The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5 – 9 June 2022, Oslo, Norway

The P-DNS Method to Solve Particle-Laden Turbulent Fluid Flows

Sergio Idelsohn[1], Juan Gimenez[2] and Eugenio Oñate[3]

[1] CIMNE/ICREA, Barcelona, Spain; sergio@cimne.upc
[2] CIMEC/CONICET, Santa Fe, Argentina; jmarcelogimenez@gmail.com
[3] CIMNE/UPC, Barcelona, Spain; onate@cimne.upc.edu

Key Words: *Multiscale Solutions, Turbulent Flows, Particle-Laden Fluids, P-DNS.*

Particle-laden flows refer to a kind of two-phase fluid flow in which one of the phases is continuously connected and the other phase is made up of small immiscible particles. A wide variety of scientific and engineering applications belong to particles-laden flows, for instance dispersion of contamination in the atmosphere, fluidization in combustion processes, deposition of aerosols in aerosol drugs, spread of virus in the air, rain formation in clouds, sand and dust storms, protoplanetary disks, volcanic eruptions, geological sedimentation processes, pharmaceutical sprays, liquid-fuelled combustion and solid rocket motors, among many others.

The equations governing interactions of particles with fluids in a particle-laden mixture have been known for many decades. However, their coupled dynamics often result in complex behaviour such as preferential concentration and turbulence modulation. These are still ongoing topics of research. The starting point for a mathematical description of almost any type of fluid flow is the classical set of Navier–Stokes equations (N-S). To describe particle-laden flows, these equations must be modified for the effect of the particles.

Typically, the fluid is treated in a Eulerian frame, while the particles are treated in a Lagrangian way. However, problem with the Lagrangian treatment of the particles is that once the number becomes large, it may require a prohibitive amount of computational power to track a sufficiently large sample of particles required. In addition, if the particles are sufficiently light, they behave essentially like a second fluid. This is the main objective of this presentation.

On the other hand, due to the interactions between turbulence structure and dispersed particles, turbulence characteristics of momentum and heat transport can be modified by the presence of particles. This last phenomenon is known as *turbulence modulation* and can lead to a significant increase or decrease in the parameters that regulate turbulence.

The authors presented in Ref. [1] a multi-scale method called Pseudo-Direct Numerical Simulation (P-DNS) [2] to study the phenomenon of turbulence modulation in a particle-laden flows. However, in that article, the particles in both, the fine scale and the coarse scale, were treated in a discrete way moving in a Lagrangian reference frame within the fluid. In this presentation, the same P-DNS method will be used to simulate the presence of particles as a continuum function that moves within the fluid. In this way, the need to represent each of the particles that move in the fluid is avoided.

REFERENCES

[1] J. Gimenez; S. Idelsohn; E. Oñate; R. Löhner. A multiscale approach for the numerical simulation of turbulent flows with droplets; *Arch. Comp. Meth. Engrg.*; (2021).

[2] S. Idelsohn, J. Gimenez, N. Nigro, E. Oñate., The Pseudo-Direct Numerical Simulation Method for Multi-Scale Problems Mechanics; *Comp. Meth. Appl. Mech. Engrg.* 380 (2021).