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Heat transfer and friction characteristics of crimped spiral finned heat exchangers with dehumidification

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Abstract

This study experimentally examines the air-side performance of a total of 10 cross flow heat exchangers having crimped spiral configurations under the dehumidification. The effect of tube diameter, fin spacing, fin height, transverse tube pitch, and tube arrangements are examined. The results indicate that the heat transfer coefficient of wet surface is slightly lower than that of dry surface. The effect of tube diameter on the air-side performance is significant. Larger tube diameter not only gives rise to lower heat transfer coefficient but also contributes significantly to the increase of pressure drops. This phenomenon is applicable in both dry and wet condition. For wet surface, the influence of fin height is negligible and the effect of fin spacing on the heat transfer performance is rather small. However, increasing of the fin spacing tends to have a lower heat transfer coefficient. The tube arrangement plays an importance role on the heat transfer coefficient, narrower transverse pitch gives higher heat transfer coefficient. The proposed correlations can predict 75% and 95% of experimental data within 15%.

Keywords: Air-side performance; Dehumidification; Crimped spiral fins

1. Introduction

The cross flow heat exchanger plays an important role in waste heat recovery process, especially, in economizer where flue gas is exchanging heat with water. Normally, the water is always

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Nomenclature

A_{min} minimum free flow area (m^2)
A_o total surface area (m^2)
$A_{p,i}$ inside surface area of tube (m^2)
$A_{p,m}$ mean surface area of tube (m^2)
$A_{p,o}$ outside surface area of tube (m^2)
b'_p slope of straight line between the outside and inside tube wall temperature (J/kg K)
b'_r slope of the air saturation curved at the mean coolant temperature (J/kg K)
$b'_{w,m}$ slope of the air saturation curved at the mean water film temperature of the external surface (J/kg K)
$b'_{w,p}$ slope of the air saturation curve at the mean water film temperature of the primary surface (J/kg K)
$C_{p,a}$ moist air specific heat at constant pressure (J/kg K)
$C_{p,w}$ water specific heat at coolant pressure (J/kg K)
d_f outside diameter of finned tube (m)
d_i tube inside diameter (m)
d_o tube outside diameter (m)
f friction factor
f_h fin height (m)
f_i in-tube friction factor of water
f_s fin spacing (m)
f_t fin thickness (m)
F correction factor
G_{max} maximum mass velocity based on minimum flow area ($kg/m^2 s$)
$h_{c,o}$ sensible heat transfer coefficient for wet coil ($W/m^2 K$)
h_i inside heat transfer coefficient ($W/m^2 K$)
$h_{o,w}$ total heat transfer coefficient for wet external fin ($W/m^2 K$)
I_0 modified Bessel function solution of the first kind, order 0
I_1 modified Bessel function solution of the first kind, order 1
i air enthalpy (J/kg)
$i_{a,in}$ inlet air enthalpy (J/kg)
$i_{a,out}$ outlet air enthalpy (J/kg)
$i_{r,m}$ saturated air enthalpy at the mean refrigerant temperature (J/kg)
$i_{r,in}$ saturated air enthalpy at the inlet of refrigerant temperature (J/kg)
$i_{r,out}$ saturated air enthalpy at the outlet of refrigerant temperature (J/kg)
$i_{s,p,i,m}$ saturated air enthalpy at the mean inside tube wall temperature (J/kg)
$i_{s,p,o,m}$ saturated air enthalpy at the mean outside tube wall temperature (J/kg)
$i_{s,w,m}$ saturated air enthalpy at the mean water film temperature of the external surface (J/kg)
Δi_m mean enthalpy difference (J/kg)
j the Colburn factor