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# Improving Efficiency of Cooling Coil Chiller Units

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**ABSTRACT**

**Air Cooled condensers were first introduced in US power industry in early 1970's, but only during last 10-15 years number of installations greatly increased largely due to growing attention being paid to environmental safety. Also, growing demand for water for both domestic and industrial use has brought an increased interest in use of Air Cooled condensers. This is a review paper which studies the performance of Air-cooled condenser under various operating conditions it is found that there is degradation in performance of air cooled condenser under high ambient temperatures and windy conditions. The heat rejection rate of ACC also depends on surface condition of fins and thus its performance is reduced due to external fouling of finned tubes due to weather conditions and by internal fouling from condensate (Ammonia corrosion). A Hybrid (dry/wet) dephlegmator achieves major enhancement in performance when ambient temperatures are high. Also shading of condensers is done for air-conditioning units to mitigate the adverse effect of high ambient temperatures due to solar radiation. Now a day's wind walls are used to reduce the effect of high wind velocity .second option is to increase the fan speed Fin cleaning plays an important role in heat rejection. External cleaning improves air side heat transfer coefficient. In order to improve the performance of an ACC Flat tubes inclined at some angle to horizontal can also be used in place of conventional circular horizontal tubes so that an improvement in heat transfer rate occurs.**

***Keywords*--** Air Cooled Condensers, Ambient Temperatures, Fin Cleaning, Heat Transfer, Performance Analysis

## I. INTRODUCTION

A condenser is a heat transfer device or unit used to condense a substance from its gaseous to its liquid state, typically by cooling it. In doing so, the latent heat is given up by the substance, and will transfer to the condenser coolant. Condensers are typically heat exchangers which have various designs and come in many sizes ranging from rather small (hand-held) to very large industrial-scale units used in plant processes. For example, a refrigerator uses a Condenser to get rid of heat extracted from the interior of the unit to the outside air. Condensers are used in air conditioning, industrial chemical processes .Such as distillation, steam power plants and other heat-exchange systems. Use of cooling water or surrounding air as the coolant is common in many condensers. The main use of a condenser is to receive exhausted steam from a steam engine or turbine and condense the steam. The benefit being that the energy which would be exhausted to the atmosphere is utilized .A steam condenser generally condenses the steam to a pressure significantly below atmospheric. This allows the turbine or engine to do more work. The condenser also converts the discharge steam back to feed water which is returned to the steam generator or boiler. In the condenser the latent heat of condensation is conducted to the cooling medium flowing through the cooling tubes.

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## II. CONDENSERS USED IN POWERPLANT

**1.** Steam Condenser
**2.** Air Cooled Condenser

## III. STEAM CONDENSER OR WATER COOLED CONDENSER

It is a device or an appliance in which steam condenses and heat released by steam is absorbed by water. A steam condenser is a device which condenses the steam at the exhaust of turbine. It serves two important functions. Firstly, it creates a very low pressure at the exhaust of turbine, thus permitting expansion of the steam in the prime mover to very low pressure. This helps converting heat energy of steam into mechanical energy in the prime mover. Secondly, the condensed steam can be used as feed water to the boiler.

## IV. 1EVAPORATOR

An evaporator is basically a heat exchanger coil that's responsible for collecting heat from inside a room

through a refrigerant gas. This component is known as the evaporator, and is where the liquid refrigerant absorbs heat and *evaporates* to become gas.

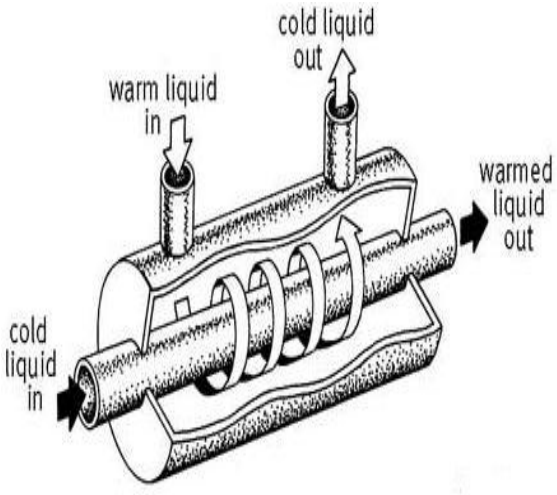
The indoor unit of a split air conditioner. It contains the evaporator coil (Photo Credit: Shutter stock Some of the most common refrigerant gases used in air conditioning systems include Hydro Fluorocarbons or HFCs (Like, R-410A) hydro Chlorofluorocarbons or HCFCs (like, R-22) and hydrocarbons (Like R-290 and R-600A). It is this gas that actually absorbs the heat from the room and travels to the next component for further processing.

## V. COMPRESSOR

As the name clearly signifies, this is where. Compression of the gaseous refrigerant occurs. It's located in the outside unit, i.e., the part that's installed outside the house.

## VI. CONDENSER

The condenser receives the vaporized refrigerant from the compressor, converts it back to liquid and expels the heat outside. Needless to say, it's also located on the outside unit of the split AC.




**There are two principal types of Steam Condensers a). Jet condensers b). Surface condenser**

**a) Jet condensers:** In a jet condenser, cooling water and exhausted steam are together. Therefore, the temperature of cooling water and condensate is the same when leaving the condenser. Advantages of this type of condenser are low initial cost, less flow area required, less cooling water required and low maintenance charges. However its disadvantage is condensate is wasted and high power is required for pumping water. **b) Surface condenser**: In a surface condenser, there is no direct contact between cooling water and exhausted steam. It consists of a bank of horizontal tubes enclosed in a cast iron shell. The cooling water flows through the tubes and exhausted steam over the surface of the tubes. The steam gives up its heat to water and is itself condensed. Advantage of this type of condenser are : condensate can be used as feed water, less pumping power required and creation of better vacuum at the turbine exhaust. However, disadvantage of this type of condenser are high initial cost, requires large floor area and high maintenance charges. The surface condenser is used for the majority of steam engine & steam turbine applications.

***Water Cooled Condenser AIR COOLED CONDENSER***

An Air cooled condenser, is simply a pressure vessel which cools a circulating fluid within finned tubes by forcing ambient air over the exterior of the tubes. A common example of an Air cooled condenser is car radiator Air cooled heat exchangers are used for two primary reasons. i. They increase plant efficiency ii. They are a good solution as compared to cooling towers and shell and tube heat exchangers because they do not require an auxiliary water supply (water lost due to drift and evaporation, plus no water treatment chemicals are required).

***Air Cooled Condenser cycle***

An air-cooled heat exchanger can be as small as your car radiator or large enough to cover several acres of land, as is the case on air coolers for large power plants the air-cooled heat exchangers are mostly used when the plant location and the ambient Conditions do not allow an easy and economic use of other cooling systems The most evident advantages of air-cooled Condensers are:

a) No problem arising from thermal and chemical pollution of cooling fluids

b) Flexibility for any plant location and plot plan arrangement because equipment requiring cooling need not be near a supply of cooling water.

c) Reduction of maintenance costs

d) Easy installation

e) Lower environmental impact than water cooled condenser due to the elimination of an auxiliary water supply resulting in water saving

f) No use of water treatment chemicals and no need for fire protection system.

Air-cooled finned-tube condensers are widely used in refrigeration and air-conditioning applications. For the same amount of heat transfer, the operation of air cooled condensers is more economic as compared with water cooled condensers typically air-cooled condensers are of the round tube and fin type.

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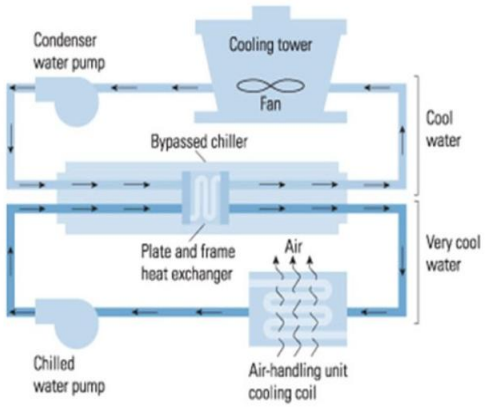


Courtesy: E SOURCE; adapted from EPA

Multiple techniques can be achieved such as enhancements on inner pipe surface, changing the tube geometry from round to flat shape and external fins. **S**The external surfaces of the finned tubes on air-cooled condensers are very prone to fouling from pollen, dust, insects, leaves, plastic bags, bird carcasses, etc. Not only is the air flow affected but also the heat transfer coefficient, the deterioration in performance increasing unit operating costs. In severe cases, fouling can also limit the power generation capacity of the turbo generator. To improve the heat removal capacity of an air-cooled condenser under conditions of high ambient air temperature, operators will sometimes spray water on the heat exchanger to reduce surface temperature. Unfortunately, depending on the quality of water used, this sometimes leads to new scale formation on the tube fins and, again, reduces the heat transfer rate if the deposits are allowed to accumulate.

***Cleaning Techniques for Air Cooled Condenser***

The three main methods for cleaning the external surfaces of air cooled condensers are as Follows:

I. Fire hose
II. High pressure Hand lance
III. Semi-Automated cleaning Machine

***1. Fire Hose***

Even though the volume of water consumed high, the washing effect of Fire hose is low due to low pressure involved. The galvanized surfaces of tubes and Fins are not damaged by this method the process is Labor and time intensive, and only a small improvement in performance even if surface seems to be optically clean. The reason is only a portion of fouling material is washed off and rest is pressed between fin tubes and cannot be washed off by this method. Again, the plant must be taken out of service and scaffolding erected in order that cleaning can be performed.

***II. High pressure Hand lance***

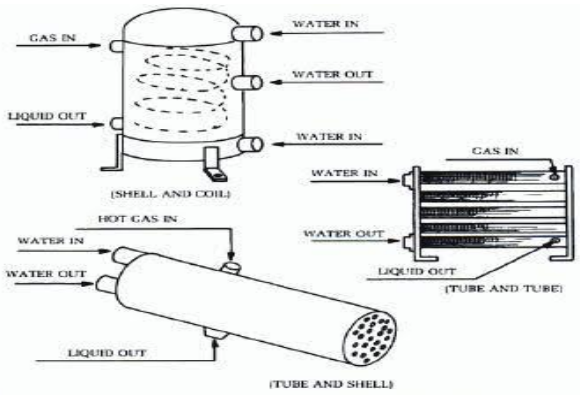
This method offers low water consumption and high water pressure .unfortunately the later can cause the galvanized surfaces to become damaged or Fins to be snapped off. As with the use of fire hose this method offers a small improvement in performance and once the fouling material has been compressed, It hinders heat transfer and obstructs air flow. Unfortunately, in order to perform cleaning the plant must be taken out of service and scaffolding erected.

***III. Automated Cleaning Machine***

The Automated cleaning Machine uses a significant volume of water, but at pressure that while allowing for effective surface cleaning avoids damaging galvanized surfaces and fins .An important advantage of automated cleaning method is that cleaning can be performed during operation while the unit is still online.

## VII. LITERATURE SURVEY

[1] A Study was performed on Performance Characteristics of an Air-Cooled Condenser under Ambient Conditions in December 2011. In this study effects of air flow pattern as well as ambient conditions were studied. Unfortunately ACC becomes less effective under high ambient temperature and windy conditions. Fin cleaning plays a vital role in heat rejection. External cleaning improves air side heat transfer coefficient. Ambient conditions affect the steam temperature and heat rejection rate. It is observed that rise in wind velocity decreases thermal effectiveness of ACC up to considerable level. Ambient temperature not only affects performance of ACC at the same time turbine back pressure also increases with rise in ambient temperature. Skirts are effective solution to reduce the effect of wind on volumetric effectiveness. Hot air recirculation increases with wind velocity. Now a day's wind walls are used to reduce this effect. Second option is to increase fan speed. It counter affects on electrical power consumption.




A study was performed to evaluate the performance characteristics of a power plant incorporating a steam turbine and a direct air-cooled dry/wet condenser operating at different ambient temperatures. The proposed cooling system uses existing A-frame air-cooled condenser (ACC) technology and through the introduction of a hybrid

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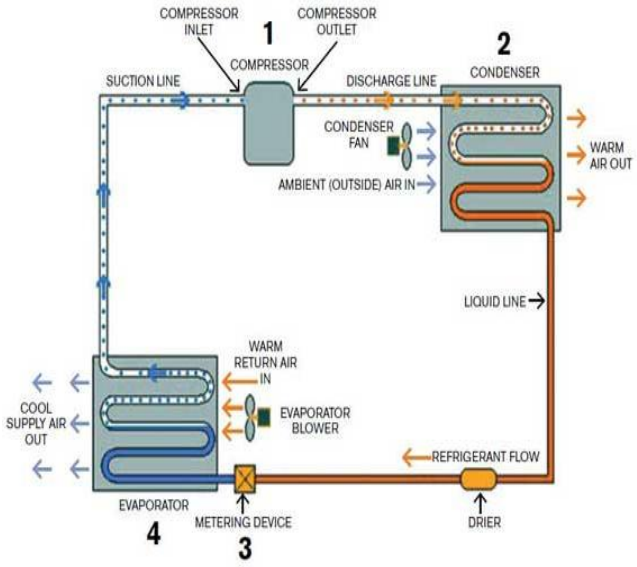
(dry/wet) dephlegmator achieves measurable enhancement in cooling performance when ambient temperatures are high. [3] In this study they found that air-conditioning system with air cooled condensers, the condensing unit has to be kept in open for easy access to outdoor air in order to efficiently dissipate heat, During Daytime the solar radiation falling on the surface of the condenser and high ambient temperature can be detrimental for the energy performance. They studied the effectiveness of shading the condensing unit to mitigate the adverse effect of high ambient temperatures due to solar radiation .and analyzed that the theoretical increase in COP due to shading is found to be within 2.5%. [4] Heat transfer by convection in air cooled condensers is studied and improved in this work. In order to enhance the performance of air cooled condensers, it is important to take into consideration both of condensation inside condenser tubes and convection outside, where the enhancement in convection side is the dominant one. Aluminumextruded micro-channel flat tubes improve the performance of condensation more than conventional circular tubes but still has potential for air side improving. So the enhancement of convective heat transfer in air side is achieved in this study by inclination of the flat tubes by a certain angle with respect to horizon.

**COMPRESSOR:** As the name clearly signifies, this is where compression of the gaseous refrigerant occurs. It's located in the outside unit, i.e., the part that's installed outside the house.

**CONDENSER:** The condenser receives the vaporized refrigerant from the compressor, converts it back to liquid and expels the heat outside. Needless to say, it's also located on the outside unit of the split AC.



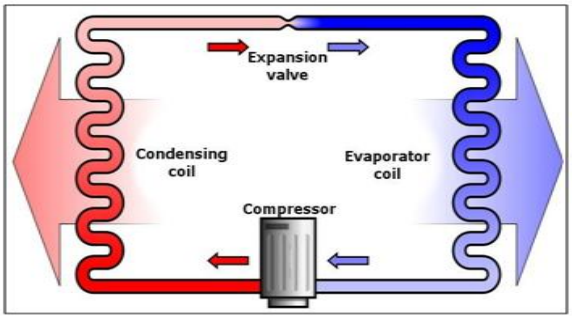

***Expansion Valve***

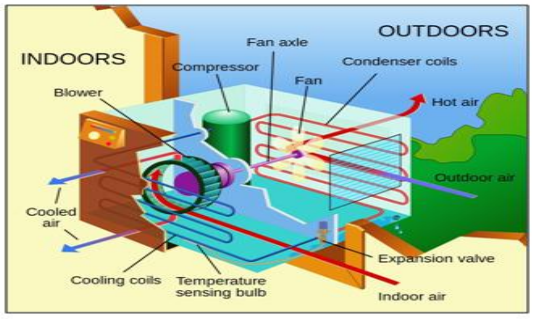
Also referred to as the throttling device, the expansion valve is located between the two sets of coils (the chilled coils of the evaporator and the hot coils of the condenser). It keeps tabs on the amount of refrigerant moving towards the evaporator. Note that in the case of window ACs, the three aforementioned components are all located inside a small metal box that is installed in a window opening. These are the main components of an air conditioner. Now let's look at how they work together to make an AC do what it does.

***Air Conditioner (AV) of Working***

*An air conditioner collects hot air from a given space, processes it within itself with the help of a refrigerant and a bunch of coils and then releases cool air into the same space where the hot air had originally been collected. This is essentially how all air conditioners work. Many folks believe that an air conditioner produces chilled air with the help of machines installed inside it, allowing it to cool a room so quickly. That might also explain why it consumes so much electricity. In reality, however, that's a misconception. An air conditioner is not a magical device; it just uses some physical and chemical phenomena very effectively to cool a given space.*

*When you switch an AC on and set your desired temperature (say, 20 degrees* Celsius), the thermostat installed in it senses that there is a difference in the temperature of the room's air and the temperature that you've chosen.




This warm air is drawn in through a grille at the base of the indoor unit, which then flows over some pipes through which the refrigerant (i.e., a coolant fluid) is flowing. The refrigerant liquid absorbs the heat and becomes a hot gas itself. This is how heat is removed from the air that falls on the evaporator coils. Note that the evaporator coil not only absorbs heat, but also wrings out

moisture from the incoming air, which helps to dehumidify the room.

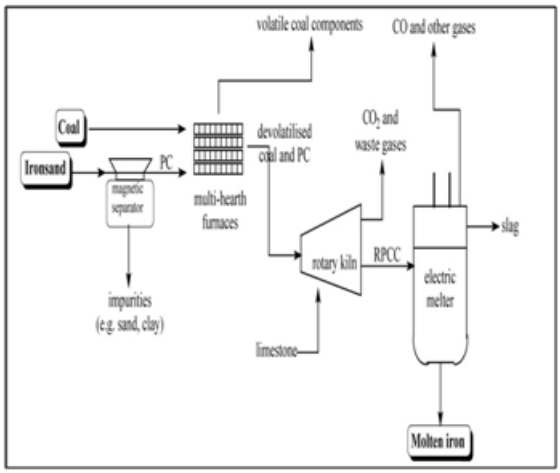
This hot refrigerant gas is then passed on to the compressor (located on the outside unit). Being true to its name, the compressor compresses the gas so that it becomes hot, since compressing a gas increases its temperature.

This hot, high-pressure gas then travels to the third component – the condenser. Again, the condenser remains true to its name, and condenses the hot gas so that it becomes a liquid.

The refrigerant reaches the condenser as a hot gas, but quickly becomes a cooler liquid because the heat of the 'hot gas' is dissipated to the surroundings through metal fins. So, as the refrigerant leaves the condenser, it loses its heat and becomes a cooler liquid. This flows through an expansion valve – a tiny hole in the system's copper tubing – which controls the flow of cool liquid refrigerant into the evaporator, so the refrigerant arrives at the point where its journey started. Here's a simplified diagram of the air-conditioning process:-

Although all the components involved in the air-conditioning process in window ACs are located inside the same metal box, the underlying process of cooling remains exactly the same. The entire process is repeated over and over again until the desired temperature is attained. In a nutshell, an AC unit keeps drawing in warm air and expelling it back into the room until there's no more warm air left to cool.

Dependent as we may be on air conditioners, it's surprising to note that they were not intended for human comfort when they were initially developed. The motivation for the first modern air-conditioning system was to eliminate certain problems in the manufacturing processes of a publishing company! To think that a machine intended to support publishing papers on a large scale could one day become an integral part of every modern household is quite something, isn't itntal in two cases




***Buffer Tank***

There are to buffer tank. One buffer tank is used to provide water at 12.c to then 3 chiller units. The other buffer tank stores the water at 6.c sent from the chiller unit. Then these storage buffer tank sent the cool water to the Air handling unit, were the air is dehumidified with these water used.

***Chilled Water Buffer Tanks***

Chilled water Buffer Tanks (CBT) is designed for chilled water system with insufficient water volume capacity in relation to the chillers capacity. Relatively low water volume system requires additional buffer capacity for the systems to eliminate problems such as excessive chillers cycling, poor temperature control, and erratic system operation.

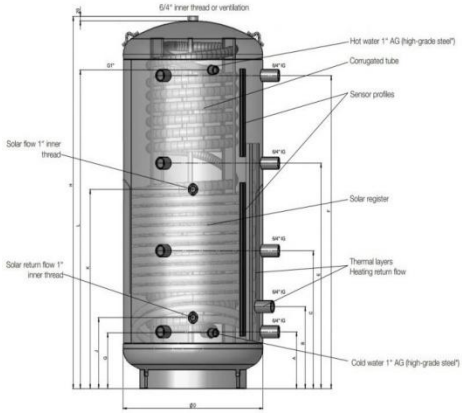
***Hot Water Buffer Tanks***

Hot water Buffer Tanks (HBT) are designed for use with today's high efficiency systems that incorporate small, modular low-mass boilers. A properly sized Hot water Buffer Tank adds necessary thermal mass to the system to dampen fast transitions and minimize boiler cycling that occurs during zero or low domestic load conditions.

## VIII. CONDENSOR OF A CHILLER UNIT

The condenser removes and dissipates heat from the compresses vapour to the surrounding air to water to condense the refrigerant vapour to a liquid. The liquid refrigerant than falls by gravity to a receiver (usually located below the condenser), where it is stored, and available for feature use in system.

In a typical refrigerant condenser. The refrigerant inters the condenser in a super-heatedstate. It is first de-superheated and then condenser as a saturated or sub-cooled liquid. Depending upon the temperature of the external medium and design of the condenser.



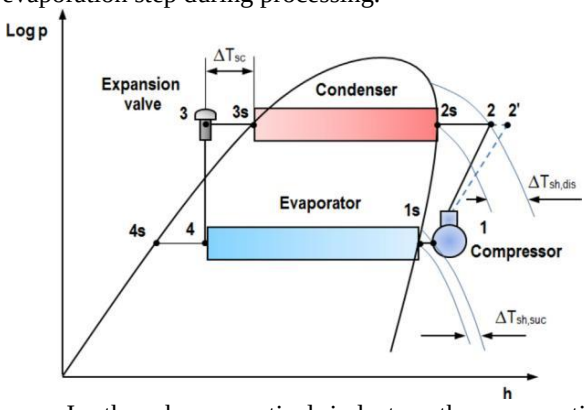

The appropriate process can be used to removed water or other liquids from liquid based mixtures. The process of evaporation is widely used to concentrate liquid foods, such as soup or make concentrated milk "condense

milk "done by evaporating water from the milk. In the concentration process, the goal of evaporation is to vaporised most of the water from a solution which contains the desire product.

An evaporator/evaporative-process can be use from separating liquid chemicals as well as to salvage solvents.

In the case of desalination of sea water or in zero liquid discharge plants, the reverse purpose applies; evaporation removes the desirable drinking water from the desired solute/product, salt.

One of the most important application of evaporation is in the food and beverage industry. Foods or beverages that need to last for a ponderable amount of time or need to have certain consistency, like coffee, go through an evaporation step during processing.




In the pharmaceutical industry, the evaporation process is used to eliminate excess moisture, providing an easily handled product and improving product stability. Perservation of long-term activity or stabilization of enzymes in laboratories are greatly assisted by the evaporation process.

Another examples of evaporation is in the recovery of sodium hydroxide in Kraft pulping [2].Cutting down waste-handling cost is another major reason for large companies to use evaporation applications. legally, all producers of waste must dispose of waste using methods compatible with environmental guidelines; these methods are costly. By removing moisture through vaporization, industry can greatly reduce the amount of waste product that must be processed.

## IX. AIR COOLED CONDENSERS

As the name implies, in air-cooled condenser air is the external fluid, i.e., refrigerant reject heat ton air following over the condenser. Air-cooled condenser can be future classified into natural convection type or forced convection type. The air cooled condenser of water steam is used for the removal of low potential heat during the water steam condensation.

In it cools with atmospheric air with a forced air draft. The area of ribbed tubes is used for the heat transfer where the cooling air flows outside the tubes and tubes. Forced air flow is provided by a propeller fan. The fan is driven by an electric motor with gearbox. Air cooled condensers are used for thermal power plants like combined cycle, concentrated solar, coal, biomass, and waste to energy. Since these kinds of power plants which are equipped with ACCs do not require a large volume of cooling water, the power plants can easily be available or where its use is restricted or expensive. Water cooled chillers are more efficient because they condense depending on the ambient temperature bulb temperature, which is lower than the ambient dry bulb temperature. The lower a chillers condenses, the more efficient it is.

- Cooling tower
- Condenser water pumps
- Make up water pumps

## X. CONCLUSION

The primary focus of this study is to evaluate the performance of Air-cooled condenser under various conditions. The performances of air-cooled condenser decreases with increase in ambient temperatures and high wind conditions. Hybrid (dry/wet) dephlegmator achieves measurable enhancement in cooling performance when ambient temperatures are high. Wind-walls are used to reduce the effect of wind .fan speed can also be increased. Changing the Shading the ACC of air-conditioned unit helps to reduce the high ambient temperature due to solar radiation. Shape of finned tubes from circular to flat and adjusting their inclination also helps in increasing heat transfer rate. Various techniques are also used to clean the tubes to increase heat transfer rate.

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