FEA Information Co.

For the LS-DYNA Global Community

www.feainformation.com

Third Issue, December 9, 2000

Welcome to the third issue of our newsletter. Our goal is to bring you a monthly synopsis of the additions/revisions to the FEA Information web sites and to assist you in focusing your attention to the new material when you consult our web pages on return visits.

When available, we'll bring you information from our participating companies, engineers, professors, consultants, and students of FEA Information. Feel free to have your associates send me an e-mail to be added to our private mailing list mv@feainformation.com

Implicit Notes I
Dr. Bradley Maker
Livermore Software Technology Corporation

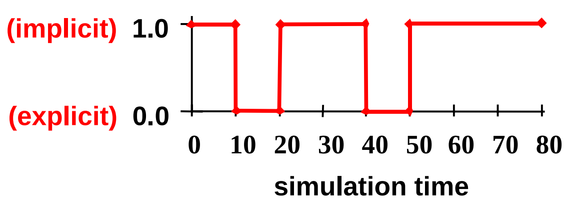
Topic A
Implicit/Explicit Switching

LS-DYNA version 960 can perform both explicit and implicit simulations. A new feature is available which allows both formulations to be used during a single simulation. A load curve can be defined which controls formulation switching. This feature can be used, for example, to simulate a statically initialized impact: Begin with a static implicit analysis, and after applying some load, switch to dynamic explicit analysis and proceed with an impact simulation. There is no limit to the number of times that the formulation may be switched, and no requirement on which type of formulation begins or ends the simulation. There is virtually no extra computational cost or overhead associated with the actual formulation switch, since no databases are required.

To use the implicit/explicit switching feature, follow the steps below:

1. Design the time scale for your simulation. Keep in mind that during the explicit portions of the simulation, problem time represents real, physical time, whereas during static implicit phases time can be chosen arbitrarily. For convenience, select similar time scales for the implicit and explicit phases.

2. Create a load curve that indicates the formulation as a function of time. During explicit phases, use a load curve value of zero, and, during implicit phases, use a value of one. The load curve will look like a square wave signal:



3. Enter the load curve ID as a negative number using the first parameter on the keyword *CONTROL_IMPLICIT_GENERAL: IMFLAG = (-lcid).

You may also include any other *CONTROL_IMPLICIT keywords that you would like to use during the implicit phases of the simulation.

Topic B
Lanczos Eigenvalue Solver

Roger Grimes has implemented the BCSLIB-EXT sparse solver and eigenvalue package into LS-DYNA. The blocked Lanczos eigenvalue solver offers greatly improved speed, and the ability to automatically extract the zero or “rigid body” modes from unsupported structures. The BCSLIB-EXT libraries are licensed from Boeing. Eigenvalue analyses require the double precision version of LS-DYNA to ensure accurate results. It is commonly known that double precision is usually needed for most implicit calculations.

To perform an eigenvalue analysis, follow these steps:

1. Use the double precision version of LS-DYNA.
2. Define a nonzero termination time using parameter TERM on *CONTROL_TERMINATION.
3. Activate implicit mode, and define a nonzero time step size using parameters IMFLAG and DT0 on *CONTROL_IMPLICIT_GENERAL
4. Enter the number of eigenvalues desired, NEIGV on *CONTROL_IMPLICIT_EIGENVALUE.

```
$
*CONTROL_IMPLICIT_EIGENVALUE
$    neigv
        10
```

By default, the lowest NEIGV eigenvalues are extracted. The eigenvalues are written to a text file named “eigout”, and the eigenvectors (mode shapes) are output to the binary database “d3eigv”. This binary database can be displayed using LS-POST, in the same manner as a d3plot file.

Additional options are available for finding eigenvalues within a frequency range by entering nonzero values for the remaining input parameters on *CONTROL_IMPLICIT_EIGENVALUE. The format for this keyword and definitions of its parameters are:

```
$
*CONTROL_IMPLICIT_EIGENVALUE
$    neigv     shift     lflag    lftend     rflag    rhtend
        20      30.0         1      10.0         1      50.0
$
$ neigv  = number of eigenvalues to compute (DEFAULT = no eigenvalues)
$
$ shift  = compute the modes nearest to frequency "shift" (DEFAULT = 0.0)
$
$ lflag  = 0: left end point of search interval is -infinity.  (DEFAULT)
$          1: left end point is given by "lftend"
$
$ lftend = left end point of search interval (required only if lflag = 1)
$
$ rflag  = 0: right end point of search interval is +infinity. (DEFAULT)
$          1: right end point is given by "rhtend"
$
$ rhtend = right end point of search interval (required only if rflag = 1)
```

The above example requests the computation of 20 eigenvalues nearest 30 Hertz contained in the interval 10 Hertz to 50 Hertz.

Topic C
Tied Contact Interfaces by constraint method

A popular modeling technique in Detroit for simulating spotwelds in linear analysis is to create individual eight-node hex elements at each spotweld location. Through a tedious preprocessing procedure, nearby nodes on the each sheet metal part are identified for each node of the hex element. Constraints are then created to tie the hex element to each sheet. These constraints can now be automatically generated in LS-DYNA using the tied contact interfaces. Keywords *CONTACT_TIED_NODES_TO_SURFACE and …_SURFACE_TO_SURFACE are now available for use in implicit mode. These contact interfaces automatically identify the nearest master segment for each slave (hex element) node, creating implicit tied constraints. The global stiffness matrix and right-hand-side vector are modified during the linear equation solving process, returning an exact solution which keeps the slave nodes in their original location within the master segments. This approach is in contrast to the penalty type implementation of tied contact, which is also available in implicit mode by appending the keyword _OFFSET to either of the above interface types.

Case Study – DaimlerChrysler

Previously Published In The
CAD-FEM Infoplanar

Case Study: DaimlerChrysler AG, Stuttgart, Germany

Safety design for the Vito, Vario and Actros

Crash simulation for Mercedes commercial motor vehicles using LS-DYNA and newly developed FEM design optimization software

Safety aspects are carefully considered for all vehicles that are designed and developed by Daimler-Benz. The goal is to transfer the high safety level of their passenger cars to their latest commercial motor vehicles consisting of significantly different size and performance characteristics. The goal was achieved very quickly and thoroughly by the extensive application of computer aided engineering (CAE) simulations using finite element methods (FEM).

Today, if you survey the buyers of motor vehicles on their purchasing decision, a very high value is assigned to safety. This is not particularly surprising. However, while buyers place extreme importance on safety, they are not willing to pay for it as compared to other features. Simply said: Buyers would like maximum safety at the minimum price.

While being the vehicle manufacturer whose name is synonymous with safety on the road, Daimler-Benz must deal with the buyers' contradiction by continuously and affordably addressing safety issues. To achieve these conflicting goals, CAE simulation is now applied in all phases of new vehicle development. This allows the consideration of the highest safety requirements at a price that is acceptable to the marketplace.

Daimler-Benz has achieved the safety goals with two of its newest commercial motor vehicle lines: the Vito, a light transporter belonging to the one-ton payload class (originally named TO) and the very comfortable V-Class sedan automobile line (Vario).

With many similarities in their skeletal structures it was decided to apply the strictest safety standards to both vehicle lines. The logical approach was to apply a proven CAE tool that had been used very successful for passenger vehicle crash simulations, LS-DYNA.

The finite element code LS-DYNA is used by many car manufacturers and suppliers, and become more and more the standard software tool for crash simulation. It can address highly nonlinear structural deformations, allowing the consideration of sudden dynamic events as well as quasi-static solutions.

Since new vehicle concepts were being applied to both new product lines, Daimler-Benz made extensive use of CAE simulation techniques -- in the various phases including pre-development (or the concept phase), continuously during the design/development phase where many trade-off iterations are considered, and finally in the optimization phase (final design) that includes vehicle production as its outcome.

The drivetrain and packaging concepts of these commercial motor vehicles placed particularly difficult design challenges for the crash design. Because both are front-wheel drive with transverse mounted engines, the entire deformation energy must be transferred from the front of the vehicle, unlike vehicles with rear propulsion. The CAE simulation had to give accurate information about the deformation behavior of the front of the vehicle when considering a frontal crash.

Because Daimler-Benz implements high requirements for passenger comfort for its commercial motor vehicles, the engine and axle were designed to be a flexible bedded unit. At the same time the unit build a framework together with the actual bearing parts so that i can absorb deformation energy from a heavy frontal crash. And in order to ensure the optimal passenger protection, the front chassis is laid out in such a way that it possesses the ability to homogeneously deform in all directions.

The design of these two vehicle lines went far beyond the current acceptable standard requirements for crash. Numerous other crash tests were applied, including the consideration of the latest stringent requirements defined by the ECE standard. The measured values for both passenger safety and structural deformation have been showed excellent results. The kinematic operational behavioral tendencies were identified in very early concept phase of design by the application of the crash simulation models.

With proper development of these crash simulation models including the accurate representation of material properties and kinematic behavior, very little difference (within acceptable tolerances) exists between the models and the actual crash tests. Daimler-Benz has substantiated the accuracy and informative capability of crash simulation. Crash simulation results are utilized especially in the early concept design stage, where few, if any tests can be conducted. For example, airbag inflation versus acceleration simulation studies are now confidently being used. Consequently, these values are used up to the final design where actual airbag crash tests are required. Few design modifications then have to be made.

As required by the new ECE regulation, an optimization study was performed on the front structure of these vehicles when subjected to frontal impact crashes into deformable barriers. Very good results were obtained for the loading that passengers are subjected to during this type of crash.

The vehicle structure was likewise computationally checked regarding crash safety in accordance with the US standard. Since the concept of these vehicles has the passengers sitting more highly, they are outside of the direct danger zone, and the loads on passengers are not critical. This calculation served to essentially check structural behavior.

What is the damage and repair costs for accidents that involve vehicles traveling at speeds of only 15 km/h and 40% coverage? These questions are decided upon by the insurers of the collision insurance classification. Knowing this, Daimler-Benz goals were to minimize the deformation of the vehicle exterior for this classification and further design to prevent costly damage to the internal engine and support mechanism. Crash simulations verified that permanent deformation was only expected in the foremost bolster screw with the underlying engine support mechanism free to plastically expand. This restricted deformation eliminates the need for realignment of the support mechanism, leading to a more favorable collision insurance classification.

CAE simulations played a crucial role in the design of Daimler-Benz‘ new heavy load vehicle line, the Actros. To design for vehicle passive safety, many new concerns were raised by the simulation models, due to a new conducting chassis framework concept with additional superstructures.

At the initiation of the design, more passenger safety considerations than ever were applied to the design of the Actros vehicle line. Structural integrity was examined for both a front and rear external pendulum impact (as requested by a Swedish design requirement) as well as the ECE standards for crash. This required the development and the application of new computational simulation methods. Successfully implemented, the Actros is the first vehicle line, worldwide, to include complete CAE simulation and evaluation of all drive-cab sections.

The new software developed by Daimler-Benz is based on LS-DYNA. The explicit integration algorithm accurately simulate dynamic structural deformation. These computational model was further adjusted to ensure favorable comparison with results from actual crash tests. CAE simulations have actually resulted in fewer design iterations during the design/development phase. Simulation has resulted in the minimization of expensive test crashes – limited to those required by the regulatory agencies.

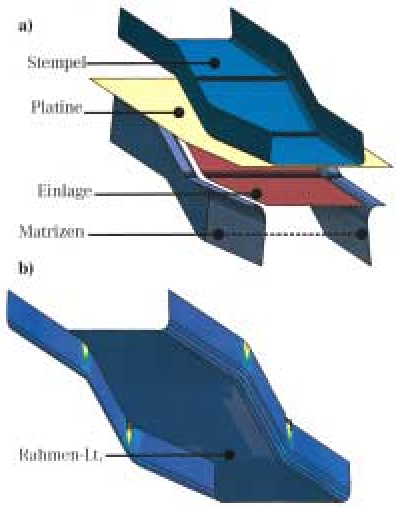
Finally, CAE simulation was extended to the airbag development for Actros vehicles. CAE simulation was used to satisfy both the trigger and non-trigger criteria for crash situations. Daimler-Benz succeeded in gaining reliable data for an area where little practical experience was available.

Captions:

Impact of a passenger car (W124) with 60 km/h relative velocity.
Source: DaimlerChrysler AG

Actros passenger simulation (with **belt and belt-tightener**) for optimal airbag passenger protection. Source: DaimlerChrysler AG

Perpendicular impact onto a rigid barrier at 50 km/h with 40% coverage (left: FEM simulation, right: Test)



Forming and stamping of a truck framework side member

a) tool arrangement
b) **strain distribution** of side member

Source: DaimlerChrysler AG

Report previously published in CAD-FEM Infoplaner

The 5th LS-DYNA Users Conference
Sponsored by Theme Engineering - Korea – October 2000

The 5th LS-DYNA Users Conference sponsored by Theme Engineering resulted in great success. The conference took place in Seoul, Korea on October 9th with over 150 attendees from industry and research centers related to automobiles, electronics and materials, and other industries utilizing LS-DYNA.

Among the highlights of the conference were ten hardware and software exhibits and thirteen excellent technical paper presentations. THEME would like to give special thanks to Dr. John O. Hallquist and Mr. Arthur Tang for their excellent presentations. Additionally, JRI's participation was highly appreciated and successful.

Best presentation award was presented by Dr. John O. Hallquist, of Livermore Software Technology Corporation, to Mr. Ho Kim of KIA Motors .

Agenda & Presentations

1. **Key Note Address – Recent Development on LS-DYNA** - by Dr. John O. Hallquist(LSTC)
2. **Validation of VPG for Full Car Simulation –** VW Golf and Other New Application - by Mr. Arthur Tang (ETA)
3. **Development of the Automotive Bumper Impact Beam using LS-DYNA**- by KUMHO Chemicals
4. **The Study on the Impact Efficiency of Bumper Beam using LS-DYNA** - by SUNGWOO Hitech.
5. **Introduction of Performance and Formability Simulation using LS-DYNA** - by HUNDAI Motors
6. **Side Impact Analysis using LS-DYNA** (ECE R95, FMVSS214) - by DAEWOO Motors
7. **Test Procedures and Computer Simulation using LS-DYNA**- by KIA Motors
8. **The Development and Draw Die using LS-DYNA** - by SSANGYONG Motors
9. **Vehicle Compatibility Research in case of Car-to-Car Frontal Offset Crash Between Large Car and Small Car** - by HUNDAI Motors
10. **Impact Analysis of Vacuum Interrupter using LS-DYNA** - by LG Industrial Systems
11. **The Application of LS-DYNA in Home Appliance** - by LG Electronics
12. **Drop/Impact Analysis of TV SET by using LS-DYNA** - by DAEWOO Electronics
13. **The Packaging Design using Impact/Drop Simulation for Printer** - by SAMSUNG Electronics

Theme Engineering - theme@soback.kornet.nm.kr

FEA Information Site Summary
Marsha Victory

Month of November additions and revisions to the FEA Information web sites:

SITE:	Additions/Revisions
www.ls-dyna.com	Metal forming FAQ by Xinhai Zhu of LSTC has been revised. On the site go to the application metal forming and the link is at the bottom of the page. FAQ 1-25 is now on the site.
www.ls-dyna.com	The history of LS-DYNA has been updated
atbmodel.com	In pdf format we added Articulated Total Body Model Version V User's Manual
AVI Library	AVI Library #52 & 53 was added – drop testing
Educational Forum	Announcement of the new Engineering Student Forum with instructions for submission of AVI's utilizing LS-DYNA (additionally in this News Letter)
Book Area	Redesigned

Publications showcased on the news during the month of November: If you would like a copy in pdf format contact Marsha mv@feainformation.com

- **Analysis of Material Performance in Automotive Applications –** Srdan Simunovic, Gustavo Aramayo and Thomas Zacharia (Posted with permission of Oak Ridge National Laboratory)
- **Springback in High Strength Anisotropic Steel –**Oladipo Onipede, Jr. and Carlos J. Gomes (University of Pittsburgh)
- **Finite Element Modeling of C0-Mingled Glass/Thermoplastic Fabrics for Low-Cost/High Volume Composites Manufacturing –** Patricia P. Buso, James A. Sherwood, Julie Chen (University of Massachusetts – Lowell)
- **Vehicle Dynamic Simulation Using A Non-Linear Finite Element Simulation Program (LS-DYNA –** G.S. Choi and H.K. Min (Kia Motors Technical Center)

Personal Message From FEA Information Co.: I'd like to end the year 2000 with a special thank you to the FEA Information Co., Worldwide Community. With your interest and assistance during this past year we've been successful in opening **16** engineering application sites. This next year I'll continue to add information to them. For the year 2001 we will be opening seven more engineering application sites. Additionally, FEA Information has purchased hardware, software and editing packages for our new multi media department. In 2001 we will additionally bring you various courses, training and other vital information to the engineering community on line and on CD.

Sincerely,

Marsha Victory – mv@feainformation.com
President

Engineering Student Forum
AVI Submissions

Dr. David Benson

Beginning in January, Dr. David Benson of the Engineering Student Forum of FEA Information will begin accepting AVI submissions. Engineering students are encouraged to send an AVI utilizing LS-DYNA. The student's AVI that is chosen monthly for posting on the web site will receive a $25.00 check from FEA Information. Additionally, it will be entered into our annual grand prize showcase.

The first place award will be $500, second place will be $200, and third place will be $100.

- All AVI submissions must be from currently enrolled students.
- AVI submissions should not exceed 1MB in size.
- AVI must be submitted with input deck.
- Copyright release will need to be signed for permission of use of AVI.
- All AVI submissions must utilize LS-DYNA.
- Submissions should be sent to Dr. David Benson

For further information contact Dr. David Benson – db@feainformation.com

Dr. David Benson –Professor, University of California, San Diego. Before joining UCSD in 1987, he worked with Dr. Hallquist at LLNL for four years on Dyna3d and Dyna2d, and currently consults for LSTC. His interests are in computational methods for nonlinear, large deformation problems in solid mechanics, ranging from Lagrangian to Eulerian finite element methods, with applications to manufacturing and material processing. Recent research applications include meso-scale simulations of ductile fracture, the shock compaction of powders, shock-initiated chemical reaction (SICR) synthesis of intermetallics, compressive failure of metallic-intermetallic composites, and the detonation of energetic materials.

FEA Information's News

December Sponsors & Products

Livermore Software Technology Corporation – LSTC
www.lstc.com

Livermore Software Technology Corporation develops and supports the LS-DYNA family of analysis tools, including LS-DYNA, a highly advanced multi-physics simulation code capable of providing accurate and rapid solutions to structural simulation problems of any size or complexity.

Products:

LS-DYNA	LS-POST
LS-OPT	

Engineering Technology Associates – ETA
www.eta.com

Engineering Technology Associates, Inc. (ETA) is a software development and engineering company specializing in automotive CAE applications worldwide. ETA's mission is to be the leading global supplier of CAE software, services, training and technology solutions.

Products:

eta/VPG (Virtual Proving Ground)	eta/FEMB
eta/DYNAFORM	eta/PostGL

Oasys, Ltd.
www.arup.com

Oasys (Ove Arup SYStems) is the software house of Arup and is the distributor of LS-DYNA in the United Kingdom and Ireland. Oasys and Arup have been distributing and working with LS-DYNA for over fifteen years. Oasys markets its own peripheral software that is fully compatible with LS-DYNA aided speed of model preparation and interpretation of results.

Products:

Oasys Primer	Oasys D3Plot
Oasys T/HIS	N/CODE
D/CODE	BBCONV