ISSN: 2278-0181
ETMET - 2016 Conference Proceedings

A Comparative Study on Behavior of Stress Wave Propagation in Different Sheet Metals under Impact Loads

Mr. Sandeep G M
Mechanical Engineering Department, NMIT
Bengaluru, India

Avinash D N
Mechanical Engineering Department, NMIT
Bengaluru, India,

Abstract: **This paper presents the effect of impact load on different sheet metals and analysis of dynamic response by stress wave propagation method. A special casing has been constructed for fixing the sheet metal. For accurate measurement of strain, strain gauges are mounted at strategic positions away from the centre of sheet metal. A steel ball is made to strike the sheet metal is at different angles, the steel ball weighing 0.230 kg is suspended from a square frame. The output in the form of voltage signals from the strain gauge is amplified; these amplified signals are recorded in the oscilloscope as voltage versus time signals. The variation in amplitudes, velocities of stress wave and effect of impedance on material has been extensively studied and compared with numerical result; the numerical analysis is carried out by commercially available Abaqus explicit dynamics software program V 6.10.**

Keywords: S*tress wave propagation, Dynamic response, Oscilloscope, Strain gauges, sheet metal and impedance.*

I. INTRODUCTION

The dynamic response of a body cannot be simulated through static solid mechanics approach, most of the real life problems and applications include a dynamic approach this can be achieved by suitable strategies called stereo mechanics, energy method, contact mechanics and stress wave propagation method. At a point when a material is subjected to impact from the outside source the outward propagation of waves will happen from the impacted region. These waves go through the body and collaborate with the boundaries. The behavior of waves in solids is not same as that of in fluids. Generally shear and compressional waves will generate upon collaborating with the boundary. In fluids, they will produce the waves of their own sort. Stress wave propagation method discovers its applications in various fields of engineering. For instance in case of Mechanical engineering field it is utilized for the analysis of nuclear explosions, automobile and aerospace applications. In the event of Civil engineering it is utilized in earth quake monitoring technique, identification of the defects in concrete structures etc... The present work includes the study on behavior of stress waves in sheet metals. In longitudinal waves the displacement of the medium is along the direction or opposite to the direction of wave propagation. Longitudinal waves are also called as Pressure waves. In transverse waves the particles of motion conveying the wave is perpendicular to the direction of wave travel. Transverse waves are also called as Shear waves.

The velocity of longitudinal wave is given by equation

$$Cp = \sqrt{E/\rho}$$

Similarly the velocity Transverse wave is given by,

$$Cs = \sqrt{G/\rho}.$$

The dependence of longitudinal waves and transverse wave on Poisson's ratio is given by

$$\frac{Cs}{Cp} = \sqrt{\frac{1-2\vartheta}{2(1-\vartheta)}}$$

M.Sadighi et al [1] studied the impact response of fiber metal laminates (FMLs) with two aluminum layer thicknesses and a similar FML containing magnesium sheets that the appropriate choice of elements has major role than failure criterion to predict satisfactory results for this type of laminate and loading. Stephen D. Boyd [2] reported that it is clear that neither the Fagel formula nor a simple FEM simulation give exact predictions of acceleration for a fully clamped square plate subject to a short duration explosive blast loading. The FEM predictive capability may be improved with more accurate materials information plus a more refined model. This experiment has produced results which can be used to refine the FE models of ship decks, subject to explosive blast loading, to predict acceleration.

II. EXPERIMENTAL METHOD

A. Specimen conditions and properties

For conducting the experiment two types of sheet metals are selected namely Aluminium and Mild steel. The thickness of sheet metal is 0.001m and its length and breadth is 0.2m. For recording the incident waves the strain gauges are mounted at a distance of 0.05m from the center of the sheet metal with the help of M-bond adhesive is shown in figure 1.

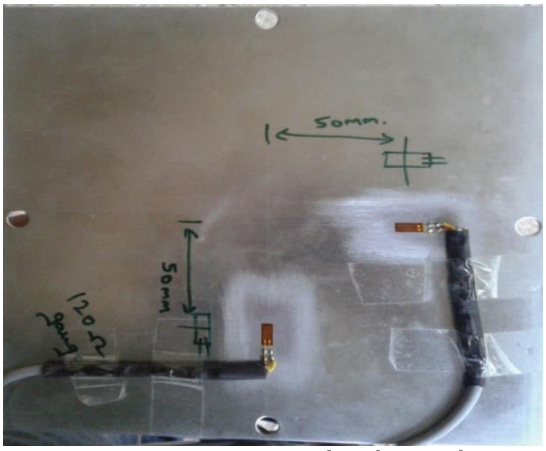

Fig 1. Strain gauges mounted on Sheet metal

B. Preparation of casing

A special casing made of mild steel having thickness 0.01m has been prepared for fixing the sheet metal. The sheet metal is fixed to the casing with the help of screw arrangements made at the four edges of the sheet metal as shown in figure 2.With the help of gas cutting process a circular hole having diameter 0.06m is made at the centre of the rear plate for connecting the strain gauge output to amplifier.


Fig 2. Steel casing

The output from the strain gauge is connected to the amplifier for amplifying the signals; the amplified signals are recorded and displayed as voltage versus time signal.

C. Frame

A pendulum made of square frame is used for supporting the steel ball weighing 0.230 Kg the arrangements are shown below. The casing attached with the sheet metal is made to impact by the simple pendulum bob at required angle.


Fig 3. Frame

D. Experimental setup

The experimental setup mainly consists of oscilloscope, amplifier, metallic frame (simple pendulum) and sheet metal mounted with strain gauges which are connected as follows. The steel ball suspended to the simple pendulum is raised to the required angle and made to impact on the sheet metal as shown in fig. 4. Due to impact the strain experienced by the electrical resistance strain gauges attached to sheet metal sends the signals to amplifier, the amplifier is connected to oscilloscope. Finally the oscilloscope displays amplified voltage versus time signals.


Fig 4. Experimental Setup

III. NUMERICAL METHOD

The numerical analysis is made through ABAQUS solver. Where the three dimensional model of required dimension is created with a grid size of 2. After that the material is assigned with material properties such as density, Young's modulus and poisons ratio. A circular section is created at the center of the sheet metal for facilitating the application of load. Later the boundary condition is assigned for fixing the ends of the sheet metal and pressure load is applied at the circular section.

The magnitude of pressure varies with the angle of impact of steel ball. The relationship between angle of impact and pressure can be given by formula

$$P = \frac{F}{A} = \frac{m\ g \sin\theta}{A}$$

Where P = Pressure, F = Force,
A = Area
m = Mass of the steel ball,
g = Gravitational force,
θ = Angle of impact.

Hence for 60^0 angle of impact the value of pressure is 48.85Pa and similarly for 40^0 angle of impact its value is 36.253 Pa. The pressure load is applied as step to the front surface of the circular section having time frequency value 0.018sec and amplitude 1. After creating the mesh the model is assigned for field output and history output. Finally the model has been submitted for analysis by creating the job. With the help of visualization module one can analyze the results. The created model with boundary condition and loading are shown below.

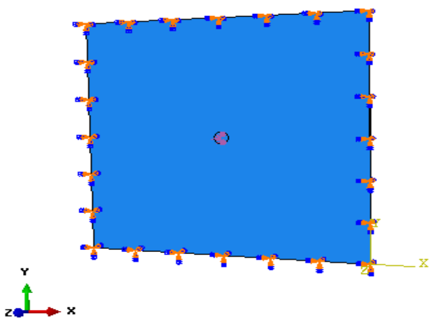

Fig.5 Model of sheet metal after application of boundary condition and load

IV. RESULTS AND DISCUSSION

Voltage versus time plots are obtained from the oscilloscope for various angles of input on mild steel and Aluminium sheet metals is compared with numerical results as follows.

- Experimental and Numerical traces of mild steel at 60^0 angle of impact

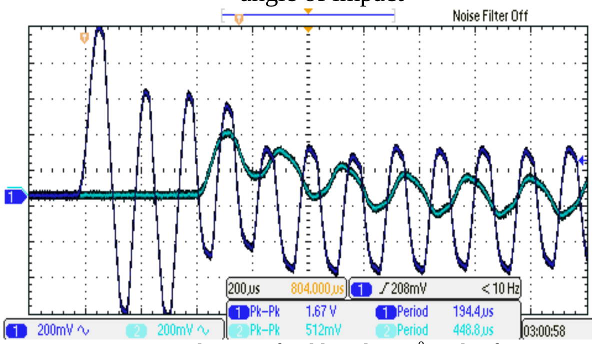

Fig 6. Experimental traces of mild steel at 60^0 angle of impact

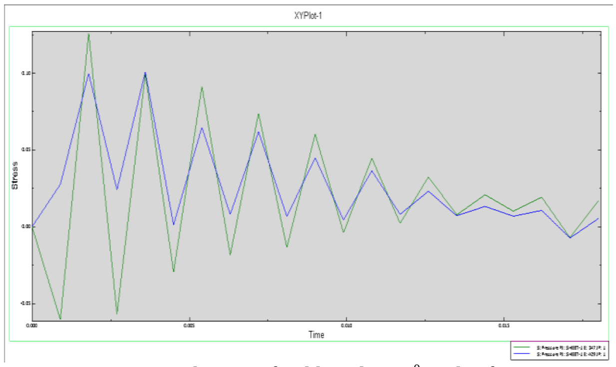

Fig 7.Numerical traces of mild steel at 60^0 angle of impact

- Experimental and Numerical traces of mild steel at 40^0 angle of impact

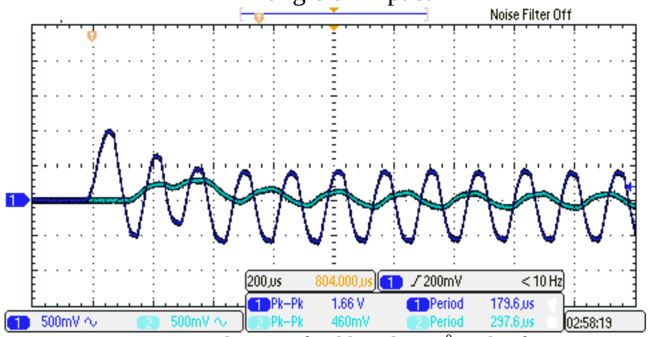

Fig 8. Experimental traces of mild steel at 40^0 angle of impact

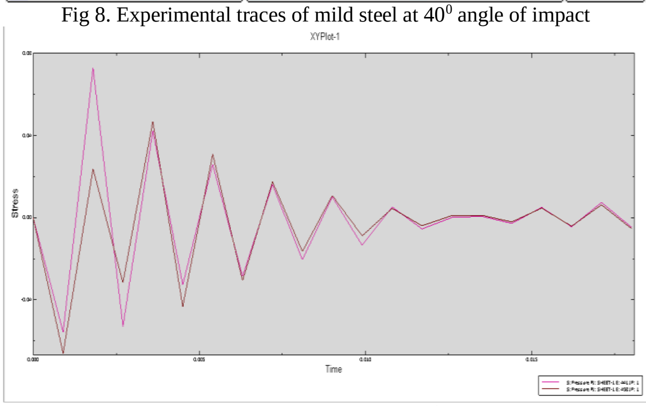

Fig 9. Numerical traces of mild steel at 40^0 angle of impact

- Experimental and Numerical traces of aluminium for 60^0 angle of impact

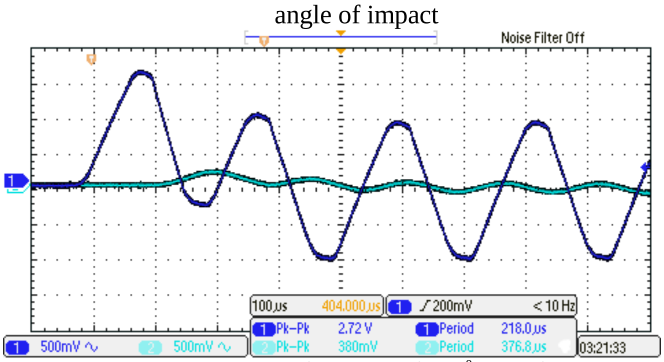

Fig 10.Experimental traces of aluminium for 60^0 angle of impact

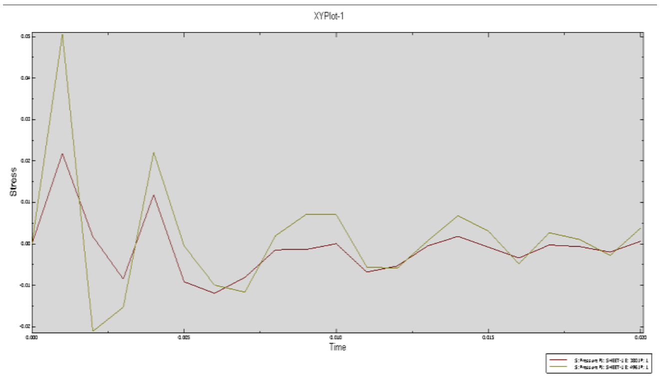

Fig 11.Numerical traces of aluminium for 60^0 angle of impact

- Experimental and Numerical traces of aluminium for 40^0 angle of impact

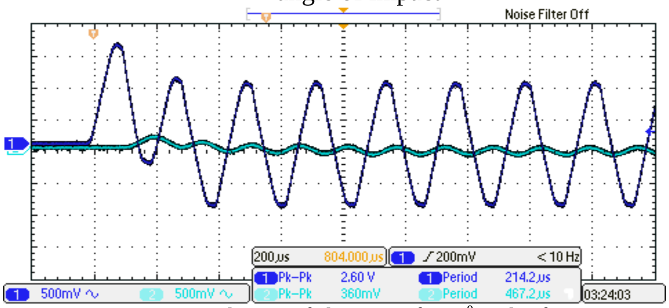

Fig 12.Experimental traces of aluminium for 40^0 angle of impact

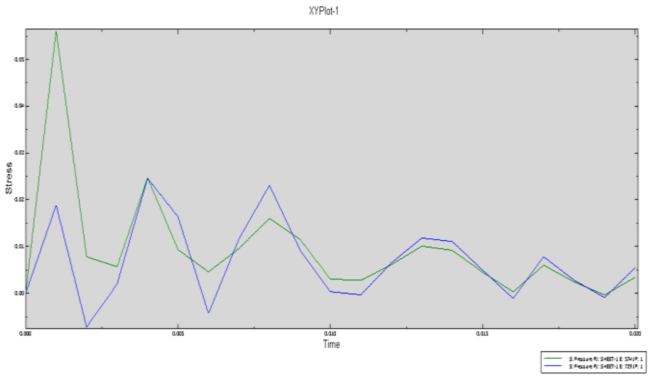

Fig 13.Numerical traces of aluminium for 40^0 angle of impact

V. CONCLUSION

By analyzing the result we can conclude that Stress wave propagation method provides best solution for studying the behavior of materials subjected to impact loads, It can be seen from the above results that the nature of graphs obtained from experimental and numerical methods for mild steel and aluminium are almost same but slight variation in amplitudes, the reason is being that minor errors occurred during the mounting of strain gauges, variation in environmental conditions while conducting the experiments etc The variation in amplitude from the region of impact to the region away from the region of impact was studied clearly. . The strain gauges mounted to sheet metals created the bridge accurately during operation.

REFERENCES

[1] M. Sadighi, et al , “Experimental and Numerical examination of Metal Type and Thickness Effects on the Impact Resistance of Fiber Metal Laminates”, Appl. Compos Mater, 27 October 2011

[2] James w. Dally and William f. Riley, “Experimental Stress Analysis”,Mcgraw - Hill Book Company.

[3] Stephen D. Boyd, “Acceleration of a Plate Subject to Explosive Blast Loading – Trial Results ”, DSTO Aeronautical and Maritime Research Laboratory, March 2000

[4] Dr. L A Louca et al “Analysis and Design of Profiled Blast Walls”,Imperial College London for the Health and Safety Executive (2004).

[5] G.Weisbsheet metal and D.Rittel “A method for dynamic fracture toughness determination using short beams”(2000).

[6] Dr. Shantharaja M, Mr. Sandeep G. M., “Experimental and Numerical analysis of stress wave propagation in sheet metals, Volume 3, Issue 10, October 2014.

[7] Kolsky H et al, “Experimental studies in plastic wave Propagation” Mech Phys Solids, 1962, 10: 195−223.

[8] CM Seddon, K Moodie et al. “preliminary Analysis of Fuel Tank Impact”, Health and Safety Laboratory, Harpur Hill, Buxton (2011).

[9] Shi Honghui and J. E. Field “Stress waves propagation in solids under high-speed liquid impact”, volume 47, No. 6, pp. 752-766, August 5, 2004.

[10] Yaning Li , Meng Luo , Jörg Gerlach , Tomasz Wierzbicki, “Prediction of shear-induced fracture in sheet metal forming”, 2010, pp 1858-1869.