

**Development of Heat Transfer Correlation and
Flow Regime Map for Heated Horizontal Pipe
Using Support Vector Machines**

by

Cheong Chan Wa

Master of Science in Electromechanical Engineering



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Map for Heated Horizontal Pipe Using Support Vector
Machines

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仁美禮知信

澳門大學

Approved by _____
Supervisor

Date _____

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Address:

Telephone: (+853) 66510652

Fax:

E-mail: Johnson@idq.org.mo

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University of Macau

Abstract

DEVELOPMENT OF HEAT TRANSFER CORRELATION
AND FLOW REGIME MAP FOR HEATED HORIZONTAL
PIPE USING SUPPORT VECTOR MACHINES

by Cheong Chan Wa

Thesis Supervisor: Prof. Tam Lap Mou
Master of Science in Electromechanical Engineering

In the field of thermal engineering and commercial HVAC applications, heat exchanger is one of the most important equipment. For practical design of heat exchanger, it is important to study the heat transfer characteristics of pipe flow such as the identification of the flow regime and the prediction of the heat transfer performance. In recent years, Ghajar and his co-workers (1994, 1995 and 2006) successfully developed heat transfer correlations and flow regime maps for horizontal circular pipes under uniform wall heat flux boundary condition and three different inlet configurations (re-entrant, square-edged, bell-mouth). The heat transfer correlations and the boundary lines of the flow regime map were developed based on the traditional method such as least-squares method with specified functional form. Recently, Support Vector Machines (SVM) were widely successfully applied for regression problem and classification problem (Chen et al., 2006, Vong et al., 2006, Trafalis et al., 2005). Therefore, the SVM method is proposed for development of heat transfer correlation and flow regime maps for heated horizontal pipe. The results show that the new flow regime map can classify the forced and mixed convection experimental data of Ghajar and Tam (1994) into different flow regimes with good accuracy, and the new heat transfer correlation can predicted majority of the transitional forced and mixed convection experimental data of Ghajar and Tam (1994) within 5% deviation.

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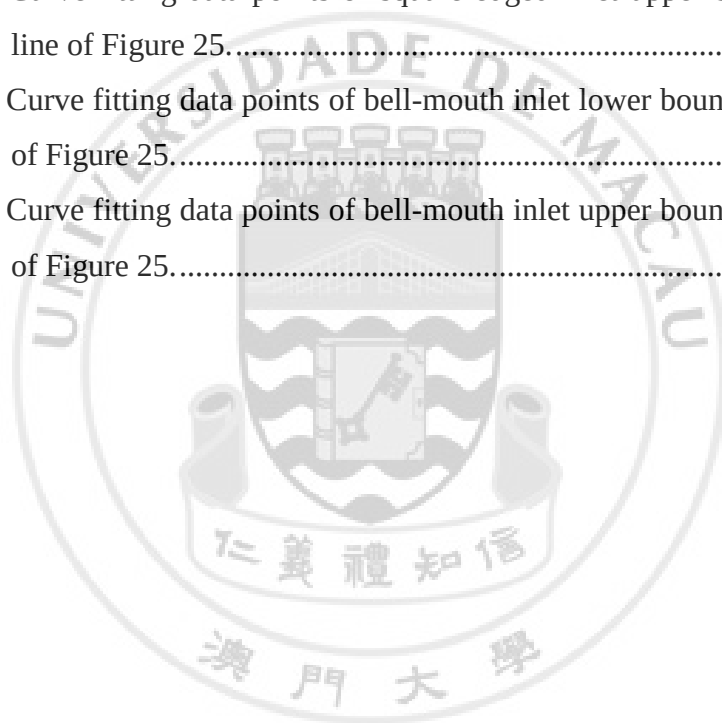
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NOMENCLATURE

b = bias term

c_p = specific heat at constant pressure, kJ/(kg-K)

$f(x)$ = activation (or transfer) function

g = acceleration of gravity, m/s²

Gr = local bulk Grashof number ($= g\beta\rho^2D^3(T_w-T_b)/\mu_b^2$)

h = local heat transfer coefficient, W/(m²-K)

h_t = local peripheral heat transfer coefficient at the top of tube, W/(m²-K)

h_b = local peripheral heat transfer coefficient at the bottom of tube, W/(m²-K)

j = Colburn j-factor ($= StPr^{0.67}$)

k = thermal conductivity, W/(m²-K)

Nu = local average or fully developed peripheral Nusselt number ($= hD/k$)

Pr = local bulk Prandtl number ($= c_p\mu_b/k$)

Ra = local bulk Rayleigh number ($= GrPr$)

Re = local bulk Reynolds number ($= \rho VD/\mu_b$)

St = Stanton number ($= Nu/Re Pr$)

T_b = local bulk temperature, °C

T_w = local wall temperature, °C

V = average velocity in the test section, m/s

x = local distance along the test section from the inlet, m

β = coefficient of thermal expansion, K⁻¹

μ_b = local bulk dynamic viscosity, Pa-s

μ_w = local wall dynamic viscosity, Pa-s

ρ = local bulk density, kg/m³

LIST OF ABBREVIATIONS

SVM = support vector machines

SVR = support vector regression

MSE = mean squared error

RBF = radial basis function



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