AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Mechanical Power Engineering Department

Experimental Study of a Liquid-to-Air Heat exchanger Using Copper Woven Wire Mesh

A Thesis submitted in partial fulfillment of the requirement of the M.Sc. in Mechanical Engineering

by

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Bachelor of Science in (Mechanical Power Engineering), 2014

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Statement

This thesis is submitted as a partial fulfilment of M. Sc. Degree in Mechanical Power Engineering, Faculty of Engineering, Ain Shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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Thesis Summary

Liquid-to-air cross-flow heat exchangers have a low heat transfer coefficient on the gas side due to poor thermal characteristics of air. One of the conventional solutions of this problem is to attach extended surfaces on the gas side, thus increasing the surface area of heat to transfer by convection. In this study, experiments were carried out to evaluate the thermal and hydraulic performance of four modules of cross flow heat exchangers. One is bare copper tubes and three wire mesh heat exchangers of different mesh spacing. Hot distilled water was pumped into the copper tubes at a constant flow rate of 9 l/min and inlet temperature of 80ºC. The heat exchanger was subjected to external cross airflow inside an air duct of 20 cm x 20 cm cross-sectional area with an average air velocity of 2.8 m/s up to 14.9 m/s. Results showed an enhancement of Nusselt number for all wire mesh modules that is an increase of the volumetric heat transfer coefficient of up to 113.9% among the three tested modules, compared to the bare module. The significance of this study is to use reasonably-priced wire mesh and maintain enhancement of the rate of heat transfer.

Keywords:

Cross flow heat exchanger, wire mesh heat exchanger, porous structure.

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List of Publications

1- M.A. Sayed, A.M.T.A. ELdein Hussin, N.A. Mahmoud, and W. Aboelsoud, "Performance evaluation of wire mesh heat exchangers". Applied Thermal Engineering Journal, 2020, Vol. 169.

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2- M. A. Sayed, A. M.T. A. ELdein Hussin, W. Aboelsoud and N. A. Mahmoud, "Experimental investigation of thermal and pressure drop performance of cross-flow wire mesh heat exchangers". Journal of Al Azhar University Engineering Sector, 2020, Vol. 15.

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Nomenclature

Symbol	Description	Units
A_c	Duct cross-section area	$[m^2]$
A_{in}	Inside tube surface area.	$[m^2]$
A_{out}	Outer tube surface area	$[m^2]$
AU	Overall heat transfer conductance	[W/K]
c_p	Specific heat at constant pressure	[J/kg.K]
c_{cold}	Specific heat of cold fluid	[J/kg.K]
c_{hot}	Specific heat of hot fluid	[J/kg.K]
C_{min}	Minimum heat capacity rate	[W/K]
d_h	Hydraulic diameter	[m]
d_{in}	Tube inside diameter	[m]
d_{out}	Tube outside diameter	[m]
d_W	Wire diameter	[mm]
f_w	Water flow friction factor	[-]
F	Correction factor	[-]
h_{in}	Tube inside heat transfer coefficient	$[W/m^2.K]$

h_{out}	Outer air convection heat transfer coefficient	[W/m^2.K]
h_V	Outer volumetric convective heat transfer coefficient	[W/m^3.K]
k_{air}	Thermal conductivity of air	[W/m.K]
k_{pipe}	Thermal conductivity of pipe material	[W/m.K]
k_w	Thermal conductivity of water	[W/m.K]
l_{duct}	Air duct side length	[m]
l_P	Copper pipe length	[m]
$\dot{m}$	Mass flow rate	[kg/s]
Nu_i	Nusselt number for the inner hot water side	[-]
Nu_o	Nusselt number based on the outer tube diameter	[-]
Np	Number of pipes	[-]
ΔP	Air pressure drop across heat exchanger module	[Pa]
ppi	Pore per inch	[-]
P/V	Pumping power per unit volume of heat exchanger module	[W/m^3]
Pr_w	Prandtl number for internal water flow	[-]
P_w	Wetted perimeter	[m]
$\dot{Q}_w$	Hot water heat transfer rate	[W]