parable to those obtained on a baseline Murman-Cole test code (over-relaxation is not used in the present scheme). Surface pressures agreed well with the results of Ref. 4. In the present method, the usual upstream to downstream sweeping was carried out in combination with Sichel's boundary conditions (actually, convergence appears to be insensitive to the actual form of the regularity conditions). All low-order terms are central differenced, provided that φ_{xxx} is approximated in the manner described. This differencing was motivated physically by the desire to account for more upstream effects than downstream if the point in question happened to be "supersonic" $(K-\varphi_x<0)$, while in the elliptic case, gradients are usually small enough that the effect of $\epsilon\varphi_{xxx}$ is generally unfelt. It should be noted[6] that the combination $a(\varphi_{i+1}-2\varphi_i+\varphi_{i-1})+b(\varphi_{i+1}-3\varphi_i+3\varphi_{i-1}-\varphi_{i-2})$ reduces to the first-order upstream operator for φ_{xx}, if $b=-a$.

Summary

A method for calculating inviscid flow has been presented that uses artificial viscosity everywhere rather than mixed differencing (this possibility was first suggested independently in Ref. 7). The small-disturbance equation used has the form of the VTE, although large values of the viscosities need to be used for numerical stability; thus, the computed results, with $\epsilon=O(h)$, are only formally first-order accurate for the inviscid solution. Convergence to the "correct" results appears to be insensitive to the actual form of the regularity conditions (some instabilities were observed, however, but a general rule for "dynamically" choosing ϵ is not yet available).

One last exploratory study was undertaken. While sweep direction is unimportant for purely elliptic problems, it is crucial when there exist embedded supersonic zones. The previous column relaxation scheme, therefore, swept from upstream to downstream to account properly for domains of influence and dependence. Because the VTE is formally parabolic, one might suspect a partial insensitivity of the convergence to "reverse sweeping." To test this idea, the row and column relaxation schemes discussed earlier were modified to sweep, respectively, from "top to bottom" and from "downstream to upstream." The iterations converged to the correct results in approximately the same number of sweeps; some differences in the surface pressures were noticed initially, but these quickly disappeared (see Fig. 1 for typical results from a "large viscosity" case). The exact reason for convergence is not yet known, and forms the subject of present investigation.

The possibility of a truly type-independent and sweep direction-independent difference scheme is extremely intriguing. While we are still far from such a general algorithm, such a development is especially important from the point of view of studying flows over complicated aerodynamic configurations. The sweeping in type-dependent methods seems to depend on the positions of supersonic zones that, in the general case, are unknown beforehand. A logically simple, "direction-independent" method would offer considerable freedom in mesh definition.

Acknowledgments

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Impulse from an Electrically Exploded Etched Copper Mesh

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THE simulation of impulse loads produced by radiation-induced material blowoff has been successfully accomplished with magnetically driven flyer plates,[1] magnetic pressure pulses,[2] and light-initiated explosives.[3] These techniques load the exterior surfaces of shell structures with short-duration pressure pulses. There is also the possibility that some material blowoff could occur on layers internal to these shell structures. In this case, the material blowoff products are confined in a gap and are not allowed to expand freely. We have explored the possibility of simulating this confined or tamped impulse load by exploding an etched copper mesh pattern‡ with the current from a capacitor discharge. Impulse intensities between 100 and 500 Pa·s (1000 and 5000 taps) were produced on a simulated shell structure which was separated from the mesh by a 1.25-mm (0.05-in.) air gap.

Experiments

The copper mesh pattern shown in Fig. 1 is a thin copper foil bonded to Mylar and chemically etched by the techniques used to manufacture printed circuits. The mesh is connected to a capacitor bank and the individual bridgewires are electrically exploded by the discharge current.

The experimental apparatus used to measure the impulse load from the electrically exploded mesh is shown in Fig. 2. There is a 1.25-mm (0.050-in.) air gap between the mesh and the suspended rod. When the mesh explodes, a pressure pulse pushes on the end of the rod. The displacement time at the other end of the rod is measured with a capacitance displacement gage. Initial rigid-body motion of the rod is linear with time, and the rod velocity and momentum can be calculated.

The results are presented in Fig. 3, where impulse is plotted as a function of stored energy in the capacitor bank. A single BICC capacitor with capacitance of 27.5 μF was charged to 12-31 kV to obtain these data.

Discussion

An impulse simulation technique for material blowoff has been explored. The data shown in Fig. 3 indicate that a practical range of impulse loads is possible with this particular mesh pattern by varying the charge voltage of the capacitor bank.

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‡This particular copper mesh pattern was previously designed to simultaneously detonate high explosives.[4,5]

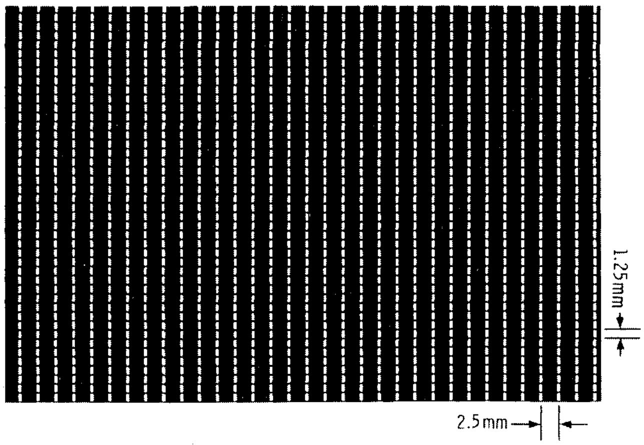

Fig. 1 Mesh patterns. The small connecting black lines are the bridgewires.

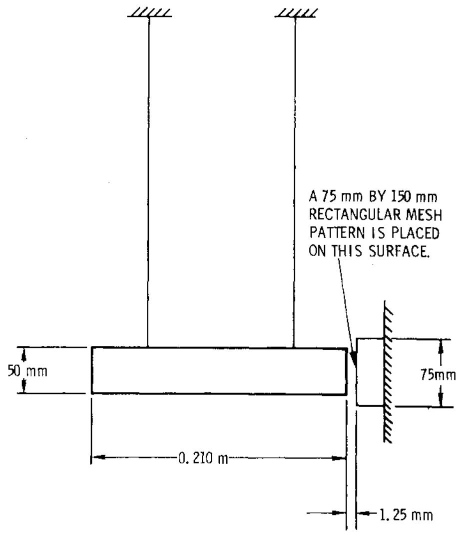

Fig. 2 Experimental arrangement.

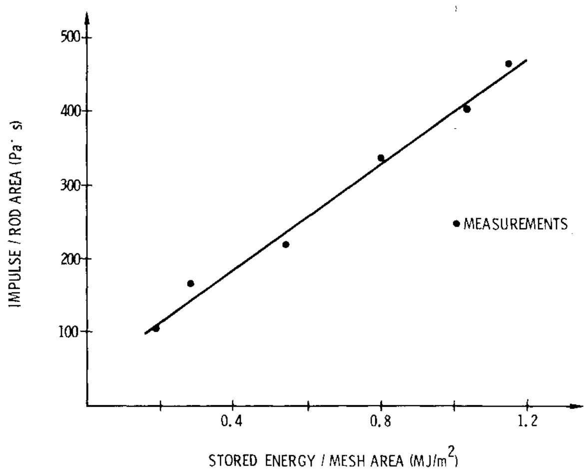

Fig. 3 Impulse vs stored energy.

Acknowledgment

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Hypersonic Free-Molecular Heating of Micron Size Particulate

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Nomenclature

M_∞ = Mach number
s = speed ratio = $M_\infty \sqrt{\gamma/2.0}$
T = ambient gas temperature
T_w = particles surface temperature
$\bar{\alpha}$ = thermal accommodation coefficient
γ = ratio of specific heats
σ = surface tangential reflection coefficient
σ' = surface normal reflection coefficient

THE purpose of this Note is to show experimental proof that the free-molecular derivations for Stanton number, recovery factor, and drag are indeed sufficient to compute the temperature and position time history of micron size particles in rarefield hypersonic gas flow. An application of this method would be to predict the observables of micrometeors or dust clouds entering the Earth's atmosphere at high altitudes.

A test program was conducted in the Hypervelocity Impact Range (SI) of the von Kármán Gas Dynamics Facility (VKF) at the Arnold Engineering Development Center (AEDC), to provide measurements of dust cloud temperature histories at pressure altitudes of nominally 30-μm Hg (the U.S. standard atmosphere equivalent of 72 km) and velocities of nominally 6.1 km/s.

A technique was worked out to launch at 10- to 20-mg "dust" cloud using a sabot fired from a gun barrel. After firing, the sabot was decelerated in the converging nozzle of the gun releasing the cloud. To further minimize the sabot's influence on the cloud it was deflected to impact in the blast tank. The dust cloud continued in flight through the 1220-cm long, 20.32-cm-diam range tank to impact on a styrofoam block. Three color radiometric measurements were made at approximately 0.4, 0.6, and 0.8 μm at three downrange stations. By then taking ratios of the observed intensities and using handbook values of emissivities, the time-dependent temperatures were calculated from Planck's radiation law.

The justification of using gas kinetics rather than continuum theory can be best appreciated by reference to Fig. 1 to see the typical size distribution, obtained using a Coulter machine, of silicon carbide particles used in one test.

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