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Design and Performance Validation of Closed Circuit Fluid Cooler

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ABSTRACT

A Fluid cooler is a heat rejection device that rejects waste heat to the atmosphere through the cooling of a water stream to a lower temperature. Fluid coolers may either use the evaporation of water to remove process heat and cool the working fluid to near the wet- bulb air temperature or, in the case of closed circuit dry Fluid coolers, rely solely on air to cool the working fluid to near the dry-bulb air temperature. Common applications include cooling the circulating water used in oil refineries, petrochemical and other chemical plants, thermal power stations and HVAC systems for cooling buildings. The classification is based on the type of air induction into the tower: the main types of Fluid coolers are natural draft and induced draft Fluid coolers.

Key Words: Fluid cooler water stream HVAC systems oil refineries, petrochemical

INTRODUCTION

In this chapter, the brief idea of Fluid cooler is stated. The working principle of Closed circuit Fluid cooler and its components is explained with the help of diagram. Also includes the problem definition of project and the objectives of the project. Fluid coolers are a type of heat exchanger that allows water and air to come in direct contact which cause instantaneous intermolecular diffusion of air and water which in turn cool down the water temperature and carry out the heat to be rejected in the atmosphere. During this process, small volumes of water evaporate, lowering the temperature the circulating water which falling over the cascade of Tube rows carrying the primary fluid which could be any like water or water-glycol mixture , Thermic fluid , low viscosity oil etc. . Common applications for Fluid coolers are process industries like polyfilm industry, autoclaves in defense, machine cooling, welding gun cooling or any process where high degree of fluid hygiene is required and cost of shutdown for repair /maintenance is

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massive.

OBJECTIVE OF THE WORK

1. 1. Stainless tube bundle pitch selection and first level design calculation
2. 2. Instrumental arrangement for testing as per CTI 105 [S]
3. 3. Comprehensive Testing of Closed circuit Fluid cooler and Calculating testing results.
4. 4. Validation of results and correction considerations.

The instrumentation which is the components of fluid cooler selected as per analytical design. Specifications of components are also given. Experimental procedure is given followed by readings taken during the experiment. Also, instruments used for measurement of parameters are listed. Also, the validation of fluid cooler is done by comparing analytical and experimental results.

Instrumentation

Components of fluid cooler

- Tube bundle
- Fills packing
- Axial fan
- Pump
- Nozzles

Analysis:

Experimental analysis is done by Temperature readings are taken and compared with predicted temperatures. Experimental temperatures are slightly higher than predicted because the turbulence is neglected in calculation and also mass transfer is neglected in tube bundle region. Predicted pressure drop is ±5% differed from experimental which is acceptable. Experimental temperatures are well in acceptable range as compared to predicted temperatures. From this comparison it is conclude that temperatures are in limit as per code. Tube bundle is situated at the top of the tower. Tubes are arranged in staggered arrangement and tubes are made up of stainless steel. Tubes are attached to the common header and there are three lines of tubes each contains 35 number of tubes being total of 70 number of tubes.

Analytical design of fluid cooler is stated. Input parameters are given as per the requirement and based on that parameters tower is designed. An iterative procedure is followed for tube bundle calculation until the outlet temperature of process fluid becomes equal to the required temperature. Height of the fill is calculated with the help of Merkle number. Pressure drop is calculated using the empirical relations which is used to select the fan.

Assumptions

In the theoretical analysis the following assumptions

i) the system is in a steady state,

ii) radiative heat transfer can be ignored

iii) Low mass transfer.

iv) Uniform distribution of recirculating water along each tube and complete wetting of the tube surface

v) The water film temperature at the air/water interface is approximately equal to the bulk film temperature.

vi) The temperature rise of the recirculating water because of pump work is negligible

vii) The air/water interface area is approximately the same as the outer surface of the tube bundle,

i.e. the water films on the tubes are very thin.

viii) The heat transfer to the surroundings from the U-bends outside the cooler or condenser can be assumed to be negligible.

Analytical design of Closed circuit Fluid cooler fluid cooler which includes tube bundle dimensions, number of tubes, arrangement of tubes, diameter of tubes etc. The iterative procedure is used for tube bundle design that deciding the number of tubes. As per this design we require

$2m \times 1.3m \times 0.9m$ tube bundle. Height of fill is also calculated which is used in selection of fills. Pressure drop across fills, air louvres, is calculated for selection of fan.

CONCLUSIONS

The conclusions drawn based on theoretical design and prototype validation are,

1. The model was tested was in good agreement with the theoretical design.
2. The model was validated and its cooling range is well matched with the theoretical range.
3. The pressure drop across fills also in the acceptable range as per code.
4. The tube bundle was also found effective in transferring its heat to water flowing over tube bundles.
5. The performance of Closed circuit fluid cooler is validated as per CTI ATC 105[S].

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