A Review of Literature on Steam Coil for Air Cooled Heat Exchanger

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Abstract - There are several sites, in the world as well as in India, where the ambient temperature reaches below 00 C to -280C, at this temperature the fluid in heat exchanger freezes. For this, we can use steam coil in Heat Exchanger for heating the working fluid. For proper working of heat exchanger, in low ambient temperature or freezing temperature, a steam coil is used. If the fluid Freezes in Heat Exchanger, the heat exchanger ceases and it would damage the heat exchanger also. In extremely cold environments, overcooling of the process fluid may cause freezing. This may lead to tube burst, and hence freeze protection is required to prevent plugging or damage to the tubes. The function of steam coil is that, when the temperature reaches near the pourpoint of working fluid, the steam coil starts & passes the steam to increase the temperature of fluid up to the designed temperature. Steam Coil is used to heat atmospheric air to the required process temperature by means of saturated steam. By using steam coil with low pressure steam we can prevent the process fluid from freezing in Air Cooled Heat Exchanger. For air or fluid heating, steam is preferred medium for heat transfer throughout of industry. Steam is easy and inexpensive to move from the boiler to the point of use, and it gives up much of its energy at a constant temperature when it condenses. Process control is easy and fast with steam, and there is essentially no lag time. Steam flows inside the tube while air passes over the finned tubes. Finned tubes are almost always used in steam coil applications and this type of coil makes use of the latent heat that is released by the steam when it condenses so it is a very effective way of heating air. In facilities where steam is available a Steam Coil can be a cost effective way to heat ambient air & process fluid .Steam has been a popular mode of conveying energy since the industrial revolution. Steam coil is just like a Tube Bundle of Heat Exchanger in which steam is flowing inside the tubes. The steam is coming in steam coil from air pre heater, which is the part of refinery or any other medium such as boiler or any other part of refinery.

Keywords- Steam Coil, Steam, Air Cooled Heat Exchanger, low ambient temperature

I. INTRODUCTION

Air Cooled Heat Exchanger

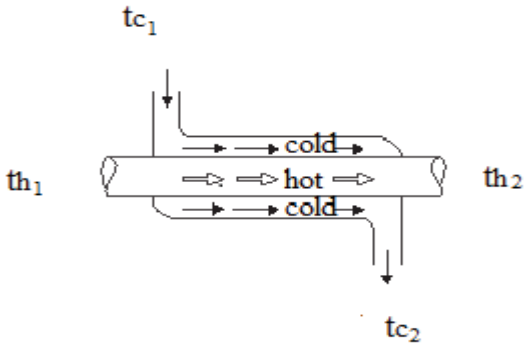
Heat exchangers are equipment that transfers heat from one medium to another. An air cooled heat exchanger, or ACHE, is simply a pressure vessel which cools a circulating fluid within finned tubes by forcing ambient air over the exterior of the tubes [10]. A heat exchanger is a heat-transfer devise that is used for transfer of internal thermal energy between two or more fluids available at different temperatures. In most heat exchangers, heat transfer between fluids takes place through a separating wall or into and out of a wall in a transient manner. In many heat exchangers, the fluids are separated by a heat transfer surface, and ideally they do not mix or leak. Heat exchangers are used in the process, power, petroleum, transportation, air conditioning, refrigeration, cryogenic, heat recovery, alternate fuels, and other industries. Common examples of heat exchangers familiar to us in day-to-day use are automobile radiators, condensers, evaporators, air pre heaters, and oil coolers. To increase the heat transfer area, appendages may be intimately connected to the primary surface to provide an extended, secondary, or indirect surface. These extended surface elements are referred to as fins. Thus, heat is conducted through the fin and convected (and/or radiated) from the fin (through the surface area) to the surrounding fluid, or vice versa, depending on whether the fin is being cooled or heated. As a result, the addition of fins to the primary surface reduces the thermal resistance on that side and thereby increases the total heat transfer from the surface for the same temperature difference. Fins may form flow passages for the individual fluids but do not separate the two (or more) fluids of the

exchanger. These secondary surfaces or fins may also be introduced primarily for structural strength purposes or to provide thorough mixing of a highly viscous liquid.

Types of Heat Exchanger-

There are three basic configurations based on the direction of the fluid flow within the heat exchanger. These are:

1. Parallel flow. The two fluids streams in the heat exchanger flow in the same direction. [3]



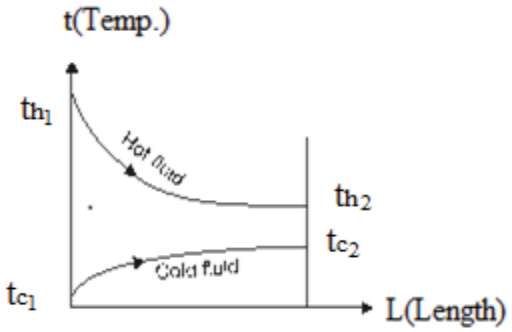
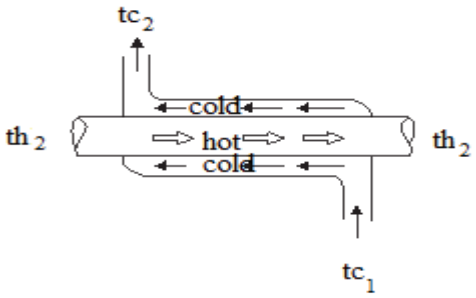


Fig. 1(a) Fig.1 (b)
Parallel flow Heat Exchanger

*2. Counter flow***.** The direction of the flow of one of the fluids streams are opposite to the direction of the other fluid. [3]



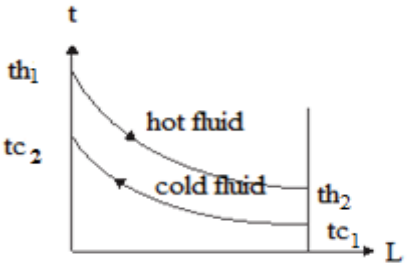
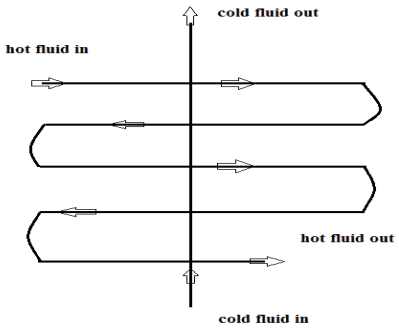


Fig.2 (a) Fig.2 (b)
Counter-flow Heat Exchanger

3. Cross flow. In a cross flow heat exchanger, one fluid flows though the heat transfer surface at a 90 degrees angle to the flow path of the other fluid. [3]



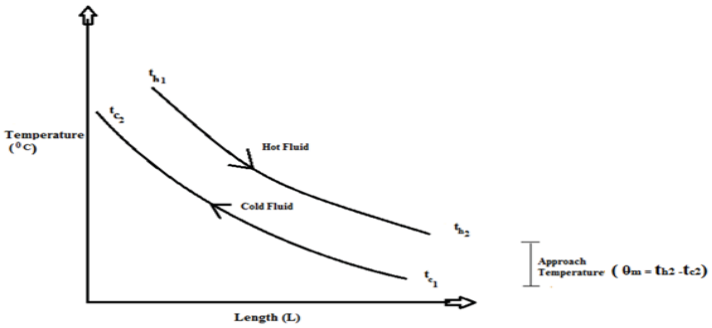
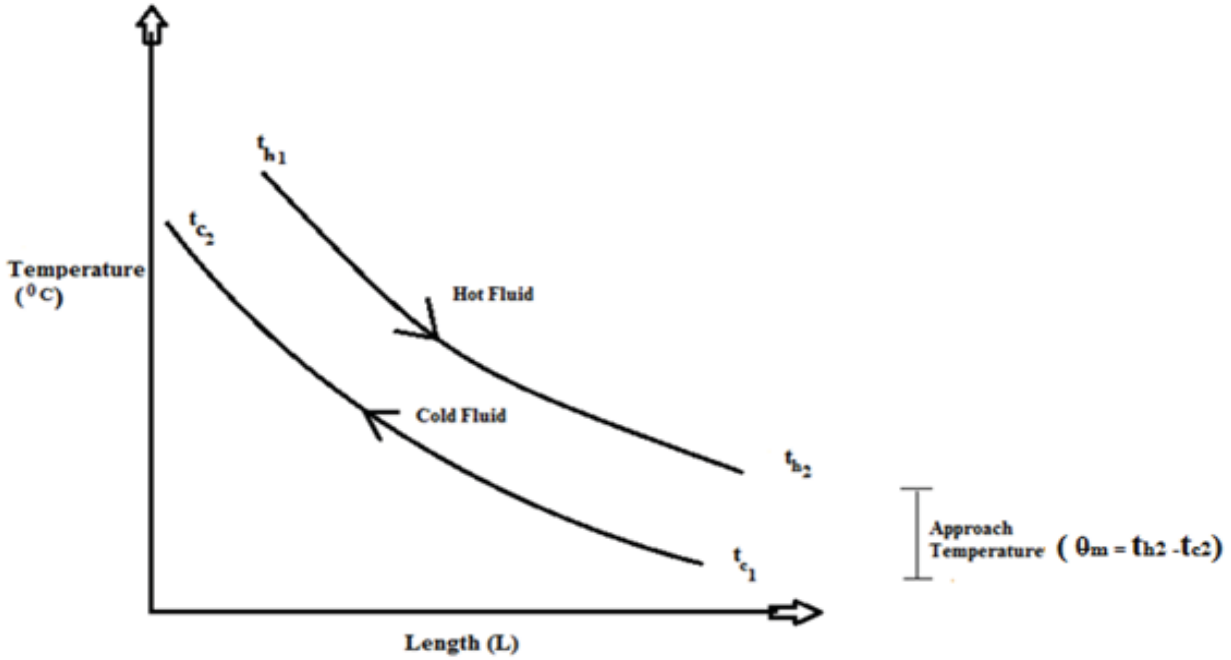


Fig.3 (a) Fig.3(b)

Cross flow Heat Exchanger

Approach Temperatures

The approach temperatures are the difference between the Outlet Temperature of one stream and the Inlet Temperature of the other stream. Although each application will have two approach temperatures, typically it is obvious which one is important from a design standpoint.



Approach Temperature = t_{h2}-t_{c1}

Problems with Heat Exchangers in Low-Temperature Environments

Heat Exchanger is designed on the basis of hot fluid temperature, cold fluid temperature & ambient temperature, but in practical sense, the ambient temperature changes throughout the year. In that case, the fluid in heat exchanger freezes. In extremely cold environments, overcooling of the process fluid may cause freezing. This may lead to tube burst, and hence freeze protection is required to prevent plugging or damage to the tubes. For this, we can use steam coil in Heat Exchanger for heating the working fluid.

II. STEAM COIL

For proper working of heat exchanger, in low ambient temperature or freezing temperature, a steam coil is used. If the fluid Freezes in Heat Exchanger, the heat exchanger ceases and it would damage the heat exchanger also. In extremely cold environments, overcooling of the process fluid may cause freezing. This may lead to tube burst, and hence freeze protection is required to prevent plugging or damage to the tubes. The function of steam coil is that, when the temperature reaches near the pour point of working fluid, the steam coil starts & passes the steam to increase the temperature of fluid up to the designed temperature. Steam Coil is used to heat atmospheric air to the required process temperature by means of saturated steam. By using steam coil with low pressure steam we can prevent the process fluid from freezing in Air Cooled Heat Exchanger For air or fluid heating, steam is the preferred medium for heat transfer throughout much of industry. Steam flows inside the tube while air passes over the finned tubes. Finned tubes are almost always used in steam coil applications and this type of coil makes use of the latent heat that is released by the steam when it condenses so it is a very effective way of heating air. In facilities where steam is available a Steam Coil can be a cost effective way to heat ambient air & process fluid. The selection of coil construction and materials is a multistep process that must take a number of factors into consideration. Steam coil is just like a Tube Bundle of Heat Exchanger in which steam is flowing inside the tubes. The steam is coming in steam coil from air pre heater, which is the part of refinery or any other medium such as boiler or any other part of

refinery. In steam coil, we flow the steam in tube and by fan we direct the steam to heat exchanger tube bundle for heating the tube bundle and ambient air to avoid the freezing of fluid. The steam coil is widely used for heating the fluid and air in industry. We use this steam coil in heat exchanger which is a part of Refinery, by which we protect the fluid from freezing and for proper functioning of Heat Exchanger.

Several standard applications for our steam coils are as below:
Commercial and industrial heating systems
Commercial and industrial drying and processing applications
Boiler air preheating
Pulp dryers
Paper machine ventilator coils
Air cooled heat exchangers
Unit/Space heaters

Steam
Steam has been a popular mode of conveying energy since the industrial revolution. Steam is used for generating power and also used in process industries. Process control is easily and quickly accomplished with essentially no lag time as is experienced with liquids.
The following characteristics of steam make it so popular and useful to the industry:
Highest specific heat and latent heat
Highest heat transfer coefficient
Easy to control and distribute
Cheap and inert

Steam- When water is heated to boiling point and beyond, it changes into **steam**, or, water in a gaseous state.

Various types of steam-
Saturated Steam
Superheated Steam
Dry Steam
Wet Steam

Saturated Steam
Saturated steam is the most common type of steam. Steam in this state is constituted of both liquid phase and gaseous phase water. This means that the rate of evaporation is equal to the rate of condensation. Steam generated by a boiler is usually saturated steam. Saturated steam has properties which make it an excellent source of heat, and is hence widely used as a 100 °C – 200 °C heat source.

Superheated Steam
Further heating of saturated steam will cause superheated steam to form. Superheated steam has a higher temperature than saturated steam at the same pressure. Superheated steam is used mainly for physical drive or propulsion applications, and is not often used for heating purposes.

Dry Steam vs. Wet Steam

In steam-using industries, two commonly referred to types of steam are dry steam (also called ”saturated steam”) and wet steam.

- Dry steam applies to steam when all its water molecules remain in the gaseous state. It's a transparent gas.
- Wet steam applies to steam when a portion of its water molecules have given up their energy (latent heat) and condense to form tiny water droplets.

Properties of Steam

Water can exist in the form of solid, liquid and gas as ice, water and steam respectively. If heat Energy is added to water, its temperature rises until a value is reached at which the water can no longer exist as a liquid. We call this the

"saturation" point and with any further addition of energy, some of the water will boil off as steam. This evaporation requires relatively large amounts of energy, and while it is being added, the water and the steam released are both at the same temperature. Equally, if steam is made to release the energy that was added to evaporate it, then the steam will condense and water at same temperature will be formed.

Liquid Enthalpy Liquid enthalpy is the "Enthalpy" (heat energy) in the water when it has been raised to its boiling point to produce steam, and is measured in kCal/kg, its symbol is hf. (also known as "Sensible Heat") The heat required to change the temperature of a substance is called its **sensible heat**.

Enthalpy of Evaporation (Heat Content of Steam) The Enthalpy of evaporation is the heat energy to be added to the water (when it has been raised to its boiling point) in order to change it into steam. There is no change in temperature, the steam produced is at the same temperature as the water from which it is produced, but the heat energy added to the water changes its state from water into steam at the same temperature. When the steam condenses back into water, it gives up its enthalpy of evaporation, which it had acquired on changing from water to steam. The enthalpy of evaporation is measured in kCal/kg. Its symbol is hfg. Enthalpy of evaporation is also known as **latent heat**.

Saturation Temperature- The temperature at which water boils, also called as boiling point or saturation temperature, saturation temperature increases as the pressure increases. When water under pressure is heated its saturation temperature rises above 100 °C. From this it is evident that as the steam pressure increases, the usable heat energy in the steam (enthalpy of evaporation), which is given up when the steam condenses, actually decreases. The total heat of dry saturated steam or enthalpy of saturated steam is given by sum of the two enthalpies hf +hfg .

Super Heat -The temperature of saturated steam is the same as the water from which it is generated, and corresponds to a fixed and known pressure. Superheat is the addition of heat to dry saturated steam without increase in pressure. The temperature of superheated steam, expressed as degrees above saturation corresponding to the pressure, is referred to as the degrees of **superheat**.

Guidelines for Air Cooled Heat Exchanger Design
We design Air Cooled Heat Exchanger by American Petroleum Institute Standard 661 guidelines. American Petroleum Institute Standard 661 is meant for air-cooled heat exchangers for general refinery service. The scope of the standard includes minimum requirements for design, materials selection, fabrication, inspection, testing, and preparation for shipment of refinery process air-cooled heat exchangers. The standard specifies that the pressure parts shall be designed in accordance with ASME Code, Section VIII, and Division 1. API Standard 661 should be specified and used as a guide in preparing the requisition/specification. When the customer's requirements deviate from API 661, the exceptions or special requirements should be listed as "Specific Requirements" .

.*Objectives of Literature Review*

1. The main objective of this master thesis is to give the idea for use of steam coil in Air Cooled Heat Exchanger at low ambient atmospheric condition.

2. To discuss the importance of steam coil in Air Cooled Heat Exchanger for low ambient temperature.

3. To discuss about protection of heat exchanger under freezing temperature, if the fluid Freezes in Heat Exchanger, the heat exchanger ceases and it would damage the heat exchanger also.

4. To discuss the importance of steam as a heating medium in Air Cooled Heat Exchanger.

5. To discuss about performance deterioration of heat exchanger in low ambient temperature

6. To discuss the various challenges faced while designing the Air cooled Heat Exchanger for Low ambient temperature

7. To give the brief perspective of steam coil for Air Cooled Heat Exchanger in low ambient temperature.

III. CONCLUSION AND OUTCOME

Steam is easily available throughout industry; Steam is cheap and cost effective way for heating the ambient air & process fluid. The following characteristics of steam make it so popular and useful to the industry: Steam is popular because of Highest specific heat and latent heat, Highest heat transfer coefficient , Easy to control and distribute ,Cheap and inert. By using steam coil in Air Cooled Heat Exchanger we can prevent the freezing of fluid within the heat exchanger, which could lead to damage of heat exchanger due to ceasing of fluid. By using steam coil we can maintain the performance of air cooled heat exchanger at low ambient temperature. By the use of steam coil we maintain the Heat exchanger approach temperature and heat exchanger tube skin temperature without compromising the performance of heat exchanger

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