Optimization in Tube Bundels of Air cooled Heat Exchanger Analysis with HTRI Software

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Abstract:-*Considering the fact that the standby fan also contributes in heat transfer we analyze the heat exchanger in three different fan conditions. They are as follows:*

1. *Two fans working and one standby(as commonly used in industries),*
2. *All three fans remain off condition, so, only natural convection is possible,*
3. *Two fans are working, which transfers heat through forced convection and also include natural convection through one fan off.*

Then with the help of HTRI (Heat transfer research Inc.) software we analyze performance of all the three conditions and conclude that the number of tube bundles can reduce for same amount of heat transfer. This results in reduction of cost and weight of the heat exchanger.

Key word: *Air cooled heat exchanger, Fan, tube bundles, HTRI Software, carbon steel tubes.*

I. Introduction: -

Air-cooled heat exchangers are used across the globe for process cooling or condensing fluid. The operating principle for this is very straight forward; hot process fluid enters the tubes on one end while ambient air flows over and between the externally finned surfaces. The process of heat transferred to the air, cooling the process fluid while expelling the heated air into the atmosphere. While, this is a fundamentally a simple concept, maintaining optimum performance takes diligence on the part of the end user. An air-cooled exchanger is used to cool fluids with ambient air. Several articles 1have been published describing in detail their application and economic analysis. This section describes the general design of air-cooled exchangers and presen2s a method of approximate size.

II. Literature survey:-

Tung S. S. 1980:- Category: *Air-Cooled Heat Exchangers and Extended Surfaces*:-

Report is submitted in order to an attempt to cover current construction and design practices of air-cooled heat exchangers in a manner helpful to engineers, designers, and executives. The list of codes and standards, description of basic types of air-cooled heat exchangers, their applicability, methods of erection, description of common design of plenums, fan decks and fan rings, tube bundle specific features, headers, nozzle connections, fin types, and motor-fan drives are covered in this report. This report considers the merits of various design details and the methods of fabrication which were not covered in other HTRI reports.

G. Breber 1990:- *Category: Airflow Performance in Induced-Draft Air-Cooled Heat Exchangers*

The submitted test results, on selected aspects of the airflow performance in induced-draft air-cooler heat exchangers. The experiments were performed on a one-third scale model of a three-fan commercial installation built in 1985 and operated at the HTRI Research Facilities from 1985 to 1988. The research unit was 1.78-m (5-ft 10-in.) wide by 4.88-m (16-ft) long, with three 1.22-m (4-ft) diameter fans operating side by side. The unit was operated first in the forced-draft mode, and later, after modification, in the induced-draft mode. All tests were isothermal and the fans were built to scale with characteristic curves similar to those of large-size fans. The results are presented on the effects of bundle height above-ground, plenum depth, fan intake- blockage, multiple fan interactions, fan ring, and fan guard. The parameters investigated include total airflow rate, airflow distribution, fan power, and fan speed. Tests showed that significant reductions in airflow with adverse distributions will occur for a given fan power under certain system and geometry conditions. Methods and correlations are presented to quantify such effects.

III. Methodology:-

The methodology comprises of following steps discussed below:-

1. Firstly, we visit in Heat Exchanger plant to see and analyze its main working components then we analyze Heat Exchanger and its components.
2. We found there are some possibilities of reducing the material in Heat Exchanger
   We review the main parts of Heat Exchanger like tube bundle, fan, motor, structure steel etc.
3. We also review the thermal data sheet of Heat Exchanger which is generated by HTRI software & found the possibilities that by reducing Maximum tube bundle to minimize the tube bundles and reduce the heat exchanger cost.
4. In HTRI all values of the Heat exchanger tube thickness, outer diameter and inner diameter ,length of tube and material used in heat exchanger are given below:-

The thickness of the tube is 2.23 cm and length of the tube is according to three fan condition is10.5 meter.

Tube Geometry

Tube type		High - Finned
Tube outer diameter	mm	25.4
Tube inner diameter	mm	20.4
Length	mm	4499.945
Area ratio(out/in)	(-)	18.8571
Layout	Staggered	
Trans pitch	mm	63
Long pitch	mm	54.558
Number of passes	(-)	6
Number of rows	(-)	6
Tube count	(-)	288
Tube count odd/even	(-)	48/48
Tube material		**CARBON STEEL**

Fin Geometry

Type		Plain round
Fin/length	fin/meter	394
Fin root	mm	25.4
Height	mm	15.675
Base thickness	mm	0.432
Over fin	mm	57.15
Efficiency	%	84.1
Area ratio (fin/bare)	(-)	21.4885
Material		Aluminum 1060-H14

Fan Geometry

No/bay	(-)	3
Fan ring type (angle of cone)		30deg
Diameter	mm	2438
Ratio, Fan/bundle face area	(-)	0.48
Driver power	Kw	3
tip clearance	mm	12.19
Efficiency	%	75

In this topic we consider that the natural fan or stand by fan heat transfer rate. The value of all fan geometry and fin geometry remains same. This value is also same in the HTRI software and then finds the air flow rate in increasing order. This high flow rate is very suitable for heat exchanger and improves the performance.

IV. Experimentation and calculation:

In HRTI software we feed different values of fan working and natural draft condition through which we analyze the optimization process are applied in the air cooled heat exchanger and reduce the heat exchanger cost without decreasing the performance of heat exchanger. HTRI Optimization process through us reduces the tube bundles, save material and save manufacturing cost.

Considering the fact that the standby fan also contributes in heat transfer, we analyze the heat exchanger in three different fan conditions.

1. Two fans working and one standby as commonly used in industries,
2. All three fans remain off condition, so only natural convection is possible,
3. The two fans working, transfers heat through forced convection and also include natural convection through one fan off.
4. Run the case as an air-cooled heat exchanger (with two fan operating) divide the total airside mass flow rate by the number of fans to obtained the flow rate of one fan, W_{fanon}

   According to first condition, the two fan working and one fan is standby. Then normally power plants are considering only two fan performance. This through both fan total flow rate may be consider and third fan values are not to be consider.

Calculation of air cooled heat exchanger in two fan running condition.

Nomenclature

Variable	**Description**
W_{avg}	Average mass flow rate of natural and forced draft
W_{fanoff}	Mass flow rate of air with fan off
W_{fanon}	Mass flow rate of air with fan on
W_{forced}	Mass flow of air for forced draft
$W_{natural\ draft}$	Mass flow of air for natural draft

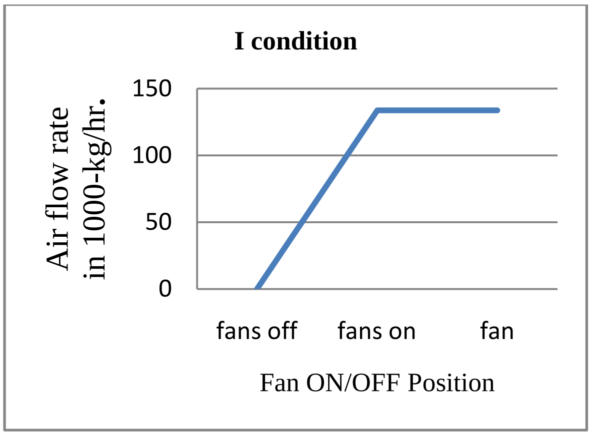
a) The process conditions flow rate of two fans is calculated and find the value of sens. Gas 267.776 (1000-kg/hr). In this testing two fan working only consider and number of tubes is taking 309 in air cooled heat exchanger.

Two fans produce 267.776 amount of flow rate so average flow of one fan is 133.88

W_{fanon} □ 267.776

W_{avg} □ 267.776/2□ 133.88 (1000-kg/hr)

Value of 133.88 (1000-kg/hr) is one artificial fan flow rate condition



FLOW GRAPH

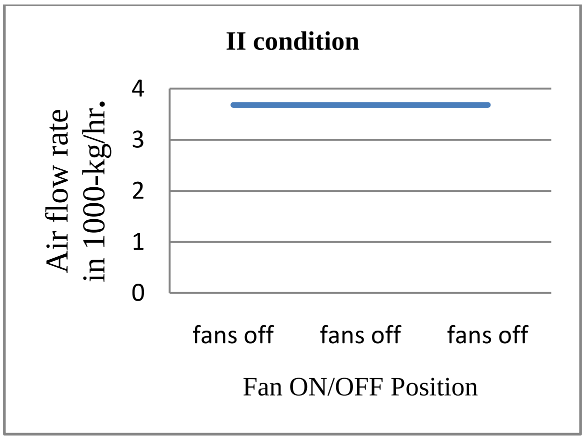
b) Run this case as a natural draft air cooler. Divide the total mass flow rate by the number of fans obtain the natural draft flow rate over one fan off, W_{fanoff}

All three fans remain off condition, so only natural convection is possible. But in this condition naturally air flow circulation is consider according to atmospheric condition, and calculate the flow rate of air and find the performance of heat exchanger.

The flow rate was taking by the HTRI software given the following value:

W_{fanoff} = Mass flow rate of air with fan of = 11.695

W_{avg} = Average mass flow rate = 11.695 of natural / 3 = 3.898 (1000-kg/hr)



FLOW GRAPH

c) Specify an airside mass flow rate on the process panel equal to the number of fan ON times plus the number of fans OFF times runs the case as an air cooled heat exchanger.

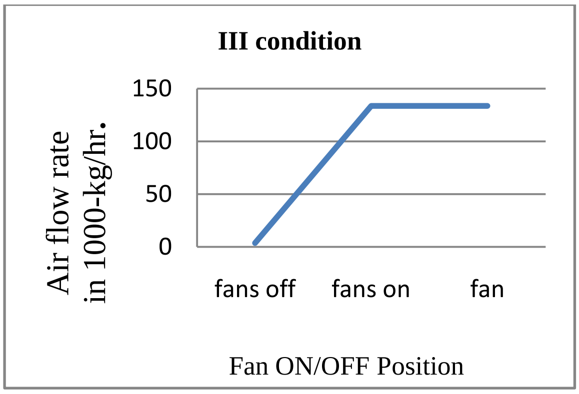
The two fans working which transfers heat through forced convection and also include natural convection through one fan off.

Add the flow rate of W_{fanon} and W_{fanoff} was taking by the HTRI software given the following value:

$W_{fan\ on}$ = Average mass flow rate = 267.776/2□ 133.88 (1000-kg/hr)

$W_{fan\ off}$ = Average mass flow rate = 11.695 of natural / 3 = 3.898 (1000-kg/hr)

W_{avg} = Average mass flow rate of fan on and off condition = 133.88+133.8+3.898
= 271.658 (1000-kg/hr)

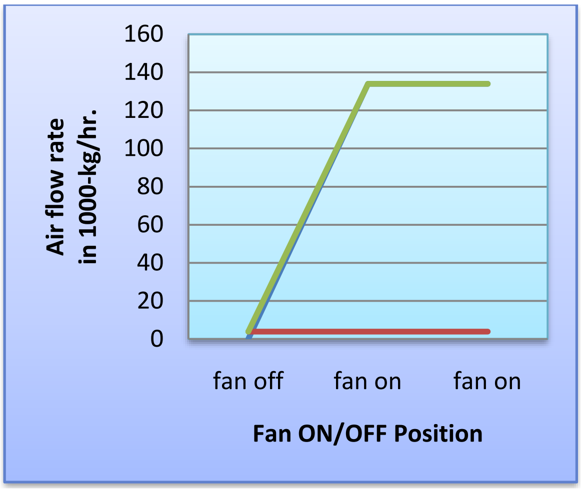


FLOW GRAPH

V. Conclusion:-

Find the different flow rate value in the HTRI software tested at three fans conditioning following observations are made:

S.NO	Condition of fan in heat exchanger	Air flow rate(1000-kg/hr)	Number of tubes required
1	Two fan working (artificial condition)	267.776	309
2	All fan off condition (natural condition)	11.695	309
3	Two fan working and one fan stand by position	272.5	288



Flow rate comparison

Other advantages of the single row technology are:

- Lower Pressure Drops Steam side/Airside
- Higher Thermal Efficiency
- Dead Zones Do Not Exist
- Lower Weight per Face Area
- Manufacturing cost reduce
- Save material
- Least price

References*:*

1. **M. McGEE : -** Engineer, engineering application, received his BS in chemical engineering from Texas A&M University, college station, Texas, USA.
2. **Briggs, D. E., Young, E. H:-** 1963 "Convection Heat Transfer and Pressure Drop of Air Flowing Across Triangular Pitch of Tubes," Chemical Engineering Progress Symposium Series, Volume 59, No. 41,
3. **Gardner, K. A:-** 1945 **"**Efficiency of Extended Surfaces," Trans ASME, Volume 67, , pp. 621-631.
4. **A. Ganguli 1986**:-Airflow Problems in Forced Draft Air-Cooled Heat Exchangers.
5. **R. S. Kistler 1994**; - Predicting Fans-Off Operation of Air-Cooled Heat Exchangers.
6. Monroe, R.C., "Minimizing Fan Energy Costs," Chemical Engineering, May 27, 1985, p. 141.