Alternative Energy

Edited by

A.K.M. Mohiuddin
Asif Hoda

IIUM Press
# Table of Contents

Table of Contents ........................................................................................................ v  
Preface .................................................................................................................... viii  
Chapter 1  
The Impact of energy utilization on environment ...................................................... 1  
M.N.A. Hawlader  
Chapter 2  
Desalination of Seawater to provide fresh water ...................................................... 9  
M.N.A. Hawlader  
Chapter 3  
A solar assisted desalination system using heat pump ............................................. 16  
M.N.A. Hawlader, Leong Chiing Yang  
Chapter 4  
An experimental study of a phase change storage system ................................... 23  
M.N.A. Hawlader and Smita Panga  
Chapter 5  
Moisture migration in a grain column subjected to drying .................................. 30  
M.N.A. Hawlader and Md. Shafique J. Chowdhury  
Chapter 6  
Solar Drying of Guavas, Papayas and Apples ....................................................... 38  
M.N.A. Hawlader and Lee Hwee Peng  
Chapter 7  
Drying under inert environment: the quality of Mango and Rockmelon .......... 47  
M.N.A. Hawlader and Pan Jiahe  
Chapter 8  
A low temperature flat plate solar collector ......................................................... 53  
M.N.A. Hawlader, M. Zakir Ullah and Maung Than Htut  
Chapter 9  
Optimization of an integrated solar heat-pump system ........................................ 60  
M.N.A. Hawlader and Ye Shaochun  
Chapter 10  
Comparative study of performance characteristics using Jatropha Oil Methyl Esters Biodiesel and Diesel ................................................................. 69  
A.K.M. Mohiuddin and Azan Mohd  
Chapter 11  
Comparative Study of Emission Characteristics using Jatropha Oil Methyl Esters Biodiesel and Diesel ................................................................. 74  
A.K.M. Mohiuddin and Azan Mohd  
Chapter 12  
Waste Cooking Oil Utilization for Biodiesel Production ...................................... 79  
A.K.M. Mohiuddin and Nabeel Adeyemi  
Chapter 13  
Flow Characteristic of Mixing Impeller for Liquid-Liquid Mixing ..................... 85  
A.K.M. Mohiuddin and Nabeel Adeyemi  
Chapter 14  
Solar Energy Management for Poverty Alleviation and Income Generating Activities .... 91  
A.K.M. Mohiuddin
Chapter 15
Turbulence model for axial mixing impeller in unbaffled vessel.................................................. 97
A.K.M. Mohiuddin, Nabeel Adeyemi and Muhamad Husaini

Chapter 16
Optimization and economic analysis of a solar assisted heat pump drying system............... 103
M.N.A. Hawlader, S. M. A. Rahman and K.A. Jahangeer

Chapter 17
A solar heat pump water heater for rural hospitals................................................................. 117
M.N.A. Hawlader and M. Zakir Ullah

Chapter 18
A solar heat-pump system for air-conditioning, water heating and drying......................... 126
M N A Hawlader, K A Jahangeer, Ye Shaochun and Choy Tack Hoon

Chapter 19
Engineering design – An approach to the development of creativity................................. 132
M.N.A. Hawlader

Chapter 20
Analysis of Engine Performance with NGV ............................................................................ 140
Sany Izan Ihsan, Nabila Sulaiman, AKM Mohiuddin and Maizirwan Mel

Chapter 21
Analysis of Engine Performance with Enhanced Fuel......................................................... 147
Sany Izan Ihsan, Khairussani Farid, Maizirwan Mel, and AKM Mohiuddin

Chapter 22
CFD analysis of an evacuated solar still................................................................. 156
Ahmad F. Ismail, Mirghani I. Ahmed, Yousif A. Abakr

Chapter 23
Developments on Solar Operated Water Desalination..................................................... 163
Mirghani I. Ahmed, Yousif A. Abakr and Ahmad F. Ismail

Chapter 24
Theoretical and experimental evaluation of LPG as refrigerator for domestic refrigerators and freezers................................................................. 169
M.M. El-Awad, M.I. Ahmed

Chapter 25
Preliminary investigation of biodiesel reactor optimization using combine CFD-Taguchi method................................................................. 179
A.K.M. Mohiuddin and Nabeel A Adeyemi

Chapter 26
Alternative mixing strategy for biodiesel production: mixed flow impeller characterization ..................................................................... 188
A.K.M. Mohiuddin and Nabeel Adeyemi

Chapter 27
Experimental Investigation of a Multistage Evacuated Solar Still.................................. 197
Yousif. A. Abakr, Ahmad F. Ismail and Mirghani I. Ahmed

Chapter 28
Modelling of electronics heat sink – Influence of the wake function generation on the accuracy of CFD analysis ......................................................... 203
M. A. Ahmed, A. F. Ismail, Y. A. Abakr

Chapter 29
The effect of the operating conditions on the apparent viscosity of crude palm oil during separation................................................................. 213
Sulaiman Al-Zuhair, Yousif A. Abakr and Mirghani I. Ahmed
Chapter 30
Thermal analysis of a micro device used for detection of colorectal cancer.......................... 220
Mirghani I. Ahmed, Meftah Hrairi

Chapter 31
Performance of different photovoltaic cells operating under the meteorological conditions
of Singapore......................................................................................................................................... 229
M.N.A Hawlader, Lee Poh Seng and Chua Kok Kiang

Chapter 32
Analyses of motion and drag coefficient of water droplets in a natural draught cooling
tower............................................................................................................................................... 240
Liu Baomin and M. N. A. Hawlader

Chapter 33
A solar assisted heat pump system for desalination................................................................. 252
Zakaria Mohd. Amin, M N A Hawlader and Azharul Karim

Chapter 34
Comparative study of combustion characteristics using Jatropha oil methyl esters biodiesel
and diesel........................................................................................................................................... 261
A.K.M. Mohiuddin and Azan Mohd

Chapter 35
Performance of evaporator collector and air collector in a solar assisted heat pump dryer.
.......................................................................................................................................................... 269
S. M. A. Rahman and M. N. A. Hawlader
Chapter 32

Analyses of motion and drag coefficient of water droplets in a natural draught cooling tower

Liu Baomin* and M. N. A. Hawlader

*Department of Mechanical Engineering, National University of Singapore
Department of Mechanical Engineering, International Islamic University Malaysia

Abstract

Cooling towers have been widely used in power plants and space air conditioning systems. The rain region plays an important role in the operation of cooling towers. In this paper, four different models have been investigated that describe the motion of water droplets in the rain region of a cooling tower. Due to the non-uniformity of the flow, heat and mass transfer processes inside the cooling tower, the velocity field of water droplets is, at least, two-dimensional. Therefore, these models were tested with a numerical simulation program that accounts for the non-uniform flow. The velocity fields of water droplets, the variations of the drag coefficient with the relative velocity of water droplets have been predicted. The effect of drag and buoyancy force on the motion of water droplets were also studied numerically. The model based on Dreyer and Erens’s correlation has been found to represent the actual situation reasonably well and is recommended for the modelling of water droplets motion in cooling towers.

Keyword: water drop, drag coefficient, cooling tower, and numerical simulation.

INTRODUCTION

In order to get the reasonable result of a practical system by numerical simulation, one needs to develop and adopt correct mathematical and physical models. However, this is very difficult to be accomplished because a real industrial process is often complicated. As to cooling towers and other exchange equipment, there exist rain areas where water drops interacts with air stream. The water drops motion in the air is quiet different from solid spherical particles due to the internal circulation, mechanical palpation, irregular vortex shedding, and the interaction between the drops (collision and disintegration). Water drops falling freely under gravity through air remain very nearly spherical for $E_o = \frac{gd^3}{\sigma} \Delta \rho / \sigma < 0.4$. Because of the large viscosity ratio $k = \frac{\mu_r}{\mu}$, internal circulation tends to be very slow, and the drag on such spherical drops follows closely to the standard drag curve for rigid spheres [1,2]. If $E_o$ increase above 0.4 as in the case of cooling towers, some distortion from the spherical shape can be detected. Flattening occurs primarily at the leading (lower) surface, so that the shape then lacks fore- and- aft symmetry. Drops accelerating in air streams may split up and it was