USING MSC/NASTRAN IN IMPACT MANAGEMENT APPLICATIONS

By: David A. Bobinger M.S. 4-06
Sr. Project Engineer
Delco Products, Div. of GMC
P.O. Box 1042
Dayton, Ohio 45401

ABSTRACT

Management of the energy encountered during a collision in automotive applications has been of interest for many years in the industry, and since 1973, Delco Products, a division of General Motors, has been a leader in supplying energy absorbing devices (EADs) to the automotive community. The EAD designed by Delco Products consists of a gas pressurized unit that is located behind the bumper and assists in the management of the loads generated during an impact.

This paper describes the analysis techniques used by Delco Products to design mass efficient and cost effective impact management components. Using an Intergraph CAD/CAM system in conjunction with MSC/NASTRAN and PDA PATRAN, EADs are simulated to reduce weight and increase efficiency A vital part of this procedure includes correlation with data acquired from actual vehicle barrier and pendulum testing. The analysis methods employed in these design procedures use linear, static finite element techniques to study structures undergoing complex impact loading.

Through the use of the CAD/CAM system and the simplified analysis approach, several design modifications to various components can be evaluated quickly and effectively, resulting in shorter design development time and improved usage of test facilities.

PRODUCT DESCRIPTION

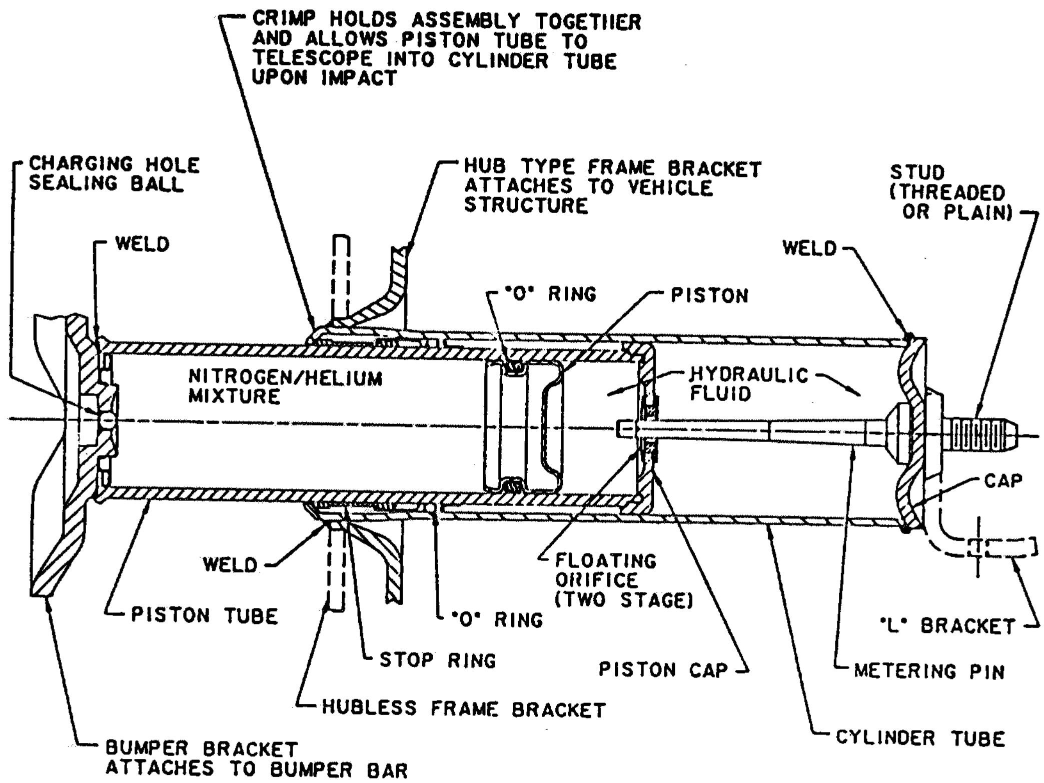


Figure 1.

Figure 1 represents a cross sectional view of a standard EAD used in many automotive applications. For this scenario, a bumper beam (metallic or plastic/composite) is used as an energy distributor to the EAD's and eventually to the vehicle frame structure. The bumper beam shape is generally determined by the styling motif of the vehicle with possibly either a bright chrome / anodized appearance or is covered by a body colored fascia.

Using packaging space as the driving design criteria, the EAD is either mounted to the beam at the face or using the rear flanges. The EAD absorbs impact energy transmitted by the bumper beam using a pressurized oil chamber and a sliding piston, with the stroke of the unit determining the amount of load directed to the vehicle frame.

DESIGN PROCESS

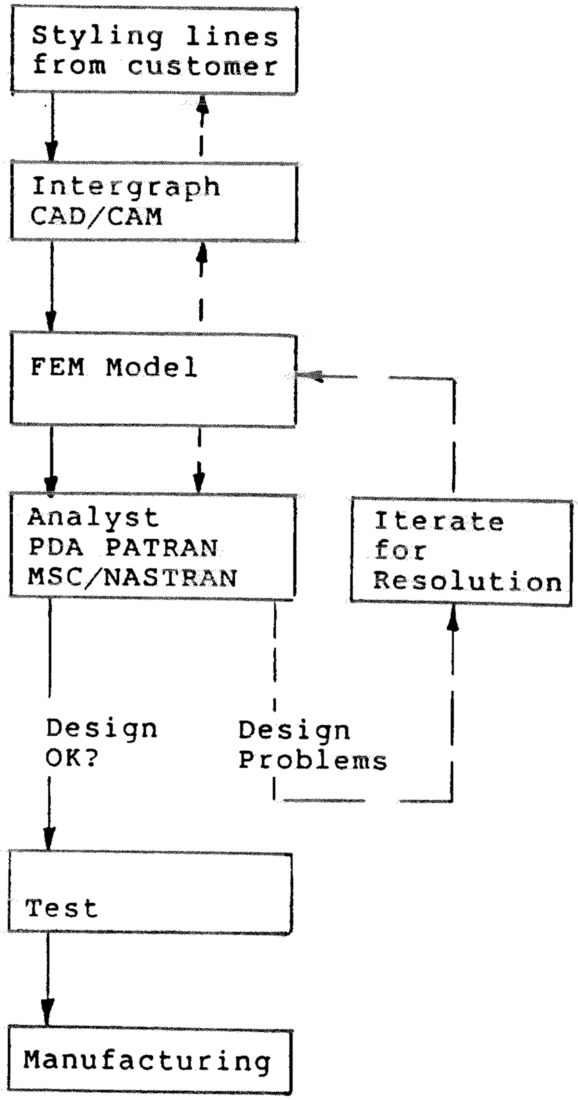


Figure 2.

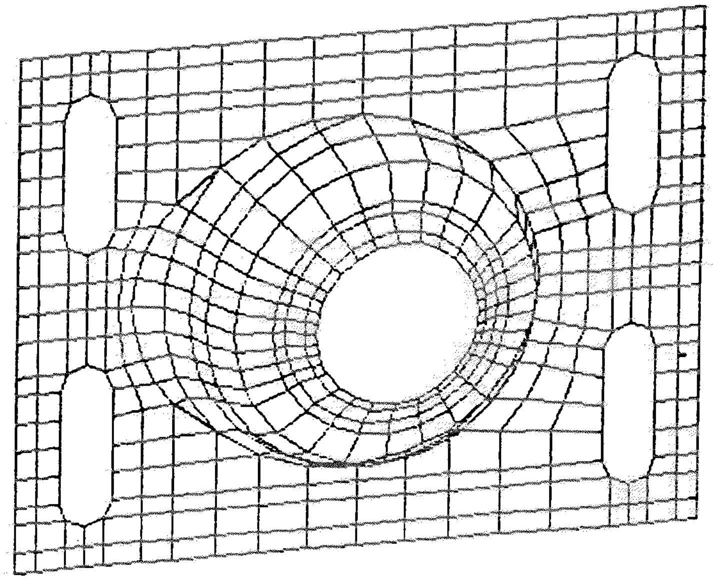
The flow chart, as shown in Figure 2., depicts the various activities that comprise the design process for energy management systems used in many automotive applications. Initially, styling provides the allowable packaging space consistent with the vehicle design intent. Electronically this data is transmitted to the Intergraph CAD/CAM system at Delco Products where it is carefully examined by designers and is used to build the finite element model of the EAD/bumper beam system. After the model is complete, a design analyst will check for accuracy, apply appropriate loads and boundary conditions to obtain stress and deflection data needed to judge the structural integrity of the system. (The analyst is aided in these tasks by the use of PDA PATRAN and MSC/NASTRAN.) After the model of the system has been established, several design iterations can be performed to optimize mass and structural effectiveness. The information generated from the finite element model is used to correlate with data obtained from barrier/pendulum testing and allows the efficient use of these facilitie by eliminating the testing of poor designs.

ANALYSIS TECHNIQUES

Finite element analysis techniques are applied to energy management systems primarily to study critical parts of the EAD, as well as, the adjoining bumper beam structure. To avoid excessively large and cumbersome models, the bumper beams and the EAD components (usually bumper and frame brackets, see Figure 1.) are modelled and analyzed separately. The analysis methods employed in these studies use a linear, static approach with the loads derived from energy calculations and/or test data. Design criteria for the EAD components consists of establishing a target stress or deflection level from a current production part and using the analysis techniques to make a judgment for proposed design changes. Bumper structural analyses use previous testing data to set acceptable design stress levels since various vehicle bumper system configurations may or may not allow for fascia protection. MSC/NASTRAN and PDA PATRAN are used to quickly and effectively study various design alternatives, as well as, present the analysis results in a form conducive to all levels of management whether engineering or manufacturing related.

Figures 3 - 6 provide some typical examples of finite element models for EAD components and bumper beam designs, with notes included describing the design improvements that were achieved from the analysis results.

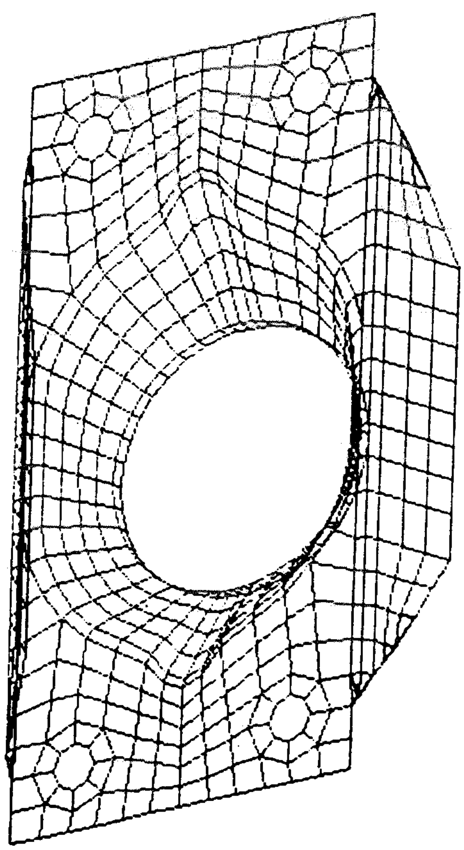
EXAMPLES OF FINITE ELEMENT MODELS



EAD Bumper Bracket Application

- deeply drawn part with known material thinning
- stress level intensity indicated low values in areas of concern

Figure 3.

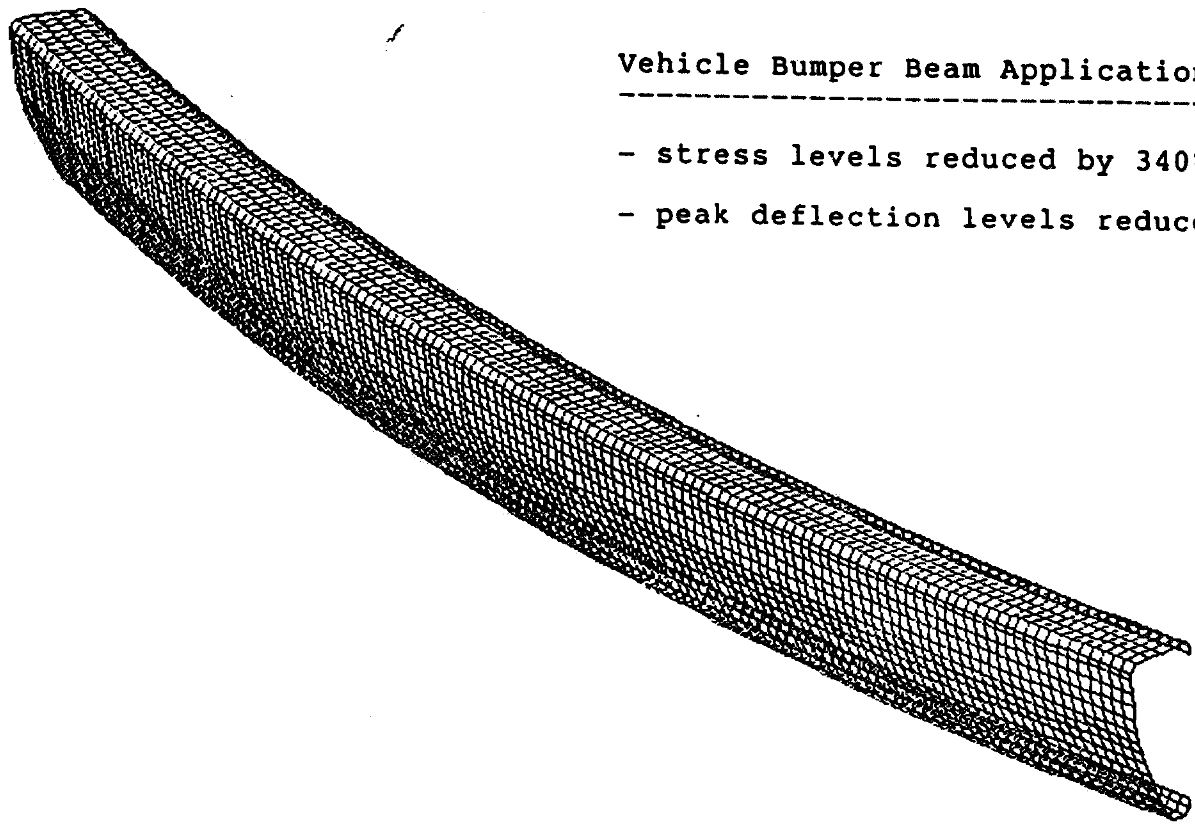


EAD Frame Bracket Application

- proved structural efficiency of height of flanges
- showed that bracket thickness must increase 59% to achieve same strength without flanges

Figure 4.

EXAMPLES OF FINITE ELEMENT MODELS



Vehicle Bumper Beam Application

- stress levels reduced by 340%
- peak deflection levels reduced 560%

Figure 5.

Truck Bumper Beam Application

- correlated well with testing
- results indicated that lower strength material could be used

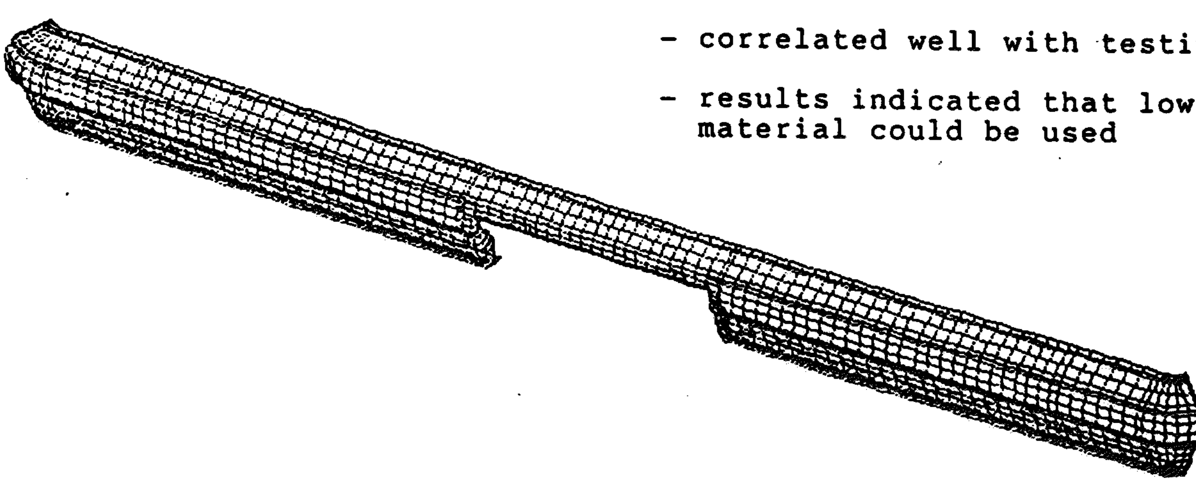


Figure 6.

CONCLUSIONS

This paper presents a brief description of the implementation of finite element techniques within the design procedure used for vehicular energy management systems. It shows that this analysis tool can be used effectively to design mass and cost efficient structures while keeping testing and prototype expenses to a minimum. Problems still exist with this integration scheme since management awareness and support must be continuously reinforced and the analysis of the various design modifications must be timely and accurately reported to be incorporated effectively into the design process.