

**Experimental Study for the Fully-developed Single-phase Heat
Transfer and Friction Factor in Micro-fin Tube**

by

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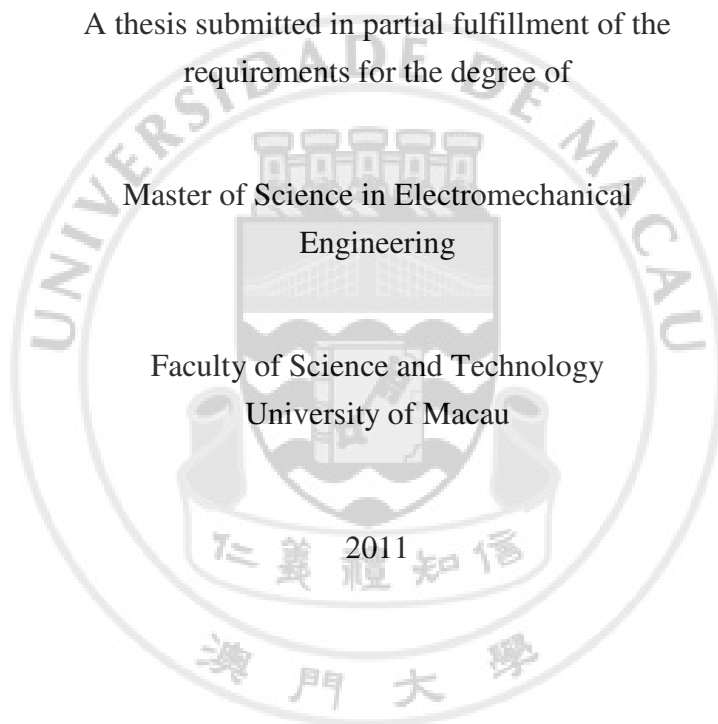
by

Chu Wun Wai

A thesis submitted in partial fulfillment of the
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Date _____

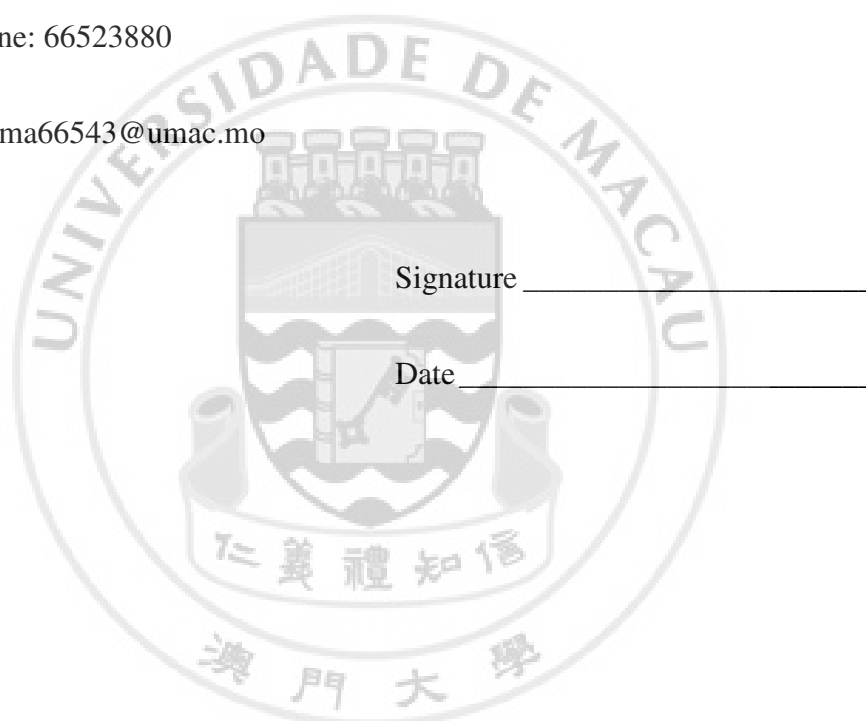
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Abstract

Experimental Study for fully-developed Single-Phase Heat Transfer and Friction
Factor in Micro-fin Tube

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To increase heat transfer, internally micro-fin tubes are widely used in commercial HVAC applications. It is commonly understood that the micro-fin enhances heat transfer but at the same time increases the pressure drop as well. In the previous studies, majority of the works were focused on the development of correlations in a particular flow regime, especially in the turbulent region. There are only a few works that fundamentally studied the continuous change in the characteristic behavior of heat transfer and pressure drop from laminar to transition and eventually the turbulent regions. Therefore, more in-depth study is necessary. In this study, heat transfer and pressure drop were measured simultaneously in a micro-fin tube and compared with the data of a plain tube. To ensure the data reliability, the micro-fin tube data were also compared with the existing correlations. From the micro-tube results, the heat transfer and friction factor characteristics from laminar to turbulent were clearly established. The transition from laminar to turbulent was found to be inlet dependent. Furthermore, it was observed that the buoyancy effect was present in the laminar region. Based on the heat transfer and friction factor characteristics, the correlations for micro-fin tube were developed by the empirical regression method. The efficiency index (the ratio of the heat transfer and the friction factor of micro-fin tube to those variables for the plain

tube) was examined and it was found to have a value larger than one when Reynolds number was larger than 5000 regardless of the type of inlet configuration used. Based on the experimental results, it is recommended that the micro-fin tube should not be used when the Reynolds number is less than 5000 since the efficiency index is less than one.



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GLOSSARY

C_f	fully developed friction factor coefficient (fanning friction factor), ($=\Delta P \cdot D_i / 2 \cdot L \cdot \rho \cdot V^2$), dimensionless
c_p	specific heat of the test fluid evaluated at T_b , J/(kg·K)
D_i	inside diameter of the test section (tube), m
D_o	outside diameter of the test section (tube), m
e	internal fin height, mm
h	fully developed peripheral heat transfer coefficient, W/(m ² ·K)
j	Colburn-j factor [$=St \cdot Pr^{0.67}$], dimensionless
k	thermal conductivity evaluated at T_b , W/(m·K)
L	length of the test section (tube), m
N_s	Number of starts/fins inside the cross-section area, dimensionless
Nu	local average or fully developed peripheral Nusselt number ($= h \cdot D_i / k$), dimensionless
p	axial fin pitch, [$=\pi \cdot D_i / (N_s \cdot \tan \alpha)$], m
Pr	local bulk Prandtl number ($=c_p \cdot \mu_b / k$), dimensionless
Re	local bulk Reynolds number ($=\rho \cdot V \cdot D_i / \mu_b$), dimensionless
St	local average or fully developed peripheral Stanton number [$=Nu / (Pr \cdot Re)$], dimensionless
T_b	local bulk temperature of the test fluid, °C
T_w	local inside wall temperature, °C
V	average velocity in the test section, m/s
x	local axial distance along the test section from the inlet, m
α	Spiral angle, degree
η	efficiency index, dimensionless
ΔP	pressure difference, Pa

μ_b absolute viscosity of the test fluid evaluated at T_b , Pa·s

μ_w absolute viscosity of the test fluid evaluated at T_w , Pa·s

ρ density of the test fluid evaluated at T_b , kg/m³



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