A Review of Literature on Air Cooled Heat Exchanger

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Abstract - A heat exchanger is a heat transfer device that exchanges heat between two or more process fluids.. A heat exchanger is used for transfer of internal thermal energy between two or more fluids available at different temperatures. In most heat exchanger fluids are separated by a heat-transfer surface, and ideally they do not mix. Heat exchangers have widespread industrial and domestic applications.
Today's heat exchangers must meet a variety of highly demanding requirements. In terms of performance, they have to ensure maximum heat transfer while keeping size to a minimum. Furthermore, the durability of heat exchangers must be extremely high, providing trouble-free performance throughout its service life at low manufacturing costs. The obvious advantage of an air cooler is that it does not require water, which means that equipment requiring cooling need not be near a supply of cooling water. In addition, the problems associated with treatment and disposal of water have become more costly with government regulations and environmental concerns. The air-cooled heat exchanger provides a means of transferring the heat from the fluid or gas into ambient air, without environmental concerns, or without great ongoing cost.
This is made possible by the large variety of aluminum-based materials and product forms that empower system designers and manufacturers with multiple options for significant design improvement and cost reduction. Aluminum, in its various forms, offers clear possibilities to achieve these goals and is also well positioned to meet the challenges of the increasing market demands for cost effective, energy-efficient products and new customized, innovative applications.

I. INTRODUCTION

An air cooled heat exchanger, or ACHE, 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 cooler is a car's radiator. Please refer to the above interactive picture for additional information.
The Air-cooled heat exchanger is a device for rejecting heat from a fluid or gas directly to ambient air. When cooling both fluids and gases, there are two sources readily available, with a relatively low cost, to transfer heat to air and water.
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 where water is not available. The Air-cooled heat exchanger is a device for rejecting heat from a fluid or gas directly to ambient air. When cooling both fluids and gases, there are two sources readily available, with a relatively low cost, to transfer heat to air and water.
A heat exchanger consists of heat-exchanging elements such as a core or matrix containing the heat-transfer surface, and fluid distribution elements such as headers or tanks, inlet and outlet nozzles or pipes, etc. Usually, there are no moving parts in the heat exchanger; however, there are exceptions, such as a rotary regenerator in which the matrix is driven to rotate at some design speed. The heat-transfer surface is in direct contact with fluids through which heat is transferred by conduction. The portion of the surface that separates the fluids is referred to as the primary or direct contact surface. To increase heat-transfer area, secondary surfaces known as fins may be attached to the primary surface

Air cooled heat exchangers are used for two primary reasons:

1. They increase plant efficiency
2. They are a "green" 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).

Uses for air-cooled heat exchangers

The applications for air cooled heat exchangers cover a wide range of industries and products, however generally they are used to cooler gases and liquids when the outlet temperature required is greater than the surrounding ambient air temperature.

The applications include:

Refineries
Gas compressor packages
Gas transmission facilities
Engine cooling
Condensing of gases (propane, refrigerants, etc)
Steam condensers

Principle of Heat Exchanger -

Basic Heat Transfer principles

The basic heat transfer relationships that exist for shell and tube exchangers also apply to the design of an air-cooled heat exchanger. However, there are more parameters to be considered in the design of an air-cooled exchanger. Since the air-cooled heat exchanger is exposed to changing climatic conditions, problems of control of the air cooler become relevant. A decision must be made as to what the actual ambient air temperature to be used for the design.

Some of the governing factors in the design of the air cooler are:

Tube diameter
Tube length
Fin height
Number of tube rows
Horse power
Plot area

To calculate the sensible heat load Q in Btu/hr, the following equation must be followed:

$\mathbf{Q = m \times Cp \ (T_i - T_o)}$ Where,

m = the flow of the fluid or gas in lb/hr.
Cp = the average specific heat in BTU/LB/oF of the liquid or gas
T_i = inlet temperature of the liquid or gas
T_o = outlet temperature of the liquid or gas

II. TYPES OF DRAFT IN AIR COOLED HEAT EXCHANGERS

Air Cooled Heat Exchangers can be built in several configurations, normally controlled by the power available, the installation and customer preferences. Diagrams of the various types of air coolers are indicated on the following pages. There are many similar configurations by different manufacturers; however most of these are a derivative of one of these types. The most common type of air cooler is the horizontal coil with horizontal fan and vertical air flow. This type is typically driven by an electric motor drive attached to the fan through v-belts to allow for speed reduction between the motor and the fan. This model can also be driven by hydraulic motors, air motors and even from an engine with special right angle gear drive arrangements. The normal application for these models are in plants or refineries where electric power is available, and where the cooler is installed away from other equipment to allow adequate air flow around the air cooler. This model is built in both induced draft and forced draft configurations. Depending on the application, and the installation site, there are advantages and disadvantages to both models.

Forced Draft ACHE

The most economical and most common style of air cooler is the forced draft ACHE, uses axial fans to force air across the fin tube bundle. The fans are positioned below the bundle thus not exposing the mechanical sections to the hot exhaust airflow. The forced draft air cooler also simplifies future plant expansion by providing direct access to bundle for replacement. Structural disassembly is not required

Induced Draft ACHE

The second most economical and most common style air cooler is the induced draft ACHE. This design uses axial fans to pull air across the fin tube bundle. The fans are positioned above the bundle thus offering greater control of the process fluid and bundle protection due to the additional structure. Lower noise levels at grade are another benefit. The induced draft air cooler does require some structural disassembly if bundle replacement is required.

III. GENERAL LAYOUT OF AIR COOLED HEAT EXCHANGER

1. Air cooled exchangers are usually composed of rectangular bundles containing several rows of tubes on a triangular pitch. Heat transfer is generally countercurrent, the hot fluid entering the top of the bundle and air flowing vertically upward through the bundle. Air cooled units have been successfully and economically used in liquid cooling for compressor engine and jacket water and other recalculating systems, petroleum fractions, oils, etc. and also in condensing service for steam, high boiling organic vapors, petroleum still vapors, gasoline, ammonia, etc.

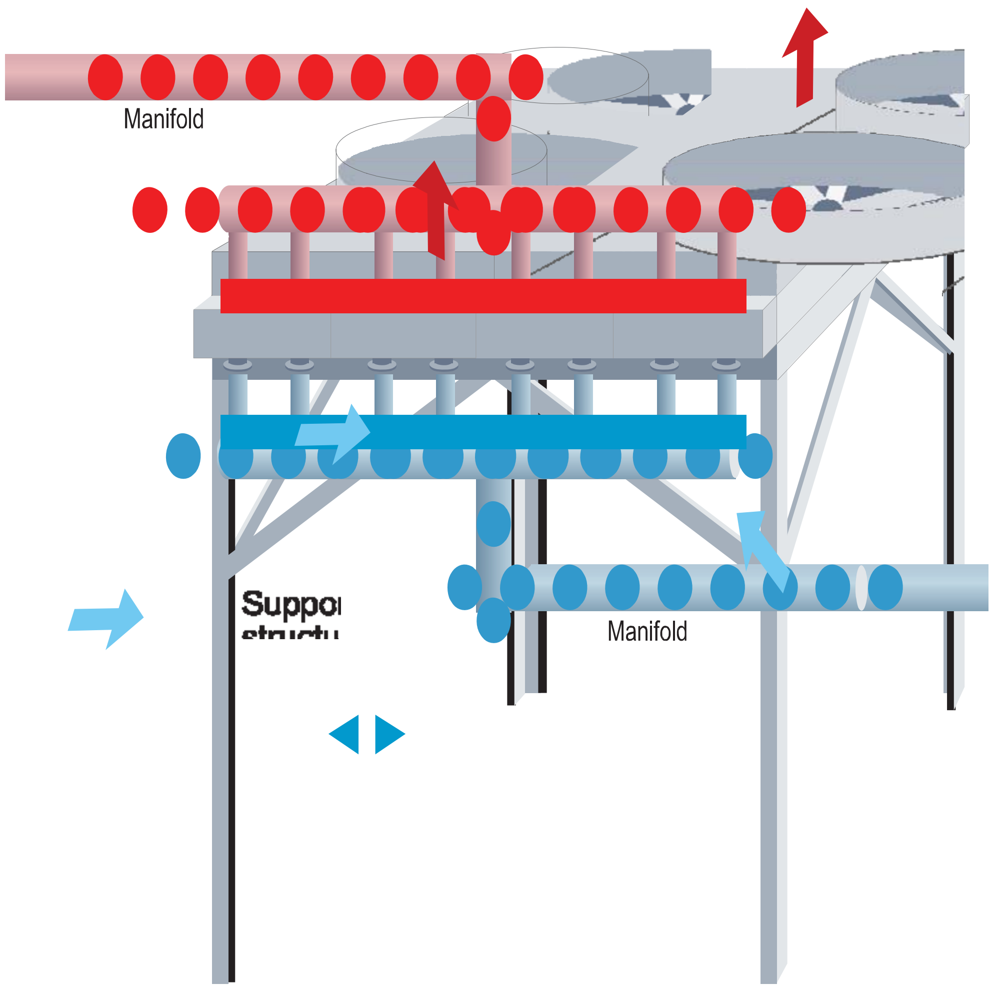
2 .Since air is a universal coolant, there are numerous applications where

economic and operating advantages are favorable to air-cooled heat transfer equipment. However, applications are limited to cases where the ambient air dry bulb temperature is below the desired cooling or condensing temperature.

3.Where expensive or insufficient water supplies are encountered or where cooling water pumping or treating costs are excessive, it is often found that air-cooled units are desirable for several services. The adverse conditions of high relative humidity or excessive space requirements occasionally create high costs or installation difficulties for cooling towers. In some of those cases, air-cooled heat transfer equipment offers a satisfactory solution.

4.Full consideration should be given to adequate winter protection of air-cooled units installed in cold climates. It is essential that all possibilities of freeze-up be eliminated and external recirculation of hot air is necessary for severe winter conditions when the unit is subject to freezing and heating coils provided for protection against freeze-up shall be in a separate bundle and not part of the process tube bundle.

5. If the fluid being handled is subject to wide variations in viscosity over the range of atmospheric temperatures encountered, provisions must be made to control the extent of cooling at the lower ambient air temperatures.



General Layout Of Air Cooled Heat Exchanger

Photograph by GEA Heat Exchangers

Air Cooled Heat Exchanger Photograph
Original Photograph by Parag

Air Cooled Heat Exchanger Photograph
Original Photograph by Parag

Coil or Bundle design and construction

The coil or bundle in the air-cooled heat exchanger is an assembly of tubes, headers, side frames and tube supports as shown in the figure on the next page. Usually the tube surface exposed to the passage of air has extended surface in the form of aluminum fins to compensate for the low heat transfer rate of air. The box header is normally fabricated from plate, and consists of a tube sheet, plug sheet, top and bottom wrappers, and end plates. In a standard box header configuration, holes must be drilled and tapped in the plug sheet opposite each tube to allow maintenance of the tubes. A plug, normally a shoulder plug with a gasket, is threaded into each hole to seal under pressure, but allow access when required.

Headers

In combination with the finned tubes, headers are an integral part of the air cooled heat exchanger pressure vessel. Headers are used to receive the fluid from the piping and direct the fluid through the tubes. Tubes are connected to the headers via expanding, welding or both. Headers are the boxes at the ends of the tubes which distribute the fluid from the piping to the tubes.

Finned Tubes

The tubes are normally round and can be produced to almost any metal suitable for the process. Tube material is selected based on the corrosion, pressure and temperature limitations of the material in the process it is exposed.

Fins are normally helical wound aluminum fins. Aluminum material is used for reasons of good thermal conductivity and economy of fabrication. The normal aluminum material used is due to its relatively low cost and superior thermal conductivity. Fins can be produced from other materials including copper, steel and stainless steel. Copper is normally used in offshore or marine environments when the airside environment is corrosive enough to justify the cost increase associated with copper material. Steel and stainless steel is normally used for very high temperature applications.

Structure

The structure consists of the columns, braces, and cross beams that support the exchanger at a sufficient elevation above grade to allow the necessary volume of air to enter below at an approach velocity low enough to allow unimpeded fan performance and to prevent unwanted recirculation of hot air. To conserve ground space in oil refineries and chemical plants, ACHEs are usually mounted above, and supported by, pipe racks, with other equipment occupying the space underneath the pipe rack. ACHE structures are designed for appropriate wind, snow, seismic, piping, dead, and live loads.

Plenums, dispersion angle, and fan coverage:

The air plenum is an enclosure that provides for the smooth flow of air between the fan and bundle. Plenums can be box type or slope sided type. The slope sided type gives the best distribution of air over the bundles, but is almost exclusively used with induced draft because hanging a machinery mount from a slope sided forced draft plenum presents structural difficulties

Mechanical Equipment

Fans may be driven by electric motors, steam turbines, gas or gasoline engines, or hydraulic motors. The overwhelming choice is the electric motor. Hydraulic motors are sometimes used when power from an electric utility is unavailable. Hydraulic motors also provide variable speed control, but have low efficiencies.

Fans

The air-cooled heat exchanger is controlled by two factors, the tube bundle size and configuration, and the ability to move air across the surface area that the bundle provides. Therefore, a major consideration of air cooler manufactures is not only the selection of the proper fan, but also the design of plenums to force the air across the surface area. The common means of moving air across the air cooler bundle is an axial flow, propeller type fan that either pushes (forced draft) the air across the bundle or pulls (induced draft) it across.

IV. STANDARDS FOR AIR-COOLED EXCHANGERS

First, almost all air coolers are built to Sect. VIII of the ASME Code, since they are pressure vessels. For refinery and petrochemical services most customers include API 661 (Air-Cooled Heat Exchangers for General Refinery Service) in their specifications. This API spec is very good since it includes all the necessary information to properly specify a cooler and provides for a high level of minimum quality in the design and fabrication of the cooler. In the back it has a very good checklist where a customer can decide exactly what type construction is needed and what options are important. These include such items as galvanizing vs. painting, types of headers, maintenance walkways and platforms, controls, and external loads on the cooler. The following details refer mostly to the API specification

V. OBJECTIVES OF LITERATURE REVIEW

The main objective of this master thesis is to evaluate the use of Air Cooled Heat Exchanger in Refineries.

VI. CONCLUSION

The outcome of this literature review is that, we can achieved power saving in Air Cooled Heat Exchanger by fans, because in Air Cooled Heat Exchanger ,the main consumption of Auxilary power are fans.

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