# UNIVERSAL ATTENUNTIOA LAWS FOR SPHERIEAL SHOCK WAVES PRAPAGATING IN PURE GASES AND IN GAS-PARTICLE SUSPENSIONS

F. Aizik, G. Ben-Dor, T. Elperin, O. Igra
Pearlstone Center for Aeronautical Engineering Studies Departmept of Mechanical Engineering Ben-Gurion University of the Negev Beer Sheve, Israel

The most common shock wave in nature is a spherical one. Every shock wave generated by a sudden release of a large amount of energy, even if its initial shape is not spherical will turn into a spherical one as it propagates into the surrounding atmosphere. This is the reason for the importance of better understanding the flow field developed behind a spherical shock wave.
The governing equations of the flow field, which is developed behind a spherical shock wave, consist of nonlinear partial differential equations. Since they must be solved simultaneously they can be solved only numerically. Such solutions require significant resources (time, computers, etc.). The complexity of solving these equations on one hand and the importance, in many applications, of knowing the flow field properties in real time on the other hand was the motivation to develop an alternative way to obtain the flow field properties immediately behind the spherical shock wave front.
Olim et al.[1] ' in their study of the flow field which developed behind an attenuating planar shock waves propagating in a dusty air, showed that the numerical simulation can be replaced by developing a semi-empirical relation describing the instantaneous shock wave Mach number. Their proposed attenuation law was

$$M_S = (M_{S,O} - 1) \exp(-x / X) + 1 \qquad (1)$$

Where Ms,o is the initial shock wave Mach number, i.e., the shock wave Mach number when it first encounters the dust-gas suspension whose edge is at x = 0. The
attenuation coefficient x was found to linearly depend on the diameter of the solid dust particles, D, and inversely on the dust loading ratio, rl, through the following expression:

$$X = 1/\eta \, [\, \alpha (M_{S,O}) + ß (M_{S,O}) D] \qquad (2)$$

In this expression a and ß are constants for a given initial shock wave Mach number. Olim et al.[1] also calculated the appr2priate values of these iwo constants for $M_{S,O}$ = 1.5. The values as obtained by ihem were α = 2.275 m and ß = $3.07 \times 10^{-4}$, The correlation proposed by Olim et al.[1] implied that the instantaneous.shock wave Mach number degenerated to a sound wave, i.e., $M_S \rightarrow 1$, when $x \rightarrow \infty$. This was shown experimentally, by Sommerfeld[2] to be the case only if the initial shock wave was weak to moderate and the dust-loading ratio was relatively high. If, however, the initial shock wave was strong and the dust-loading ratio was low to moderate, the shock wave did not attenuate to a sound wave, but to a finite strength shock wave whose Mach number, Me, was larger than unity.
Owing to this observation, Aizik et al.[3] modified tlte attenuation law suggested by Olim et al.[1] by replacing equaüon (1) with the following more general expression:

$$M_s = (M_{S,O} - M_e) \exp(-x / X) + M_e \qquad (3)$$

Where X and $M_e$ were found to depend on $M_{S,O}$, D and, η in the following way:

$$X = X (M_{S,O}, D, \eta) \qquad (4)$$

and

$$M_e = M_e\,(M_{S,O},\eta) \tag{5}$$