

Impact analysis using explicit Dynamics analysis ON different materials

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ABSTRACT:

High velocity impact is of concern to many different fields and has been the subject of much research, especially in the last 50 years. Over this period of time, the methods used to analyze impact have changed naturally, as have the disciplines interested in these analyses. Researchers are still trying to get a clear cut picture of the impact performance. Mainly this applies to the defense industry. Armor flexibility and impact resistance are extremely important in warfare applications. The failure of an AL6061-T6 and steel 1006 composite plate under high-velocity impact from an S-S (structural Steel) projectile tool was investigated using the nonlinear explicit finite element software, ANSYS AUTODYN. velocity range of 700 m/s were used for FEM simulation. It was analyzed that AL6061-T6 is more resistant than steel 1006 at both ranges but steel 1006 is light in weight than AL6061 and have more application in aviation industry. The composite laminate and the tool were venerated by solid FEM elements. The contact between the tool and plate was simulated using a surface-to-surface eroding contact algorithm. It was also observed that tool dimension and mass play important role in failure conditions. The Explicit Dynamics method is made to enable to simulate nonlinear structural mechanics applications involving high velocity impact analysis, stress wave propagation, high frequency response, large deformations, material model and behaviour, structural buckling and failure between bonded surfaces like welds, bolted joints etc

I. INTRODUCTION

High velocity impact is of concern to many different fields and has been the subject of much research, especially in the last 50 years. Over this period of time, the methods used to analyze impact have changed naturally, as have the disciplines interested in these analyses. Researchers are still trying to get a clear cut picture of the impact performance. Mainly this applies to the defense industry. Armor flexibility and impact resistance are extremely important in warfare applications. Many theories and

procedures emerged to study the impact and blast phenomena. Blast phenomena leads to portion progress which in turn leads to impact. In space travel applications impact plays a vital role in designing the sacrificial armor against the debris. Latest innovations like friction stir welding and repair require the data of impact to read the impact event to exactly assess the damage and repair parameters. Low velocity impacts can cause severe damage to soft material like muscle tissue. In early days metals armors were used, now with

advent of composites light weight armor materials are introduced which are more portable. Lighter materials increase the flexibility and portability. For design and construction of lightweight transportation systems such as aircraft, high-speed trains, fast ferries and automobile, structural weight saving is one of the major considerations. To meet this requirement, sandwich construction is frequently used instead of increasing material thickness. This type of construction consists of two thin facing layers separated by a core material. Potential materials for sandwich facings are aluminium alloys or composites depending on the specific mission requirement. Several types of core shapes and core material have been applied to the construction of sandwich structures. Among them, the honeycomb core that consists of very thin foils in the form of hexagonal cells perpendicular to the facings is the most popular. For design and construction of lightweight transportation systems such as aircraft, high-speed trains, fast ferries and automobile, structural weight saving is one of the major considerations. To meet this requirement, sandwich construction is frequently used instead of increasing material thickness. This type of construction consists of two thin facing layers separated by a core material. Potential materials for sandwich facings are aluminium alloys or composites depending on the specific mission requirement. Several types of core shapes and core material have been applied to the construction of sandwich structures. Among them, the honeycomb core that consists of very thin foils in the form of hexagonal cells perpendicular to the facings is the most popular. A sandwich construction provides excellent structural efficiency, i.e., with high ratio of strength to weight. Other advantages offered by sandwich construction are elimination of welding,

superior insulating qualities and design versatility. Even if the concept of sandwich construction is not very new, it has primarily been adopted for non-strength part of structures in the last decade. This is because there are a variety of problem areas to be overcome when the sandwich construction is applied to design of dynamically loaded structures. The aim of the present study is to investigate the dynamic behaviour of a thin-walled crash box for a racing car, built by Picchio S.p.A. and made of aluminium sandwich material. Since the main goal of the presently discussed dynamic simulation of the crash-box is the consideration of the most part of the failure modes, a three-dimensional modelling approach with solid elements for the core and shell elements for the face sheets was adopted. The development in technology demands engineering design field to be competitive and creative to meet the challenging competition. Nowadays, careful attention in meeting precision, eco friendly products and modularity in designing are gaining importance. Since the main goal of the presently discussed dynamic simulation of the crash-box is the consideration of the most part of the failure modes, a three-dimensional modelling approach with solid elements for the core and shell elements for the face sheets was adopted.

2. Explicit

A direct computation of the dependent variables can be made in terms of known quantities q . Unknown appears only on one side of the equation

$$\bullet x(t+h) = x(t) + h f(x(t)) u$$

3. Implicit

The dependent variables are defined by coupled sets of equations, and either a matrix or iterative technique is needed to obtain the solution q . Unknown appears on both sides of the equation $\bullet x(t+h) = x(t) + h f(x(t+h))$

Implicit:

- Solve for $t+\Delta t$ using state at t and $t+\Delta t$ – don't know state at $t+\Delta t$ yet
- Newton-Raphson method used typically ABAQUS/Standard, ANSYS, MARC,
- take initial guess and iterate to convergence
- end up solving “linear-like” equation for each iteration: $Ku = F$ – very accurate – can use relatively large time steps

4.Explicit, LS DYNA

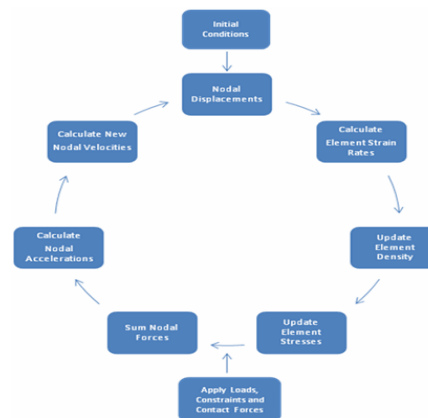
- Internal and external forces are summed at each node point and a nodal acceleration is computed by dividing by nodal mass
- Solution is advanced by numerical integration of the above computed acceleration in time
- Courant condition limits largest stable time step
- Typically requires many relatively inexpensive time steps
- Well suited for dynamic simulations such as impact and crash (short duration) n external n internal
- $[M]\{\ddot{x}\} = [F] - [F]$

5.IMPLICIT, LS DYNA

- A global stiffness matrix is computed, inverted and applied to the nodal out of balance force to obtain a displacement increment
- Large numerical effort required to form, store and factorize the stiffness matrix
- Typically involve a relatively small number of expensive time steps
- Well suited for static and quasi-static simulations q Quasi -static analysis: “time” represents a monotonically increasing parameter which characterizes the evolution of the loading
- $[M]\{\ddot{x}\} [K]\{x\} [F] [F] [M]\{x\}$

When working on an FEA consulting project, converting a finite element model from a static analysis to an explicit dynamic analysis is not as simple as you might think. There are a number of details that are part of this type of finite element analysis that need to be addressed such as applying loads in the time domain and modifying the mesh to eliminate tiny elements. One issue that's often overlooked is the need to consider the strain-rate sensitivity of materials. It's typically not enough to use the same stress-strain curve as the one you used in your static analysis. Materials can behave very differently at the higher strain rates typical of moderate to high speed dynamic events such as drop tests and impacts.

FINITE ELEMENT ANALYSIS: EXPLICIT DYNAMICS



The Explicit Dynamics method is made to enable to simulate nonlinear structural mechanics applications involving

high velocity impact analysis, stress wave propagation, high frequency response, large deformations, material model and behaviour, structural buckling and failure between bonded surfaces like welds, bolted joints etc. Explicit Dynamics is most suited to simulate events which take place over very short periods of time, a few milliseconds or less. Simulation results which last more than 1 second can be modelled; however, long run times can be expected. Techniques such

as mass scaling and dynamic relaxation are available to improve the efficiency of simulations based results with long durations. In an Explicit Dynamics simulation based solution, user start with a discretized domain (meshing of geometry) with assigned material properties making with various models available in simulation codes, loads, constraints and initial velocity conditions. This initial state, when integrated in time, will produce motion at the node points in the mesh. Figure a shows clear picture of explicit dynamics simulation.

CONCLUSION

The failure of an AL6061-T6 and steel 1006 composite plate under high-velocity impact from an S-S (structural Steel) projectile tool was investigated using the nonlinear explicit finite element software, ANSYS AUTODYN. velocity range of 700 m/s were used for FEM simulation. It was analyzed that AL6061-T6 is more resistant than steel 1006 at both ranges but steel 1006 is light in weight than AL6061 and have more application in aviation industry. The composite laminate and the tool were modeled by solid FEM elements. After thorough analysis on two material with high velocity range 700 m/s we conclude that steel 1006 has better stress and deformation factors than AL6061-T6. Steel 1006 shows less deformation than AL6061-T6 and while comparing stress factors steel 1006 has relatively low factors than AL6061-T6.

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