Chapter-III
Self Similar Study of a Blast Wave
Generated by Line Explosion

3.1 INTRODUCTION:

Blast waves are generated in case of collapse of higher pressure gas containers or steam boilers, electrical discharges including lightning, detonations of solid explosives and detonable gaseous mixtures, hyper velocity impacts and laser beam focusing in ambient air Glass [1] Takayama [2]) Due to their wide appearance in nature, many works have been carried out so for to model their propagation in space Taylor [3], Brode [4], Vonue mann [5], Bach [6] and Backer [7]. There are also many pioneer works which were devoted to analytical and numerical studies of blast wave. Similarity laws proposed by Von Neumann [5] and Taylor [3] describe well the motion of blast waves at their early stage when they remain strong. An analytic approximation reported by Bach and Lee [6] describes the weak blast waves based on the assumption of a power law density profile behind them Numerical solutions of spherical blast wave were given by Brode [8] and differential equations of gas motion were solved.

The observational data shows that the unsteady motion of large mass of the gas followed by sudden release of energy results in flare-ups in novae and super novae carrus et al. [9] Sedov [10], Purohit [11] Singh [12] and Singh Vishwakarma [13] have discussed the self similar adiabalic or isothermal flows in self gravitating gas.
They have obtained numerical solutions assuming that the total energy of the wave is either constant or increases with time.

The present work is to clarify the propagation of a cylindrical blast wave created by line explosion in a conducting medium. A qualitative behaviour of the gaseous mass has been investigated with the help of equations of motion, taking gravitational forces into account. In addition of pressure we have also taken material pressure into consideration. The total energy of the flow increases with time because of the pressure exerted on the gas by an expanding surface when the wave is driven by fresh solar plasma for some time under the assumption that the temperature gradient is zero. The similarity solutions of the field variables for the cylindrical blast wave propagating in a non-uniform atmosphere at rest are obtained.

3.2 **EQUATIONS OF THE MOTION OF THE GOVERNING FLOW:**

If we neglect viscosity and thermal conductivity, the basic differential equation governing the isothermal flow in self gravitating gas are given by

\[ \frac{\partial p}{\partial t} + \frac{1}{r^2} \frac{\partial}{\partial r} (rp\dot{u}) = 0 \]  \hspace{1cm} (1)

\[ \frac{\partial u}{\partial t} + u \frac{\partial u}{\partial r} + \frac{1}{\rho} \frac{\partial}{\partial r} (p + \bar{p}) + \frac{Gm}{r^2} = 0 \]  \hspace{1cm} (2)

\[ \frac{\partial p}{\partial t} + u \frac{\partial p}{\partial r} + \gamma p \left( \frac{\partial u}{\partial r} + \frac{2u}{r} \right) = 0 \]  \hspace{1cm} (3)
\[
\frac{\partial \bar{P}}{\partial t} + u \frac{\partial \bar{P}}{\partial r} + \gamma \bar{P} \left( \frac{\partial u}{\partial r} + \frac{2u}{r} \right) = 0
\] (4)

\[
\frac{\partial m}{\partial r} = 4 \pi \rho r^2
\] (5)

\[
\frac{\partial T}{\partial r} = 0
\] (6)

Where \( r, t, u, \rho, P, \bar{P}, m, T \) are radial distance from the centre, time, velocity density, pressure, material pressure, mass contained in a sphere of radius \( r \) and the temperature of the fluid particles respectively, \( G \) represents the gravitational constant eqn (6) with the help of perfect gas law \( (p = \Gamma \rho T) \) can be replaced by

\[
\frac{P}{P_2} = \frac{\rho}{\rho_2}
\]

where suffix, 2 denotes the quantities just behind the shock. Initial flow variables immediately ahead of the shock by suffix 1 are

\[
u_1 = 0
\] (8)

\[
\rho_1 = A r_1^{-\omega} \quad (2 \leq \omega \leq 2.5)
\] (9)

\[
m_1 = \frac{4 \pi A}{(3-\omega)} r_1^{3-\omega}
\] (10)

\[
P_1 = \frac{2 \pi A^2 G}{(\omega - 1)(3-\omega)} r_1^{2-2\omega}
\] (11)

\[
\bar{P}_1 = \frac{2 \pi A^2 G}{(\omega - 1)(3-\omega)} r_1^{2-2\omega}
\] (12)

where \( r_1 \) is the shock radius and \( A \) and \( \omega \) are constants. These are the solutions of the equilibrium equations.
3.3 **JUMP CONDITIONS**:

The disturbance is headed by an isothermal shock and jump conditions at is are

\[ \rho_1 U = \rho_2 (U - U_2) = m \]  

(13)

\[ P_2 - P_1 = m \]  

(14)

\[ T_1 = T_2 \]  

(15)

\[ m_1 = m_2 \]  

(16)

Where \( U \) denotes the shock velocity. The present self similar model, including a driven wave produced by a flare energy \( E \) release that is time dependent, has been adopted and it is given by

\[ E = B t^q \quad (0 \leq q \leq 1) \]  

(17)

Where \( B \) and \( q \) are constants.

3.4 **SIMILARITY SOLUTIONS**:

By a standard dimensional analysis of Sedov [1959] the non dimensional variable \( \eta \) is defined by

\[ \eta = (\alpha AG)^{-1/\omega} rt^{-\delta} \]  

(18)

where \[ \delta = \frac{2}{\omega} = \frac{2+q}{5-\omega} \]

which discloses that

\[ q = \frac{2}{\omega} (5-2\omega) \]

and the limits of \( q \) and \( \omega \) are

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\( 0 \leq q \leq 1 \) and \( 2 \leq w \leq 2.5 \)

The other transformations for flow variables are

\[
u = \frac{r}{t} \, V(\eta) \tag{19}\]

\[
\rho = \frac{1}{Gt^2} \, R(\eta) \tag{20}\]

\[
p = \frac{r^2}{Gt^4} \, P(\eta) \tag{21}\]

\[
\bar{p} = \frac{r^2}{Gt^4} \, P(\eta) \tag{22}\]

\[
m = \frac{r^3}{Gt^4} \, M(\eta) \tag{23}\]

\( \alpha \) is a constant to be determined by the condition that \( \eta \) assumes the value 1 at the shock front.

### 3.5 SOLUTIONS OF EQN. OF MOTION:

\[
\frac{\partial \rho}{\partial t} + \frac{1}{r^2} \frac{\partial}{\partial r} (r^2 \rho u) = 0 \tag{1}\]

\[
\frac{\partial \rho}{\partial t} + \frac{1}{r^2} \, r^2 \, \frac{\partial}{\partial r} (\rho u) + \frac{1}{r^2} \, \rho u \, \frac{\partial}{\partial r} (r^2) = 0
\]

\[
\frac{\partial \rho}{\partial t} + u \frac{\partial \rho}{\partial r} + \rho \frac{\partial u}{\partial r} + \frac{2 \rho u}{r} = 0 \tag{24}\]

as

\[
\rho = \frac{1}{Gt^2} \, R(\eta) \tag{20}\]

\[
\frac{\partial \rho}{\partial r} = \frac{1}{Gt^2} \, R'(\eta) \, \frac{\partial \eta}{\partial r}
\]
equation (18) is
\[ \eta = (\alpha AG)^{-1/\alpha} \pi^{-5} \]
\[ \frac{\partial \eta}{\partial \tau} = (\alpha AG)^{-1/\alpha} t^{-5} \]
\[ \frac{\partial \eta}{\partial \tau} = \eta \]
\[ \frac{\partial \eta}{\partial \tau} = \frac{\eta}{r} \]

Hence
\[ \frac{\partial \rho}{\partial \tau} = \frac{1}{Gt^2} \frac{R(\eta)}{r} \]

(25)

Now from equation (20)
\[ \frac{\partial \rho}{\partial \tau} = - \frac{2}{Gt^3} R(\eta) + \frac{1}{Gt^3} R'(\eta) \frac{\partial \eta}{\partial \tau} \]

and from (18) we can find
\[ \frac{\partial \eta}{\partial \tau} = - \frac{\delta \eta}{t} \]

Hence
\[ \frac{\partial \rho}{\partial \tau} = - \frac{2}{Gt^3} R(\eta) - \frac{1}{Gt^3} \delta \eta R'(\eta) \]
\[ \frac{\partial \rho}{\partial \tau} = - \frac{1}{Gt^3} [2R + R' \delta \eta] \]

(26)

Now take
\[ u = \frac{r}{t} V(\eta) \]

(19)

\[ \frac{\partial u}{\partial \tau} = \frac{V(\eta)}{t} + \frac{r}{t} V'(\eta) \frac{\partial \eta}{\partial \tau} \]

as
\[ \frac{\partial \eta}{\partial \tau} = \frac{\eta}{r} \]

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Hence

\[ \frac{\partial u}{\partial r} = \frac{1}{t} [V(\eta) + \eta V'(\eta)] \]

Now substitute the values of \( \frac{\partial \rho}{\partial t}, \frac{\partial \rho}{\partial r}, \frac{\partial u}{\partial r}, \rho \) and \( u \) in equation (24)

\[ \frac{\partial \rho}{\partial t} + u \frac{\partial \rho}{\partial r} + \rho \frac{\partial u}{\partial r} + \frac{2\rho u r}{r^2} = 0 \]  \hspace{1cm} (24)

\[- \frac{1}{Gt^3} [2(R(\eta) + R'(\eta)\delta \eta)] + \frac{r}{t} V(\eta) \frac{1}{Gt^2} R'(\eta) \frac{\eta}{r} + \frac{1}{Gt^2} R(\eta) \frac{1}{t} [V(\eta) + \eta V'(\eta)] \]

\[ + \frac{2}{r} \frac{1}{Gt^2} R(\eta) \frac{r}{t} V(\eta) = 0 \]

\[-[2R(\eta) + R'(\eta)\delta \eta] + V(\eta) \eta R'(\eta) + V(\eta) R(\eta) \eta + R(\eta) [V(\eta) + \eta V'(\eta)] \]

\[ + 2 R(\eta) V(\eta) = 0 \]

\[ n [V'(\eta) + \frac{V(\eta)R'(\eta)}{R(\eta)} - \frac{\delta R'(\eta)}{R(\eta)}] - 2 + 3 V(\eta) = 0 \]

\[ n [V'(\eta) + (V(\eta) - \delta) \frac{1}{R(\eta)} R'(\eta)] - 2 + 3 V(\eta) = 0 \]  \hspace{1cm} (27)

Now we take equation (2)

\[ \frac{\partial u}{\partial t} + u \frac{\partial u}{\partial r} + \frac{1}{\rho} \frac{\partial}{\partial r} (P + \bar{P}) + \frac{Gm}{r^2} = 0 \]

\[ \frac{\partial u}{\partial t} + u \frac{\partial u}{\partial r} + \frac{1}{\rho} \frac{\partial \rho}{\partial r} + \frac{1}{\rho} \frac{\partial \bar{P}}{\partial r} + \frac{Gm}{r^2} = 0 \]  \hspace{1cm} (28)

\[ u = \frac{r}{t} V(\eta) \]  \hspace{1cm} (19)

\[ \frac{\partial u}{\partial t} = -\frac{r}{t^2} V(\eta) + \frac{r}{t} V'(\frac{\delta \eta}{\partial t}) \]

\[ \therefore \frac{\partial \eta}{\partial t} = -\frac{\delta \eta}{t} \]
\[
\frac{\partial u}{\partial t} = -\frac{r}{t^2} [V(\eta) + \eta \delta V'(\eta)]
\]

\[
P = \frac{r^2}{Gt^4} P(\eta)
\]

\[
\frac{\partial p}{\partial r} = \frac{2r}{Gt^4} P(\eta) + \frac{r^2}{Gt^4} P'(\eta) \frac{\partial \eta}{\partial r}
\]

\[
\frac{\partial p}{\partial r} = \frac{r}{Gt^4} [2P(\eta) + \eta P'(\eta)]
\]

as

\[
\bar{P} = \frac{r^2}{Gt^4} P(\eta)
\]

\[
\therefore \frac{\partial \bar{P}}{\partial r} = \frac{r}{Gt^4} [2P(\eta) + \eta P'(\eta)]
\]

Now we put all these values in eqn (28)

\[
-\frac{r}{t^2} [V(\eta) + \eta \delta V'(\eta)] + \frac{r}{t} V(\eta) \left[\frac{1}{t} (V(\eta) + \eta V'(\eta))\right]
\]

\[
+ \frac{t^2G}{R(\eta)} \left[\frac{r}{Gt^4} (2P(\eta) + \eta P'(\eta))\right] + \frac{t^2G}{R} [2\bar{P}(\eta) + \eta \bar{P}'(\eta)] + \frac{Gm}{r^2} = 0
\]

\[
- [V(\eta) + \eta V'(\eta) \delta] + V(\eta) [V(\eta) + \eta V'(\eta)]
\]

\[
+ \frac{1}{R} [2P(\eta) + \eta P'(\eta) + 2\bar{P}(\eta) + \eta \bar{P}'(\eta)] + \frac{Gm^2}{r^3} = 0
\]

Since

\[
m = \frac{r^3}{Gt^2} M(\eta)
\]

\[
M(\eta) = \frac{Gm^2}{r^3}
\]
Hence

\[- [V(\eta) + \eta V'(\eta)] + [V(\eta) + \eta V'(\eta)] V(\eta)\]

\[+ \frac{1}{R} [2P(\eta) + \eta P'(\eta) + 2\bar{P}(\eta) + \eta \bar{P}'(\eta)] + M(\eta) = 0\]

\[\eta[V'(\eta) (V(\eta) - \delta) + \frac{1}{R} P'(\eta)] + V(\eta) [V(\eta) - 1] + M + \frac{2}{R} [P(\eta) + \bar{P}(\eta)] \]  \(29\)

Now we take eqn (3)

\[\frac{\partial P}{\partial t} + u \frac{\partial P}{\partial t} + \gamma P \left( \frac{\partial u}{\partial t} + 2 \frac{u}{r} \right) = 0\]  \(3\)

\[P = \frac{r^2}{G t^4} P(\eta)\]

\[\frac{\partial P}{\partial t} = - \frac{4r^2}{G t^5} P(\eta) + \frac{r^2}{G t^4} P'(\eta) \frac{\partial \eta}{\partial t}\]

\[= - \frac{4r^2 P(\eta)}{G t^5} + \frac{r^2}{G t^4} P'(\eta) \left( - \frac{\delta \eta}{t} \right)\]

\[\frac{\partial \eta}{\partial t} = - \frac{\delta \eta}{t}\]

Hence

\[\frac{\partial P}{\partial t} = - \frac{4r^2 P(\eta)}{G t^5} - \frac{r^2}{G t^4} P'(\eta) \delta \eta\]

Now we put the values in eqn (3)

\[- \frac{4r^2 P(\eta)}{G t^5} - \frac{r^2 \delta \eta P'(\eta)}{G t^5} + \frac{r^2 V(\eta)}{t^2 G} [2 P(\eta) + \eta P'(\eta)]\]

\[+ \frac{\gamma r^2}{G t^5} P(\eta) [V(\eta) + \eta V'(\eta)] + 2 \gamma P(\eta) V(\eta) = 0\]  \(30\)
or \(-4 P(\eta) - \delta \eta P'(\eta) + V(\eta)[2 P(\eta) + \eta P'(\eta)] + \gamma P(\eta)[V(\eta) + \eta V'(\eta)] + 2 \gamma P(\eta) V(\eta) = 0\)

Eqn (4) is given by

\[
\frac{\partial P}{\partial t} + u \frac{\partial P}{\partial x} + \gamma P \left( \frac{\partial u}{\partial x} + \frac{2u}{r} \right) = 0
\]

on putting the values of \(\bar{P}\), \(\frac{\partial \bar{P}}{\partial t}\), \(\frac{\partial \bar{P}}{\partial x}\), \(\frac{\partial u}{\partial x}\), and \(u\), we get

\[
-4 \bar{P}(\eta) - \delta \eta \bar{P}'(\eta) + V(\eta) [2 \bar{P}(\eta) + \eta \bar{P}'(\eta)] + \gamma \bar{P}(\eta) [V(\eta) + \eta V'(\eta)] + 2 \gamma \bar{P}(\eta) V(\eta) = 0
\]

(31)

Eqn (5) is

\[
\frac{\partial m}{\partial r} = 4 \pi \rho r^2
\]

(5)

where \(m = \frac{r^3 M(\eta)}{G t^2}\)

(23)

where \(\eta = \eta(r)\)

\[
\frac{\partial m}{\partial r} = \frac{3r^2 M(\eta)}{G t^2} + \frac{r^3}{G t^2} \frac{M'(\eta) \partial \eta}{\partial r}
\]

\[
\therefore \frac{\partial \eta}{\partial r} = \frac{\eta}{r}
\]

\[
\therefore \frac{\partial m}{\partial r} = \frac{r^2}{G t^2} [3M(\eta) + \eta M'(\eta)]
\]

Hence eqn (5) becomes

\[
\frac{r^2}{G t^2} [3M(\eta) + \eta M'(\eta)] = 4 \pi \rho r^2
\]
\[ \frac{r^2}{Gt^4} [3M(\eta) + \eta M'(\eta)] = \frac{4\pi R}{Gt^2} r^2 \]

\[ 3M - M' \eta = 4\pi R = 0 \]  \hspace{1cm} (32)

Now we take

\[ P_2 = C^2 \rho_0 \]

as

\[ Q = \frac{C^2}{U^2} \]

\[ \Rightarrow \quad C^2 = U^2 Q \]

hence

\[ P_2 = Q U^2 \rho_2 \]

\[ \frac{r^2}{Gt^4} p(\eta) = Q U^2 \frac{1}{Gt^2} R(\eta) \]

\[ \frac{r^2}{t^2} P(\eta) = Q U^2 R(\eta) \]

as

\[ u = \frac{r}{t} V(\eta) \]

\[ U = \frac{r}{t} V(\overline{\eta}) \]

\[ U = \frac{r}{t} \sigma \]

On putting the value of \( U \) we get

\[ \frac{r^2}{t^2} P(\eta) = Q \frac{r^2}{t^2} \sigma^2 R(\eta) \]
\[ P (\eta) = Q \sigma^2 R (\eta) \]  

(33)

The transformed shock conditions are

\[ P_2 - P_1 = m_s u_2 \]  

(14)

\[ \frac{\gamma P_2 p_2}{\gamma p_2} - \frac{\gamma P_1 p_1}{\gamma p_1} = m_s u_2 \]

Since

\[ M^2 = \frac{U^2 \rho_1}{\gamma P_1} \]

\[ \Rightarrow \frac{\gamma P_1}{\rho_1} = \frac{U^2}{M^2} \]

Now put this value in above eqn.

\[ \frac{U^2}{M^2} \frac{\rho_2}{\gamma} - \frac{U^2 \rho_1}{M^2 \gamma} = m_s u_2 \]

\[ \frac{1}{\gamma M^2} \left[ \frac{U^2 \rho_2}{m_s} - \frac{U^2 \rho_1}{m_s} \right] = u_2 \]

\[ \frac{1}{\gamma M^2} \left[ \frac{U^2 \rho_2}{\rho_2 (U - u_2)} - \frac{U^2 \rho_1}{\rho_1 U} \right] = u_2 \]  

(13)

\[ \frac{1}{\gamma M^2} \left[ \frac{U^2}{(U - u_2)} - U \right] = u_2 \]

\[ \frac{1}{\gamma M^2} [U^2 - U^2 + Uu_2] = u_2 (U - u_2) \]

\[ \frac{Uu_2}{\gamma M^2} = u_2 (U - u_2) \]
\[ \frac{U}{\gamma M^2} = u_2 (U-u_2) \]

\[ u_2 = U \left[ 1 - \frac{1}{\gamma M^2} \right] \]

\[ u_2 = U \left[ 1 - \frac{1}{\gamma U^2 \rho_1} \frac{\gamma p_1}{p} \right] \]

\[ u_2 = U \left[ 1 - \frac{p}{U^2 \rho_1} \right] \]

but \[ c^2 = \frac{p}{\rho} \]

also

\[ \frac{C^2}{U^2} = Q \]

\[ u_2 = U \left[ 1 - Q \right] \]

at shock front

\[ \eta = \eta_0 = 1 \]

\[ \frac{r}{t} V (l) = \frac{r}{t} V (\bar{\eta}) \left[ 1 - Q \right] \]

\[ V (l) = (1-Q) \sigma \]

equation (13) is

\[ \rho_1 U = \rho_2 (U-u_2) \]

\[ \rho_1 U = \rho_2 \left[ U - U(1 - \frac{1}{\gamma M^2}) \right] \]
\[ \rho_1 = \rho_2 \frac{1}{\gamma M^2} \]

\[ \rho_2 = \rho_1 \gamma M^2 \]

\[ \rho_2 = \rho_1 \frac{\gamma U^2 \rho}{\gamma p} \]

\[ = \frac{U^2}{C^2} \rho_1 \]

\[ \rho_2 = \frac{1}{Q} \rho_1 \]

\[ \rho_2 = \frac{2(\omega - 1)(3 - \omega) \alpha}{\pi \omega^2} \rho_1 \]

At shock front \( \eta = \eta_0 = 1 \)

\[ \frac{1}{Gt^2} R (\eta_0) = \frac{2(\omega - 1)(3 - \omega)}{\pi \omega^2} \alpha \frac{1}{Gt^2} R (\bar{\eta}) \]

\[ R (1) = \frac{2(\omega - 1)(3 - \omega)}{\pi \omega^2} \alpha \frac{1}{\alpha} \]

\[ R (1) = \frac{2(\omega - 1)(3 - \omega)}{\omega^2} \]

Eqn (33) is

\[ \eta^2 P (\eta) = Q \sigma^2 R (\eta) \]

\[ P (\eta) = \frac{Q \sigma^2 R (\eta)}{\eta^2} \]

at shock front

\[ P (1) = \frac{Q \sigma^2 R (1)}{1} \]

equation (35) we get
\[ P(1) = \frac{2\sigma^2 (\omega - 1)(3 - \omega)}{\pi\omega^2} Q \]  

(36)

\[ m_1 = \frac{4\pi A}{(3 - \omega)} r_2^{3-\omega} \]

(10)

\[ = \frac{4\pi A}{(3 - \omega)} r_2^3 \frac{\rho_1}{A} \quad \text{by using (9)} \]

\[ = \frac{4\pi}{3 - \omega} \rho_1 r_2^3 \]

\[ = \frac{4\pi}{3 - \omega} \frac{1}{Gt^2} R(\eta) r_2^3 \]

as

\[ m_1 = m_2 \]

(16)

\[ \frac{4\pi}{(3 - \omega)} \frac{1}{Gt^2} R(\eta) r_2^3 = \frac{r_2^3}{Gt^2} M(\eta) \]

at shock front \( \eta = \eta_0 = 1 \)

\[ \frac{4\pi}{(3 - \omega)} r^3 R(1) = M(1) r^3 \]

\[ r^3 M(1) = \frac{4\pi}{(3 - \omega)} \frac{2(\omega - 1)(3 - \omega)}{\pi\omega^2} r_2^3 \]

\[ M(1) = \frac{8(\omega - 1)}{\omega^2} \frac{r_2^3}{r^3} \]

(37)

As

\[ u = \frac{r}{t} V(\eta) \]

\[ u_2 = \frac{R}{t} V(1) \]
where

\[ \eta = \beta^{-1/\alpha} \, r^{-\delta} \]

\[ \eta_0 = \beta^{-1/\alpha} \, R^{-\delta} \]

\[ \frac{\eta}{\eta_0} = \frac{r}{R} \quad \text{and} \quad \eta_0 = 1 \]

\[ \eta = \frac{r}{R} \]

Now

\[ \frac{u}{u_2} = \frac{r}{R} \frac{V(\eta)}{V(1)} \]

\[ \frac{u}{u_2} = \eta \frac{V(\eta)}{V(1)} \quad (38) \]

As

\[ \rho = \frac{1}{Gt^2} \, R(\eta) \]

\[ \rho_2 = \frac{1}{Gt^2} \, R(1) \]

\[ \frac{\rho}{\rho_2} = \frac{R(\eta)}{R(1)} \quad (39) \]

\[ p = \frac{r^2}{Gt^4} \, P(\eta) \]

\[ p_2 = \frac{R^2}{Gt^4} \, P(1) \]

\[ \frac{p}{p_2} = \frac{r^2}{R^2} \frac{P(\eta)}{P(1)} \quad (40) \]
And

\[ m = \frac{r^3}{Gt^2} \, m(\eta) \]

\[ m_2 = \frac{R^3}{Gt^2} \, M(l) \]

\[ \frac{m}{m_2} = \frac{r^3}{R^3} \, \frac{M(\eta)}{M(l)} \]

\[ \frac{m}{m_2} = \eta^3 \, \frac{M(\eta)}{M(l)} \]  \hspace{1cm} (41)

**RESULTS AND DISCUSSIONS:**

To illustrate the behavior of present similarity problem the solution of equation 27-32 are obtained for \( \gamma = 1.4 \) in the region with gravitating effect. We have used.

\[ V(l) = (1-Q) \, \delta, \]

\[ R(l) = \frac{2 (\omega-1) (3-\omega)}{\pi \omega^2} \]

\[ P(l) = \frac{2\delta^2 (\omega-1) (3-\omega)}{\pi \omega^2} \]

\[ M(l) = \frac{8 (\omega-1)}{\omega^2} \]

\[ Q = \frac{C^2}{U^2} \]
We have calculated our problem for $\omega = 1.5,2$ we conclude that field parameter changes rapidly when gravitational forces imported. The variation of velocity, pressure, density and mass has been illustrated through figures.
Velocity Distribution

$\frac{u}{u_1}$ vs $\eta$

$\omega = 1.5$

$\omega = 2.0$

Graph showing the velocity distribution with two curves for different values of $\omega$. The x-axis represents $\eta$ and the y-axis represents $\frac{u}{u_1}$. The curves indicate the variation of velocity with respect to $\eta$.
Pressure Distribution

\[ \frac{p}{p_t} \]

\( \omega = 1.5 \)

\( \omega = 2.0 \)
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