1 Introduction

According to the basic concepts of thermodynamics[1], a reversible process is that in which a phenomenon proceeds with an infinitely slow velocity. Practically such a process can never take place and we observe only irreversible processes in which some phenomena proceed with a certain finite velocity.

On the other hand, in order to analyze some physical or chemical phenomena quantitatively, it is convenient to apply some mathematical formula introduced from basic sciences. Such basic mathematical formulae are, however, in general introduced from the basic laws of sciences which can essentially be applied only to reversible processes, namely in equilibrium or quasiequilibrium states.

These mathematical formulae are very often applied also to irreversible phenomena under the assumption that the observed irreversible phenomena can approximately be treated as reversible ones. The formulae can be applied to phenomena proceeding very slowly, but never to distinctly irreversible phenomena, for example, rupture of material, electric discharge, or earthquake.

The combustion is an oxidation of materials being accompanied by light emission, heat release, and pressure or shock waves. The combustion phenomena have long time been investigated by many scientists and engineers not only from their academic interests but also with intentions of the practical and industrial applications and many books as well as reports of the phenomena have been published. In these books and reports the combustion phenomena have mainly been explained according to the theories based on the first law of thermodynamics expressed in mathematical formulae which can be applied only to reversible processes, though the combustion phenomena are distinctly irreversible.

In this book, comparing with the classical theories, ignition, explosion, combustion, and detonation waves are explained according to an irreversible theory based on the second law of thermodynamics. The explanations and results introduced from the irreversible theory are, therefore, quite different from those described in the classical books, but so clear and simple that they can easily be applied to the understanding, investigation, and numerical estimation of the combustion phenomena as well as detonation waves for practical and industrial purposes.

In combustible mixtures or materials some ignitions take place and then flames propagate from the ignition points, being accompanied by light emission, heat release, and shock waves. As the flame propagation is regarded as a succeeding ignition, the ignition phenomena are first to be studied for understanding the combustion phenomena. In this book, after the explanation of explosion according to the classical theories, a stochastic theory for irreversible phenomena, its application to nucleation and then shock tube as the experimental apparatus of ignition in gases are explained. Next the theoretical and experimental results of spontaneous and spark ignitions in gaseous mixtures are explained mainly according to the stochastic ignition theory. Then combustion waves, ionization in flames, detonation waves, interaction between shock and combustion waves are described as irreversible phenomena. Subsequently, some practical and industrial applications of the stochastic ignition theory and detonation waves are also proposed.

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