

ENGINEERING ASSESSMENT ON THE UTILITY OF VEHICLE FRONTAL PROTECTIVE GUARDS AND THEIR AGGRESSIVENESS IN VEHICLE COLLISIONS

By

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ABSTRACT

The most difficult load estimation occurs with impacts due to its complicated nature of involving energy transfer, elastic/plastic deformations, and stress wave propagation. This complicated nature inherently makes the engineering analysis and design of mechanical components, structures and machines that involve impact and shock loading at best difficult to perform. This is evident by the many years of experimental testing conducted on vehicular designs to determine their effectiveness in collision environments. Traditional impact dynamics analyses such as stereomechanics, energy method, stress-wave propagation and contact mechanics are limited to very simplified geometries. These methods are useful in making predictions and understanding the dominant features of an impact problem.

In engineering practice, impact problems present a complexity of geometry, stiffness, mass distributions, contact areas and impact angles that are impossible to analyze and design with the traditional impact dynamics methods. In these cases, the only tool or choice is the finite element method. However, more likely than not of modeling of an impact event by the FEA method will only yield erroneous results as the lack of knowledge and experience in modeling impact events. Gaining knowledge and experience by the reviews of literature and FEA manuals is nearly fruitless as a lack of modeling techniques, guidelines and benchmark problems exists for the analysis of impact dynamics using the FEA method. The first part of research is the development of FEA modeli?-g techniques for impact scenarios. Impact problems that had been previously analyzed by the traditional dynamics impact analysis or experimentally analyzed are modeled, ran, and remodeled until satisfactory agreement is obtained with theory or experimental results. Notes, on element types, material constitutes time step size along with contact parameters such as area, stiffness and distance are noted and documented for future guidance for impact modeling. An impact problem that is occurring with increasing frequencies in North America is vehicle/large game contacts at highway speeds. In Kansas alone, roughly 10,000 vehicle/deer contacts occur per annum. These contacts pose both injuries to occupants and economic loss. For the commercial vehicles, two known manufacturers have frontal protection guards that are claimed to prevent heat exchanger damage due to a large animal strike. Use of these industrial guards will likely be increasing to stop deer strike damage. Also various manufacturers

provide small frontal guards for consumer sports utility vehicles mainly for vanity purposes claiming little about the degree of protection for any type of impact. With the popularity of SUVs and LTV's, these types of frontal guards are increasing in use. The second part of this research is to determine the effectiveness against vehicle damage for both the commercial and consumer guards to a deer impact at highway speeds. With a confidence in FEA impact modeling established from the first part of this research, a commercial frontal protection guard for tractor-trailers designed to mitigate damage for deer impacts at highway speeds is examined for its effectiveness against animal strike damage using a low-end FEA code. This FEA model is verified through a 41,000 ft-lbf impact test of the commercial guard. Likewise, a frontal protection guard exemplary for the use on SUV's and LTV's is examined for its effectiveness in providing animal strike damage. An exemplary consumer guard is obtained for reverse engineering purpose and laid out in CAD. The CAD model is transferred to an FEA processor and meshed. The consumer guard is then virtually impacted to determine if it provides any real degree of protection in animal strikes. As many consumer frontal guards are in use and more commercial guards will be used, the third part of this research is novel by examining whether or not aggressiveness or collision severity increases with the use of frontal protection guards when attached to a vehicle impacting another vehicle. Due to the guards' geometry with respect to the struck vehicle geometry and the change in frontal stiffness of the striking vehicle, a possibility exists that the frontal guards could produce higher cabin accelerations in the struck vehicle along with greater intrusion of striking vehicle. The commercial frontal guard from the second part of the research is mounted to a 17,600 lbf GVW truck and virtually impacted into the side of a passenger vehicle at an impact speed of 32 mph using a high-end FEA code. The aggressiveness of the guard is determined by examination of the difference in the passenger vehicle's acceleration along with the extent of frontal guard intrusion into the struck vehicle as compared to that of a truck impact without a frontal guard. The fourth part of this research is novel by examining how the parameters of the striking velocity along with the frontal protection guard stiffness relate to the struck passenger vehicle's acceleration and guard intrusion, when side impacted by a consumer guard. A computational method is developed to economically conduct this parametric research using a low-end FEA code. A consumer guard is obtained for reverse engineering purpose and laid out in CAD. The CAD model is transferred to an FEA processor and meshed. The consumer guard is then virtually impacted to determine if it provides any real degree of protection in animal strikes. As many consumer frontal guards are in use and more commercial guards will be used, the third part of this research is novel by examining whether or not aggressiveness or collision severity increases with the use of frontal protection guards when attached to a vehicle impacting another vehicle. Due to the guards' geometry with respect to the struck vehicle geometry and the change in frontal stiffness of the striking vehicle, a possibility exists that the frontal guards could produce higher cabin accelerations in the struck vehicle along with greater intrusion of striking vehicle. The commercial frontal guard from the second part of the research is mounted to a 17,600 lbf GVW truck and

virtually impacted into the side of a passenger vehicle at an impact speed of 32 mph using a high-end FEA code. The aggressiveness of the guard is determined by examination of the difference in the passenger vehicle's acceleration along with the extent of frontal guard intrusion into the struck vehicle as compared to that of a truck impact without a frontal guard. The fourth part of this research is novel by examining how the parameters of the striking velocity along with the frontal protection guard stiffness relate to the struck passenger vehicle's acceleration and guard intrusion, when side impacted by a 5' consumer guard. A computational method is developed to economically conduct this parametric research using a low-end PEA code.