Engine and Auxiliary Systems

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

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Table of Contents

Chapter 28

Direct numerical simulation (DNS) and large eddy simulation (LES)

Asif Hoda

Department of Mechanical Engineering, International Islamic University Malaysia

Introduction

The most reliable and accurate prediction of turbulent shear flows can be obtained by solving the full Navier Stokes and energy equations, equations (1)-(3) with the appropriate boundary conditions.

Continuity:

$$\frac{\partial \tilde{u}_i}{\partial x_i} = 0 \tag{1}$$

Momentum:

$$\frac{\partial \tilde{u}_i}{\partial t} + \tilde{u}_j \frac{\partial \tilde{u}_i}{\partial x_j} = -\frac{1}{\rho}\frac{\partial \tilde{p}}{\partial x_j} + \nu \frac{\partial^2 \tilde{u}_i}{\partial x_j \partial x_j} \tag{2}$$

Energy:

$$\frac{\partial \tilde{\theta}}{\partial t} + \tilde{u}_j \frac{\partial \tilde{\theta}}{\partial x_j} = \alpha \frac{\partial^2 \tilde{\theta}}{\partial x_j \partial x_j} \tag{3}$$

Equations (1) through (3) are universally believed to give the exact description of turbulence in fluids and can be solved numerically to obtain solutions for a wide range of flow problems. This solution methodology is called direct numerical simulation (DNS).

Direct Numerical Simulation

DNS involves the discretization of the governing equations on a finite difference mesh with appropriate numerical schemes for coupling the continuity and momentum equations. Although the numerical problem is not so severe, the appropriate resolution of the smallest length scales is an essential requirement and places a severe constraint on the finite difference domain to be used for the purpose. The mesh should not only span the entire