International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 Issue: VI Month of publication: June 2018

DOI: http://doi.org/10.22214/ijraset.2018.6304

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue VI, June 2018- Available at www.ijraset.com

Spherical Adiabatic Shock Waves in Uniform Medium

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Abstract: The Rankine-Hugoniot conditions are used to determine the flow variable of the uniform medium perturbed by strong spherical shock assuming adiabatic propagation of shock waves, the analytical relations for the Mach Number is obtained for the case when the shock is strong.
The Chester-Chisnell-Whitham method is used as the basic tool of the problem. The Mach Number so computed is directly used to obtain flow variables. The modification in the flow variables are investigated by considering the effect of overtaking disturbances.
Finally the results are compaired with those for isothermal shock waves.

I. INTRODUCTION

The spherical adiabatic shock in uniform medium play an important role in the dynamics of an astrophysical problems, hypersonic flight applications, high temperature thermodynamic phenomena and in many other geophysical problems.

Marshak (1958) has obtained similarity solutions of the radiation hydrodynamics equations for plane symmetry taking radiation energy and pressure negligible. The cases he consider were those of (i) constant density (ii) constant pressure and (iii) power law time dependence of temperature. In particular he considered penetration of radiation from a heat slab into a cold medium, in the first two cases the temperature of the slab decreases exponentially. The last case (i.e. the power law), which unlike the first two is an exact solution from the point of view of the hydrodynamics as well as the radiation.

Elliott (1960) has studied the explosion problem including radiation heat flux in uniform atmosphere. Helliwell (1966, 1969) has considered the piston problem with radiation heat flux having varying density. The propagation of shock waves near the surface of the star has been discussed by Sachdev and Ashraf (1971) assuming the flow behind the shock as isothermal.

Very recently, Prakash, Tyagi, Singh and Gangwar (2018) strength of overtaking waves on the freely propagating strong spherical converging shock waves in the dustry gaseous non-uniform medium has been investigated. It is observed that the presence of non-idealness in the gaseous medium has significant effects on flow variables of shock propagation. Neglecting the effect of overtaking disturbances, Dwivedi (2003) studied the propagation of shock waves in rotating non-uniform atmosphere taking radiative heat flux into consideration using Chester (1954), Chisnell (1955) and Whitham (1958) method.The significance and importance of overtaking disturbances has been explained by Yousaf (1974, 1985) and Yadav (1992). Therefore, being astrophysically importance, the motion of shock waves in self-gravitating fields under the influence of overtaking disturbances is important to study.

In (2004), Ribeyre and Tikhonchuk studied for compressible Rayleigh-Taylor instabilities in supernova remnants and shown hat for several configurations, the effect of compressibility can be significant in supernovae remnants. In (2005), Hosseiniand and Takayama discussed about implosion of a spherical shock wave reflected from a spherical wall and observed the sequence of diverging and converging spherical shock-wave propagations and their interaction with gaseous explosion products. The convergence, acceleration and stability of the imploding shock wave in the test section were studied.

For strong shock, shock velocity and shock strength decreases with propagation distance r as well as with specific heat index γ in both freely propagation and in the presence of overtaking disturbances.Non-dimensional particle velocity and non-dimensional pressure decreases with propagation distance r as well as with specific heat index g in both freely propagation and in presence of overtaking disturbances.

It is further found that with the inclusion of effect of overtaking disturbances, the flow variables are enhanced significantly.

A. Basic Equations

Under the assumption that the gas is in viscous and non-conducting of heat, the system of the equations for one-dimensional adiabatic flow are

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$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial r}+\frac{1}{\rho}\frac{\partial p}{\partial r}=0 \qquad ...(1)$$

$$\frac{\partial \rho}{\partial t}+\rho\frac{\partial u}{\partial r}+u\frac{\partial \rho}{\partial r}+\frac{2\rho u}{r}=0 \qquad ...(2)$$

$$\left(\frac{\partial}{\partial t}+u\frac{\partial}{\partial r}\right)\left(p\rho^{-\gamma}\right)=0 \qquad ...(3)$$

where u (r, t), p (r, t) and ρ (r, t) denote respectively the particle velocity, the pressure and density at a distance r from the origin at time t and γ is the specific heat index of the gas.

B. Boundary Conditions

Let p_0 and ρ_0 denote the undisturbed values of pressure and density infront of the shock wave and p_1 and ρ_1 be the values of respective quantities at any point immediately after the passage of the shock, then the well known Rankine-Hugoniot conditions permit us to express u_1, p_1 and ρ_1 in terms of the undisturbed values of those quantities by means of the following equations

$$p=p_1=\rho_0 a_0^2\left[\frac{2M^2}{\gamma+1}-\frac{(\gamma-1)}{\gamma(\gamma+1)}\right]$$

$$\rho=\rho_1=\rho_0\left[\frac{(\gamma+1)M^2}{(\gamma-1)M^2+2}\right] \qquad ...(4)$$

$$u=u_1=\frac{2a_0}{\gamma+1}\left[M-\frac{1}{M}\right]$$

$$U=a_0 M$$

where $M=U/a_0$, U being the shock velocity, a_0 is the sound velocity in undisturbed medium and M is Mach number.

C. Theory

The characteristic form of the system of the equations

$$dp+\rho a du+\frac{2\rho a^2 u\, dr}{(u+a)\, r}=0 \qquad ...(5)$$

In case of uniform atmosphere

p_0 = constant, ρ_0 = constant ...(6)

Case I : For strong shock, $U \gg a_0$, then boundary conditions reduces to

$$p_1=\frac{2\rho_0 a_0^2 M^2}{(\gamma+1)},\quad \rho_1=\rho_0\frac{(\gamma+1)}{(\gamma-1)} \text{ and } u_1=\frac{2U}{(\gamma+1)}=\frac{2a_0 M}{(\gamma+1)} \qquad ...(7)$$

The freely propagation of spherical shock wave in uniform medium

For uniform density medium (ρ_0 = constant)

using equation (4), we get-

$$dp=\rho_0 a_0^2\frac{4M}{\gamma+1}dM \qquad ....(i)$$

$$\therefore \quad \rho a du=\frac{2\rho_0 a_0^2}{\left[(\gamma-1)M^2+2\right]}\left(1+M^2\right)dM \qquad ...(ii)$$

$$u+a=\frac{2a_0}{(\gamma+1)}\left\{M-\frac{1}{M}\right\}+a_0=\frac{a_0}{(\gamma+1)}\left\{2M-\frac{2}{M}+(\gamma+1)\right\} \qquad ...(iii)$$

$$\frac{2\rho a^2 u}{r}=\frac{4}{r}\frac{\rho_0 a_0^3\left(M^2-1\right)M}{\left[(\gamma-1)M^2+2\right]} \qquad ...(iv)$$

$$\therefore \quad \frac{2\rho a^2 u}{r(u+a)} = \frac{4}{r}\,\frac{\rho_0 a_0^2 \left\{M^2-1\right\} M(\gamma+1) M}{\left[(\gamma-1)M^2+2\right]\left[2M^2-2+(\gamma+1)M\right]} \qquad \text{...(v)}$$

substituting all these values in equation (5), we get

$$dp + \rho a du + \frac{2\rho a^2 u\, dr}{(u+a)\, r} = 0$$

$$\frac{1}{2M^2\left(M^2-1\right)}\Big[4(\gamma-1)M^5 + 2\left(\gamma^2+\gamma\right)M^4 + \left(\gamma^2-2\gamma+13\right)M^3$$

$$+4(\gamma+1)M^2 + \left(\gamma^2+2\gamma-7\right)M - 2(\gamma+1)\Big]dM + (\gamma+1)^2\frac{dr}{r} = 0$$

For strong shock U >> a_0 or U/a_0 = M >>1

$$\frac{1}{2M^4}\Big[4(\gamma-1)M^5 + 2\left(\gamma^2+\gamma\right)M^4 + \left(\gamma^2-2\gamma+13\right)M^3$$

$$+4(\gamma+1)M^2 + \left(\gamma^2+2\gamma-7\right)M - 2(\gamma+1)\Big]dM + (\gamma+1)^2\frac{dr}{r} = 0$$

here M >>1 so $\frac{1}{M}, \frac{1}{M^2}, \frac{1}{M^3} << 1 \rightarrow 0$

$$\left\{2(\gamma-1)M + (\gamma+1)\gamma\right\}dM + (\gamma+1)^2\frac{dr}{r} = 0$$

on integrating, we get

$$\frac{1}{(\gamma+1)^2}\left\{(\gamma-1)\frac{M^2}{2} + (\gamma+1)\gamma M\right\} + \log_e r = \log_e K_1$$

$$(\gamma-1)M^2 + \gamma(\gamma+1)M = (\gamma+1)^2 \log_e K_1/r \qquad \text{...(8)}$$

where K_1 is a constant of integration.

using Shridhracharya theorem, we get

$$M = \frac{-\gamma(\gamma+1) \pm \sqrt{\gamma^2(\gamma+1)^2 + 4(\gamma-1)(\gamma+1)^2 \log_e K_1/r}}{2(\gamma-1)}$$

$$M = \frac{-\gamma(\gamma+1) \pm (\gamma+1)\sqrt{\gamma^2 + 4(\gamma-1)\log_e K_1/r}}{2(\gamma-1)}$$

taking positive sign for M >>1

$$M_+ = \frac{U_+}{a_0} = \frac{-\gamma(\gamma+1) + (\gamma+1)\sqrt{\gamma^2 + 4(\gamma-1)\log_e K_1/r}}{2(\gamma-1)}$$

so, the expression for **Shock velocity**

$$U_+ = \sqrt{\frac{\gamma p_0}{\rho_0}}\left\{\frac{-\gamma(\gamma+1) + (\gamma+1)\sqrt{\gamma^2 + 4(\gamma-1)\log_e K_1/r}}{2(\gamma-1)}\right\} \qquad \text{...(9)}$$

and the expression for **Shock strength**

$$M_+ = \frac{U_+}{a_0} = \frac{-\gamma(\gamma+1) + (\gamma+1)\sqrt{\gamma^2 + 4(\gamma-1)\log_e K_1/r}}{2(\gamma-1)} \qquad \text{...(10)}$$

D. Propagation Of Spherical Shock Wave In Presence Of Overtaking Disturbances

To estimate the effect of overtaking disturbances, we are using the differential equation

$$dp - \rho a du + \frac{2ua^2\rho}{r}\frac{dr}{(u-a)} = 0 \qquad \text{...(11)}$$

from equations (i), (ii) and (iv), we have

$$dp=\frac{\rho_0 a_0^2}{(\gamma+1)}4M\,dM \qquad ...(i)$$

$$\rho a\,du=\frac{2\rho_0 a_0^2}{\{(\gamma-1)M^2+2\}}\left(M^2+1\right)dM \qquad ...(ii)$$

$$\frac{2ua^2\rho}{r}=\frac{4}{r}\frac{\rho_0 a_0^3 M\left(M^2-1\right)}{\{(\gamma-1)M^2+2\}} \qquad ...(iv)$$

here

$$u-a=\frac{a_0}{\gamma+1}\left\{\gamma M-\frac{2}{M}-(\gamma+1)\right\} \qquad ...(vi)$$

substituting all these values in equation (11), we get

$$\frac{1}{2M^2\left(M^2-1\right)}\left\{4(\gamma-1)M^5-2\left(\gamma^2+\gamma\right)M^4+\left(\gamma^2-2\gamma+13\right)M^3-4(\gamma+1)M^2\right.$$
$$\left.+\left(\gamma^2+2\gamma-7\right)M+2(\gamma+1)\right\}dM+(\gamma+1)^2\frac{dr}{r}=0 \qquad ...(12)$$

For strong shock M=U/a_0>>1 or U>>a_0

$$\frac{1}{2M^4}\left\{4(\gamma-1)M^5-2\gamma(\gamma+1)M^4+\left(\gamma^2-2\gamma+13\right)M^3-4(\gamma+1)M^2\right.$$
$$\left.+\left(\gamma^2+2\gamma-7\right)M+2(\gamma+1)\right\}dM+(\gamma+1)^2\frac{dr}{r}=0$$

$\frac{1}{M},\ \frac{1}{M^2},\ \frac{1}{M^3}$ are so small so we can neglect these

$$\frac{1}{2(\gamma+1)^2}\left[4(\gamma-1)M-2\gamma(\gamma+1)\right]dM+\frac{dr}{r}=0$$

$$(\gamma-1)M^2-\gamma(\gamma+1)M=(\gamma+1)^2\log_e\frac{K_2}{r} \qquad ...(13)$$

using Shridhracharya theorem

$$M_-=\frac{\gamma(\gamma+1)\pm\sqrt{\gamma^2(\gamma+1)^2+4(\gamma-1)(\gamma+1)^2\log_e K_2/r}}{2(\gamma-1)} \qquad ...(14)$$

taking positive sign for M >>1

$$M_-=\frac{\gamma(\gamma+1)+(\gamma+1)\sqrt{\gamma^2+4(\gamma-1)\log_e K_2/r}}{2(\gamma-1)} \qquad ...(15)$$

In presence of overtaking disturbances, the resultant pressure increment

$dp=dp_++dp_-$ is written as

using equation (7),we get

$$d\left\{\rho_0 a_0^2\left(\frac{2M^{*2}}{(\gamma+1)}\right)\right\}=d\left\{\rho_0 a_0^2\left(\frac{2M_+^2}{(\gamma+1)}\right)\right\}+d\left\{\rho_0 a_0^2\left(\frac{2M_-^2}{(\gamma+1)}\right)\right\}$$

on integtrating and simplifying,we get

$$U^{*2}=U_+^2+U_-^2+\frac{K(\gamma+1)}{2\rho_0}$$

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$$M^{*2} = M_+^2 + M_-^2 + \frac{K(\gamma+1)}{2\rho_0 a_0^2}$$

or ...(16)

To differentiate the modified flow variables from unmodified we are using star (*) for modified value.

E. Modified shock velocity

$$U^* = \left[\frac{\gamma p_0}{\rho_0}\left\{\frac{-\gamma(\gamma+1)+(\gamma+1)\sqrt{\gamma^2+4(\gamma-1)\log_e K_1/r}}{2(\gamma-1)}\right\}^2 + \frac{\gamma p_0}{\rho_0}\left\{\frac{-\gamma(\gamma+1)+(\gamma+1)\sqrt{\gamma^2+4(\gamma-1)\log_e K_2/r}}{2(\gamma-1)}\right\}^2 + \frac{K(\gamma+1)}{2\rho_0}\right]^{1/2} \quad ...(17)$$

Modified shock strength

$$\frac{U^*}{a_0} = \left[\left\{\frac{-\gamma(\gamma+1)+(\gamma+1)\sqrt{\gamma^2+4(\gamma-1)\log_e K_1/r}}{2(\gamma-1)}\right\}^2 + \left\{\frac{-\gamma(\gamma+1)+(\gamma+1)\sqrt{\gamma^2+4(\gamma-1)\log_e K_2/r}}{2(\gamma-1)}\right\}^2 + \frac{K(\gamma+1)}{2\gamma p_0}\right]^{1/2} \quad ...(18)$$

The expressions for non-dimensional particle velocity, non-dimensional pressure immediately behind the strong shock for freely propagation (u/a_0, p/p_0) and under the influence of overtaking disturbances (u^*/a_0, p^*/p_0) are

F. Non-Dimensional Particle Velocity

$$\frac{u}{a_0} = \frac{2}{(\gamma+1)}M_+ = \frac{2}{(\gamma+1)}\left\{\frac{-\gamma(\gamma+1)+\sqrt{\gamma^2(\gamma+1)^2+4(\gamma-1)(\gamma+1)^2\log_e K_1/r}}{2(\gamma-1)}\right\}$$

$$\frac{u}{a_0} = \frac{2}{(\gamma+1)}M_+ = \left\{\frac{-\gamma+\sqrt{\gamma^2+4(\gamma-1)\log_e K_1/r}}{(\gamma-1)}\right\} \quad ...(19)$$

G. Non-Dimensional Pressure

$$\frac{p}{p_0} = \frac{2\gamma}{(\gamma+1)}M_+^2 = \frac{2\gamma}{(\gamma+1)}\left\{\frac{-\gamma(\gamma+1)+\sqrt{\gamma^2(\gamma+1)^2+4(\gamma-1)(\gamma+1)^2\log_e K_1/r}}{2(\gamma-1)}\right\}^2$$

$$= \frac{\gamma(\gamma+1)}{2(\gamma-1)^2}\left\{-\gamma+\sqrt{\gamma^2+4(\gamma-1)\log_e K_1/r}\right\}^2 \quad ...(20)$$

H. Modified Non-Dimensional Particle Velocity

$$\frac{u^*}{a_0} = \frac{2}{(\gamma+1)}M^* = \frac{2}{(\gamma+1)}\frac{U^*}{a_0}$$

$$= \frac{2}{(\gamma+1)}\left[\left\{\frac{-\gamma(\gamma+1)+(\gamma+1)\sqrt{\gamma^2+4(\gamma-1)\log_e K_1/r}}{2(\gamma-1)}\right\}^2 + \left\{\frac{-\gamma(\gamma+1)+(\gamma+1)\sqrt{\gamma^2+4(\gamma-1)\log_e K_2/r}}{2(\gamma-1)}\right\}^2 + \frac{K(\gamma+1)}{2\rho_0 a_0^2}\right]^{1/2} \quad ...(21)$$

I. Modified Non-Dimensional Pressure

$$\frac{p^*}{p_0} = \frac{2\gamma}{(\gamma+1)} M^{*2} = \frac{2\gamma}{(\gamma+1)} \left(\frac{U^*}{a_0}\right)^2$$

$$= \frac{2\gamma}{(\gamma+1)} \left[\left\{ \frac{\gamma(\gamma+1) + (\gamma+1)\sqrt{\gamma^2 + 4(\gamma-1)\log_e K_1/r}}{2(\gamma-1)} \right\}^2 \right.$$

$$\left. + \left\{ \frac{\gamma(\gamma+1) + (\gamma+1)\sqrt{\gamma^2 + 4(\gamma-1)\log_e K_2/r}}{2(\gamma-1)} \right\}^2 + \frac{K(\gamma+1)}{2\rho_0 a_0^2} \right] \quad ...(22)$$

II. RESULTS AND DISCUSSION

A. *For strong shock*

1) *Shock velocity and shock strength:* The expressions (9) and (17) are obtained for the shock velocity of strong spherical adiabatic shock propagating freely and under the influence of overtaking disturbances, respectively. The expressions (10) and (18) are the corresponding relations for shock strength for both cases. Initially, taking U/a_0=20 at r =20 for ρ_0=1.29 kg/m^3, p_0=1.01 x 10^5 N/m^2 and γ=1.4, the shock velocity and shock strength are numerically computed for various situations and are represented in the tables (1) and (3) respectively.

From tables (1) and (3), it is found that when strong spherical diverging shock propagates adiabatically , the shock velocity and shock strength for both freely propagation as well as with the inclusion of overtaking disturbances decreases with propagation distance and with specific heat index. Yadav et al. (2006) has been obtained the similar variations with these parameters. Table (1) shows that as shock propagates from 20 to 30 the shock velocity decreases from 5565.190 to 5458.430 for freely propagation and from 10354.800 to 10211.500 in presence of overtaking disturbances.Shock strength decreases from 16.809 to 16.487 for freely propagation and from 31.276 to 30.843 in presence of overtaking disturbances, respectively.

Table (3) shows that as specific heat index increases from 1.40 to 1.50, the shock velocity decreases from 5565.190 to 5412.00 for freely propagation and from 10354.80 to 9993.560 in presence of overtaking disturbances. Shock strength decreases from 16.809 to 15.792 for freely propagation and from 31.276 to 29.161 in presence of overtaking disturbances, respectively.

The variation of shock velocity with propagation distance r, specific heat index γ are also shown in figures. Shock velocity decreases with propagation distance r and specific heat index γ in both the case FP and EOD as shown in figures (1.1 and 3.1). Similarly the variation in shock strength with propagation distance r and specific heat index γ is shown in figures (1.2 and 3.2). These results are in good agreement with the observations obtained by Gangwar(2006).

B. *Non-dimensional particle velocity and non-dimensional pressure*

The expressions for non-dimensional particle velocity and non-dimensional pressure immediately behind the shock for freely propagation (u/a_0, p/p_0) are given by equations (19) and (20) and under the influence of overtaking disturbances (u^*/a_0, p^*/p_0) are given by equations (21) and (22) respectively.The expressions are used to compute the flow variables. The variations of these variabes with different parameters are shown in tables (1 - 4) respectively.

Tables (2) and (4) show that when strong spherical diverging shock propagates adiabatically in uniform density region, the non-dimensional particle velocity and non-dimensional pressure decreases with propagation distance and with specific heat index for both freely propagation as well as with inclusion of overtaking disturbances.

From table (2) it is found that, the non-dimensional particle velocity decreases from14.0078 to 13.739 and non-dimensional pressure from 329.646 to 317.119 for freely propagation, the non-dimensional particle velocity decreases from 26.0634 to 25.7026 and non-dimensional pressure from 1141.22 to 1109.85 in presence of overtaking disturbances as the shock propagates from 20 to 30.

From table (4), it is found that, the non-dimensional particle velocity decreases from 14.0078 to 12.6339, the non-dimensional pressure from 329.6460 to 299.2770 for freely propagation and the non-dimensional particle velocity decreases from 26.0634 to 23.3291, the non-dimensional pressure from 1141.2200 to 1020.4700 in presence of overtaking disturbances as the specific heat index increases from 1.40 to 1.50.

Non-dimensional particle velocity and non-dimensional pressure decreases with propagation distance r and specific heat index γ for both the case FP and EOD are also shown in figures (2.1, 2.2, 4.1 and 4.2).

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Table-1 : Variation of shock velocity and shock strength with propagation distance when strong spherical diverging shock propagates adiabatically in uniform density region (initially taken U/a_0 = 20 at r = 20 for $□_0$=1.29kg/m^3, p_0=1.01 x 10^5N/m^2 and □ = 1.4)

Propagation distance r	Shock velocity U	Modified shock velocity U*	Shock strength U/a_0	Modified shock strength U^*/a_0
20	5565.190	10354.800	16.809	31.276
21	5552.430	10337.700	16.771	31.224
22	5540.240	10321.300	16.734	31.175
23	5528.580	10305.600	16.699	31.128
24	5517.390	10290.600	16.665	31.082
25	5506.640	10276.200	16.633	31.039
26	5496.300	10262.300	16.601	30.997
27	5486.330	10248.900	16.571	30.956
28	5476.710	10236.000	16.542	30.917
29	5467.420	10223.500	16.514	30.880
30	5458.430	10211.500	16.487	30.843

Table-2 : Variation of non-dimensional particle velocity and non-dimensional pressure with propagation distance when strong spherical diverging shock propagates adiabatically in uniform density region (initially taken U/a_0 = 20 at r = 20 for

$□_□$=1.29kg/m^3, p_0=1.01 x 10^5N/m^2 and □□□ 1.4)

Propagation distance r	Non-dimensional particle velocity u/a_0	Modified non dimensional particle velocity u^*/a_0	Non dimensional pressure p/p_0	Modified non dimensional pressure p^*/p_0
20	14.0078	26.0634	329.646	1141.22
21	13.9757	26.0202	328.136	1137.45
22	13.9450	25.9790	326.697	1133.85
23	13.9156	25.9396	325.322	1130.41
24	13.8874	25.9018	324.007	1127.12
25	13.8604	25.8655	322.746	1123.96
26	13.8344	25.8305	321.534	1120.92
27	13.8093	25.7969	320.369	1118.00
28	1378.51	25.7644	319.247	1115.19
29	13.7617	25.7330	318.164	1112.47
30	13.7390	25.7026	317.119	1109.85

(*) is used when we are taking the effect of overtaking disturbances.

Table-3 : Variation of shock velocity and shock strength with specific heat index when strong spherical diverging shock propagates adiabatically in uniform density region (initially taken U/a_0 = 20 at r = 20 for $□_□$=1.29kg/m^3, p_0=1.01 x 10^5N/m^2 and □□□ 1.4).

Specific heat index γ	Shock velocity U	Modified shock velocity U*	Shock strength U/a_0	Modified shock strength U^*/a_0
1.40	5565.190	10354.800	16.809	31.276
1.41	5545.270	10307.400	16.690	31.022
1.42	5526.520	10262.900	16.575	30.779
1.43	5508.890	10221.200	16.464	30.547
1.44	5492.320	10182.100	16.357	30.324
1.45	5476.740	10145.400	16.254	30.111
1.46	5462.090	10110.900	16.155	29.905
1.47	5448.340	10078.700	16.060	29.708
1.48	5435.440	10048.400	15.968	29.519
1.49	5423.340	10020.100	15.878	29.337

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue VI, June 2018- Available at www.ijraset.com

1.50	5412.000	9993.560	15.792	29.161

Table-4 : Variation of non-dimensional particle velocity and non-dimensional pressure with specific heat index when strong spherical diverging shock propagates adiabatically in uniform density region (initially taken U/a_0 = 20 at r = 20 for □□=1.29kg/m^3, p_0=1.01 x 10^5N/m^2 and □□□ 1.4).

Specific heat index γ	Non-dimensional particle velocity u/a_0	Modified non dimensional particle velocity u^*/a_0	Non dimensional pressure p/p_0	Modified non dimensional pressure p^*/p_0
1.40	14.0078	26.0634	329.6460	1141.2200
1.41	13.8503	25.7446	325.9320	1126.1000
1.42	13.6980	25.4376	322.3940	1111.7900
1.43	13.5505	25.1415	319.0220	1098.2400
1.44	13.4075	24.8559	315.8060	1085.3800
1.45	13.2689	24.5800	312.7340	1073.1700
1.46	13.1344	24.3133	309.8000	1061.5600
1.47	13.0039	24.0553	306.9940	1050.5300
1.48	12.8770	23.8056	304.3100	1040.0200
1.49	12.7538	23.5637	301.7400	1030.0100
1.50	12.6339	23.3291	299.2770	1020.4700

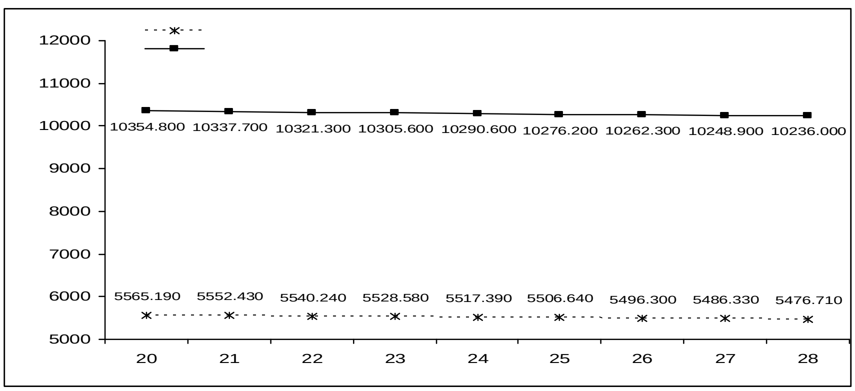

Fig 1.1: Shock velocity versus propagation distance diagram illustrating effect of overtaking disturbances when strong spherical diverging shock propagates adiabatically in uniform density region.

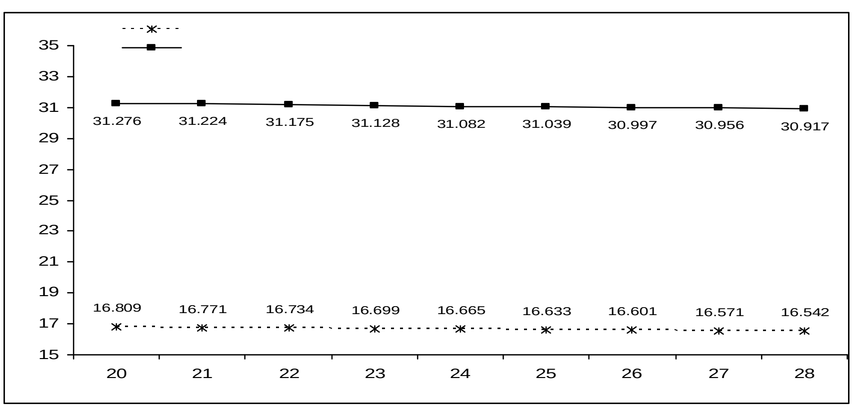

Fig 1.2: Shock strength versus propagation distance diagram illustrating effect of overtaking disturbances when strong spherical diverging shock propagates adiabatically in uniform density region .

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ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue VI, June 2018- Available at www.ijraset.com

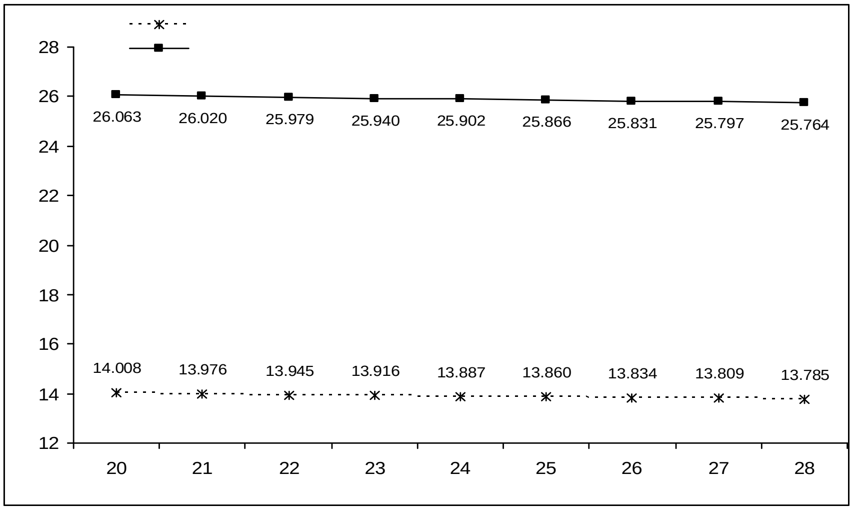

Fig 2.1: Non-dimensional particle velocity versus propagation distance diagram illustrating effect of overtaking disturbances when strong spherical diverging shock propagates adiabatically in uniform density region.

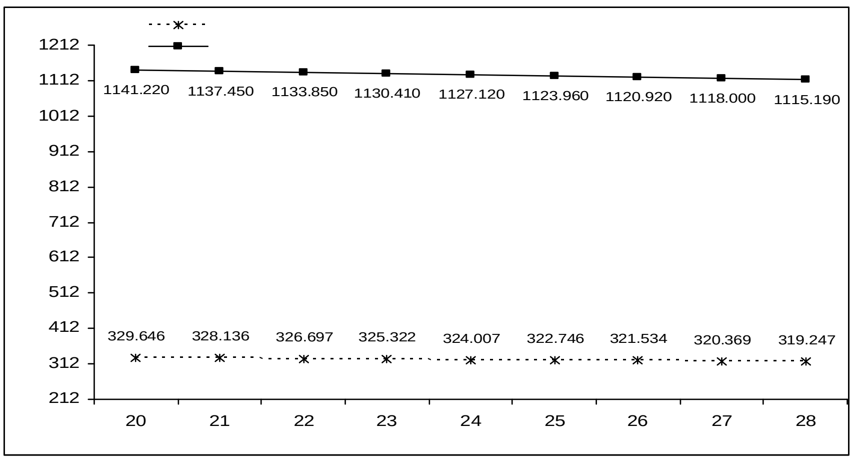

Fig 2.2: Non-dimensional pressure versus propagation distance diagram illustrating effect of overtaking disturbances when strong spherical diverging shock propagates adiabatically in uniform density region.

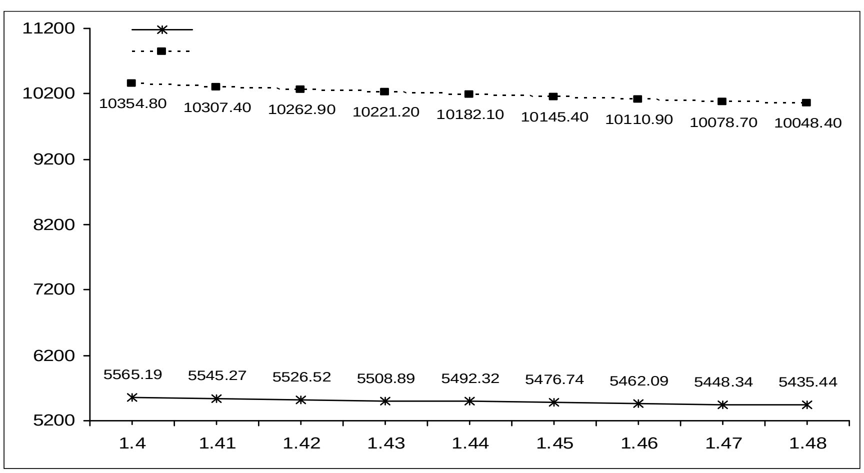

Fig 3.1: Shock velocity versus specific heat index diagram illustrating effect of overtaking disturbances when strong spherical diverging shock propagates adiabatically in uniform density region.

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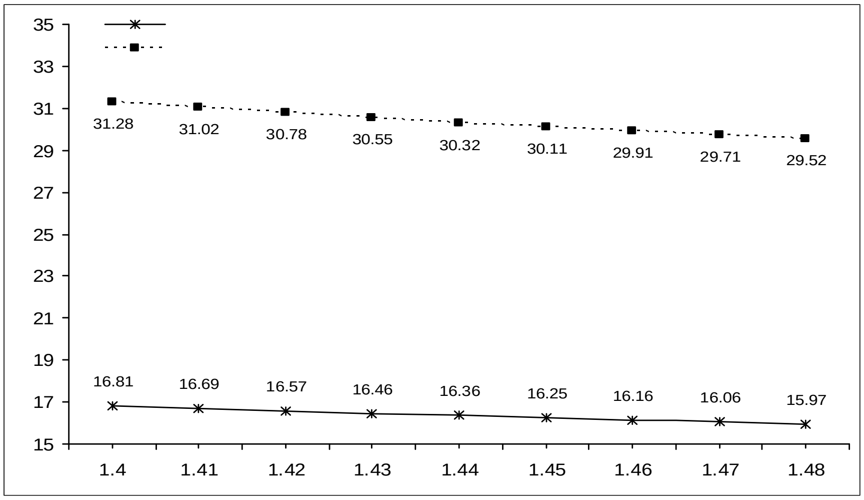

Fig 3.2 : Shock strength versus specific heat index diagram illustrating effect of overtaking disturbances when strong spherical diverging shock propagates adiabatically in uniform density region.

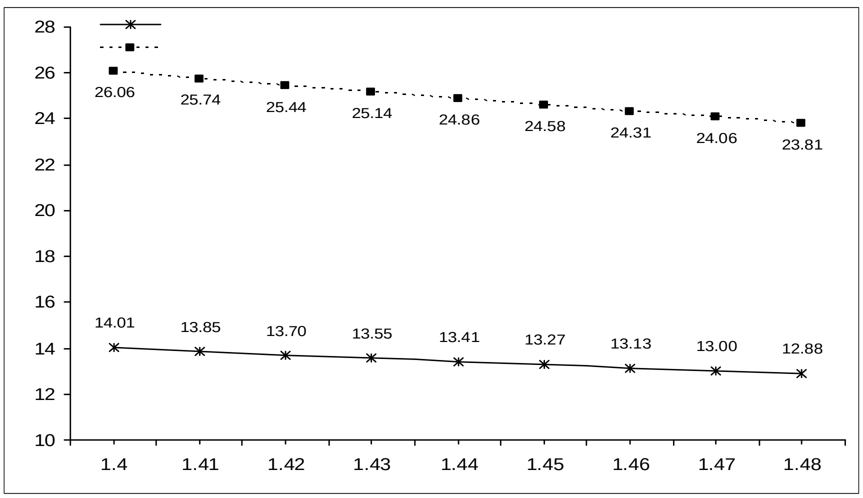

Fig 4.1: Non-dimensional particle velocity versus specific heat index diagram illustrating effect of overtaking disturbances when strong spherical diverging shock propagates adiabatically in uniform density region.

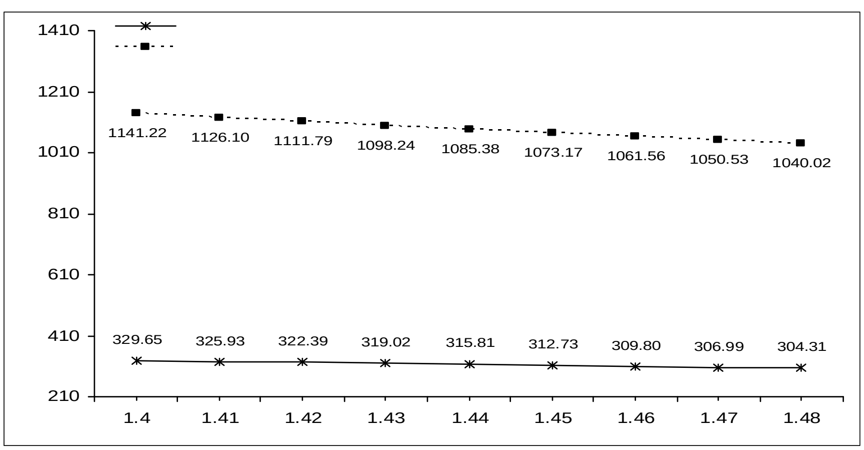

Fig 4.2: Non-dimensional pressure versus specific heat index diagram illustrating effect of overtaking disturbances when strong spherical diverging shock propagates adiabatically in uniform density region.

III. CONCLUSION

The propagation of spherical shock waves in uniform and non-uniform self-gravitation gas atmosphere has astrophysically significance specially in context to star formation, in many practical situations in nuclear physics and space science. When shock propagates in the atmosphere, perturbation of the medium takes place either adiabatically or isothermally. These are the two extreme and ideal situations occurs in the medium, all the actual phenomena lie in between these two situations. In the present study flow variables of the perturbed medium are investigated for these two extreme situations by Chester-Chisnell-Whitham method and improved Yadav approach for overtaking disturbances. It is concluded that strengthening and weaking of the shock depends on the specific heat index and propagation distance r. The change in radiation heat flux contributes very significantly in the propagation of shock waves.

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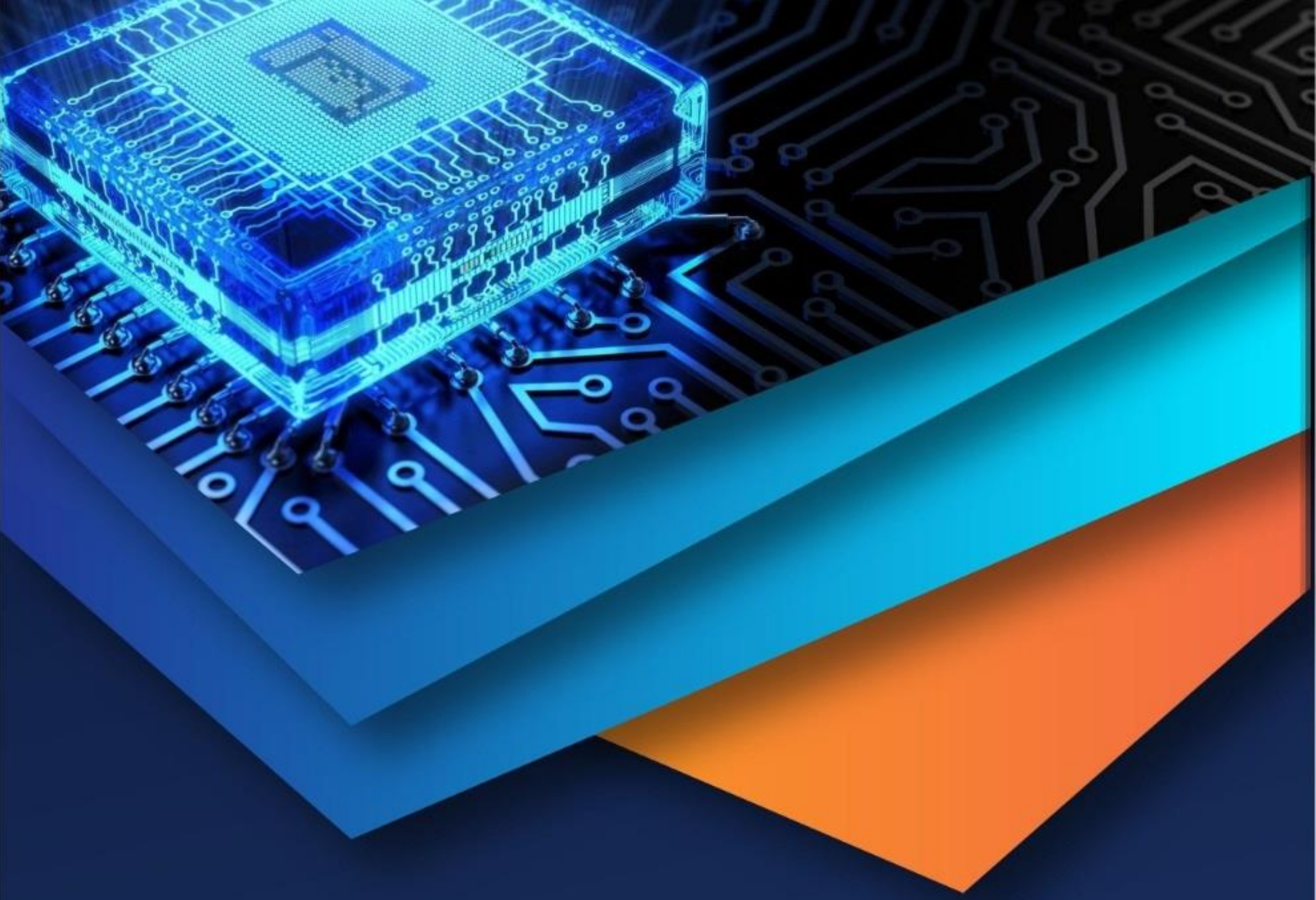

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