CHAPTER I

BASIC IDEAS

1. INTRODUCTION:

The differential equations govering the flow of gases are based on the conservation of mass, mometum and energy. These, together with appropriate euxiliory conditions, determine the (mathematical) state of the gas. gas flows are often characterized by internal discontinuities, that is shocks may appear in the flow of the gas.

In this chapter physical and mathematics picture for shock waves are given also the Rankine-Hugnoniont relations (R.H.r.) are included.

In the rest of the present chapter we give some general ideas about Eulerian and Lagrangian approaches, discretization in Computational Fluid Dynamics and limitations imposed by computers.

2. PHYSICAL PICTURE OF A SHOCK WAVE

Consider the propagation of a wave in a gas, produced for example, by a small compressive displacement of a piston at one end of a long tube of the fluid initially at rest. Describing this situation by the lineariesed hydrodynamic equations, we find that a pressure wave of constnt shape travels down the tube with the speed of sound. Such a wave is called a sound wave. Suppose that the displacement of the piston is no-longer small, to describe the motion we must retain the non-linear terms in the equations. We find that the profile of the wave changes shape as it moves down the tube, the slope of the wave front gradually steepening (see Fig.1). The increasing slope means , that the pressure gradient across the wave front is increasing, as are the gradients of density and velocity. Eventually if the tube is long enough these gradient become so large that neglect of the physical diffusion dissipation processes (heat conduction and viscosity) is no longer justified. Including the appropriate physical diffusion processes we find that the steepness of the wave front is limited so that it reaches a steady shape known as the permanent regime profile. It is the steady profile produced by the balance of non-linear and dissipative effects which corresponds to shock wave. The physical explanation of these modifications of the simple wave picture is as follows. The non-linear effects arise from two sources. Since the sound speed increases with pressure the wave velocity at A(Fig.1) is greater than at B. Moreover, the fluid velocity varies across the wave front,being greater at A than at B. Thus both fluid and wave velocity are greater at A than at B, so that A tends to catch up with B, causing the wave front to steepen. The physical explanation of dissipative effects is clear from the way of their introduction. They oppose any large gradients. For example, as the wave front steepen the temperature gradient across it increase until the steady state is reached. In practice, we always have this situation where advective and dissipative effects opposing each other. It is not possible, of course, to have significant non-linear effects without some dissipation mechanism being brought into play. The smaller the coefficients of dissipation the more nearly the shock wave approaches a discontinuity... Gas properties may change considerably across a shock wave and the shock is thus a steady transition region between the undisturbed (unshocked) gas and the gas through which the shock has passed. The dependent variables on both sides of the shock are related to each other through the RANKINE-HUGONIONT relations. Practically speaking, at see-level conditions, shock thicknesses are variables of the order of molecular mean free paths. The most remarkable physical phenomena is a decleration of 1000 m/sec can occur in 0.0001 cm. Shocks occur when supersionic flow is turned through a compression corner or otherwise meets a sudden pressure rise.