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ATTENUATING SHOCK WAVES BY USE OF GRIDS OR ORIFICE PLATES

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Shock waves interaction with porous barriers of different geometry and porosity (perforated plates or a slit like barriers) is examined experimentally and numerically. In the experimental part a barrier is installed inside the shock tube test section. It causes the following wave pattern upon the head-on collision between the incident shock wave and the installed barrier. A reflected shock from the barrier and a transmitted shock propagating towards the shock tube end wall. Once the transmitted shock wave reaches the tube's end wall it is reflected back towards the barrier. This is a beginning of multiple reflections between the barrier and the end wall. This full cycle of shock reflections/interactions resulting from the incident shock wave collision with the barrier is studied in a single shock tube test. In the numerical part the resulted flow is studied first as being one-dimensional, inviscid flow. This is a very rough approximation of the complex flow resulting from the head-on collision between the incident shock wave and the barrier and as could be expected only modest agreement is found between experimental findings and simulations based on the one-dimensional flow approximation. In the second step the flow is approximated as being a two-dimensional, inviscid flow. Now a better agreement is found between simulations and experimental findings. In the third step the flow viscosity is included in the numerical study, i.e., the Navier-Stokes equations are solved. It is shown that the flow viscosity plays an important role in the unsteady post-shock flow behind the barrier. Based on obtained numerical and experimental findings an optimal design procedure for shock wave attenuator is suggested. The suggested attenuator ensures the safety of shelter's ventilation systems.

Sample of obtained results is given in the following figures. In Fig. 1 the used shock tube is shown along with a wave diagram showing the evolved wave pattern. Barriers of different porosity were placed, alternatively at different distances from the tube's end-wall. Comparison between numerical results for the interaction of a planar shock wave with a slit-like barrier is given in Fig. 2. Figure 2a shows results obtained for a viscid flow while in Fig. 2b results obtained for similar invicsid case is given. Comparing these two figures reveals that in the inviscid case (Fig. 2b) vortices detached from the slit-like barrier (seen just ahead of pressure gauge N1) propagate further downstream than in the viscose case and finally fill the entire conduit cross-section. Hence, omitting the gas viscosity results in non-physical flow behavior between the slit-like barrier and the transmitted shock wave. The vortices trail does not evolve into a jet stream, as is the case in a real flow (Fig. 2a). In the considered flow the gas viscosity is the main mechanism in subsiding the vortices trail, developed behind the transmitted shock wave, and altering it into a jet stream. When comparing recorded pressures history at stations N1, N2 and N3 with appropriate numerical predictions, the results obtained for the viscose flow case are in better agreement with experimental findings than those obtained for the inviscid case.

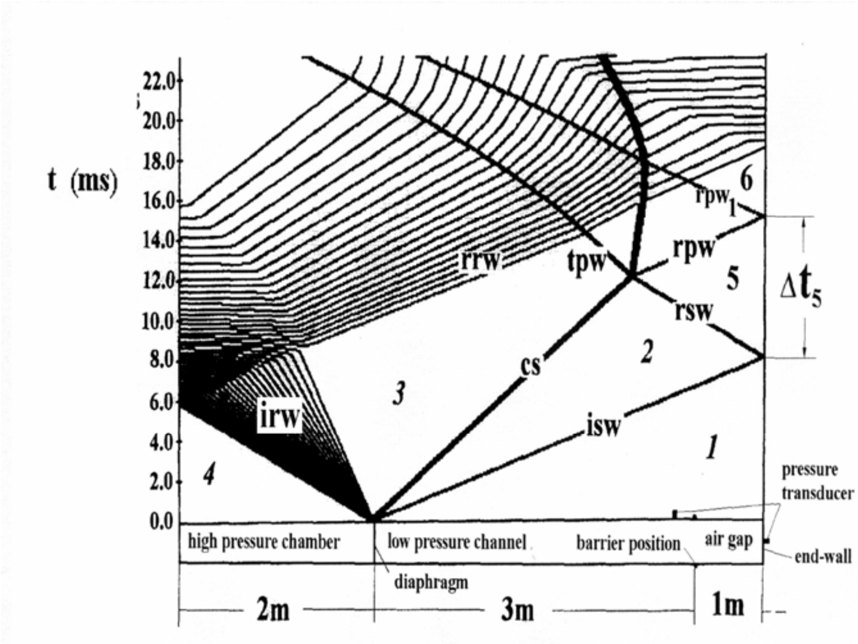
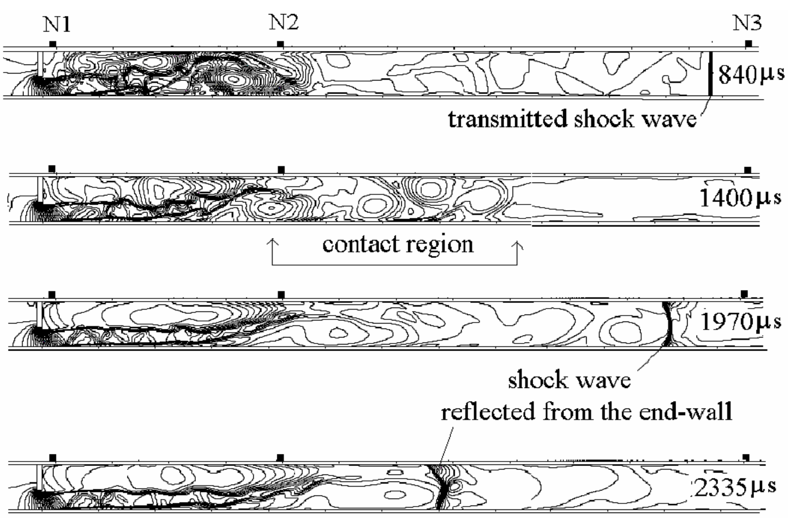
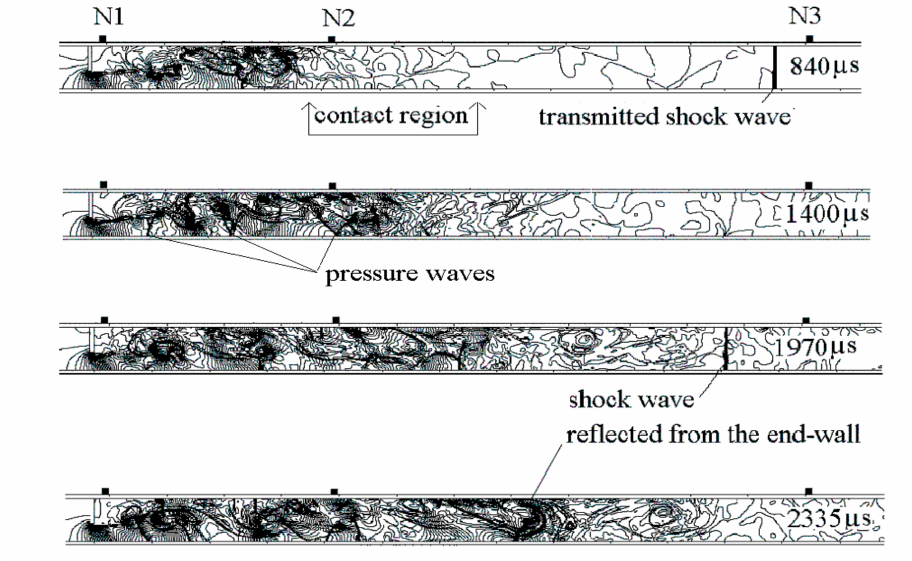


Fig. 1 Wave diagram of the shock tube flow: isw – incident shock wave, irw – incident rarefaction wave, rsw- shock wave reflected from the tube's end-wall, cs- contact surface, rpw- reflected compression wave, tpw - transmitted compression wave, rrw – reflected rarefaction wave.



(2a)



(2b)

Fig. 2 The flow field resulted from the head-on collision between a planar shock wave (Ms = 1.48) and a slit-like barrier (the barrier porosity is 0.4). (a) When the fluid is treated as viscid (using the Navier-Stokes Eq.) and (b) When the flow is treated as being invicsid (using the Euler Eq.). N1, N2 & N3 are ports for pressure measurements.