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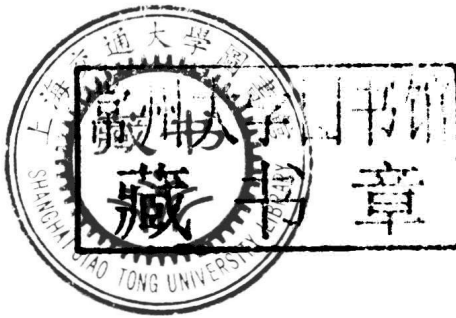
**Heat Transfer and Fluid Flow
with Entropy Generation in a
Porous Duct**

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Wissam H. Khalil

**Heat Transfer and Fluid Flow with Entropy Generation in a Porous
Duct**

Republic of Iraq
Ministry of Higher Education
University of Technology
Department of Mechanical
Engineering



Numerical and Experimental Study of Heat Transfer and Fluid Flow with Entropy Generation in a Square Porous Duct

A Thesis

*Submitted to Department of Mechanical Engineering/
University of Technology in Partial Fulfillment of the
Requirements for the Degree of Doctor of Philosophy*

In

*Mechanical Engineering
Baghdad - Iraq*

By

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2010

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا
إِلَّا مَا عَلَّمْتَنَا إِنَّكَ أَنْتَ
الْعَلِيمُ الْحَكِيمُ .

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Finally, I would like to apologize to my family for the long period that consumed in completing this work, and for the pain caused by me.

Wissam

Dedications

First of all, I offer my apologize to every one for sever waiting.

I would like to present my dedication to the soul of my father who waits for a long time and departs without delight.

***My dedication presented to my parents, my dearest mother (may Allah protect her), my brothers, my sisters, my sons (Ghassan, Ahmed, Sarah) with my love
Before of all and after of all I wish to present my dedication to my wife with my hope that this will improve her health.***

Wissam

Supervisors certification

We certify that the preparation of this thesis entitled "**Numerical and Experimental Study of Heat Transfer and Fluid Flow with Entropy Generation in a Square Porous Duct**" is made under our supervision in the Mechanical Engineering Department of the University of Technology, in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Mechanical Engineering.

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I certify that this thesis entitled "**Numerical and Experimental Study of Heat Transfer and Fluid Flow with Entropy Generation In a Square Porous Duct**" is prepared under my linguistic supervision. Its language was amended to meet the style of the English language.

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Title: Lecturer

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NOMENCLATURE

Symbol	Description	Dimension
A	Cross sectional area of test section	m^2
a	Cross sectional area of test section	m^2
$a_E, a_W, a_N, a_S,$ a_R, a_L	Coefficient in General Finite-Volume Equation	-
B	Dimensionless pressure gradient	-
C_p	Specific heat at constant pressure	$J/kg \cdot K$
$\cos\theta$	Power factor	-
D_h	Hydraulic diameter	m
D_p	Particle diameter(porous media)	m
D	Distance	m
F_v	Drag factor	-
F	Friction factor	-
g	Gravitational acceleration	m/s^2
H	Height	m
H	Boundary condition of constant heat flux	-
h	Heat transfer coefficient	$W/m^2 \cdot ^\circ C$
I	Current	Ampere
i,j,k	Indices which indicate positions in the (x, y, z) direction	-
K	Porous media Permeability	m^2
k	Thermal conductivity	$W/m \cdot ^\circ C$
L	Channel Length	m
\dot{m}	Mass flow rate	kg/s

Symbol	Description	Dimension
P	Pressure	N/m ²
Q	Total input power	W
q	Power absorber water	W/m ²
S	Entropy	W/m.°C
S _{gen.}	Entropy generation per unit volume	W/m ³ .°C
S	Spacing	m
T	Temperature	°C
T	Boundary condition of constant wall Temperature	-
t	Time	s
U,V,W	Non-dimensional velocity components	-
u,v,w	Velocity componenets	m/s
V	Electrical voltage	Volt
W	Rate of work done	W
w	Duct width	m
X _{th}	Thermal dimensionless entrance length	m
X,Y,Z	Non-dimensional axis	-
x,y,z	Coordinate axis	m

GREEK SYMBOLS

Symbol	Description	Dimension
θ	Dimensionless temperature, $\frac{T - T_w}{T_{in} - T_w}$	-
α	Thermal diffusivity	m/sec ²
γ	Shape parameter of porous media	-
\mathcal{E}	Porosity	-