Datapoint

Reporting on developments in material properties for engineering design

EDITORIAL

Material Testing Key to Virtual Product Development Initiatives

In contrast to metals, with their relatively simple and well-understood behavior, materials such as plastics, rubber and foams exhibit complex non-linear and multi-dependent behavior. Working with such materials can pose a significant challenge for new product development. A lack of thorough understanding of material behavior is often the cause of poor design leading to failures in production or performance. The past five years have seen significant growth in testing for use in design and product development. The challenge lies in being able to provide product designers with accurate material properties that account for the use and abuse the product will see in real life. Advances in testing and material modeling have improved to the stage that such data can be reliably generated.

In the past, product evaluations were done by prototype testing at conditions replicating the product's real life environment. It involved the creation of prototypes and testing them under end use conditions at a substantial cost in terms of time and money. Product failure at that stage resulted in an even more expensive and time consuming "back to the drawing board" situation.

CAE companies over the past ten years have made great progress in improving the reliability, speed and ease of use of their simulations. Aside from material modeling issues, there is only one other factor that complicates the utilization of this technology: the description of the real life environment. Trying to account for all the effects in a real life environment can be a daunting task. Considerable effort is being devoted to this area and significant progress has been made, so that the virtual prototyping environment is now becoming a reality.

With the advent of virtual design tools (Computer Aided Engineering), the whole concept of 'Product Testing' has moved up several stages earlier in the product development en-

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FOCUS: Virtual Product Development

The virtual product development environment is rapidly coming of age with the convergence of many technologies. CAE tools are providing new means to account for the complexities of reality. With the new connectivity between software tools and availability of large computing power many of the hurdles facing this technology are beginning to disappear.

In this issue, we look at the materials related aspects of this emerging field, describing important issues and illustrating with a case study.

Write-ups on new software releases are on Page 2, in addition to news about DatapointLabs' partnership with, MSC.Software. Look for us at some of the shows in the show calender.

Jamie Antosh at the Stars and Stripes Nationals Race in Pittsburgh.

Our Own Reasons for Studying Bicycle Helmets

Jamie Antosh, champion BMX cyclist and member of the DatapointLabs Team, while not testing plastics, satisfies his craving for adventure in the form of BMX biking. He has been the New York State Champion for two years in a row and is placed nationally in his class.

While Extreme sports certainly illustrate the need for protective gear, the need and market for this kind of equipment ranges from the athletic field to the care of the elderly.

Material models for such simulations require rate dependent stress-strain data developed at high strain rates.

ANSYS 6.0 RELEASE

ANSYS release aids virtual prototyping

ANSYS 6.0, released in November 2001 empowers engineers and analysts with a robust design simulation and virtual prototyping solution to support and streamline the product development process. ANSYS 6.0 has enhanced virtual product simulation capabilities designed to minimize costs and improve time to market by allowing all necessary structural, thermal, electromagnetic and fluid-flow design tests to be conducted within a virtual environment. Product teams can better determine the real-world behavior of 3-D product designs, including the effects of multiple physics for added accuracy and product reliability.

The new ANSYS 6.0 suite features a number of enhancements to provide engineers the necessary tools to design, test and verify products under real-world conditions. Usability is key for the end user, and the ANSYS 6.0 suite offers enhanced functionality. A new Probabilistic Analysis Method Wizard simplifies the determining process for the appropriate probabilistic analysis method, and a Shell Section Builder eases the definition of layered composite elements. Furthermore, a Variable Viewer that integrates time and history variables into one comprehensive interface has been added. This addition greatly simplifies the post-processing of these variables.

ANSYS 6.0 provides an extensive array of nonlinear elements to handle complex assemblies. The nonlinear capability allows analysis of stresses, temperatures, displacements and contact pressure distributions on component and assembly designs.

To enhance solution speed, ANSYS 6.0 added a Symbolic Assembler - an algorithm with faster ordering - and the introduction of parallel version of the Sparse solver routines across all computer platforms. These enhancements to the solver capabilities reduce global matrix assembly time for the following analysis types: Static, Transient, Modal, Cyclic Symmetry, Buckling, Harmonic, Spectrum, and Mode Superposition.

-Ann Stanton, ANSYS Inc.

Plastics Testing Crucial to New Product Development

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vironment. Today, CAE engineers routinely analyze issues related to manufacturability, dimensional tolerance and product performance using these tools. With CAE, it is possible to subject components to virtual environments and visualize their behavior without prototyping. Since most modern designs start with solid models, such testing can be performed very early in the design stage where changes are inexpensive and design improvements easy to make. By eliminating poor designs, fewer prototypes need to be tested and the likelihood of prototype failure is reduced. The cost benefits are enormous.

Representation of a plastic product in a CAE/virtual design environment requires the measurement of precise quantitative properties on test specimens exposed to conditions and environments that the product will see in real life. This kind of testing is different from the development of 'typical' design properties that one finds in material databases, and far removed from data found in a materials specification sheet. 'Typical' properties are measured on virgin or carefully conditioned materials following carefully defined specifications, and may not display the influence of the product's real life environment. For use in design, we might need stress-strain properties of the plastic after exposure to engine coolant for one application, but high strain rate properties at low temperature for the same plastic in another case. While the properties of a metal may not differ significantly in the examples above, the complex nature of plastics would result in different measured properties. Failure to observe and compensate for these differences can result in flawed designs. Armed with good representative properties however, CAE engineers can truly analyze product performance. Since it is impractical to measure all properties under all possible conditions and environments, a careful evaluation of the specific needs of each class of applications is needed to keep costs under control. An examination of the real life environment leads us to an understanding of the kinds of material properties needed. An expert material testing lab is then able to select and perform the appropriate tests.

CAE technologies have resulted in greater emphasis being placed on material testing that elicits quantified measures of plastic behavior. The cost of durability prove-out will be reduced as fewer design iterations of a product will need to be tested. While testing for product development requires significantly greater expertise, the payoff is useful data that goes beyond the current 'testing for comparative purposes' and is replaced instead by 'testing to quantitatively characterize plastic behavior'.

-Hubert Lobo, President, DatapointLabs

TAP EXPANSION

DatapointLabs partners with MSC

DatapointLabs is now a Software Partner of MSC.Software. This partnership was driven by the needs of our mutual clients: "Published material property data is simply not extensive enough to provide the fidelity that we require in our engineering environment, particularly for injection molded plastics commonly used in medical products." says John Cogger, President, Innova Engineering Inc and MSC.MARC user.

http://www.mscsoftware.com/partners/

MPI 3.0 RELEASE

More material model options available

Moldflow, in its new 3.0 release now allows users viable, easy-to-implement options for material modeling. While previous versions relied primarily on a 2nd order viscosity model and a single PVT and shrink/warp model, MPI 3.0 shifts to semi-empirical Cross viscosity and Tait PVT models. However, other models including their classical models are not excluded. Of greatest interest is the ability to implement one of three shrinkage models. The choice of which model to use depends heavily on the material, with simpler models being feasible for some materials. This may help increase the application of Moldflow for shrinkage predictions, by reducing the need for the time-consuming shrinkage characterization as a prerequisite for shrinkage analysis.

EVENTS CALENDAR

DatapointLabs at Moldflow meet

DatapointLabs is a Silver Level sponsor at the rescheduled Moldflow International User Group Conference. Meet Hubert Lobo and S. Scott Kumpf at the Sponsor Event.

Upcoming events

SAE 2002 World Congress, March 4-7, Detroit, MI

Moldflow 2001 International User Group Conference, March 17-19, Boston, MA

ASTM D20 Committee on Plastics Spring Meeting, March 10-13, Pittsburgh, PA

2002 ANSYS Users Conference and Exhibition, April 22-24, Pittsburgh, PA

SPE Annual Technical Conference 2002, May 5-9, San Francisco, CA

ABAQUS World User's Conference, May 29-31, Newport, RI

IMPACT SIMULATION

Helmet Impact Simulation Benefits from Foam Material Data

The study of the performance of products and components under impact conditions is vital to many industry segments ranging from automotive and aerospace to consumer products and toys. Considerable effort is devoted to testing of finished products to determine their ability to meet the challenges they will face in daily life. The objective of this study was to show how virtual prototyping could help improve the efficiency of product development by providing answers about viable designs early in the cycle.

Protective sports equipment is in widespread use in recreational activities ranging from bicycling to roller blading. The ability to protect the wearer from injury while remaining lightweight and comfortable to wear is an important feature of any design. ANSYS/LS-DYNA was used to simulate head impact when a child rides a bike at 25 miles per hour into a telephone pole. The child's bicycle helmet was the only barrier between the modeled human skull and the rigid telephone pole. The helmet, skull and pole were created using standard CAD tools (Fig. 1). It was meshed using TrueGrid, courtesy of Livermore Software Technologies, Inc. (LSTC).

The bicycle helmet was made of a cellular energy dissipating foam covered with plastic membrane or skin. The material properties of the foam were derived from physical testing of an existing, medium cost helmet that is typically sold in toy and department stores. DatapointLabs, an ANSYS Inc. ESP partner, did the testing and produced material properties that were ANSYS input ready, meaning that the analyst was able to simply take the data supplied by DatapointLabs, add it to the geometric and environmental simulation models, and run the explicit dynamics simulation. The properties were derived using the following procedures. Cylindrical test specimens were cut from the foam material. These specimens were then placed between compressive platens and subjected to compression under impact loads of 2 and 4 m/s in a Dynatup Instrumented Impact Tower. The resulting load-time data were converted to load deformation traces, from which, the stress-strain data were calculated. Compressive data were also developed using a conventional universal testing machine.

The data were fit to a crushable foam material model, which is capable of fitting the highly non-linear stress vs. strain response of these materials. Note the behavior of a typical crushable foam (Fig. 2): there is a small linear elastic range, followed by a long crush range, then an exponential increase in stiffness as the foam reaches its crush limit. A viscoelastic material model was used to simulate the head response. The density was increased by a factor of 3x in order to account for the brain matter that was not modeled. The pole was considered to be a rigid material since it is much stiffer than the helmet or the head.

Contact was modeled between the skull and the helmet, the helmet and the pole, skull and the pole using general node to surface contact elements. A static friction coefficient of 0.2, dynamic friction coefficient of 0.1 and a viscous damping coefficient of 10 was used. For simplicity, the same values were used for all cases. The loading for the model consisted of an initial velocity of 25 MPH (440 in/s) forward into the pole (+Z direction), and 6 MPH (105.6 in/s) downward (-Y direction), applied to both the skull and helmet.

The simulation run time on a single processor NT PC was estimated to be 30 days. The same problem was run on an SGI with 8 CPU's, and results were calculated in two hours. The results show that while the helmet does absorb a significant amount of the energy of the impact, a high amount of energy is transferred to the skull and a skull fracture is the predicted outcome (Figs. 3 &4). While model refinement could have some effect on the calculated solution, the results suggest that a helmet redesign would be needed to dissipate more of the energy while preventing protective cavity intrusion by the pole. Alternatively, the helmet could be rated for a lower impact velocity which would ensure helmet wearer survivability.

-Joe Metrisin and Steve Pilz, ANSYS Inc.

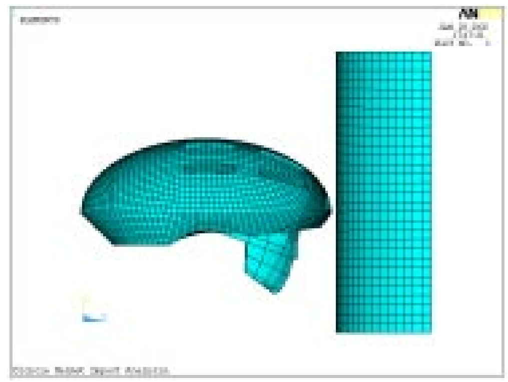

Figure 1. Geometric model of setup

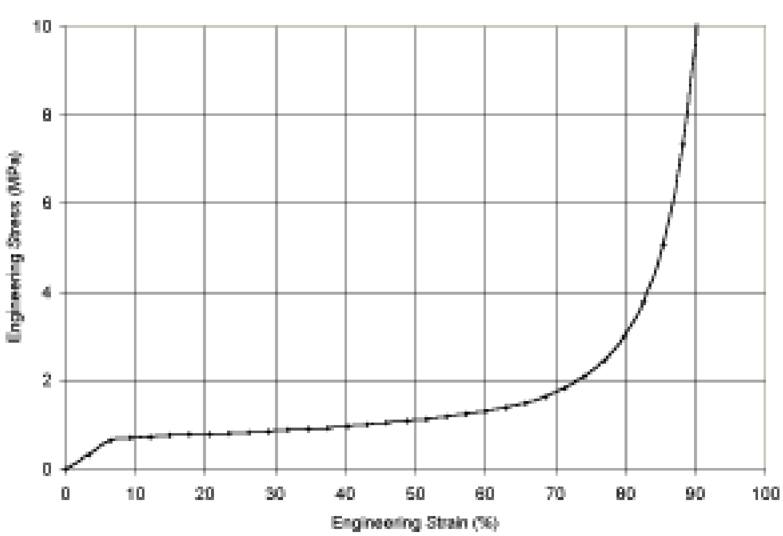

Figure 2. Material data for a crushable foam

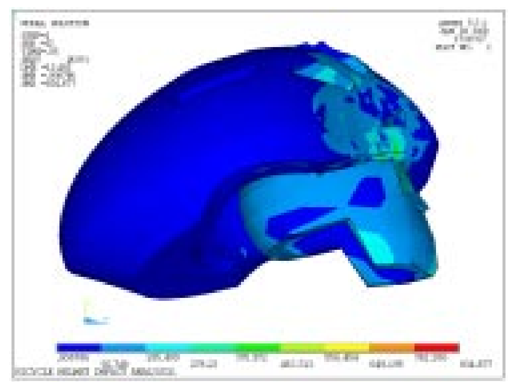

Figure 3. Side view of helmet after impact

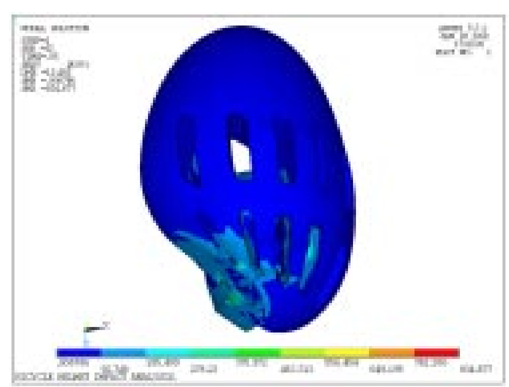

Figure 4. Top view of helmet after impact