Thesis for Master Degree

Development of an Eco-friendly High-Efficiency Heat Exchanger Providing Healthy Indoor Environment with a Minimum Energy Loss or Gain

Pham Minh Man

Department of Mechanical and Automotive Engineering

Graduate School, Inje University

Advisor : Prof. Dae Hee Lee

Development of an Eco-friendly High-Efficiency Heat Exchanger Providing Healthy Indoor Environment with a Minimum Energy Loss or Gain

Pham Minh Man

Department of Mechanical Engineering

Graduate School, Inje University

A thesis submitted to the Graduate School of
Inje University in partial fulfillment of the requirements
for the degree of Master of Science Degree

Advisor : Professor Dae Hee Lee

Dec. 2013

Approved by committee of the Graduate School of Inje University in partial fulfillment of the requirements for the Master of Science Degree for PHAM MINH MAN

Committee Chairman Hyung Man Kim (signature)

Committee Member Moo Geun Kim (signature)

Committee Member Dae Hee Lee (signature)

Graduate School, Inje University

Dec. 2013

ABSTRACT

Development of an Eco-friendly High-efficiency Heat Exchanger Providing a Healthy Indoor Environment with a Minimum Energy Loss or Gain

Pham Minh Man

(Advisor: Professor Dae Hee Lee)

Department of Mechanical Engineering

Graduate School, Inje University

This thesis provides a new cross-counter-cross plate-type- aluminums heat exchanger with a minimum energy loss or gain. The experimental results showed that the heat exchanger is highly efficient, which contributes an excellent idea of reducing energy loss from air-to-air flow streams. It also showed that the cross-counter-cross heat exchanger unit, including eighty plates of 0.2 mm-thick aluminum sheets which are arranged in cross-counter-cross order of flow, achieved the highest efficiency. It can minimize the temperature difference between indoor air and outdoor air, thereby keeping the indoor temperature nearly constant. Besides, this heat exchanger is capable of supplying fresh outdoor air and exhausting contaminated indoor air, improving the quality of indoor air with a low carbon dioxide

concentration. An additional innovative feature of this heat exchanger is to effectively remove dust from incoming outdoor air, using a filter unit which consists of a plurality of poles, each having a semi-circular cross-section so that turbulent eddies are generated when the outdoor air collides on the concave surface of pole and the dust falls down. The current research results show that the carbon dioxide concentration inside the room decreased by 65% from 1350-ppm to 450-ppm, while the room temperature difference was maintained within $\pm$ 1.5°C before and after the operation of the heat exchanger. The maximum effectiveness of 0.909 occurred at an air flow rate of 76.5m^3/h. The effectiveness of the heat exchanger takes into consideration the limitations of heat transfer between two airflows due to these parameters. In addition, the performance of the heat exchanger is governed by various parameters like mass flow rates, pressures, and temperatures of working airflows.

Keywords: Plate-type Heat Exchanger, cross-counter-cross flows, Eco-friendly, Concentration of Carbon Dioxide, Heat Exchanger Effectiveness, ε – NTU Method.

Table of content

List of tables and figures

Nomenclatures

A_{total}	:*Total surface area of heat exchanger*	[m^2]
c	:*Specific heat*	[J/kg°C]
C	: *Capacity ratio,* $C = \mathrm{C_{min}} / \mathrm{C_{max}}$.	
C_{min}	:*Capacity rate of the minimum fluid*	[W/°C]
C_{max}	:*Capacity flow of the maximum fluid*	[W/°C]
h	:*Convection heat transfer coefficient*	[W/m^2°C]
k_{al}	:*Thermal conductivity of aluminum*	[W/ m°C]
$\dot{m}$	:*Mass flow rate*	[kg/s]
NTU	:*Number of Heat Transfer Unit*	
Q	:*Heat transfer rate*	[W]
t	:*Aluminum foil thickness*	[m]
T_{Oo}	:*Temperature of outdoor air outlet*	[°C]
T_{Oi}	:*Temperature of outdoor air inlet*	[°C]
T_{Io}	:*Temperature of indoor air outlet*	[°C]
T_{Ii}	:*Temperature of indoor air inlet*	[°C]
U	:*Overall heat transfer coefficient*	[W/m^2°C]
ε	:*Effectiveness of heat exchanger*	[%]
ε_{cross}	:*Effectiveness of cross-flow arrangement*	[%]
$\varepsilon_{counter}$	:*Effectiveness of counter-flow*	[%]

	arrangement	
$\dot{V}$	*:Volume flow rate*	[m^3/h]
v_m	*:Mean specific volume*	[m^3/kg]
σ	*:The ratio of the free-flow area to frontal area*	
$\Re$	*:The free-flow area*	[m^2]
$\Re_c$	*:The frontal area*	[m^2]
G	*:Mass velocity*	
f	*:The Friction factors* $f = \frac{24}{\text{Re}}$	
Δp	*:Pressure-drop*	[Pa]