

A Review on Performance Analysis of Air-Cooled Condenser under Various Atmospheric Conditions

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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.

CONDENSERS USED IN POWERPLANT:

1. Steam Condenser
2. Air Cooled Condenser

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.

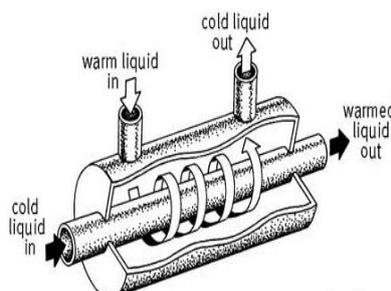


Fig 1. Water Cooled Condenser

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.

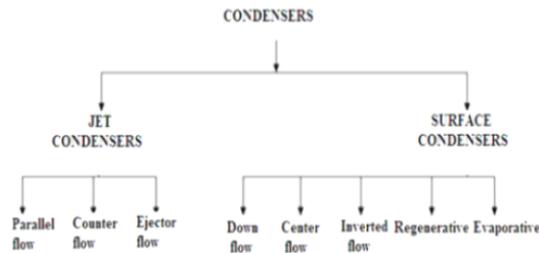


Fig 2. Types of Water Cooled Condenser

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).

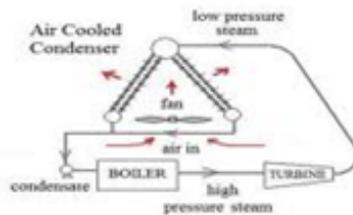


Fig 3.Basic Air Cooled Condenser cycle

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. To improve the performance of air-cooled condensers

multiple techniques can be achieved such as enhancements on inner pipe surface, changing the tube geometry from round to flat shape and external fins.

FOULING TENDENCIES OF AIR COOLED CONDENSER

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:

- Fire hose
- High pressure Hand lance
- 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.

IV. 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.

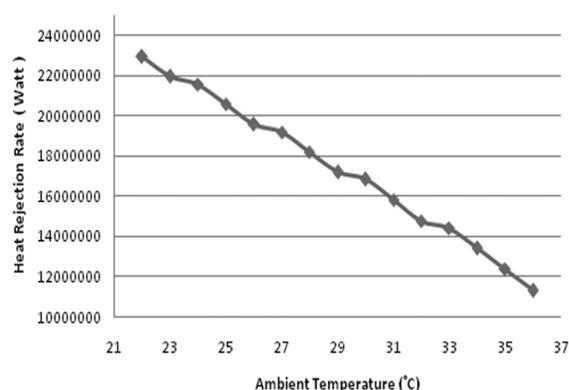


Fig. 4 Heat Rejection for various Ambient Temperatures. (Courtesy: Nirma Institute of technology - NUI CONE – 2011)

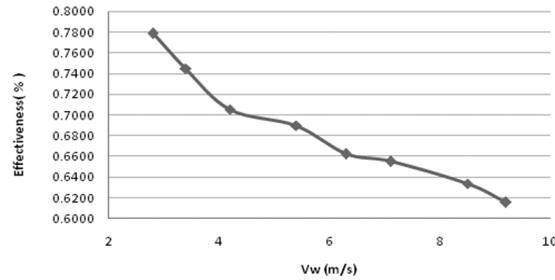


Fig.5. Effectiveness at different Wind Velocities
 (Courtesy: Nirma Institute Of technology - NUiCONE – 2011)

[2] 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 (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. Aluminum extruded 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 horizontal in two cases.

V. 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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