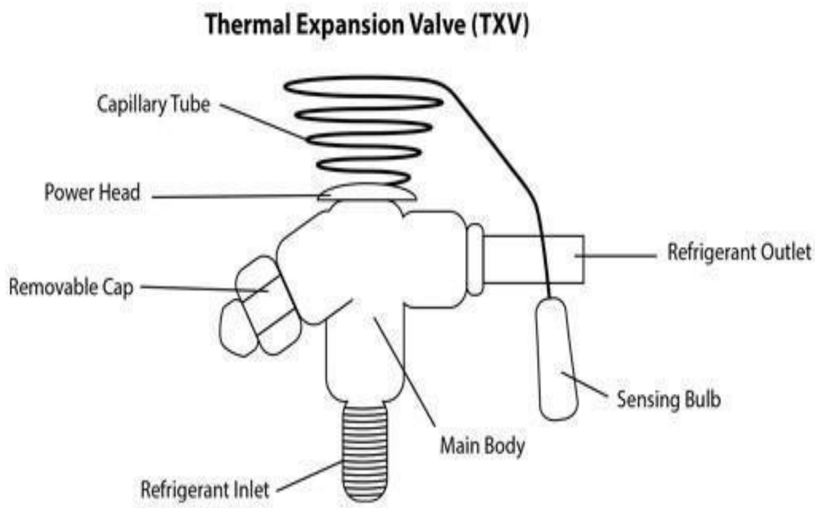

FIG 1.7: EXAPNSION VALVE

Function of expansion valve:

The expansion valve removes pressure from the liquid refrigerant to allow expansion or change of state from a liquid to a vapour in the evaporator Refrigerant: A refrigerant is a working fluid used in the refrigeration cycle of air conditioning systems and heat pumps where in most cases they undergo a repeated phase transition from a liquid to a gas and back again.

Types of refrigerants used:

- R-22 Refrigerant.
- R-410A Refrigerant.
- R-407C Refrigerant.
- R-134a Refrigerant.
- R-32 Refrigerant.
- R-454B Refrigerant.
- Ammonia

1.5. HONEY-COMB WET PAD

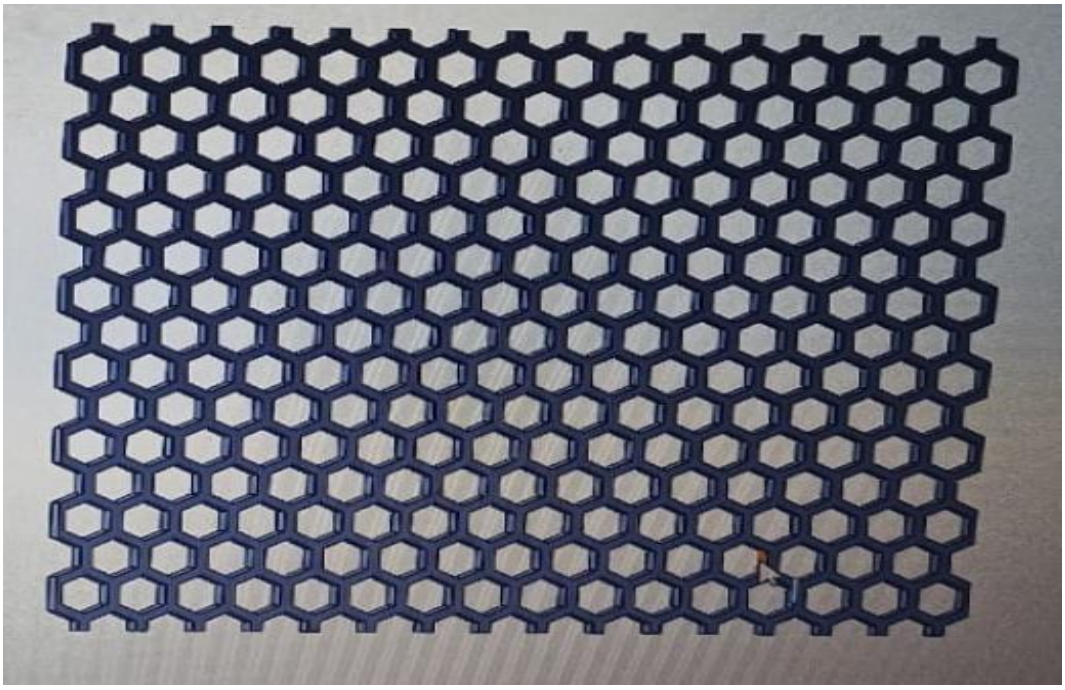

FIG.1.8: HONEY COMB WET PAD

• When the air passes through honey comb structured wet pad, the condensated water flowing over the honey comb structured wet pad absorbs the heat from that air causing the water evaporate that results cool & moisturized air into the evaporated chambers.

• Wet pad insertion in an air conditioner is a method used to enhance the cooling efficiency of evaporative air conditioning systems. It involves inserting wet pads or media into the air conditioner to increase the moisture content of the air passing through the system. Here are some advantages of using wet pad insertion:

• Improved Cooling Efficiency: By adding wet pads, the air conditioner can cool the incoming air more effectively. The pads provide a larger surface area for evaporation to occur, allowing for greater heat transfer and lower air temperatures. This can result in a more comfortable indoor environment, especially in hot and dry climates.

• Energy Efficiency: Wet pad insertion can increase the energy efficiency of the air conditioner. Evaporative cooling relies on the principle of evaporating water to cool the air, which consumes less energy compared to traditional air conditioning systems that rely solely on refrigeration and compression. By utilizing evaporative cooling through wet pads, the air conditioner can reduce energy consumption and potentially lower utility bills.

• Cost Savings: Due to the lower energy consumption, wet pad insertion can lead to cost savings for homeowners or businesses. Evaporative cooling systems typically have lower operating costs compared to conventional air conditioners, making them an economical choice in regions with suitable climatic conditions.

• Environmentally Friendly: Wet pad insertion promotes a more environmentally friendly cooling method. Evaporative cooling systems do not use refrigerants, which can have negative environmental impacts. Instead, they rely on the natural process of water evaporation. Additionally, the lower energy consumption contributes to reduced

• Greenhouse gas emissions.

• Simplicity and Maintenance: Wet pad insertion is a relatively simple and low maintenance method. The wet pads can be easily inserted and replaced when needed. Regular

• Maintenance, such as cleaning or replacing the pads, ensures optimal performance and longevity of the system.

• It's worth noting that wet pad insertion is typically used in evaporative cooling systems rather than traditional split air conditioning systems. Evaporative coolers are more suitable for dry climates with low humidity levels, as they add moisture to the air during the cooling process.

CHAPTER 2

LITERATURE

According to Harby and et al. [3] using evaporative cooling principle, COP in air conditioning system with air cooled condenser can be improved by about 134% and power consumption can be reduced up to 58%. Detail literature review have been carried out in this project work and experiment set up and main findings of different researchers for improvement of air conditioning system using pre-cooling ambient air by evaporative cooling principle is presented in Table 1.

Table 1. Details of literature available on performance improvement of air conditioning system

Scientist	Research	Methodology	Discovery
Ebrahim Hajidavalloo, 2007[4]	Experimental Investigation	Two evaporative cooling pad with water injecting facility is used on two sides of window air conditioner to cool the air entering to the condenser.	They found reduction in power consumption by about 16% and increase in COP by 55% in window air conditioner with evaporative cooling pad in comparison to window air conditioner without evaporative cooling pad.
Ebrahim Hajidavalloo & Eghtedari, 2010[5]	Experimental Investigation	An evaporative cooler was constructed and fixed to the existing air-cooled condenser of a split-airconditioner.	They found that by using evaporative cooled air condenser, the power consumption can be reduced up to 20% and the COP can be improved around 50% in hot weather condition.
Martínez et al., 2016[6]	Experimental Investigation	with R407C refrigerant charge have been used without and with cellulose evaporative cooling pad manufactured by Munters of 50 mm, 100 A split air conditioner mm and 150 mm thickness.	Their experimental results indicate that Cellulose evaporative cooling pad of 100 mm thickness gives optimum performance and it reduces compressor power consumption by 11.4% the overall COP is increased by 10.6%.

CHAPTER 3

METHODOLOGY AND DESIGN

The effect of different cooling pad material and thickness on the overall performance of air conditioning system is experimentally determined by measuring the air flow rate and temperature at inlet and outlet of IDU, refrigerant temperatures and the energy consumption of the system including water circulation pump. For the analysis cooling capacity and total power consumption have been calculated using Eq. (1) and (2). For cooling capacity DBT and WBT at inlet and outlet of IDU and air velocity using anemometer is measured. Power consumption is measured using energy meter. Saturation efficiency of evaporative cooling pad and EER of system have been calculated using Eq. (3) and (4). Saturation efficiency is defined as the ratio of the actual drop in temperature of air across the cooling pad to the wet bulb depression at entry of it. R-22 p-h diagram have been used to calculate theoretical COP of air conditioning system assuming simple saturated VCR cycle. Theoretical and actual COP are found using Eq. (5) and (6) respectively.

$$Q_c = \dot{m}_{air}(h_i - h_o) \tag{1}$$

Where,

$$\dot{m}_{air} = \rho_a A_o C_o \tag{2}$$

$$P_{net} = W_c + W_f + W_p \tag{3}$$

$$\eta_s = \frac{t_i - t_o}{t_i - t_i^*} \tag{4}$$

$$\text{Theoretical COP} = \frac{h_1 - h_4}{h_2 - h_1} \tag{5}$$

$$\text{Actual COP} = \frac{Q_c}{P_{net}} \tag{6}$$

Introduction to Solid works

SolidWorks is a powerful computer-aided design (CAD) software used primarily for 3D modeling, simulation, and engineering analysis. It allows users to create detailed models of parts and assemblies, simulate how they will function in real-world conditions, and generate technical drawings for manufacturing. SolidWorks features an intuitive user interface and a wide range of tools for designing mechanical components, sheet metal parts, electrical systems, and more. It's widely used in industries such as automotive, aerospace, consumer goods, and machinery manufacturing. If you're just starting out, exploring tutorials and practicing basic modeling techniques is a good way to get familiar with its capabilities.

CHAPTER 4

DESIGN AND ANALYSIS

4.1. DESIGN

DESIGNING OF AIR CONDITONING COIL USING SOLIDWORKS 2022 R2.

4.2. PROCEDURE:

• First select the front plane and select sketch then draw a straight line with 200mm and define it.

• Then, we select the line and use the linear sketch pattern and fix the number of lines in y-direction.

• By using three point arc we draw arc at the end of the lines to make sure it looks like a condenser coil.

• Then draw a circle at the end of the outlet and make it tangent to the line.

• By using helix and spiral we draw a curve with 270 degrees.

• By selecting the end of the curve plane and front plane as reference plane and drawn a line from the end of the curve.

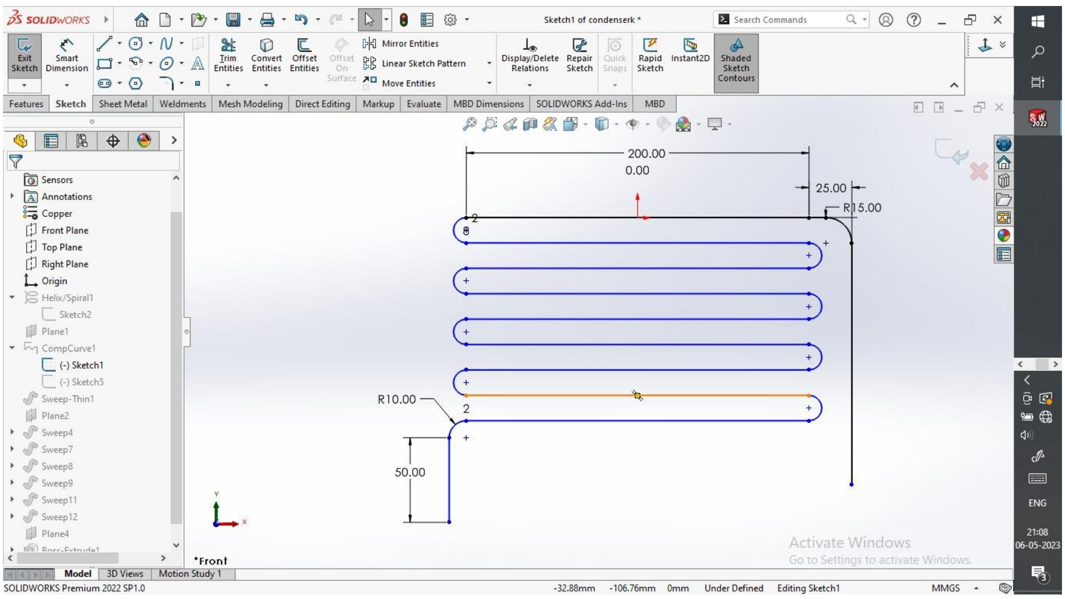

FIG 4.1: SKETCH OF AIR CONDITIONING COIL

• Then by using swept volume feature we make the coil with 10mm diameter.

• Then select the front plane and draw a fine line and by using the linear sketch pattern and the mirror feature we make sure that the fins are covered throughout the coil for better efficiency.

• The condenser coil is made up of copper for better thermal conductivity.

• And fins are made up of polished aluminium.

• This is the procedure we followed to design the condenser coil.

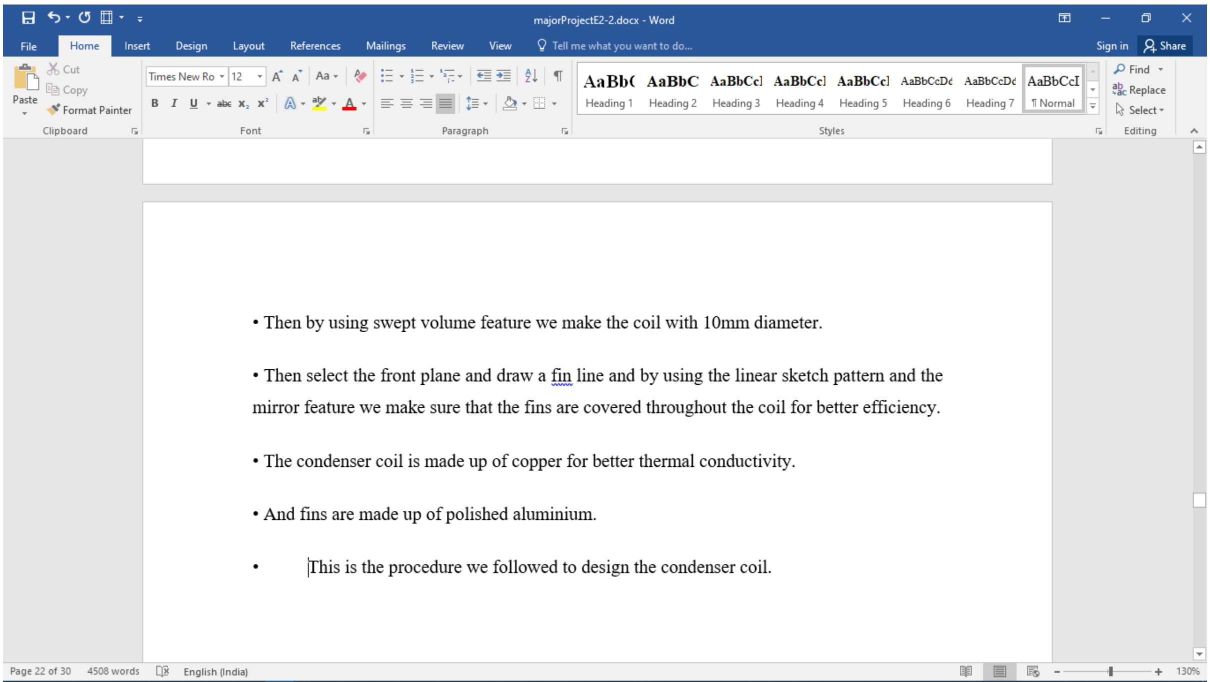

FIG 4.2: 3-D MODEL OF CONDENSOR

• Later for the analyses purpose we converted the file extension from .SLDPRT to .IGS format.

Analysis has been performed by using ANSYS

Introduction to ANSYS

ANSYS is one of the best analysis and simulation software used to simulate engineering solutions. ANSYS 2.0 was released as the first version in the year of 1971. ANSYS simulates 3d models or structures or machine parts designs to stress, strength, temperature distribution, thermal conductivity, elasticity, fluid flow, air flow, etc. Most of the analysis performed in an ANSYS APDL and simulations into ANSYS Workbench, which are one of the main products.Ansys Mechanical is a finite element analysis (FEA) software used to perform structural analysis using advanced solver options, including linear dynamics, nonlinearities, thermal analysis, materials, composites, hydrodynamic, explicit, and more.Ansys offers a comprehensive software suite that spans the entire range of physics, providing access to virtually any field of engineering simulation that a design process requires. Organizations around the world trust Ansys to deliver the best value for their engineering simulation software investment.

4.3. Simulation in ANSYS :

The analysis is performed in the ANSYS workbench 2022.

• Firstly select the Fluid flow (Fluent) analysis from the analysis systems then select the geometry and import the design i.e in .igs format by selecting the import geometry option.

• Then open the geometry and select the edit geometry in design modeler option. In the design modeler select then generate option for the generation of imported geometry.

• Select all the individual bodies and form a new body by using form new part option.

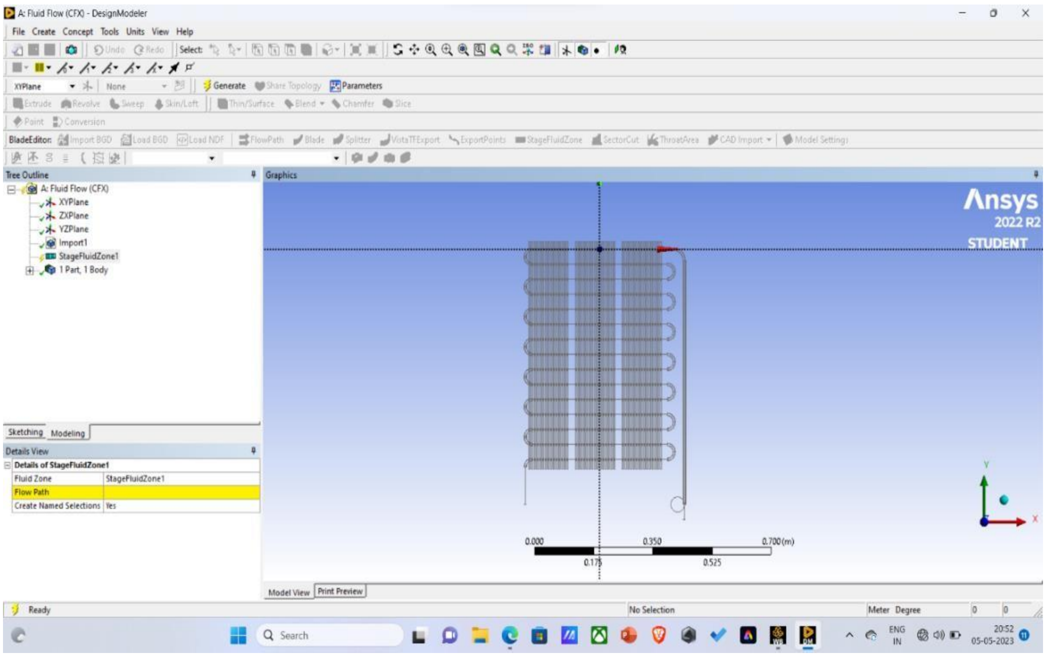

FIG 4.3: GEOMETRY GENERATION IN DESIGN MODULER

• Now close the design modeler and select the mesh option, then you will get the edit option by right clicking on it.

• After selecting it you will get the new tab with imported geometry for mesh analysis.

• By using the CFD solver with resolution 1 we have done the meshing of condenser.

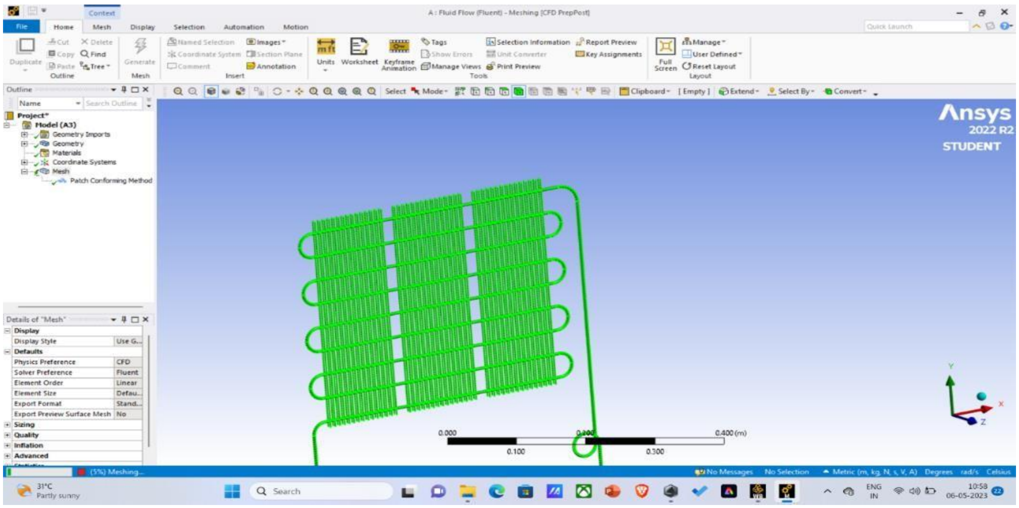

FIG 4.4: MESHING OF CONDENSER BY CFD SOLVER

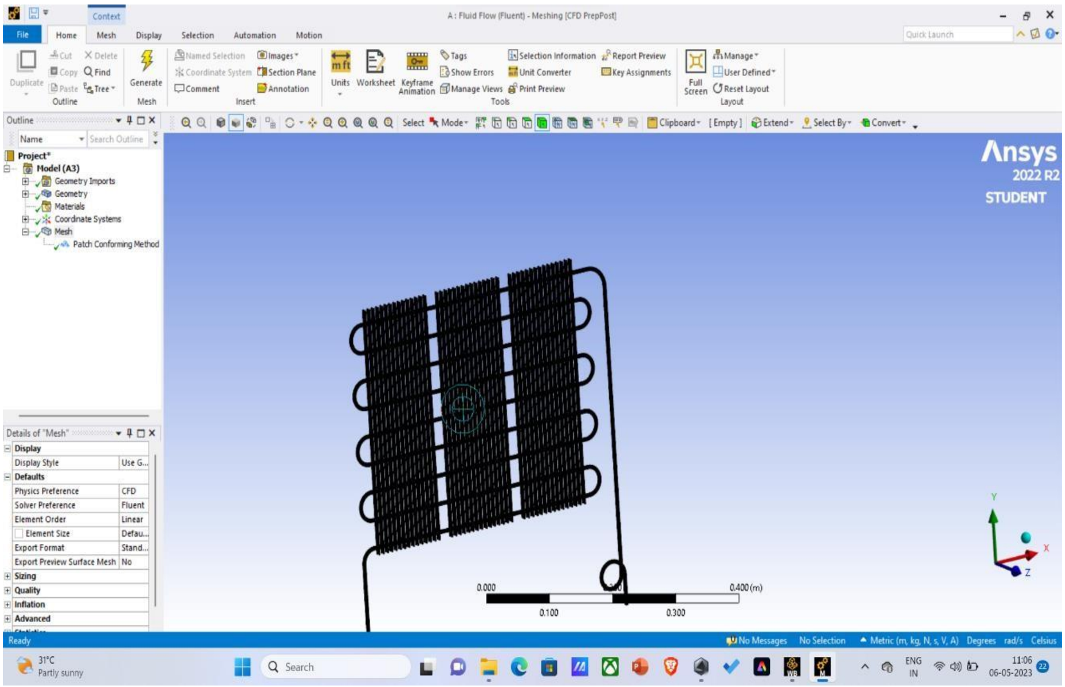

FIG 4.5: AFTER MESHING

• After meshing, we select the inlet and outlet of the coil and name them.

• By choosing the name of the fluid pipe and the fins accordingly and close the meshing tab.

• Then select the setup feature and click the double precision and solver processes as 4.

• And initialize the analysis.

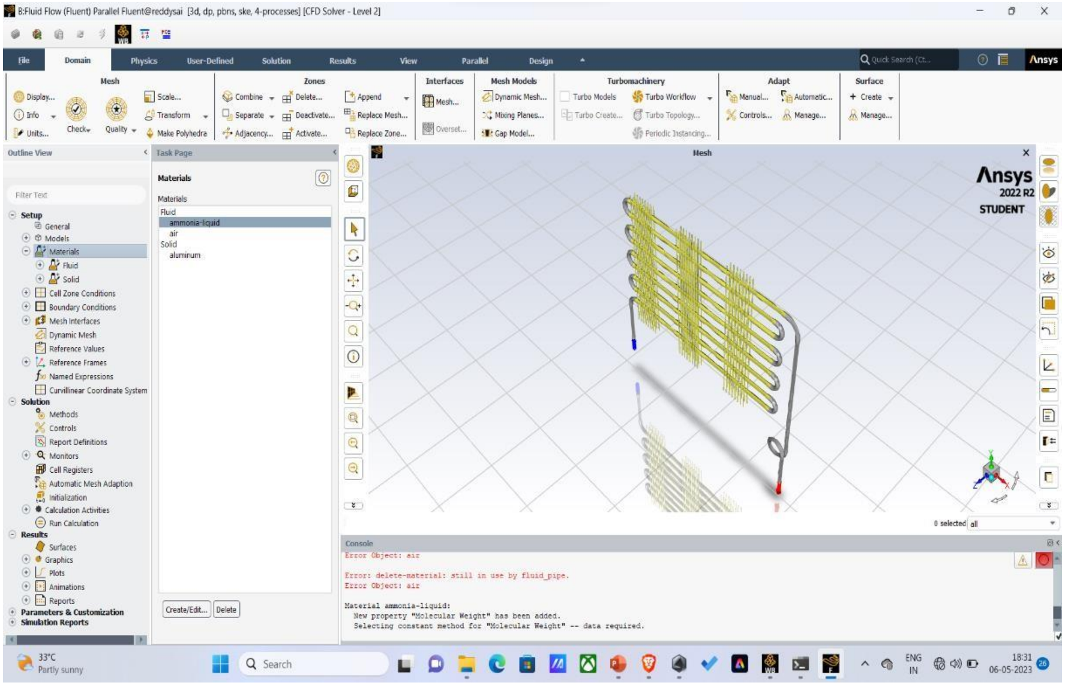

FIG 4.6: THERMAL ANALYSIS INTIALIZATION OF COIL

• By selecting the type of refrigerant as ammonia and air as the surrounding medium and set the input temperature of the 373k.

• Then by initializing the thermal analysis of the condenser coil having refrigerant we get the graphical representation of temperature variation from inlet to outlet and the report of maximum and minimum temperature of refrigerant passing through the condenser coil.

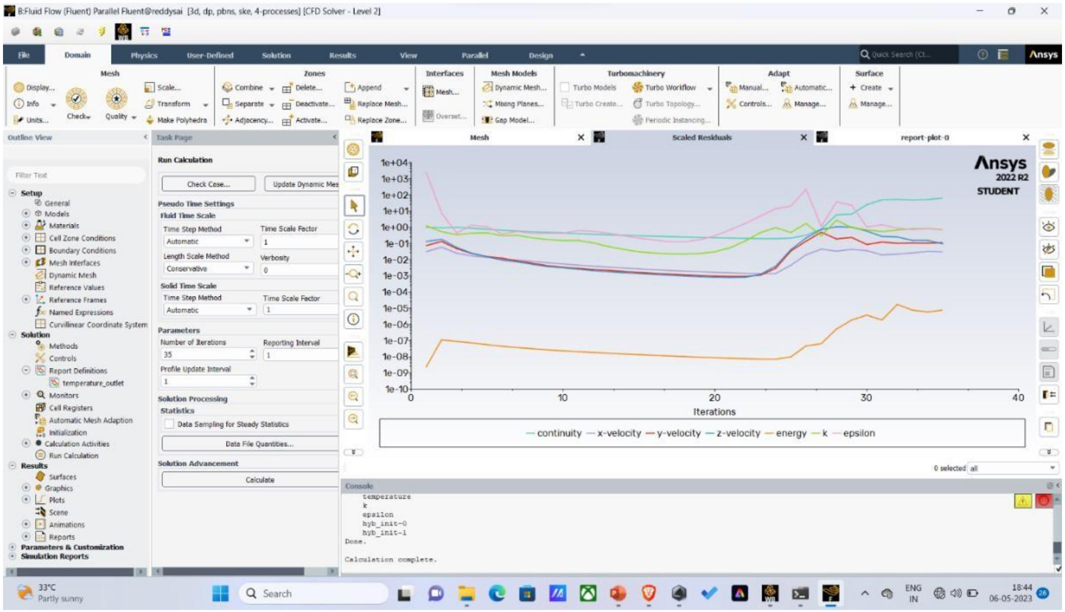

FIG 4.7: TEMPARATURE VARIATION OF AMMMONIA

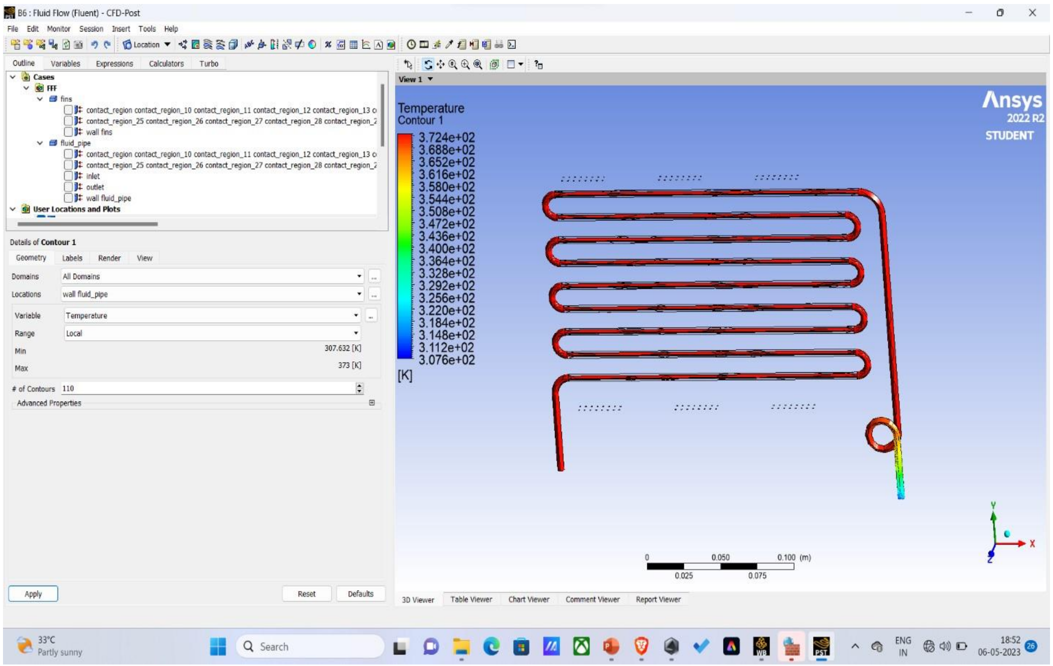

FIG 4.8: RESULT FROM THERMAL ANALYSIS OF AMMONIA

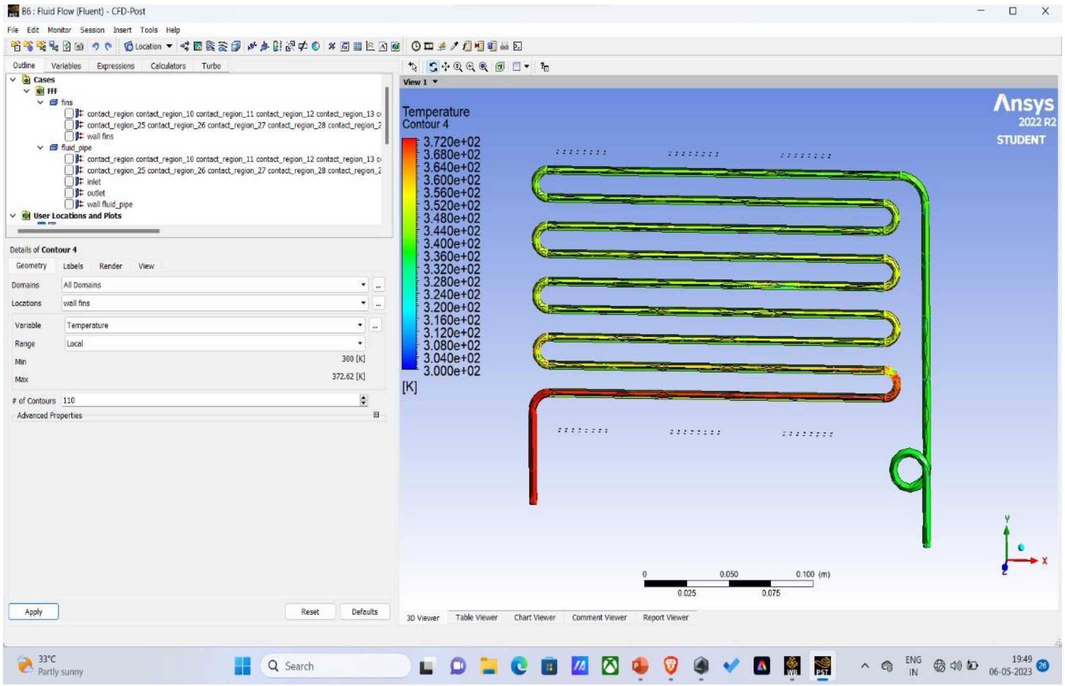

FIG 4.9: TEMPERATURE VARIATION OF REFRIGRANT AFTER SETTING A WETPAD

MATERIAL PROPERTIES

Copper

Copper is a versatile metal known for its excellent electrical and thermal conductivity. It's widely used in electrical wiring, plumbing, and electronics due to these properties. Additionally, copper is malleable, ductile, and corrosion-resistant, making it suitable for a variety of applications. Its antimicrobial properties also make it valuable in healthcare settings. Copper is often alloyed with other metals to enhance its properties for specific purposes. Overall, it's a crucial material in many industries, including construction, transportation, and telecommunications.

CHAPTER 5

RESULTS AND DISCUSSIONS

The experiment results without and with evaporative cooling pad of different materials, for R-22 vapour compression refrigeration cycle and air at different location in set up, is given in Table 1. Among the various material investigated cellulose evaporative cooling pad results in to maximum saturation efficiency as shown in Table 1. The experiment results without and with cellulose cooling pad, for R-22 vapour compression refrigeration cycle and air at different location in set up.

Calculation of Theoretical COP

h1 = 420.0 kJ/kg

h2 = 449.0 kJ/kg

h3= 249.0 kJ/kg

Theoretical COP = $\frac{h_1 - h3}{h_2 - h_1}$ (without EC pad)

$= \frac{420-249}{449-249}$

= 8.55

h1 = 421.0 kJ/kg

h2 = 447.0 kJ/kg

h3= 235.0 kJ/kg

Theoretical COP = $\frac{h_1 - h3}{h_2 - h_1}$ (with EC pad)

$= \frac{421-235}{447-235}$

= 8.77

Test Condition	P_s (bar)	P_d (bar)	T1 (°C)	T2 (°C)	T3 (°C)	T4 (°C)	h1 (kJ/kg)	h2 (kJ/kg)	h3 (kJ/kg)	Theoretical COP
Without EC Pad	6.0	16.6	19.3	71.83	34.33	11.00	420.0	449.0	249.0	8.55
With Cellulose EC Pad	5.4	14.2	22.5	72.00	31.33	8.67	421.0	447.0	235.0	8.77

Table 1

Calculation of Actual COP

$Q_c = 2.70$

$P_{net} = 1.12$

$$\text{Actual COP} = \frac{Q_c}{P_{net}}$$

$$= \frac{2.70}{1.12} \quad \text{(without EC pad)}$$

$$= 2.42$$

$Q_c = 2.74$

$P_{net} = 0.99$

$$\text{Actual COP} = \frac{Q_c}{P_{net}}$$

$$= \frac{2.74}{0.99} \quad \text{(with EC pad)}$$

$$= 2.76$$

Test Condition	Evaporator Inlet		Evaporator Outlet		C_o	A_o	ρ_a	Q_c	P_{net}	Actual
	DBT(°C)	WBT(°C)	DBT(°C)	WBT(°C)	(m/s)	(m^2)	(kg/m^3)	(kW)	(kW)	COP
Without EC Pad	31.0	19.8	13.4	12.2	2.0	0.052	1.22	2.70	1.12	2.42
With Cellulose EC Pad	31.3	20.1	15.0	12.6	2.0	0.052	1.21	2.74	0.99	2.76

Table 2

5.1. ADVANTAGES

• Increased Energy Efficiency: CAEC can improve the energy efficiency of split air conditioning systems by up to 40%. This is because the cooled air that enters the evaporator coil requires less energy to be cooled further, reducing the workload of the compressor.

• Reduced Energy Bills: By improving energy efficiency, CAEC can also reduce energy bills for homeowners or businesses that use split air conditioning systems.

• Improved Comfort: CAEC can improve the comfort of the occupants of a room by providing cooler and more comfortable air. The air that is cooled by CAEC is typically cooler and more humid, which can be more comfortable for occupants.

• Environmentally Friendly: By reducing energy consumption, CAEC can also reduce greenhouse gas emissions and contribute to a more sustainable environment.

• Cost-Effective: CAEC is a cost-effective technology that can be retrofitted to existing split air conditioning systems without the need for major modifications.

APPLICATIONS

• Residential Buildings: Split air conditioners with condensate assisted evaporative cooling can be installed in homes to provide energy-efficient cooling. This can help homeowners save money on their energy bills while also reducing their carbon footprint.

• Commercial Buildings: Condensate assisted evaporative cooling can be applied to split air conditioners in commercial buildings, such as office buildings, shopping centers, and hospitals. This can help to reduce energy costs for businesses while also improving indoor air quality for employees and customers.

• Data Centers: Data centers require constant cooling to maintain optimal operating temperatures for the servers and other equipment. By incorporating condensate assisted evaporative cooling into split air conditioning systems, data centers can reduce energy consumption and improve cooling efficiency, which can help to reduce operational costs.

• Industrial Settings: Condensate assisted evaporative cooling can also be applied in industrial settings, such as factories and warehouses. This can help to cool down hot and humid environments while also reducing energy consumption, making it a more sustainable choice for industrial operations.

• Agricultural Settings: In agricultural settings, such as greenhouses or animal shelters, condensate assisted evaporative cooling can be used to maintain optimal temperatures and humidity levels. This can help to increase crop yields, improve animal welfare, and reduce energy costs for farmers.

FUTURE SCOPE

• Smart Controls: The integration of smart controls and sensors can improve the energy efficiency of the system by adjusting the cooling capacity based on real-time data such as room occupancy and temperature.

• Improved Materials: The use of advanced materials such as nano-coatings and specialized heat transfer surfaces can enhance the performance and efficiency of the system.

• Alternative Refrigerants: The development of low global warming potential refrigerants can further reduce the environmental impact of split air conditioning systems.
• Hybrid Systems: Hybrid air conditioning systems that combine traditional refrigerant- based cooling with condensate assisted evaporative cooling can offer even greater energy efficiency and performance.
• Internet of Things (IoT) Integration: IoT integration can enable the system to be controlled remotely through mobile devices, allowing for better energy management and optimization.

CHAPTER 6

CONCLUSION

In conclusion, energy efficiency improvement of split air conditioner through condensate assisted evaporative cooling has several advantages and applications. By incorporating this technology into split air conditioning systems, energy consumption can be reduced, cooling capacity can be increased, indoor air quality can be improved, and the lifespan of the system can be extended. This technology can be applied in residential, commercial, industrial, data center, and agricultural settings, making it a versatile and sustainable option for cooling. As energy costs continue to rise and climate change becomes a pressing concern, it is essential to adopt energy-efficient technologies like condensate assisted evaporative cooling to reduce energy consumption and carbon emissions while maintaining optimal cooling and air quality.

CHAPTER 7

REFERENCES

Ebrahim Hajidavalloo, 2007[4], Experimental Investigation. Two evaporative cooling pad with water injecting facility is used on two sides of window air conditioner to cool the air entering to the condenser. They found reduction in power consumption by about 16% and increase in COP by 55% in window air conditioner with evaporative cooling pad in comparison to window air conditioner without evaporative cooling pad.

Ebrahim Hajidavalloo & Eghtedari, 2010[5], Experimental Investigation. An evaporative cooler was constructed and fixed to the existing air-cooled condenser of a split-airconditioner. They found that by using evaporative cooled air condenser, the power consumption can be reduced up to 20% and the COP can be improved around 50% in hot weather condition.

Martínez et al., 2016[6], Experimental Investigation, with R407C refrigerant charge have been used without and with cellulose evaporative cooling pad manufactured by Munters of 50 mm, 100 A split air conditioner mm and 150 mm thickness. Their experimental results indicate that Cellulose evaporative cooling pad of 100 mm thickness gives optimum performance and it reduces compressor power consumption by 11.4% the overall COP is increased by 10.6%.

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