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Concepts of Gas Dynamics

1.1. Introduction

Gas dynamics is mainly concerned with the motion of gases and its effects. It differs from fluid dynamics. Gas dynamics considers thermal or chemical effects while fluid dynamics usually does not.

The term gas dynamics is very general and alternative names have been suggested, *e.g.*, supersonic flow, compressible flow, aerothermochemistry, aerothermodynamics etc., which have more restricted field of application.

In the present course, aerothermodynamics of gases in motion will be considered mainly with a short introduction to various propulsion systems. Classical gas dynamics considers gas as a continuum. It is not particularly interested in the behaviour of the individual molecules. This treatment is allowable as long as the mean free path of the gas molecules is very small. The mean free path increases with the temperature and reduced pressure hence it varies with altitudes. At an altitude of 60 km the mean free-path is of the order of couple of centimetres whereas at an altitude of 120 km it increases to about 30 cm. As the gas becomes more and more rarefied the phenomenon has to be studied, applying the principles of gas dynamics, kinetic energy of gases and statistical mechanics. These form the basis of modern science called the rarefied gas dynamics or superaerodynamics.

The dimensionless ratio l/L, also called Knudsen number, also demarcates the regions of flow, where l is the mean free-path and L is the characteristic dimension of the body in the gas stream.

It is usual to denote the region according to the following values of l/L :

$l/L < 0.01$ Gas dynamics
$l/L = 1$ Slip flow
$l/L = 10$ Free molecule flow.

1.2. Applications

Gas dynamics is of interest to both mechanical and the aeronautical engineers but particular fields of interest of the two are different. It may be said that the aerodynamicist is concerned with how an object in motion is influenced as it flies through the still air. In contrast to it the thermodynamicist is more interested in the cases in which the object is stationary and the fluid is in motion. Actually there is no sharp line of demarcation. Consider an example of jet propelled aircraft. Here the aerodynamicist will be interested mainly in the necessary contours of the structure and the thermodynamicist might be interested with the fluid flow process within it.