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ORIGINAL ARTICLE

Quasi-similar solution of the strong shock wave problem in non-ideal gas dynamics

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Abstract The quasisimilar theory is used to investigate the solution of the blast wave problem with generalized geometries in a non-ideal gas satisfying the equation of state of the Van der Waals type. Here it is assumed that the distribution of normalized velocity, pressure and density are nearly similar in the narrow range of the shock strength. A comparison between approximate analytical solution and numerical solution of the problem is presented for the cylindrical geometry. The numerical solutions are presented for the generalized geometry in a non-ideal gas. It is also assessed as to how the non-idealness of the gas affects the behavior of the flow parameters.

Keywords Quasi-similar solution · Shock wave · Non-ideal gas

1 Introduction

Astrophysical environments feature many different types of shock waves. Some common examples are supernovae shock waves or blast waves traveling through the interstellar medium, the bow shock caused by the Earth's magnetic field colliding with the solar wind and shock waves caused by galaxies colliding with each other. Another interesting type of shock phenomenon in astrophysics is the quasi-steady reverse shock or termination shock that terminates the ultra relativistic wind from young pulsars. In many astrophysical phenomena associated with the release of a large amount of energy in a very small region during the short times, the critical aspect is the propagation through the ambient medium of the resulting shock wave. The propagation of blast waves establishes a problem of great interest to researchers in a variety of fields such as astrophysics, nuclear science, plasma physics and geophysics. A number of analytical solutions for the blast wave propagation have been obtained by Rogers (1957), Sakurai (1953, 1954), Madhumita and Sharma (2003, 2004), Arora and Sharma (2006), Sedov (1959), Lin (1954) and Taylor (1950a, 1950b). Anisimov and Spiner (1972) studied the problem of point explosion in a non-ideal gas by taking the equation of state in a simplified form to describe the behavior of the medium. However, when the gas flow takes place at a high temperature and density is too low the assumption that the gas is ideal is no longer valid. In recent years, many theoretical and experimental studies have been performed on the strong shock waves as an energy source for the generation of very high pressures and temperatures. Ramu and Ranga Rao (1993) studied the self-similar solutions for the converging spherical and cylindrical strong shock waves in a non-ideal gas satisfying the equation of state of the Mie-Gruneisen type. Wu and Roberts (1995, 1996) investigated the similarity solutions and the stability for strong spherical implosions for both ideal and van der Waals gases. Singh et al. (2011a, 2011b, 2011c) presented the numerical and analytical description of imploding shocks in non-ideal gas in the presence of magnetic field by using the well known similarity method of Sedov (1959).

The basic and fundamental concept of the quasisimilarity is to assume the separation of variables that is, the dependent variables are represented as product of two functions, each of which contains only one independent variable then using the boundary conditions. The partial derivative with respect to one of the variables is explicitly expressed as a function of the other variables and a parameter. This pa-

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