# Engine and Auxiliary Systems

Edited by
Prof. Dr. A.K.M. Mohiuddin

IIUM PRESS

INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA

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IIUM Press

Published by:
IIUM Press
International Islamic University Malaysia

First Edition, 2011


Perpustakaan Negara Malaysia Cataloguing-in-Publication Data

A.K.M. Mohiuddin
Engine and Auxiliary Systems
A.K.M. Mohiuddin

ISBN: 978-967-418-216-8

Member of Majlis Penerbitan Ilmiah Malaysia – MAPIM
(Malaysian Scholarly Publishing Council)

Printed by :
**IIUM PRINTING SDN. BHD.**
No. 1, Jalan Industri Batu Caves 1/3
Taman Perindustrian Batu Caves
Batu Caves Centre Point
68100 Batu Caves
Selangor Darul Ehsan

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Chapter 29

# Reynolds averaged navier stokes (RANS) Simulation

Asif Hoda

Department of Mechanical Engineering, International Islamic University Malaysia

## Introduction

Turbulence is a highly unstable, stochastic process which cannot be analyzed by deterministic tools and instead, one relies on statistical methods. The statistical tools used for RANS simulation are rather simple and involve the decomposition of the instantaneous velocity and temperature field into mean and fluctuating quantities, known as Reynolds decomposition:

$$\tilde{u} = U + u \tag{1}$$

$$\tilde{p} = P + p \tag{2}$$

$$\tilde{\theta} = \Theta + \theta \tag{3}$$

The Reynolds averaged continuity, Navier Stokes, and energy equations are obtained by substituting (1), (2) and (3) in to continuity, momentum and energy equations and time averaging the equations. The resultant form of the averaged equations is given as:

*Continuity:*

$$\frac{\partial U_i}{\partial x_i} = 0 \tag{4}$$

*Momentum:*

$$\frac{\partial U_i}{\partial t} + U_j \frac{\partial U_i}{\partial x_j} = -\frac{1}{\rho}\frac{\partial P}{\partial x_j} + \nu \frac{\partial^2 U_i}{\partial x_j \partial x_j} - \frac{\partial}{\partial x_j}\left(\overline{u_i u_j}\right) \tag{5}$$

*Energy:*

$$\frac{\partial \Theta}{\partial t} + U_j \frac{\partial \Theta}{\partial x_j} = \alpha \frac{\partial^2 \Theta}{\partial x_j \partial x_j} - \frac{\partial}{\partial x_j}\left(\overline{\theta u_j}\right) \tag{6}$$