Simulation of Reacting Flows: Contributions to Modeling

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ABSTRACT

A great deal of progress has been made in understanding turbulent flows but even more remains to be done, especially when extra effects such as chemical reaction are included. Until recently, most research was experimental but measurements are very difficult to make in combusting flows. Advances in computers and algorithms have produced tremendous advances in turbulence simulation. Until recently, almost all computational work was based on the Reynolds averaged Navier-Stokes (RANS) equations in which models play a dominant role. These have had mixed success, especially when difficulties such as combustion are present. Many flows are dominated by shear. In shear flows, one mechanism of turbulence generation is dominant and a single RANS model may be able to predict many flows. When "extra strains" (rotation, curvature, heat release, stratification, etc.) are present, RANS modeling is much more difficult.

The availability of powerful workstations and supercomputers has made it possible to consider the application of large eddy and direct numerical simulation to the study of these flows. Simulations have already taken their place alongside experimental methods as an approach to investigating the physics of other types of turbulent flows and they have reached the point at which simple types of combustion can be simulated. There is already a considerable body of work demonstrating that this is possible.

In this paper, we discuss some advances in combustion modeling that the past decade has produced. These include not only the numerical simulations of turbulent flows but also new types of models. The plan of this paper is as follows. After a brief section introducing direct numerical simulation (DNS) and large eddy simulation (LES), we shall review some of what has taken place in combustion and what can be expected in the future.