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The motion of weak spherical shock waves in highly viscous medium

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ABSTRACT

The interaction of shock waves with viscosity is one of the central problems in the supersonic regime of compressible fluid flow. The propagation of weak spherical shock waves in highly viscous uniform medium has been investigated by CCW method. It is found that the shock velocity and shock strength both decreases as shock advances for low viscous region of a medium to the high viscous region. The pressure and particle velocity behind strong shock decreases with adiabatic index and Small decreasement in the pressure and particle velocity is found with the increase in viscosity coefficient. It is shown that applications of the CCW method and the neglect of overtaking disturbances are equivalent.

Keywords*- Shock Wave, CCW, Method and Viscosity*

1. INRODUCTION

Weak shock theory applies of very weak shocks and it is mainly concerned with the flow profile behind the shock front (the shock wave). In this theory an initial pressure pulse is allowed to propagate along the straight rays given by geometrical acoustics (**keller 1954**).The pulse of non-linearized by allowing the speed of propagation to increase with over pressure. Eventually the shock overturns and at that point shocks are fitted into the pressure profile using the equal area tube. For weak shocks, the propagation speed of the shock front is proportional to the pressure jump (over pressure at the discontinuity).Thus, the geometry of the shcok front is given by geometrical acoustics and the variation in propagation speed of different parts of the shock wave with over pressure is found from nonlinear aging in ray tubes (**Whitham 1974**). Note that the shocks are just fitted in, the propagation of the shock - containing pulse is treated identically to the propagation the same way as a nonlinear pressure wave.

In the weak shock limit the shock strength is proportional to the inverse to the square root of the ray tube area. If the shock does focus, or form a caustic, the ray tube area vanishes and thus weak shock theory predicts an artifical singularity in the shock strength. Experimentally, the shock strength always remains finite and the shape of the weak shock at the focus does not correspond to that predicted by geometrical acoustics. This unphysical behaviour shows that weak shock theory is a poor approximation near a focus. **Sakurai and Takayame(2005)** studied the analytical solution of a flow field for weak mach reflection over a plane surface.The mechanism of laser deformation and the reason for the production of the shock wave are carried out by **Chaojun et al.(2006)**. **Fan et al. (2007)** studied experimentally and numerically the interaction of a planer shock wave with a loosed dusty bulk layer.**Chan(2008)** studied the combined effects of thermophoresis and electrophoresis on particle deposition onto a wavy surface disk.On the effect of viscosity on the shock waves for a hydrodynamical medium by **Huseyin cavus (2013)**. **Anand Raj and H.C.Yadav (2011)** studied propagation of shock waves in a viscous medium. **Anand Raj and H.C.Yadav (2016)** studied the effect of viscosity on the structure of shock waves in a non –ideal gas. Similarity solution of spherical shock wave effect of viscosity by **Dipak et. al.(2016).**

The aim of the present part is to study the propagation of weak spherical shock waves propagating in a uniform medium. When shock moves freely. The shock strength, shock velocity, pressure and particle velocity both decreases as spherical shock. The effect of overtaking disturbances is to inhance the values. The results obtained here are compared with those **(Anand Raj and H.C.Yadav 2011)**.

2. BASIC EQUATIONS

The general equations of exploding shock waves in presence of uniform viscous medium

$$\frac{\eth u}{\eth t}+u\frac{\eth u}{\eth r}+\frac{1}{\rho}\frac{\eth P}{\eth r}\text{-}-\frac{4}{3}\mu\frac{\eth u}{\eth r}=0$$

$$\frac{\eth \rho}{\eth t}+u\frac{\eth \rho}{\eth r}+\rho\frac{\eth \rho}{\eth t}+\frac{\alpha\rho u}{r}=0$$

$$\frac{\eth P}{\eth t}+u\frac{\eth P}{\eth r}-a^2\left[\frac{\eth r}{\eth t}+u\frac{\eth \rho}{\eth r}\right]=0$$

$$\frac{\eth P}{\eth t}+u\frac{\eth P}{\eth r}+a^2\rho\left[\frac{\eth r}{\eth t}+\frac{\alpha u}{r}\right]=0$$

where,u(r,t), P(r,t) and □ (r,t) denote particle velocity, pressure, density at a distance r from the origin at time t , □ is the adiabatic index of gas , □ is the coefficient of viscosity and □ = 2 for spherical shock waves.

3. BOUNDARY CONDITIONS

Let P_0 and □□□denotes the unperturbed values of pressure and density in front-

$$\mathrm{P}=a_0{}^2\mathrm{\rho}_0\left[\frac{2\,M^2}{(\gamma+1)}-\frac{(\gamma-1)}{(\gamma+1)}\right]$$

$$\mathrm{\rho}=\mathrm{\rho}_0\left[\frac{(\gamma+1)\,M^2}{(\gamma-1)M^2+2}\right].$$

$$\mathrm{U}=\frac{2\,\mathrm{a}_0}{(\gamma+1)}\left[\mathrm{M}-\frac{1}{\mathrm{M}}\right]$$

$$\mathrm{a}=\mathrm{a}_0\sqrt{\frac{[2\,\gamma\,M^2-(\gamma-1)\,]\,[(\gamma-1)\,M^2+2]}{(\gamma+1)}}$$

where, M=U/a0 is Mach number, U is the shock velocity, a and a0 are the sound velocity in disturbed and undisturbed medium respectively.

3.1 Weak Shock Waves

For weak shock waves i.e. ($U<<a_0$) the boundary conditions, M=1+□□reduce to-

$$\mathrm{P}=\frac{\gamma\,\mathrm{P}_0}{(\gamma+1)}\left[\frac{(\gamma+1)}{\gamma}+4\,\varepsilon\right]$$

$$\mathrm{\rho}=\mathrm{\rho}_0\left[1+\frac{4\,\varepsilon}{(\gamma+1)}\right]$$

$$\mathrm{U}=\mathrm{a}_0[1+\varepsilon]$$

$$\mathrm{u}=\frac{4\,\mathrm{a}_0\,\varepsilon}{(\gamma+1)}$$

3.2 Characteristic Equation For Freely Propagation of Shock Wave

The characteristic equation for exploding shock is given as-

$$dP+\rho a\;du+\frac{\alpha\,\rho\,\mathrm{a}^2\,u}{r}\frac{dr}{(u+a)}-\frac{4}{3}\frac{\mu\,\rho\,a\,du}{(u+a)}=0$$

Solving, this equation-

$$\varepsilon=\mathrm{k\,r}^{-\frac{\alpha}{\left[2-\frac{4}{3}\frac{\mu}{\mathrm{a}_0}\right]}}$$

The expression for shock velocity may be written as-

$$\mathrm{U}=\mathrm{a}_0\left[1+\mathrm{k\,r}^{-\frac{\alpha}{\left[2-\frac{4}{3}\frac{\mu}{\mathrm{a}_0}\right]}}\right]\qquad(1)$$

The expression for shock strength may be written as-

$$\mathrm{M}=\frac{\mathrm{U}}{\mathrm{a}_0}=\left[1+\mathrm{k\,r}^{-\frac{\alpha}{\left[2-\frac{4}{3}\frac{\mu}{\mathrm{a}_0}\right]}}\right]\qquad(2)$$

4. RESULTS AND DISCUSSION

4.1 Weak Spherical Shock Waves

Expression (1) and (2) represents the shock strength and shock velocity for the freely propagation of weak shock, in uniform medium. Shock strength is a function of propagation distance r, adiabatic index □, shock symmetry parameter □ and viscosity coefficient □.

Table 1:Variation of variable with propagation distance for strong spherical shock waves (□ =1.4, □= 0.000172 ,□ =2 and□□=1.29)

r	U	M	P	u
10.0	1.3201	1.3001	1.3597	0.5231
10.2	1.3141	1.2941	1.3563	0.5129
10.4	1.3084	1.2885	1.3530	0.5029
10.6	1.3028	1.2831	1.3449	0.4935
10.8	1.2975	1.2778	1.3469	0.4843
11.0	1.2924	1.2728	1.3440	0.4755

Table 2:Variation of variable with adiabatic index for weak spherical shock waves (r□□, □ = 0.000172 ,□ =2and□□=1.29)

r	U	M	P	u
1.33	1.30509	1.300048	1.3972	0.5231
1.40	1.35437	1.300052	1.4084	0.5307
1.66	1.47033	1.300057	1.5916	0.5393
1.69	1.48364	1.300066	1.6144	0.5425
1.75	1.51423	1.300069	1.6682	0.5591

Table3:Variation of variable with viscosity coefficient for weak spherical shock waves (□ =1.4, □□□ ,□ =2 and□□=1.29)

r	U	M	P	u
0.0000172	1.3201	1.3001	1.3597	0.5231
0.0001720	1.3169	1.2873	1.3564	0.4929
0.0017200	1.3029	1.32757	1.3439	0.4417
0.0172000	1.42757	1.2512	1.3352	0.4039
0.1720000	1.2427	1.2238	1.3161	0.3902

5. CONCLUSIONS

It is concluded that shock strength, shock velocity, pressure and particle velocity decrease with propagation distance and viscosity coefficient. These parameter increases with adiabatic index. But similar results are found for strong shock propagating in non-uniform medium.

6. REFERENCES

[1] R. K. Anand and H.C.Yadav, Physcis Scr.83065402 (2011)
[2] R. K. Anand and H.C.Yadav, Acta Physica Vol.129 2016.
[3] Dipak Kumar Satpathi, Addepalli Ramu and Narsimhulu,Proecciones, Journal of Mathematics Vol.35pp11-31,2016.
[4] Chaojun.Y.J.Z.,Young-Kang,Z.,Jian-Zhong,N.,Ming-Xing,D.,Jain-Jun,H.,Shu,Ai., Xin.,F. and Lei.-Long,Z., The mechanism of laser deformation and the reason for the production of the shock wave, Frontiers of Mech. Engineering, 1, (4), pp. 448,2006.
[5] Chien-Li Chen and Kun- Chieh Chan**,** Combined effects of thermo- phoresis and electrophoresis on particle deposition onto a wavy surface disk, Int. of Heat and Mass Transfer, 51, pp.2657-2664,2008.
[6] Fan.B.C., Chen, Z.H.,Jiang,X.H. and Li.H.Z., Interaction of a shock wave with a loose dusty bulk layer, Shock waves,16,(3),179,2007.
[7] Huseyin cavus**,** advances in astronomy pp1-6,2013.
[8] Keller, J.B.**,** Theory of weak shock waves, J. Appl.Phys.25 (8), 938-947,1954.
[9] Sakuari, A. and Takayama, F.**,** Shock waves, 14(4), 225,2005.
[10] Whitham, G. B. : **(1974),** Linear and nonlinear waves (John Wiley & Sons, New -York)