A Review on Parametric Study and Optimization of H-Type Finned Tube Heat Exchangers using Taguchi Method

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Abstract - **In order to improve the heat exchange efficiency and extend surface heat transfer, H-type finned tubes have been widely used in boilers and waste heat recovery in recent years. H-type finned tubes are derived largely from rectangle finned tubes. Because of their unique groove structure on the fin surface, H-type finned tubes have excellent anti-wear and anti-fouling performance.**

Keyword-: **fine efficiency, CFD, Taguchi method.**

I. INTRODUCTION

Heat exchangers are widely used in various industries, such as space heating, refrigeration, air conditioning, power stations, chemical plants, petrochemical plants, petroleum refineries and waste heat recovery process. A heat exchanger is a device used to transfer heat between one or more fluids, which may be separated by a wall to prevent mixing or may be in direct contact. In order to optimize heat exchangers, it is necessary to enhance heat transfer, decrease fan power and reduce volume of heat exchangers at the same time.

For many heat exchangers, air is often chosen as one of the working fluids while the other fluid is often water with high heat transfer coefficient. Hence it is especially important to improve the heat transfer at the air side of heat exchangers where the major thermal resistance lies. One of the important approaches is to use the extended heat transfer surface, such as plate fin [1], wave fin [2], louver fin [3], slit fin [4], etc. For industrial gases, such as gas of a boiler furnace and discharged gases from many engineering furnaces, discrete fins with rectangular shape are often used to enhance the gas convective heat transfer.

In recent years, with the developments in manufacturing techniques, the configurations of fins become more complicated, among which are the widely used H-type finned tubes in boiler economizer. H-type finned tube as shown in Fig. 1 is derived, in large part, from the rectangle-type finned tube. Because of its unique groove structure in fin surface, H-type finned tube has excellent anti-wear and anti-fouling performance, which is of great importance for the application in the heat exchangers of waste heat recovery. In addition, some heat transfer areas of the fin in the separation zone are removed to reduce the negative effect on heat transfer.

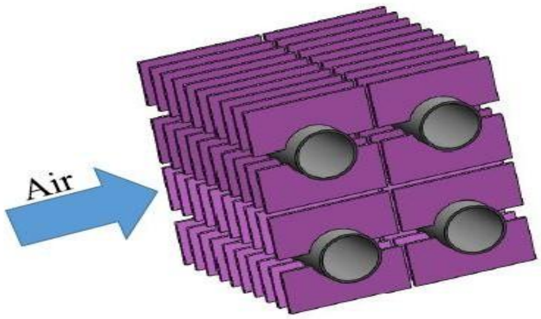

Fig.1. Schematic configuration of an H-type finned tube heat transfer surface.

II. LITERATURE SURVEY

Yu et al. studied the heat transfer and pressure drop characteristics of H-type finned tube banks by numerical simulation. The effects of geometric parameters and Reynolds number were examined.
Liu et al. carried out an experimental study on heat transfer and flow friction characteristics of H-type finned tube and proposed the correlations of Nusse. lt number (Nu) and Euler number (Eu).

Wang et al. numerically examined the heat transfer and resistance characteristics as well as the comprehensive performance of two kinds of H-type finned tube (single and double).

Zhang et al. employed the one-factor-at-a-time method to optimize the geometric parameters of H-type finned tube, including fin height, fin pitch, transverse pitch and longitudinal pitch, in order to achieve the best comprehensive performance.

Jin et al. numerically studied the effects of some parameters on heat transfer and pressure drop characteristics of H-type finned tube bank with 10 rows.

Chen et al. experimentally investigated the effects of fin height, fin width, fin pitch and air velocity on fin efficiency, convective heat transfer coefficient, integrated heat transfer capacity and pressure drop.

Wu et al. numerically studied the heat transfer characteristics of H-type finned tube in both staggered and in-line arrangement.

Jiang et al. proposed a novel H-type finned tube with longitudinal vortex generators and employed CFD method to study the external flow and heat transfer characteristics.

Yu et al., Chen and Lai and Wu et al. performed experimental tests to examine the heat transfer and resistance characteristics of H-type finned tube banks and provided some reference for the design of the H-type finned tube bundles. Much research is limited to single factor experiments, limiting the obtained experimental correlations due to restricted experimental conditions and different fin structures.

Wang et al. conducted numerical studies on the H-type finned oval tube with bleeding dimples and longitudinal vortex generators, where parametric effects of gas temperature, acid vapor concentration, water vapor concentration and Reynolds number on heat transfer and acid condensation were investigated. Zeng et al. numerically optimized some parameters of a vortex-generator fin-and-tube heat exchanger using Taguchi method.

Turgut et al. experimentally determined the optimal parameter for the concentric heat exchanger with injector turbulators using Taguchi method. However, no study has been done to make a comprehensive parametric optimization of H-type finned tube heat exchangers using Taguchi method, which can simplify the design process in terms of time and effort.

Zhang et al. carried out numerical simulation on heat transfer characteristics of H-type finned tube. The effects of the number of tube rows and longitudinal space on heat transfer coefficient were also analyzed. However, so far no systematic study has been conducted for the effects of geometric parameters on heat transfer and pressure drop characteristics of H-type finned tube. As far as the mechanism of heat transfer enhancement is concerned, in 1998, Guo et al. proposed a novel concept about the enhancement of convective heat transfer for parabolic flow and showed that the reduction of the intersection angle between the velocity and temperature gradient can effectively enhance the heat transfer. This concept is now called as field synergy principle. A lot of experimental and numerical studies have been conducted, showing that the field synergy principle could well explain the mechanism of the convective heat transfer enhancement. The examples in the above mentioned references are all in laminar flow.

III. FINNED TUBE

H fin tube known as square fin tube, There are two type of H fin tubes, one type with single tube, normal called square fin tube, the other with Double tube, normal called rectangular fin tubes. Due to rectangular shapes, which can offer large surface area compared to the Spiral Finned tubes. Due to larger surface area available, these finned tubes are used mostly in Air Heating application to reduce the overall size of the equipment.

H fin tube is a kind of boiler parts, to have two steel circular symmetry to be welded on fluorescent tubes to form fins positive shape much like letter "H", so called H-fin tube. H-economizer widely used in utility boilers, industrial boilers, marine power, such as the tail of heat exchanger components.

IV. CONCLUSION

A three dimensional numerical model of the H-type finned tube heat exchanger is performed. Based on Taguchi method, geometric parameters of the H-type finned tube are optimized. Five parameters (fin width, fin height, fin pitch, longitudinal tube spacing, and transverse tube spacing) are selected as the dependent variables. The optimization range of each factor is specified to three levels. Heat transfer and flow friction characteristics are two main aspects of heat exchanger performance so they are regarded as the objectives to be optimized. In addition, the overall thermal-hydraulic performance is set to be another objective in this study that takes both heat transfer and flow friction characteristics into account. The objective of the optimization is to reach the highest heat transfer and overall thermal-hydraulic performance as well as the lowest flow friction through combining optimal levels of the five geometric parameters.

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