CRASH SIMULATION USING ANSYS EXPLICIT DYNAMICS

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SUMMARY: The current paper discusses the development, modification, and analysis of a finite element model of car body. A simple FE model is developed in ANSYS, cleaned in ANSA and it is solved for full frontal impact in ANSYS LS-DYNA explicit code. Computational simulations and various results are plotted and analyzed.

INTRODUCTION

With the development of society, people have more and more stringent demands for automobile passive safety and fuel economy, which requires the improvement of automobile structure crashworthiness and light weighting degree . A major concern of both the industry and government is the development of vehicles that would consume less fossil fuel, thus compromising the safety of occupant resulting from the reduced weight of the automobile.

Today's automobile manufacturers are increasingly using lightweight materials to reduce weight; these include plastics, composites, aluminum, magnesium and new types of high strength steels. Many of these materials have limited strength or ductility, in each case rupture is a serious possibility during the crash event. Furthermore, the joining of these materials presents another source of potential failure . Both material and joining failure will have serious consequences on vehicle crashworthiness and must be predicted.

During an automobile crash, some parts in the front of the automobile body may have plastic deformation and absorb a lot of energy. Structural members of a vehicle are designed to increase this energy absorption efficiency and thus to enhance the safety and reliability of the vehicle.

The crashworthiness of each member needs to be evaluated at the initial stage of vehicle design for good performance of an assembled vehicle. As the dynamic behavior of structural members is different from the static one, the crashworthiness of the vehicle structures has to be assessed by impact analysis.

Hence it becomes necessary to check the car structure for its crash ability so that safety is achieved together with the fuel economy. There are two ways by which this safety feature can be assessed.

a. Performing an actual crash test.

b. Simulating the crash in some FE code like ANSYS LS DYNA.

Though the first option is more accurate and reliable, it demands time and high cost. A more practical solution which results in a compromise between the factors of accuracy, cost and time is simulation. With appropriate initial conditions, loads and element formulations, engineers can develop a precise enough FE model to judge the crash response in an actual accident. This technique has superseded the testing using an actual model. Thus computer simulations are used to find the automobile model's crash ability.

The model to be simulated is usually developed using data obtained from the disassembly and digitization of an actual automobile using a reverse engineering technique.

There are various test configurations. We have limited our analysis to frontal impact with a rigid bar at a high speed.

ANSYS LS-DYNA

ANSYS LS-DYNA is an explicit dynamic program intended to solve short duration dynamic problems. ANSYS LS-DYNA tech-nology is the result of a collaborative effort between ANSYS, Inc. and Livermore Software Technology Corp. (LSTC). Introduced in 1996, the capabilities and robustness of ANSYS LS-DYNA soft-ware have helped thousands of customers in numerous industries resolve highly intricate design issues.

EXPLICIT DYNAMIC ANALYSIS

ANSYS explicit dynamics engineering simulation solutions are ideal for simulating physical events that occur in a short period of time and may result in material damage or failure. These types of events are often difficult or expensive to study experimentally. Simulation provides insight and a detailed understanding of the fundamental physics taking place and gives engineers a chance to make necessary changes before their products are put into service, when mistakes in design can be costly.

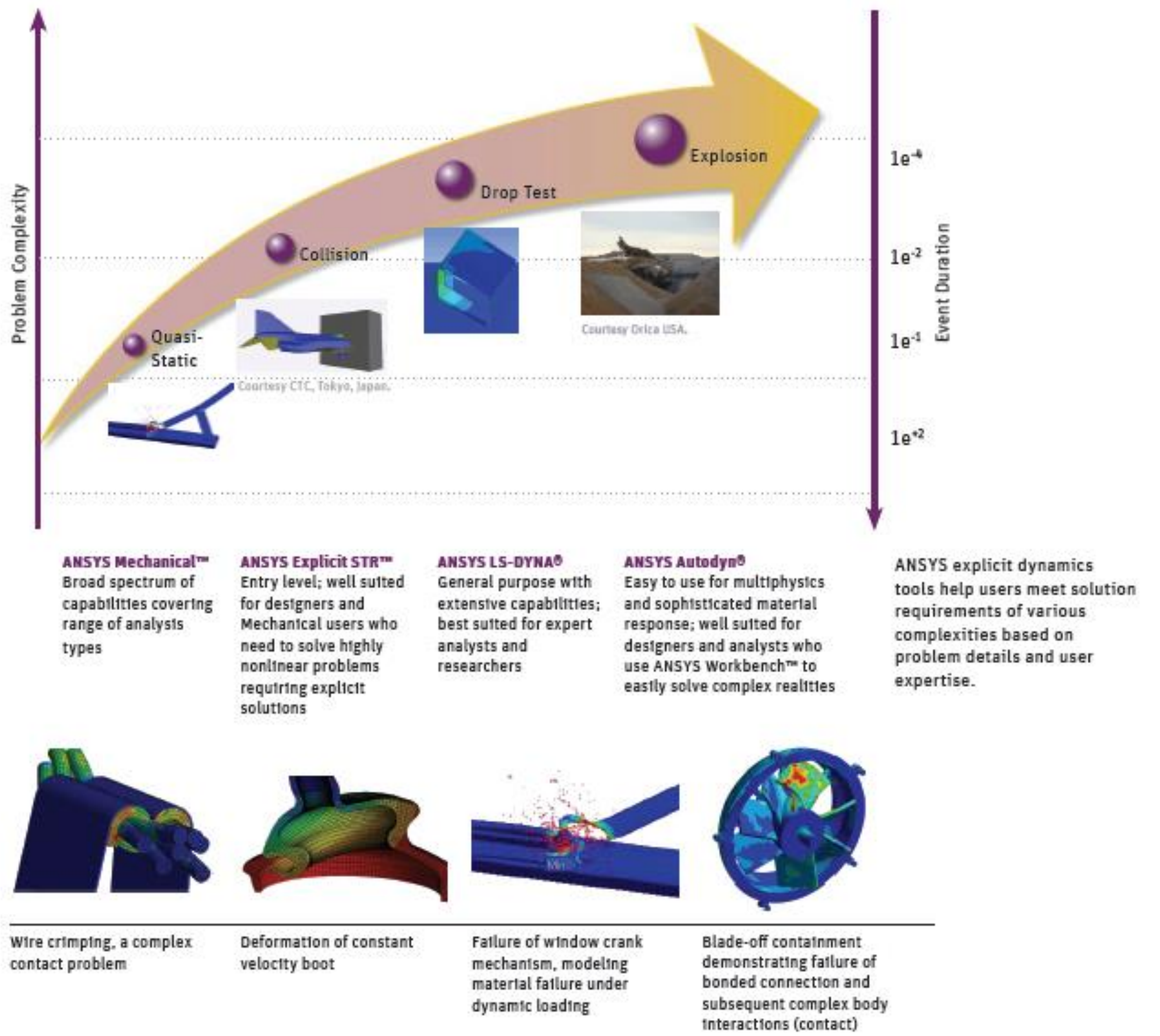


Fig. 1

EXPLICIT VS IMPLICIT DYNAMICS

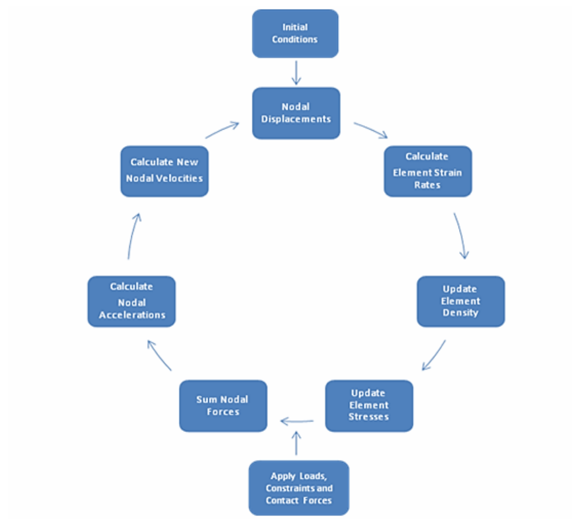
Explicit dynamics analysis is used to determine the dynamic response of a structure due to stress wave propagation, impact or rapidly changing time-dependent loads. Momentum exchange between moving bodies and inertial effects are usually important aspects of the type of analysis being conducted. This type of analysis can also be used to model mechanical phenomena that are highly nonlinear.

THE SOLUTION STRATEGY

In an Explicit Dynamics solution the model preparation steps are: a discretized domain (mesh), assigned material properties, loads, constraints and initial conditions. This initial state, when integrated in time, will produce motion at the node points in the mesh.

- The motion of the node points produces deformation in the elements of the mesh
- The deformation results in a change in volume (hence density) of the material in each element
- The rate of deformation is used to derive material strain rates using various element formulations
- Constitutive laws take the material strain rates and derive resultant material stresses
- The material stresses are transformed back into nodal forces using various element formulations
- External nodal forces are computed from boundary conditions, loads and contact (body interaction)
- The nodal forces are divided by nodal mass to produce nodal accelerations
- The accelerations are integrated Explicitly in time to produce new nodal velocities
- The nodal velocities are integrated Explicitly in time to produce new nodal positions
- The solution process (Cycle) is repeated until a user defined time is reached

All these computation steps are



illustrated in Fig. 2

Fig.2 Explicit algorithm

The advantages of using explicit dynamics for time integration of nonlinear problems are:

- The equations become uncoupled and can be solved directly (explicitly). There is no requirement for iteration during time integration.
- No convergence checks are needed because the equations are uncoupled.
- No inversion of the stiffness matrix is required. All nonlinearities (including contact) are included in the internal force vector.

RESULTS

Model preparation was performed in ANSA for a much better discretization.

Fig. 3

Mesh quality check

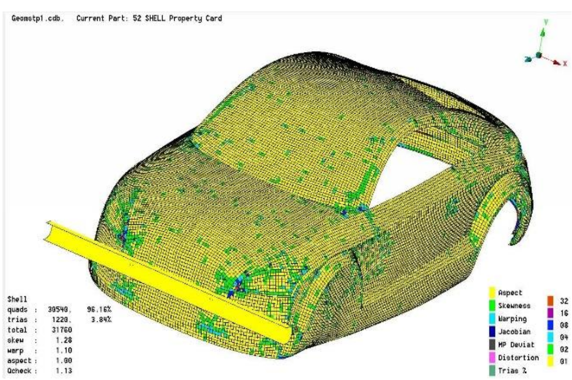


Fig. 4

The model was constrained accordingly with the following picture.

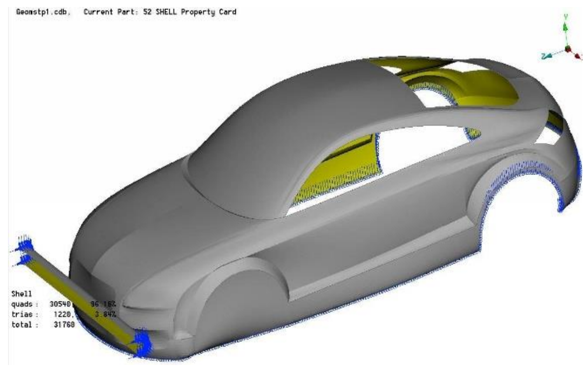


Fig.5

ANSYS Simulation scheme

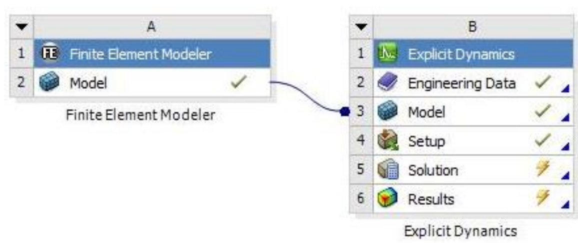


Fig. 6

Equivalent stress result

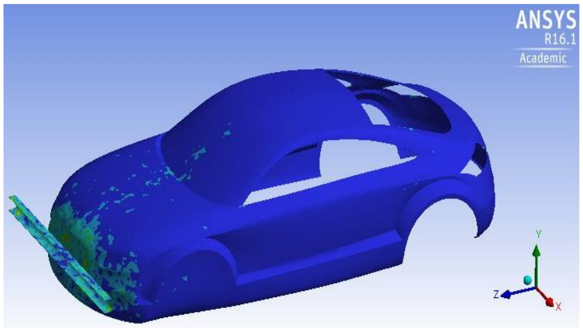


Fig. 7

CONCLUSION

A crash simulation produces results without actual destructive testing of a new car model. This way, tests can be performed quickly and inexpensively in a computer, which permits optimization of the design before a real prototype of the car has been manufactured. Using a simulation, problems can be solved before spending time and money on an actual crash test. The great flexibility of printed output and graphical display enables designers to solve some problems that would have been nearly impossible without the help of a computer.

When simulating events involving short-duration, large-strain, large-deformation, fracture, complete material failure or structural problems with complex contact interactions, there is an **ANSYS explicit dynamics solution** to meet any customer's needs. Almost no application is too severe to be simulated with a high-quality software tool from ANSYS. These explicit dynamics products from ANSYS take over where implicit dynamics leaves off.

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