EFFECTS OF DISSOCIATION OR IONIZATION ON
HYPERSONIC FLOW PAST A CONE

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SUMMARY

The effects of dissociation or ionization of air on inviscid hypersonic flow past a circular cone at zero angle of incidence, with an attached shockwave, are studied on the assumption of thermal equilibrium. A complete solution for the flow between the surface of the cone and the shock wave is obtained. Viscosity and heat conduction, etc., are completely neglected.

SYMBOLS

R, θ = polar co-ordinates.
u, υ = velocity components.
p = pressure.
ρ = density.
T = absolute temperature.
a = \( \left[ \left( \frac{\partial p}{\partial \rho} \right)_s \right]^\frac{1}{4} \), velocity of sound.
a = semi-vertical angle of the cone.
ϕ = shock wave angle.
δ = angle of deflection of the stream on the shock wave.
β = angle of deflection of the stream at any point (R, θ) in the shock layer.
u,∞ = free-stream velocity.
M,∞ = free-stream Mach number.
C = maximum speed of air under adiabatic conditions.
u,0 = value of u on the surface of the cone.
C, p = pressure coefficient.
C, D = drag coefficient.
Effects of Dissociation or Ionization on Hypersonic Flow Past a Cone

\[ h = \text{specific enthalpy.} \]
\[ \nu_1 = \text{ratio of specific heats in the absence of dissociation or ionization.} \]
\[ \nu_2 = \text{ratio of specific heats in the presence of dissociation or ionization.} \]
\[ m_1 = \text{molecular weight of air in the absence of dissociation or ionization.} \]
\[ m_2 = \text{effective molecular weight of air in the presence of dissociation or ionization.} \]
\[ K = \text{density ratio, } \rho_1/\rho_2. \]
\[ p_3 = \text{pressure behind the shock wave corresponding to zero speed.} \]
\[ \rho_3 = \text{density behind the shock wave corresponding to zero speed.} \]

**Subscripts**

1, 2 denote conditions ahead of the shock and behind it respectively. 
\( a, \psi, \theta \) denote values on the surface of the cone, on the shock wave, and at an angle \( \theta \) between the surface of the cone and the shockwave respectively.

1. **Introduction**

The problem of obtaining aerodynamic information at hypersonic speed has currently received considerable interest in connection with the development of intercontinental ballistic missiles, satellites and space ships. At hypersonic speeds, dissociation of oxygen and nitrogen molecules occurs and thermal ionization of many of the constituents may occur. As a result, the convective heat transfer will be different from that of the perfect gas. The decelerated gas radiates energy and the radiative heat transfer must be considered for hypersonic vehicles. At very high temperature, the gas becomes electrically conducting and can be influenced by a magnetic field.

The irrotational flow at high speeds past an infinite solid circular cone, at zero angle of incidence, with attached shock wave, has been considered by Taylor and Maccoll, Maccoll, Busemann, Karman and Moore, Hayes and Probstein, and Hord. But they have not considered the effects of dissociation or ionization of air behind the shock wave. Zien Kiewicz and Nath have obtained an approximate solution of the flow past a cone at zero angle of incidence, with attached shock wave, in the presence of dissociation or ionization of air behind the shock wave under the assumption of thermodynamic equilibrium.

Here, the present author has obtained the complete solution of the flow past a circular cone, with attached shock wave, at zero angle of incidence,