Mix Experiments using a Two-Dimensional Convergent Shock Tube

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Principle of Design

Compressed Gas

Diaphragm

Shock Profiles

Zone of Dense Gas

Detonable Gas
Experiments performed

Basic cylindrical

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0
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2cm

radius

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20cm

---

35cm

air

---

dense gas SF6

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Notch

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20mm

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20mm
Shock Pressure Waveform

Radius 50cm

Firing pulse
Primary shock A
Reflection off air/SF6 boundary B
Reflection from apex Shock B reflected from gas chamber C
Shock C reflected from gas chamber

pressure, bar vs time, microsec
Details of the Dense Gas Containment

- **SF₆ outlet (series of small holes)**
- **SF₆ fill pipes**
- **Seeded SF₆**
- **Air**
- **Microfilm membranes supported on tungsten wires/mesh with spacing or aperture of 4mm x 4mm**
- **8mm x 8mm**
Detonable Gas Chamber
Oxy-acetylene gas chamber

- Porous plate diffuser
- Aluminium foil
- Gas inlet
- Gas outlet
- Wires (75 micron dia.)
- 30 spark plugs (at 1º intervals)
- H.V. supply unit
  - 10kV
  - 25J
- Current monitors
Small Detonation Test-cell
to check for simultaneity of multi-point detonation

Optical test cell representing a 1/10 volume of the gas chamber - features 3 spark plugs. It allows photographic study of the detonation process.
Small Detonation Test Cell - Sample Images

Detonation test cell

Example of non-simultaneous spark ignition
Shadowgraph Images

(air / SF$_6$ / air cylindrical experiment)
Shadowgraph Images

(air / SF$_6$ / air cylindrical experiment)

1.27ms 1.33ms 1.40ms
1.67ms 1.80ms 2.00ms
2.13ms 2.27ms 2.40ms
Shadowgraph Images

(air / SF$_6$ / air cylindrical experiment)
Shadowgraph Images

(air / SF$_6$ / air cylindrical experiment)
Cylindrical polar mesh.

Semi-Lagrangian calculation - r - direction mesh moves with the mean fluid velocity.

Mesh used in the 3D region (r, θ, z): 344 x 200 x 140.

Random pertubations imposed at each interface:

Wavelengths: 0.5 to 5.0cm
s.d: 0.01cm
Notch Experiment

Experiment: 0.93ms

Turmoil 3D code: 0.9ms
Notch Experiment

Experiment

Turmoil 3D code

1.13ms

1.05ms
Notch Experiment

Experiment

1.20ms

Turmoil 3D code

1.15ms
Notch Experiment

Experiment

Turmoil 3D code

1.87ms

1.75ms
Turmoil 3D Calculations

Cylindrical Experiment

0
1.2 ms
1.5 ms
1.8 ms
Conclusions

1. Successfully demonstrated suitability of a Convergent Shock Tube for performing R-M experiments with gases in 2D geometry

2. Achieved compressions of dense gas of typically 25 : 1 using shock Mach No. \( \sim 3 \)

3. Achieved good understanding of design requirements for constructing a new improved Convergent Shock Tube
Future Work

• Construct new Convergent Shock Tube which operates with the laser sheet diagnostic (and variants)
  • Establish seeding with fluorescent gas suitable for:-
    • use of notch filter to ‘remove’ laser light scattered from membrane fragments
    • seeding at high gas compression
  • Continue experiments with different perturbation profiles
  • Substitute Xe gas for SF$_6$
  • Establish calibration technique for gas data analysis of laser sheet images
  • [Consider ‘inverse’ experiment to check the influence of the side walls ]