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ENHANCING PERFORMANCE OF DETONATION DRIVEN SHOCK TUBE

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ABSTRACT

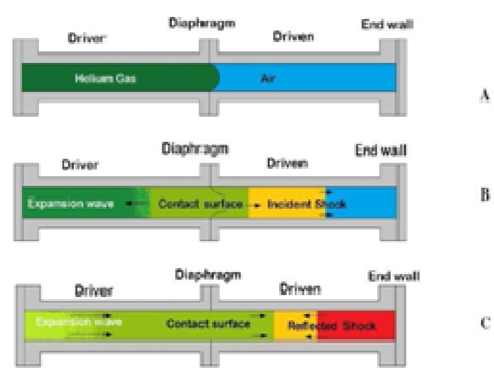
To produce high enthalpy flow detonation driven shock tube is needed. If a damping section is attached at the end of the driver then it can eliminate the high reflection pressure which is produced by detonation wave, and as a result the backward detonation driver can be employed to generate high enthalpy and high density test flow. By using this apparatus, a strong shock wave is generated by detonating an oxygen-hydrogen mixture. The detonation wave is induced by the expansion of helium or air. A detonation wave is produced by this method which propagates downstream that transition into a shock wave in the driven section.

KEYWORDS: Shock Tube, Detonation-Driven, High-Enthalpy

The shock tube is required to reproduce and direct blast waves at a sensor to simulate actual explosions and their effects. A detonator is a device used to trigger an explosive device .Shock tube produces a moving normal shock wave by sudden bursting of a diaphragm which separates a high pressure section and a low pressure section. This is basically a closed tube divided by a diaphragm into two sections of substantially different pressures. The material used for shock tubes is mostly brass or steel. The diaphragms are made of cellophane, copper, aluminum, or steel depending upon the strength of the shock wave required. The diaphragm is ruptured either by increasing the pressure difference between the sections or by puncturing with a mechanical device. When the diaphragm gets ruptured the gas at high pressure (driver) side acts like a piston and presses the gas at low pressure (driven) side. As a result a shock wave propagates into the driven section and compresses the test gas. A detonator is a device used to trigger an explosive device. A shock tube detonator is a non-electric explosive fuse or initiator in the form of small-diameter hollow plastic tubing used to transport an initiating signal to an explosive charge by means of a percussive wave traveling the length of the tube. It contains a small quantity of high explosive, but safer and more reliable than detonating cord with the same quantity of explosive. A shock tube detonator designed to initiate explosions, generally for the purpose of demolition of buildings and for use in the blasting of rock in mines and quarries. Instead of electric wires, a hollow plastic tube delivers the firing impulse to the detonator, making it immune to most of the hazards associated with stray electric current. It consists of a small diameter, three-layer plastic tube coated on the innermost wall with a reactive explosive compound, which, when ignited, propagates a low energy signal, similar to a dust explosion.

METHODOLOGY

A shock tube detonator is a non-electric explosive fuse or initiator in the form of small-diameter hollow plastic tubing used to transport an initiating signal to an explosive charge by means of a percussive wave traveling the length of the tube. It contains a small quantity of high explosive, but safer and more reliable than detonating cord with the same quantity of explosive. Another early product contained an enclosed combusting, non-detonating fiber.



The most common product is 3mm outer diam eter and1 mm inner diameter, with a tiny dusty inner surface, which detonates down the tube at a speed greater than 6500 feet per second but does not burst the tube. Being non-electrical and non- metallic, shock tubes are less sensitive to static electricity and radio frequency energy and thus have replaced many uses of electric detonators and are safer to handle and store than detonating cord. A version containing an explosive gas mixture has the additional advantage of being entirely inert until the tubing is charged with the gas.

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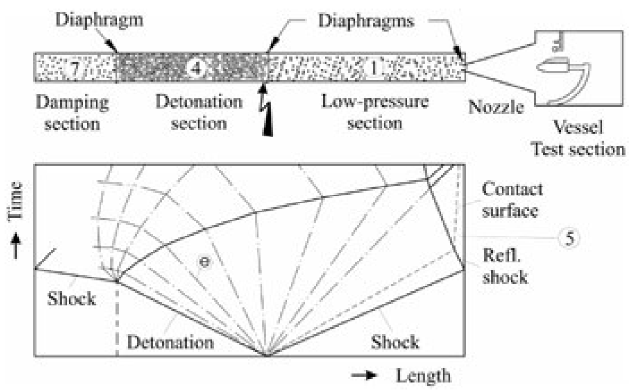
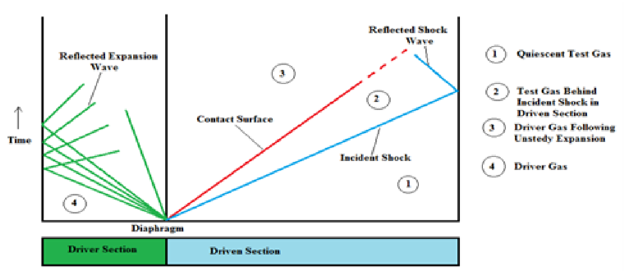
One manufacturer estimates that over 2 billion feet of shock tube are used each year worldwide, in commercial blasting, military demolition, theatrical special effects, automobile airbags, aircraft escape systems, IED initiation and professional fireworks.

The commercial use of explosives uses electrical detonators or the capped fuse which is a length of safety fuse to which an ordinary detonator has been crimped. Many detonators' primary explosive is a material called ASA compound. This compound is formed from lead aside, lead styphnate and aluminum and is pressed into place above the base charge, usually TNT or tetryl in military detonators and PETN in commercial detonators.



Other materials such as DDNP (diazo dinitro phenol) are also used as the primary charge to reduce the amount of lead emitted into the atmosphere by mining and quarrying operations. Old detonators used mercury fulminate as the primary, often mixed with potassium chlorate to yield better performance. Two modes of operation are possible. In the upstream-or backward propagation mode, the ignition source is just upstream of the primary diaphragm between the detonation and driven sections. In this case, the detonation wave propagates upstream.



The pressure rise following the detonation wave is constant, but the momentum imparted to the driver gas by the detonation wave is directed upstream, that is, opposite to the main flow. This leads to a reduction of the effective driver performance. Shortly after initiation, the main diaphragm opens and the burnt products exhaust into the low-pressure section, driving the incident shock that compresses and heats the test gas. A Taylor expansion immediately follows the detonation wave, decelerating the burnt gas to zero velocity along the characteristic labeled. Detonation is a type of combustion involving a supersonic exothermic front accelerating through a medium that eventually drives a shock front propagating directly in front of it. Detonations occur in both conventional solid and liquid explosives, as well as in reactive gases. The velocity of detonation in solid and liquid explosives is much higher than that in gaseous ones, which allows the wave system to be observed with greater detail (higher resolution). An extraordinary variety of fuels may occur as gases, droplet fogs, or dust suspensions. Oxidants include halogens, ozone, hydrogen peroxide and oxides of nitrogen. Gaseous detonations are often associated with a mixture of fuel and oxidant in a composition somewhat below conventional flammability ratios. They happen most often in confined systems, but they sometimes occur in large vapor clouds. A shock wave or shock is a type of propagating disturbance. When a wave moves faster than the local speed of sound in a fluid it is a shock wave. Like an ordinary wave, a shock wave carries energy, and can propagate through a medium; however it is characterized by an abrupt, nearly discontinuous change in pressure, temperature and density of the medium. In supersonic flows, expansion is achieved through an expansion fan also known as a Prandtl- Meyer expansion fan.

RESULTS

The inputs are as given below:

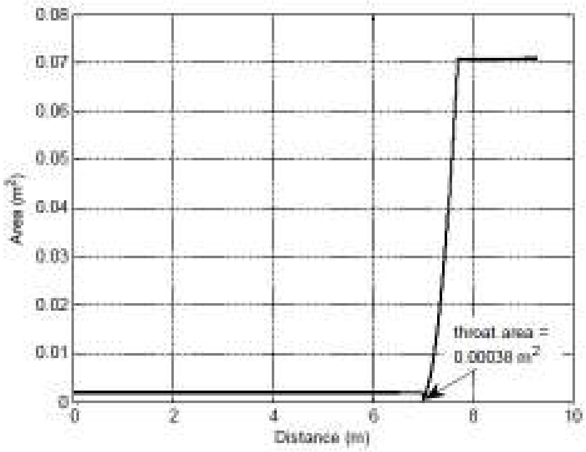
Pressure in driver section – 15 bar (Helium).

Pressure in driven section – 0.2 bar (Air).

Pressure in the nozzle – 0.00002 bar (Air).

Temperature all three section – 300K.

Variation of diameter of shock tunnel, pressure, temperature, velocity can be clearly seen.



CONCLUSION

This work has been done to design 1D shock tube with one and two diaphragms with help of different numerical solver. A CFD solver was developed for a rectangular CD nozzle having unit width which gives a Mach number 5. A shock tunnel CFD solver was also developed to study the properties variation in a shock tunnel which gives a shock Mach number nearly equal to 6. Two solvers were also developed for calculation of fluid and flow properties across the shock wave and Mach number using EXCEL. Simulation is done to obtain a wide range of Mach number varying the pressure ratio and using different driver gases.

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