Bachelor of Science in Mechanical and Chemical Engineering

Thesis

Study of the shock wave interaction with a liquid in a container

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ABSTRACT

All around the world, the modern civilization is trying to find ways to utilize energy. And the major source that many of the used worldy things is the fossil fuel.

As the shock wave plays a high role in the energy part ,and produces a high force it can be used as an alternative energy sometimes if it's utilized in a proper way.

As we can see the world uses this shock wave nowadays in the weapons (like America used while bombing japan),particularly the heavy guns to cause destruction apart from the fire the shock wave is useful and hazardous.

Hence, from this we can know the usefulness of the shock wave.

In our project we studied experimentally on how this shock wave interacts with a liquid confined in a steel tube, and we experienced that the liquid level raises when the shock wave propagation reaches the tube. As the shock is increased the water raise increases until gets out of the tube to the atmosphere with ahigh energy, and our objective was achieved successfully.

Objectives:

We performed this experiment for several reasons. They are given in the following:

1.We want to study about shock wave.

2.We want to study about the classification,types of shock wave.

3.We want to study about the great impact of shock wave over the environment.

4.We want to make a practical experiment about how shock wave influence on the fluctuation of water substance.

5.Make a relationship between the shock wave & liquid fluctuation.

Characteristics of the shock wave:

1.It is a strong pressure wave.

2.It propagates through any elastic medium such as air, water or solid substance.

3.Shock waves are characterized by an amplitude dependant wave velocity.

4.They are also characterized by an abrupt, nearly discontinuous change in the characteristics medium.

How the shock wave is generated:

Shock waves arise from sharp violent disturbance generated from a lightening stroke,bomb blast or other form of intense explosion & from steady supersonic flow over substance.

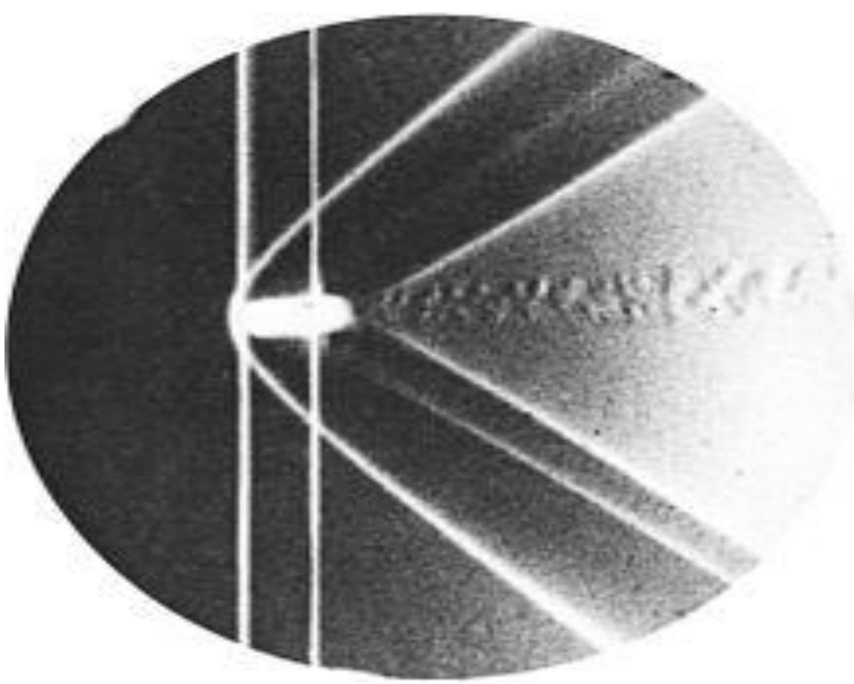

Fig: Shadowgraph of the detach ached shock on a bullet in supersonic flight.

How the shockwave can be visualized naturally:

The abrupt nature of shock wave in a gas can best be visualized from a schilren photograph or shadow graph of supersonic flow over objects.

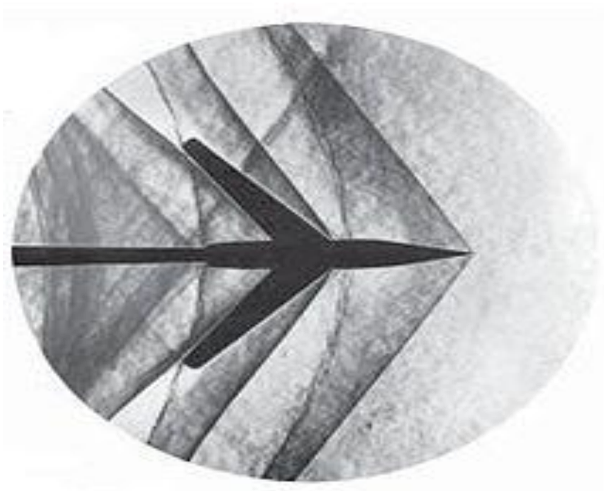

Fig: Schilren photograph of supersonic flow.

Examples of shock wave:

Moving shock

- Usually consists of a shockwave propagating into a stationary medium
- In this case, the gas ahead of the shock is stationary (in the laboratory frame), and the gas behind the shock is supersonic in the laboratory frame. The shock propagates with a wave front which is normal (at right angles) to the direction of flow. The speed of the shock is a function of the original pressure ratio between the two bodies of gas.
- Moving shocks are usually generated by the interaction of two bodies of gas at different pressure, with a shock wave propagating into the lower pressure gas, and an expansion wave propagating into the higher pressure gas.
- Examples: Balloon bursting, Shock tube, shock wave from explosion

Detonation wave

- A detonation wave is essentially a shock supported by a trailing exothermic reaction. It involves a wave traveling through a highly combustible or chemically unstable medium, such as an oxygen-methane mixture or a high explosive. The chemical reaction of the medium occurs following the shock wave, and the chemical energy of the reaction drives the wave forward.
- A detonation wave follows slightly different rules from an ordinary shock since it is driven by the chemical reaction occurring behind the shock wave front. In the simplest theory for detonations, an unsupported, self-propagating detonation wave proceeds at the Chapman-Jouguet velocity. A detonation will also cause a shock of type 1, above to propagate into the surrounding air due to the overpressure induced by the explosion.
- When a shockwave is created by high explosives such as TNT (which has a detonation velocity of 6,900 m/s), it will always travel at high, supersonic velocity from its point of origin.

Detached shock

- These shocks are curved, and form a small distance in front of the body. Directly in front of the body, they stand at 90 degrees to the oncoming flow, and then curve around the body. Detached shocks allow the same type of analytic calculations as for the attached shock, for the flow near the shock. They are a topic of continuing interest, because the rules governing the shock's distance ahead of the blunt body are complicated, and are a function of the body's shape. Additionally, the shock standoff distance varies drastically with the temperature for a non-ideal gas, causing large differences in the heat transfer to the thermal protection system of the vehicle. See the extended discussion on this topic at Atmospheric reentry. These follow the "strong-shock" solutions of the analytic equations, meaning that for some oblique shocks very close to the deflection angle limit, the downstream Mach number is subsonic. See also bow shock or oblique shock
- Such a shock occurs when the maximum deflection angle is exceeded. A detached shock is commonly seen on blunt bodies, but may also be seen on sharp bodies at low Mach numbers.
- Examples: Space return vehicles (Apollo, Space shuttle), bullets, the boundary (Bow shock) of a magnetosphere. The name "bow shock" comes from the example of a bow wave, the detached shock formed at the bow

(front) of a ship or boat moving through water, whose slow surface wave speed is easily exceeded

Recompression shock

- These shocks appear when the flow over a transonic body is decelerated to subsonic speeds.
- Examples: Transonic wings, turbines
- Where the flow over the suction side of a transonic wing is accelerated to a supersonic speed, the resulting re-compression can be by either Prandtl-Meyer compression or by the formation of a normal shock. This shock is of particular interest to makers of transonic devices because it can cause separation of the boundary layer at the point where it touches the transonic profile. This can then lead to full separation and stall on the profile, higher drag, or shock-buffet, a condition where the separation and the shock interact in a resonance condition, causing resonating loads on the underlying structure.

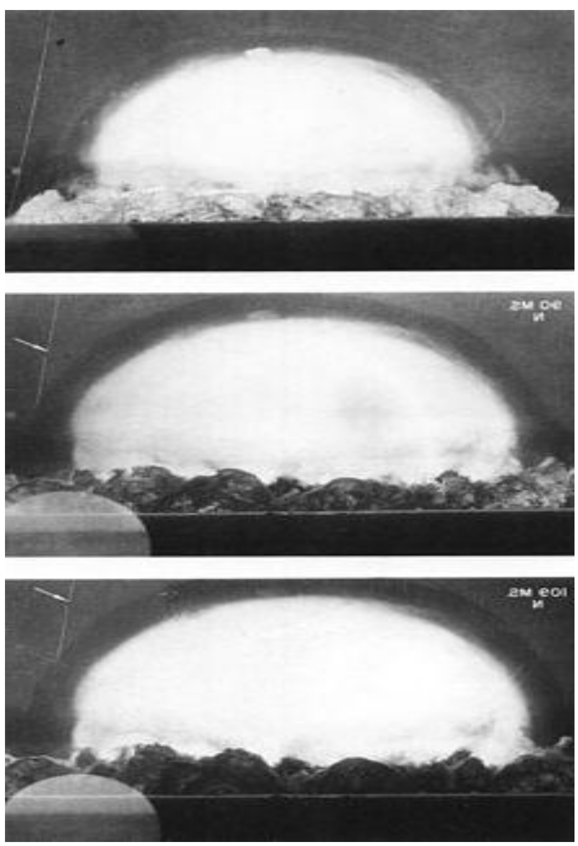

Fig: shock wave propagating into a stationery medium,ahead of the fireball of explosion.

Application of the shock wave:

- **Main Shock Med applications**

- Orthopaedics
- Rehabilitation
- Sport medicine
- Aesthetic medicine

These are the main pathologies that are suitable for shock wave application:

- Elbow – epicondylitis, epitrocleitis
- Shoulder - insertional tendinopathies, impingement
- Knee – Patellar and “goose’s foot” tendinopathies
- Pubis – Adductor tendinopathies (pubalgy)
- Ankle - Achilles tendinopathies, calcaneal apophysis

The main objective of using shock wave is to eliminate the calorific deposits from the body.

How the shock wave can be produced experimentally:

Shock waves are produced by rapidly imparting momentum over a large flat surface.shock tube for producing shock wave.Compressed air passes through the shock tube then it hits the diaphragm placed at outlet of the shock tube &then explosion will occur which causes the fracture of the diaphragm plates & thus it produces shock wave.

Then a small box made by stee,filled with water will be located behind the diaphragm to meet our objectives which is obtaining experimentally the impact of shock wave on water container.

Images of the setup:-

Image of the shock tube

Fig : shows the shock producing tube

Apparatus used:

1.Water tube:We have used mild steel tube of diameter 4.5 inch, thickness of 2ml & length of 12 inch.

2.Ball valves: We used ½” ball valves.

3.Liquid: We used colorful (Blue) water as liquid.

Apparatus setting:

1.We welded both sides of the tube in such a way that there is no leakage.

2.We made two holes on the top of the tube.

3.One hole contains the glass tube(to measure the water level).

4.One hole contains the ball valves to control the water level.

5.Then we placed a steel shit around the tube.

6.We hammered that sheet to convey the shock to the tube.

7.Then the sound made deflection in the water level.

8.We increase the rate of sound gradually ,the water level also gradually increased.

Outcome of the action:

As there was no interaction between the source & the water container so we can say that the fluctuation occur only for producing shock wave around the container by hammering on the copper surface.

Figure 1Initial water level

Figure 2 Deflection after interaction with shock wave.

Figure 3 Highest Deflection after interaction with shock wave.

Relationship between shockwave & waterlevel:

From the above experiment we can obviously say that there is an obviously relationship between the shockwave & deflection.When we gradually increased the rate of sond (increasing shock level) ,the water level was also increasing.on the other hand ,when we decrease the sound level,the water level was also decreasing.so we can take a decision that:

Shock wave proportional to the deflection of water.

This is a very important relationship among the shock wave & water level of the liquid substance.As the water level is rising velocity,density is also rising.It has a great impact on environment.Due to the bomb blast,huge rate of shock waves are produced in the affected area.As a result there should occur severe damage for deflection of water substances.

Fig:Destruction for producing Shock wave in Japan 1945 atomic explosion.

Limitations

Due to the shortage of facilities in IUT laboratory we could not measure the the rate of shock wave production.We think our farther project students will make the following measurement:

1.Measure the density of liquid.

2.Measure the pressure of liquid.

3.Measure the velocity of liquid substance.

References

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