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AN INTRODUCTION OF WORLD OF SHOCK WAVE

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ABSTARCT

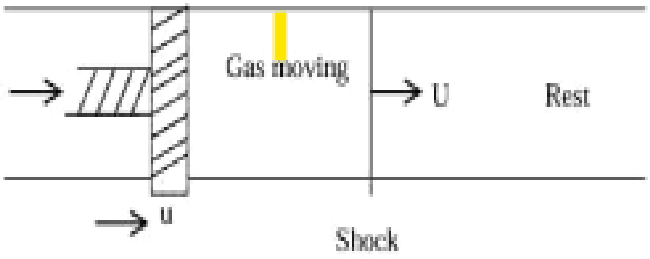
This paper give brief introduction of Shock wave its origin, method of solving problem related to shock wave its applications in different aspects like in field of industry, medical line, aerodynamics etc. An introduction of sonic boom and Dopler effect also explained in this paper with the help of Mach number.

I. INTRODUCTION

Shock wave is basically an ordinary wave following almost all properties of wave like carry energy and can propagate through medium. It is generated in high pressure region when there is sudden increase in physical parameters such that pressure, temperature, density. It always propagates with supersonic speed (speed more than speed of sound).

II. ORGIN OF SHOCK WAVE

Basically, in general term word shock relates sudden increase in heart beat when something unpleasant happen in life. In the similar manner when there are sudden increase in physical parameters such as temperature, pressure and density give birth to shock wave. Shock wave is plane discontinuities pulse like in nature and are sometimes more appropriately called **SHOCK FRONT**. For formation of shock wave, we consider a tube with piston which will move with velocity u ,tube will call as **SHOCK TUBE.**



The gas particles within the vicinity of the piston acquire the uniform velocity u but those some way ahead of the piston are at rest. A plane normal discontinuities or shock front travel forwards with the velocity U>u into the region of gas as piston advances into the tube. The shock is the mechanism by which gas between it and the piston acquire the velocity u. The existence of the shock wave can be detected experimentally by certain delegate kinds of photographic methods such as shadowgraph. The velocity U>a, the local speed of sound in the fluid. A simple physical explanation of shock formation in this case is as follows.

Suppose we approximate the continuous motion of the piston by the set of forward moving pulses of short duration. When the piston makes the first short movement forward a small disturbance is propagated forward into the gas at the speed of sound. This small amplitude wave (or sound wave) heats the gas slightly and since speed of sound is directly proportional to square root of temperature the second pulse will propagated as another sound wave at a speed slightly higher than of first one similarly the third pulse will be propagated at the speed slightly in excess of second one and so on .Thus the discreate pulses causes a train of sound waves of ever increasing velocity to propagate through the gas .The model discussed here is simplified model explaining shock formation in the tube when the piston is activated with constant velocity.

III. HOW SHOCK WAVE IS DIFFERENT FROM SOUND WAVE?

In the sound wave when two waves travel, they can be compressed with each other whereas in shock wave generated due to sudden increased values of physical parameters so when two shock wave travels, they travel with different velocity at different times differ by may be fraction of seconds so they can't be compressed. Amplitude of shock wave is inversely proportional to square of distance from origin so as shock wave moves its

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amplitude decreases. So, after some time its amplitude and intensity both will die. Although when the speed of sound wave is equal to normal speed in such cases shock wave is converted into ordinary sound wave.

IV. CHARACTERISTIC OF SHOCK WAVE

- Intensity of shock wave depends upon sudden change in physical parameters such as pressure temperature and density occur in propagating medium.
- Its speed always greater than the speed of sound.
- Its effect decreases faster.
- Shock wave follow law of conservation of energy and when there is decrease in energy of shock wave then there is increase in entropy of medium.

V. UNSTEADY FLOW OF SHOCK WAVE

In aerodynamics gas industry unsteady flow of Shock wave is very important in order to calculate magnitude of force applied and loading of gases .In order to solve unsteady shock wave problem Euler or Navier Stokes equation are used but these methods are very expensive in order to cope of this problem we use two dimensional ,linear potential methods because it requires less computational effort for calculations. But these methods are non properly work in case of flows with moderate Shocks and three dimensional vorticity.

So there is a linearized Euler Methods which we can apply is steady and unsteady flows which can be three dimensional vorticity but with condition that level of unsteadiness is small.

A 2-dimensionless linearized Euler method was developed by Hall and Crawley. It is also useful for Shock fitting because an unsteady left in compression or fan flutter occur from Shock motion.

VI. SOME PROBLEMS ON SHOCK WAVE

- Doppler Effect
- Sonic Boom
- Rankine Hugoniot Jump Condition for Shock Wave
- Riemann Problem for Burger Equation

DOPPLER EFFECT

Before discussing the Doppler Effect, we need to know **Mack Number** this is defined as

$$M=\frac{q}{a}$$

Where q is speed of source and a is speed of sound

And second thing to be relate here relationship among frequency, wave length and speed of sound.

Wave length $\alpha \frac{1}{Frequency}$

So whenever there is increase in frequency then wave length decreases and speed of sound related to wavelength and frequency by formula given below.

$V = F\lambda$

Where v is speed

F is frequency

And λ is wavelength

Doppler effect is actually change in wave length whenever there is relative motion between wave source and observer it occur in light as well as for sound objects.

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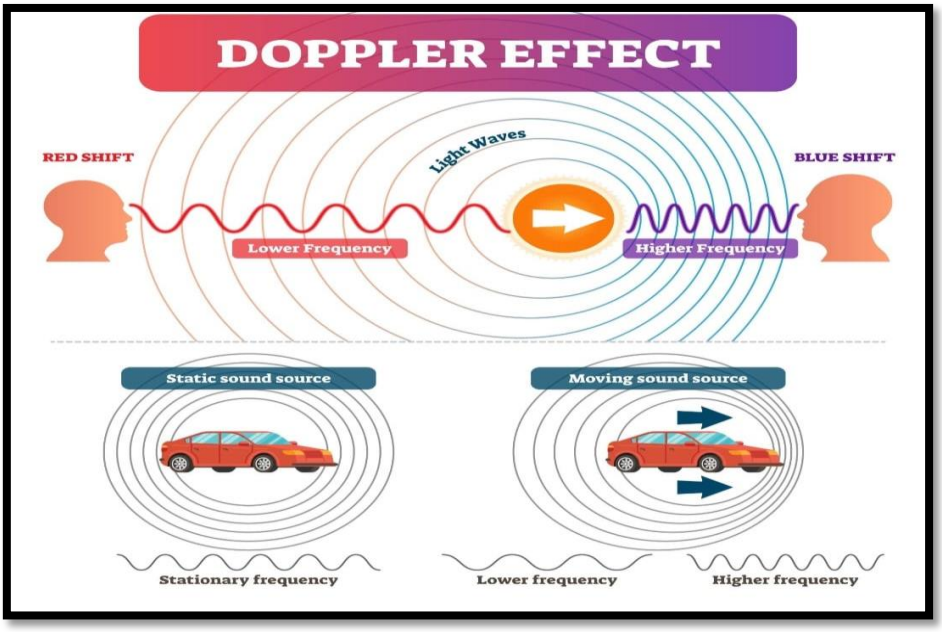


In the above figure it is clear that as sound wave moves forward to observer frequency of sound waves increases and wavelength decreases and vise versa occur. It is used basically in astronomy in order to understand spectra of stars.

SONIC BOOM

Before going to discuss we need to know about Mach number in details As we know that

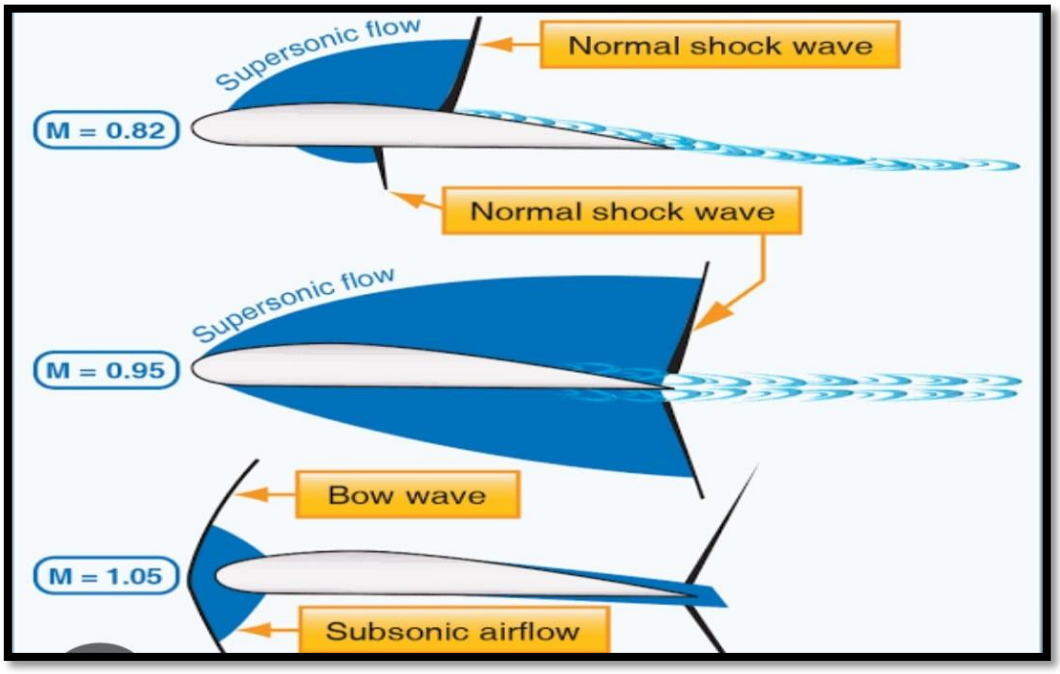
$M = \frac{q}{a}$

Case :1 when q=a then M=1 then wave generated known as **SONIC WAVE.**

Case :2 when q>a then M>1 then wave generated know as **SUPERSONIC WAVE.**

Case:3 when q<a then M<1 then wave generated known as **SUBSONIC WAVE.**

Whenever there is supersonic wave there will be formed of SONIC BOOM like when aircraft moving with supersonic speed all sound wave joined together and formed a single shock wave have very high pressure and temperature and at that point SONIC BOOM is formed.



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RANKINE HUGONIOT JUMP CONDITION FOR SHOCK WAVE

Let us consider a Rankine Hugoniot Jump condition for equation of motion

$$U_t + fU_x = 0$$

Let us consider a wave is jumping across the curve $U_L(t)\ to\ U_R(t)$

Where $U_L = U_R = Constant$

That is speed remains constant

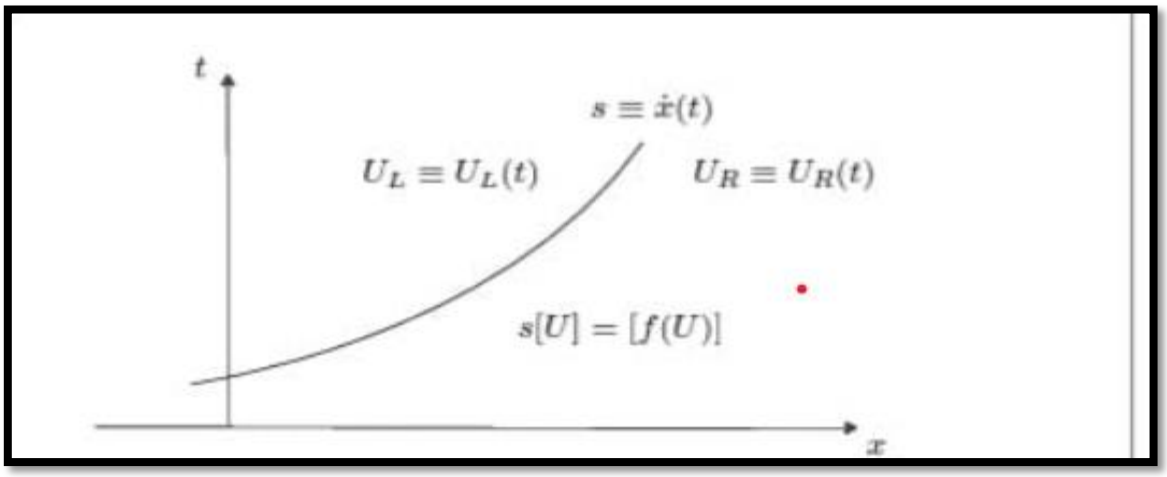
The Rankine Hugoniot jump condition states that there will be a legitimate shock wave speed of shock wave is given by

S=$\frac{dx}{dt}$

Must be related to jump speed ie $S[U] = [f(U)]$

So $[U] = U_R - U_L$

And $[f(U)] = f(U_R) - f(U_L)$ as given in figure below



Rankine -Hugoniot Jump Condition For Shock Wave

In order to calculate speed S we use Burger Equation

$$u_{t+}\left(\frac{u^2}{2}\right)_x = 0$$

With flux function

$$f(u)=\frac{u^2}{2}$$

And in such case

$$S=\frac{[f]}{[u]} = \frac{1}{2}\frac{(U_R^2-U_L^2)}{(U_R-U_L)} = \frac{(U_R+U_L)}{2}$$

We conclude that speed of legitimate shock must be average of speed of shock wave on left and right.

BURGER EQUATION

When the initial data of wave is given as

$$u_0(x) = \begin{cases} u_L & x \le 0 \\ u_R & x \ge 0 \end{cases}$$

Then the initial value problem given by

$$u_t + f(u)_x = 0$$
$$u(x,0) = u_0(x)$$

When $u_L < u_R$

Ie velocity on left side is less than the velocity on right

Then by the scalar conservation law

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$$u_t + f(u)_x = 0$$

And $$f(u_x) = \frac{df(u)}{dx} u_x$$

As f is function of u

By simple wave principal

Let $\lambda = \frac{df(u)}{dx}$

and speed $\frac{dx}{dt} = \lambda$

In case of Burger Equation

f(u) = $\frac{1}{2}u^2$

Stherefore, Simple wave for Burger Equation

$$u_t + uu_x = 0$$

It concludes that Burger Equation expresses that u(x, t) should be constant along line of speed

$$\frac{dx}{dt} = u$$

And So Burger Equation we can construct rarefactions wave solution of Riemann Problem whenever

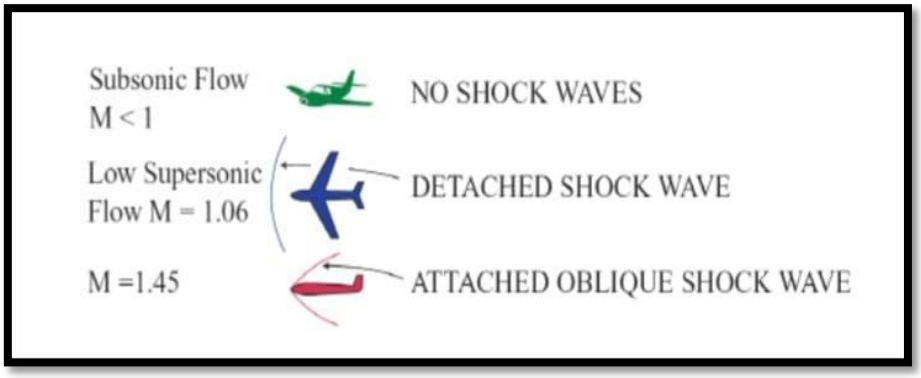
$$u_L < u_R$$

VII. APPLICATION OF SHOCK WAVE

In Aerodynamics

From fig it is clear that different types of Shock wave formation in different velocity when aircraft is moving.

Given air act as a fluid and when aircraft moving it moves with different speed and some Supersonic and Subsonic wave formation depends on Mack Number as (M> $1, M = 1, M < 1$) respectively then whenever speed of wave (object aircraft) comes.



In Industry

(a) Explosive Welding

In this under water shock wave is generated with the help of some geometrical set up device and high explosive welding for a thin metal plate or foils are used.

(b) Pencil Manfacutring

Shock Wave also used in dramatic reductions in process time of pencile. So that it speed up manufacturing of pencils in industry.

(c) Metal Sheet Forming

Underwater explosive metal forming is a type of metal forming technique that uses underwater Shock Wave from explosion of explosive in water to form metal plates.

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Medical Application

(a) ESWL

Extracorporeal Shock Wave Lithotripsy invented by Chausseetal in 1980. It is commonly used in treatement for upper urinary tract stone.

(b) CSWT

Cardiac Shock Wave Therapy is is basically used in cure of cardiac attack.It is in use since 1999. There are so many studies which summarize the results and quality of efficiency of CSWT ON CAD(coronary artery disease) treatment.

(c) In treatment of primary Bone marrow Enema Syndrome

In case of treatment of Primary Bone Marrow Enema Syndrome shock wave treatment applied efficiently by using magnetic character means using Electromagnetic Shock wave having property of penetration due to this it help in cure of bone marrow disease.

VIII. CONCLUSION

By going through paper we will able to understand completely shock wave and its application in different fields which will surely help for further study and use of shock wave in other aspects.

IX. REFERENCES

[1] A.N. Arunkumar, Y.b.Srinlvasa, G. Ravl kurnar, "A new shock wave assisted sandalwood oil extraction technique."

[2] M.S. Heriharan, S.Janardhanraj, S.Saravanan and G.Jagadeesh "Diaphragmless shock wave generators for industial application of shock wave."

[3] Clyde M.Williams ,Juri v kaude, Robert C.Newman, John C.Peterson and William C. Thomas "Extraporeal Shock WAVE Lithotrisphy."

[4] F.ioppolo j.d.rompe, j.p.furia,a.cacchio" Clinical application of Shock Wave therapy in musculoskeletal disorders."