AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING

EXPERIMENTAL INVESTIGATION OF THE PERFORMANCE OF A FIVE LAYERED GAS-TO-GAS HEAT EXCHANGER WITH A POROUS MEDIUM

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B.Sc. Mechanical Engineering, Power Section, 2009

A Thesis Submitted In Accordance With the Requirements for the Degree of Master of Science

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Cairo
2015

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Acknowledgement

I thank all who in one way or another contributed in the completion of this thesis. First, I give thanks to God for protection and ability to do work.

I am so grateful to the Faculty of Engineering at Ain Shams University for making it possible for me to study here. I give deep thanks and gratitude to my supervisor, Prof. Dr. Hussein Zaky Barakat, for introducing me to the topic as well for the support on the way.

Furthermore I would like to thank Dr.Nashwa Abbas Mohamed for the useful comments, remarks and engagement through the learning process of this master thesis.

My special thanks to Mr. Amin Abd El-Latif the lab supervisor for his assistance.

I also thank my family who encouraged me and prayed for me throughout the time of my research and always.

Abstract

This thesis works investigate experimentally the influence of the insertion of porous segments with different thicknesses and same composition on heat transfer enhancement and the pressure drop as these are the most determining factors in most engineering applications. The experimental research is done on a new designed five-layered radiant type of gas-to-gas heat exchanger.

The present study is concerned about the convective-radiant heat exchanger between the two air streams (hot stream, and cold stream) as they flow inside the proposed heat exchanger.

In this experimental work, the objective is to study the effect of the variation of each of the hot and cold air volume flow rates (which are changed together to same values and to different values as well) and the thickness of porous material on the cold air outlet temperature, the hot air outlet temperature, the heat gained by cold air, the heat rejected by hot air, the heat loss, the heat recovery ratio, and the pressure drop across each of the heat exchanger chambers.

This is done in order to investigate the optimum thickness of porous material to achieve the maximum heat recovery ratio, while the other operating parameters remain unchanged and the optimum air volume flow rate to achieve the maximum heat recovery ratio for each layer thickness under the same operating condition. Also, to investigate the pressure drop corresponding to each case.

For the purpose of increasing the heat recovery rate especially in the lower temperature region, the same experiments were conducted using the walls with corrugated shaped fins.

The key parameters in the present experiments are selected as follows; inlet gas temperature of the HT: 100, 200, 300, 400 and 500℃. Thickness of aluminum oxide porous plate: 30 to 70 mm. Volume flow rates of hot and cold air changes from 0.2 m^3/min. to 0.5 m^3/min.

Porous media has large contact surface with fluids which enhance the heat transfer performance. Hence, introducing a porous medium into the heat exchanger chambers efficiently improves the heat transfer performance of the heat exchanger. It is found that using porous material of 50mm thickness is the optimum value because after increasing the thickness beyond 50mm, the total heat recovery ratio reaches an asymptotic value.

It is also found that the pressure drop across each of the heat exchanger chambers is negligible in the case of no porous segments insertion in both cases of bare and finned heat exchangers. With the insertion of porous media the pressure drop has increased up to 3767.5 kPa with bare and 4178.5 kPa with finned walls.

The finned walls are quite effective to promote heat recovery from the high temperature gas. Increasing the hot air inlet temperature has increased the heat recovery rate due to the role of the radiant heat transfer from the porous segments to the enclosure and fins.

Nomenclature

$\dot{m}$	Air mass flow rate………………………………......	kg/sec.
$c_{p,c}$	Cold air specific heat capacity at constant pressure...	J/kg.K
$c_{p,h}$	Hot air specific heat capacity at constant pressure…	J/kg.K
$T_{c,i}$	Cold air inlet temperature…………………………..	℃
$T_{c,o}$	Cold air outlet temperature…………………………	℃
$\bar{T}_c$	Average cold air temperature………………………	℃
$T_{h,i}$	Hot air inlet temperature……………………………	℃
$T_{h,o}$	Hot air outlet temperature…………………………..	℃
$\bar{T}_h$	Average hot air temperature…..……………………	℃
$H_{R.}$	Heat recovery ratio……………………………	--
Q_h	Rejected heat rate by the hot air…………………….	Watt
Q_c	Heat recovery rate………………………………..	Watt
$\%Q_{loss}$	Percentage of heat loss……………………………...	%
τ	Optical thickness of porous material plate………….	--
HR1	First Heat Recovery Section……………………..	
HR2	Second heat recovery section……………………	
HR3	Third heat recovery section………………………	
HT1	First high temperature section……………………	
HT2	Second high temperature section…………………	
HL	Low temperature chamber……………..………..	

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Chapter 1

Introduction

The process of heat exchange between two fluids that are at different temperatures occurs in many engineering applications. The device used to implement this exchange is termed a heat exchanger.

In some cases, a solid wall may separate the fluids and prevent them from mixing. In other designs, the fluids may be in direct contact with each other. In the most efficient heat exchangers, the surface area of the wall between the fluids is maximized while simultaneously minimizing the fluid flow resistance. Fins or corrugations are sometimes used with the wall in order to increase the surface area and to induce turbulence.

Heat exchangers are essential elements in a wide range of systems, including the human body, automobiles, computers, power plants, and comfort heating/cooling equipment. Specific applications may be found in space heating and air-conditioning, power production, waste heat recovery, and chemical processing.

Heat Exchangers are used in a wide variety of specific applications as in the process, power, industries space heating and air-conditioning, refrigeration, cryogenics, waste heat recovery, and manufacturing and chemical processing. In the power industry, various kinds of fossil boilers, nuclear steam generators, steam condensers, regenerators, and cooling towers are used. In process industry, two-phase flow heat exchangers are used for vaporizing, condensing, freezing in crystallization, and as fluidized beds with catalytic reactions. The air conditioning and refrigeration industries need large amount of condensers and evaporators.

Heat Exchangers are typically classified according to *flow arrangement* and *type of construction*.