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car bumper design manual

In this paper, the most important design parameter like thickness is studied for design and analysis of an automotive front bumper beam to improve the crashworthiness design in lowvelocity impact. The simulation of original bumper under condition impact is carried out according to the lowspeed standard of automotive stated in E.C.E. United Nations Agreement, Regulation no. 42, 1994. In this research, a front bumper beam made of three different thicknesses 4mm, 4.5mm and 5mm are studied by impact analysis to determine the deflection and plastic strain induced in the bumper beam. The mentioned characteristics are compared to each other to find best choice of Bumper thickness. Download fulltext PDF In this paper, the most important design parameter like thickness is studied for design an d analysis of a n automotive front bump er beam to improve the crashworthiness design in lowvelocity impact. The simulation of original bumper under condition impact is carried out according to the low speed standard of automotive stated in E.C.E. United Nations Agreement, Regulation no. 42, 1994. In this research, a front bumper beam made of three different thicknesses 4 mm, 4.5 mm and 5mm are studied by impact analysis to determine the deflection and plastic strain induced in the bumper beam. The mentioned chara cteristics are compared to each other to find best choic e of Bumper thickness. Keywords — crash, optimization, simulatio n 1. INTRODUCTION Car accidents are happening every day. Most drivers are convinced that they can avoid such troublesome situations. These numbers call for the necessity to improve the sa fety of automobiles during accidents. Bumper systems are designed to prevent or reduce physical damage to the front or rear e nds of passenger motor vehicles in collision condition. Different countries have differ ent performance standards for bumpers.http://www.vos-web.nl/userfiles/3gs-iphone-manual.xml

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In North America FMSS Federal Motor Vehicle Safety Standards and Canada CMVSS Canadian Motor Vehicle Safety Standards, it should be meet 4KMPH pendulum and barrier im pacts. Efforts were ta ken to model the bumper as similar as possible to reality. Thus, the computer aided design CAD data of the bumper was imported directly into Hypermesh pre processor and meshed in order to make a precise model. Since the real lowvelocity test stated in the ag reement requires laboratory equipm ent, si mplifications were assumed to make finite element modelling possible. Figure 1 Low Speed impact test. 2. CRASHWORTHINESS Crashworthiness is a measure of the vehicle's structural ability to plastically deform and yet maintain a sufficient survival space for its occupants in crashes involving reasonable deceleration loads.The front end of vehicles is designed to crumple in a controlled manner in a collision to give their occupants the nec essary additional tim e to safely decelerate in a crash. At a minimum, partial collapse of the structural cage, w hich surrounds the occupant, allows vehicle parts e.g., the engine or steer ing mechanism to "intrude" into the occupan t space and strike the occup ant causing injury. In extrem ely s evere collisions, the occupant compartment may suffer a tragic collapse, and allow the occupant to be crushe d. So the structure of a vehicle should be designed to efficiently absorb the kinetic energy in case of vehicle crash. To improve the crashworthiness of a vehicle, the load carrying capacity and collapse mode has to be estimated at the initial stage of design. As a conservative design, collapse behaviour has to be such that the front part of a car deforms severely with absorption of most impact energy whil e there is little deflection toward the passenger room. The absorber is fixed to an installation bench, and a constant displacement load pr oduced by a rigid indenter is applied to the middle of the bumper beam.http://sewersp.com/fckfiles/3gs-user-manual.xml

Based on observations, design improvem ents have been suggested. Modified front bumper design was tested using FEM software for deflection and Plastic strain. Results of modified bumper have been compared against existing design. FEM is backbone of today's automotive industry. In recent times FE analysis is widely used to validate the complex designs like bumper. Use of FEA not only reduces product development time but also saves lot of cost. Hence, this work proposes FE analysis of bumper to validate the design modifications in from bumper of car. 4. VEHICLE SAFETY STANDAR DS The National Highway Tr affic Safety Administration NHTSA strives to establish test procedures in regulatory r equirements that l ead to improvements in real world safety, often in connection with performance standards. According to the Law, the entire vehicle must meet and pass c ertain safety tests before they are sold but legislation provides a minimum statutory standard of occupant safety for new cars. To make the standard, experimental crash tests ar e conducted under the governing norm s of the Natio nal Highway Traffic Safety Administration NHTSA and Insurance I nstitute of highway Safety IIHS, two US government bodies, and EU Directive of the European Union. The below standards t hat has helped in reducing causalities in case of full frontal crashes a re. Federal motor vehicle safety standard F MVSS 208. The test shal l m ake it poss ible to verify whether the protective devices of the vehicle meet the requirements of this Regulation. The test area shall be large enough to accommodate the impactor striker propulsion system and to permit afterimpact displacement of the vehicle impacted and installation of the test equipment. The vehicle shall be at rest. The front wheels shall be in the straightahead position. The brakes shall be d isengaged and the transmission control shall be in neutral position. The impactor shall be of rigid construc tion, the impact contour being of hardened steel.

The impacting surface shall conform to the diagram in the figure. With plane A of the impactor vertical, the reference line shall be horizontal. The first contact of the im pactor with the vehicle shall be by the i mpact contour on the protective device. T he reference height is 445 mm. Longitudinal impact test. This test consists of two impacts on the front surface and two impacts on the rear surface of the vehicle.Using SHELL element with an element size of 5 creates the finite element model of the Front Bumper structure. The ratio of surface area to the wall thickness is less than 5 and hence SHELL elements are preferred for creating the FE model of the Front Bumper str ucture which is as shown in the Figures 3 to 5. In this case a f iner mesh is preferred as to obtain better accuracy of the results. The thickness of the Baseline Bumper design was 4.0 mm which is assigned to FE model. Figure 3 Finite Element model of Front Bum per Figure 4 Finite Element model of Structur e. Figure 5 Finite Element model of Baseline Ca r Here the analysis involves the understanding of the minute parameters of the original model like dimensions, material properties and structural characteristics. The overall goal of the model is to be Main area of interest is in the crashworthiness and the displacement of the front bumper structure. The FE model of the Front Bumper is connected to mounting brackets through bolts. The bolting is represented by rigid links. Then the mounting bracket is arc welded to structure using shell elements. These connections are shown in th e figure 4. Thus the bumper is connected to base structure through mounting brackets and l oad path is developed. The impact force gets transferred from bumper to base structure via mounting brackets. All these assembly task are done in the Hypermesh environment. After assembling the front bumper structure, next step is t o assign the material to th e front bumper structure.

LSDYNA is having a wide range of material and equation of state model, each with a unique number of history variables. The stressstrain relation for this material is defined with stressvs.strain points. With these material models, failure based on a plastic strain or a minimum time step size can be defined. In the FE m odel, this mate rial is primarily used for the front bumper. The parts made from this material model are considered to belong to a rigid body. This material model provides a convenient way of turning one or more parts comprised of beams, shells or solid elements in to a rigid body. Rigid bodies do not undergo any deformation. Figure 6 shows the Rigid wall and bumper structure. Figure 6 Front Bumper with Rigid wall 5.4 BOUNDARY CONDITIONS Boundary conditions includes defining contacts, constraints etc. In this c ase contact be tween rigid wall and bumper are defined. As presently implemented, one surface of the interface is identified as a master surface and the other as slave. By using number of different algorithm, a search for penetration is carried out during the execution of solution. In general, an i nput f or the contactimpact algorithm, only the slave surface is defined and each node in the surface is checked each time step t o ensure that it does not penetrate through the surface.The Figures 9 shows Displacement Plot of crash Simulation of frontal impact of Baseline Bum per into a rigid wall. The maximum displacement is 103.1 mm. Here we can see that the Bumper has been completely collapsed. The Figures 10 shows Plastic strain Plot of crash Simulation of frontal impact of Baseline Bumper into a rigid wall. The maximum Plastic strain observed i s 19 %. This is above the acceptable breaking plastic strain of 15%. The maximum displacement is 95.4 mm. Here we can see that the Bumper displacement is lower than the Baseline design. The maxim um Plastic strain observed is 17 %.The maximum displacement is 86.2 mm.

Here we can see that the Bumper displacement is lower than the Baseline design. The maxim um Plastic strain observed is 14 %. The maximum Plastic strain observed in the Baseline bumper design is 19 %. This is above the acceptable breaking plastic strain of 15%. Hence Design From the Nonlinear f inite elem ent analysis following conclusion were drawn. This has resulted in reduced Bumper deformation whi ch in turn resulted into reduced plastic strain.According to National Highway Traffic Safety Administration NHTSA, there were over six million vehicle crashes in the United States in the year 2000, which claimed the lives of more than forty thousand persons. Vehicle crashworthiness is difficult to satisfy in a manner appeasing to other design decisions about the vehicle. This paper aims at developing a novel methodology for crashworthiness optimization of vehicle structures. Based on observations of the manner of structural deformation, the authors propose the abstraction of the actual vehicle structure, which is to be represented as a linkage mechanism having special nonlinear springs at the joints. The special springs are chosen to allow the motion of the mechanism to capture the overall motion of the actual vehicle structure. It thus becomes possible to optimize the mechanism, which is an easier task than directly optimizing the vehicle structure. A realization of the optimized mechanism is then performed to obtain an equivalent structure, and then direct optimization of the realized structure is performed for further tuning. The study presented shows the success of the proposed approach in finding better designs than direct optimization while using comparatively less computational resources.

View Show abstract Design and analysis of an automotive bumper beam in lowspeed frontal crashes Article Aug 2009 THIN WALL STRUCT Javad Marzbanrad Masoud Alijanpour Mahdi Saeid Kiasat In this paper, the most important parameters including material, thickness, shape and impact condition are studied for design and analysis of an automotive front bumper beam to improve the crashworthiness design in lowvelocity impact. The simulation of original bumper under condition impact is according to the lowspeed standard of automotives stated in E.C.E. United Nations Agreement, Regulation no. 42, 1994. The bumper beam analysis is accomplished for composite and aluminum material to compare the weight and impact behavior. The strength in elastic mode is investigated with energy absorption and impact force in maximum deflection situation.A good design of this part of automotives must prepare for the safety of passengers; meanwhile, should have low weight. Beside the role of safety, fuel efficiency and emission gas regulations are being more important in recent years that encourage manufacturer to reduce the weight of passenger cars.In this research, a front bumper beam made of three materials aluminum, glass mat thermoplastic GMT and highstrength sheet molding compound SMC is studied by impact modelling to determine the deflection, impact force, stress distribution and energyabsorption behavior. The mentioned characteristics are compared to each other to find best choice of material, shape and thickness. The results show that a modified SMC bumper beam can minimize the bumper beam deflection, impact force and stress distribution and also maximize the elastic strain energy. In addition, the effect of passengers in the impact behavior is examined. The time history of the calculated parameters is showed in graphs for comparison.

Furthermore, beside the abovementioned benefits, some more advantages like easy manufacturing due to simple shape withoutribs, economical aspects by utilizing lowcost composite material and reducing weight with respect to others can be achieved by SMC material. View Show abstract Adaptive Frontal Structure Design to Achieve Optimal Deceleration Pulses Article Jan 2005 Willem Witteman To minimize the injury of car occupants during a frontal crash not only the restraint system must be View Show abstract Feasibility study of an adaptive energy absorbing system for passenger vehicles Conference Paper Fulltext available Jun 2005 Marian Ostrowski Paulius Griskevicius Jan HolnickiSzulc Many car front crashes happen with an offset between the car and the obstacle or the second car. In this case, present design of car front crash zone is made as a compromise reconciling requirements of frontal crash tests with and without offset. Using the principle of pyrotechnic detachable connectors, a control of car deceleration is possible. System controller recognizing initial precrash parameters velocity, mass, stiffness and overlap can choose several levels of dissipated energy for each absorber. Three methodologies with different levels of simplification have been chosen to calculate absorbed energy and levels of deceleration. Two crash scenarios were analyzed full front crash and 50% offset crash for two cases with an unmodified vehicle and when the absorbing structure was equipped in adaptive system. The objective of the system was to get similar levels of absorbed energy and crushing distance in both impact cases. A feasibility study of adaptive energy absorbing system has been performed based on comparison of crash analysis results.

View Show abstract Maximization of the crushing energy absorption of tubes Article Jan 1998 STRUCT MULTIDISCIP O Koetsu Yamazaki Jing Han This paper concerns the development of crashworthiness maximization techniques for tubular structures, and the application to the axial crushing problem of cylindrical tubes as well as square tubes. In the program system presented in this study, an explicit finite element code, DYNA3D is adopted for simulating complicated crushing behaviour of tubular structures. The response surface approximation technique is applied to construct an approximated design subproblem in the preassigned design space by using the technique of designofexperiment. The approximated subproblem is solved by the usual mathematical programming technique. These optimization processes are repeated until the given convergence conditions are satisfied. Moreover, a comparison of the crushing energy absorption between cylindrical tubes and square tubes is discussed. In the case of a qualitative evaluation of plastic surfaces, haptic is emerging as a key field of innovation. This technology allows greater design freedom, while at the same time the ability to vary haptic impression from velvetydry to rubberlike. Grayish green paint smears scattered on a silvery gray coated plastic bar were taken from a blue car and referred to as questioned samples. These were analyzed to determine whether the paint smears found in the blue car could have been the transfers from the green car. Although each of the three methods, when used alone, suffered from unequal bases for making comparison i.e., layering whole paint vs.Based on the results presented in this report, the questioned grayish green paint smears collected from the blue car and the known green paint chips from the green car are of the same class of paint; that is, the possibility of the above stated paint transfers cannot be eliminated.

View fulltext Conference Paper The Evolution of Styrenic Polymers in Automotive Applications February 1983 Kenneth J. Ritzema Styrenebased polymers have been used widely in automotive applications for more than 25 years, and during the past few years, the styrenic family has undergone a dramatic evolutionary change. With the downsizing of the automobile and the move to eliminate the painting of the plastic parts, new enduse requirements are being placed on the styrenic family. Read more Discover more Download citation What type of file do you want. RIS BibTeX Plain Text What do you want to download. Citation only Citation and abstract Download ResearchGate iOS App Get it from the App Store now. Install Keep up with your stats and more Access scientific knowledge from anywhere or Discover by subject area Recruit researchers Join for free Login Email Tip Most researchers use their institutional email address as their ResearchGate login Password Forgot password. Keep me logged in Log in or Continue with LinkedIn Continue with Google Welcome back. Keep me logged in Log in or Continue with LinkedIn Continue with Google No account. All rights reserved. Terms Privacy Copyright Imprint. For the ride, see Bumper cars. Bumpers ideally minimize height mismatches between vehicles and protect pedestrians from injury. Regulatory measures have been enacted to reduce vehicle repair costs and, more recently, impact on pedestrians.The construction of these bumpers was not reliable as they featured only a cosmetic function.In formula formSmall increases in bumper protection can lead to weight gain and loss of fuel efficiency.Bumpers do not protect against moderate speed collisions, because during emergency braking, suspension changes the pitch of each vehicle, so bumpers can bypass each other when the vehicles collide.

The platform bed of a typical tractortrailer is at the head height of seated adults in a typical passenger car, and can cause severe head trauma in even a moderatespeed collision.Similar or identical to bull bars, offroad bumpers feature a rigid construction and do not absorb by plastic deformation any energy in a collision, which is more dangerous for pedestrians than factory plastic bumpers. The legality of the aftermarket offroad bumpers varies by jurisdiction.The 1974 bumpers protroude farther from the body and the rear one no longer contains the taillamps.The 1973 model year passenger cars sold in the US used a variety designs.The US bumpers are larger and protrude farther from the bodywork.With very few exceptions, such as Volvo 240 and RollsRoyce Silver Shadow, foreign manufacturers only sold this feature in markets that mandated it, the U.S. and Canada, so restoftheworld models had a notably distinct appearance. Unlike international safety regulations, U.S. regulations were written without provision for hydropneumatic suspension.The results illustrated the effect of the Retrieved 15 March 2014. England Guinness Publishing. p. 256. ISBN 0851127681. Retrieved 20 July 2018. Retrieved 20 July 2018. MBI Publishing. p. 58. ISBN 9780760318645. Retrieved 20 July 2018. Retrieved 21 June 2016. The reduction in speed divided by the time over which it takes place defines deceleration. Injuryproducing forces are proportional to the deceleration experienced by the occupant. Occupant protection aims at reducing these forces by spreading the occupants changes in speed over longer times. The theoretical best protection would be for the occupant to slow down from the initial vehicle speed to zero speed at a constant deceleration using the entire distance between the occupants body and the vehicles point of impact.Retrieved 15 March 2014. Retrieved 6 January 2014. Publications International.Retrieved 6 January 2014. Retrieved 21 June 2016. Retrieved 6 January 2014.

Retrieved 2 July 2015. Retrieved 7 July 2015. By using this site, you agree to the Terms of Use and Privacy Policy. When a low speed collision occurs, the bumper system absorbs the shock to prevent or reduce damage to the car. Some bumpers use energy absorbers or brackets and others are made with a foam cushioning material. Automobile bumpers are not typically designed to be structural components that would significantly contribute to vehicle crashworthiness or occupant protection during front or rear collisions. It is not a safety feature intended to prevent or mitigate injury severity to occupants in the passenger cars.It applies to front and rear bumpers on passenger cars to prevent the damage to the car body and safety related equipment at barrier impact speeds of 2 mph across the full width and 1 mph on the corners. The standard requires protection in the region 16 to 20 inches above the road surface and the manufacturer can provide the protection by any means it wants. For example, some vehicles do not have a solid bumper across the vehicle, but meet the standard by strategically placed bumper guards and corner guards. The agency has chosen not to regulate bumper performance or elevation for these vehicle classes because of the potential compromise to the vehicle utility in operating on loading ramps and off road situations. This standard called for passenger cars, beginning with model year 1973, to withstand 5 mph front and 2.The new standard which applied to passenger cars beginning with model year 1979, was referred to as the Phase I Standard. At the same time, a "no damage" requirement Phase II was placed on bumper systems for model year 1980 and subsequent years. See question 6 for more information on Phase I and II requirements. This amendment reduced test impact speeds from 5 mph to 2.5 mph for longitudinal front and rear barrier and pendulum impacts and from 3 mph to 1.5 mph for corner pendulum impacts.

In addition, Phase I damage resistance criteria were substituted for Phase II criteria and a bumper height requirements of 16 to 20 inches was established for passenger cars. How do they differ and how much damage does the standard allow Phase I of the standard became effective on September 1, 1978 for passenger cars beginning with model year 1979. It incorporated the FMVSS 215 safety criteria, and added new performance criteria which prohibited damage to all exterior vehicle surfaces. For model year 1979, the standard required that there be no damage to safetyrelated parts and exterior surfaces not involving the bumper system e.g., sheet metal; lamps; and fuel, exhaust and cooling systems with damage to the face bar and its fasteners at impact test speed of 5 mph front and rear impacts with barrier and pendulum; 3 mph corner impact with pendulum. The evaluation determined the net benefits the change in costs to the consumer attributable to each successive standard applicable through model year 1980 in relation to unregulated bumper systems in model year 1972 and prior years.The evaluation concluded that 1 the costs to consumers did not change as a result of the modification of the bumper standard from 5 to 2.5 mph; 2 the net effect, over a car's 10 year life, is a small increase in repair costs, which is offset by a reduction in the cost of the bumpers; and 3 the change in the bumper standard did not compromise the protection of safetyrelated parts. Every vehicle is impacted twice on the front and rear surfaces and once on each front and rear corner with the impact line at any height between 500mm 20 inches and 400mm 16 inches. While the impact speed in the Canadian standard is higher than that in the U.S. standard, the Canadian standard has less stringent protective criteria. Specifically, the protective criteria for the Canadian standard requires that the vehicle does not touch the test device, except on the impact ridge with a force that exceeds 2000 lbs.

Since this is a minimum performance standard, the manufacturer may be providing a greater level of protection. The agency does not require manufacturers to report the actual performance capabilities of their bumper systems. Many parameters such as vehicle masses, the preimpact velocity of both vehicles, impact angles, crush resistance, metallurgical fatigue, etc., affect how the bumpers behave during an impact. Each crash must be analyzed with respect to all of the parameters before an estimate can be made. However, the Insurance Institute for Highway Safety IIHS conducts yearly tests on a number of models for bumper ratings in terms of strength and repair cost. Information can be obtained through their web site at or at 703 2471500. These ratings can be obtained through our web site at However, some states and localities have requirements that limit bumper height for other vehicle types. We suggest individuals contact their local or state agency responsible for motor vehicle regulations. However, bumper elevation is not solely responsible for mismatched contact in vehicle collisions. The effect of braking and interaction of suspension dynamics and vehicle weight can also be attributed to the mismatch. This issue is being addressed as a part of the agency's consideration of the broader issue of vehicle compatibility. Compatibility involves differences in vehicle characteristics between passenger cars and LTVs such as weight, height off the ground, geometry and stiffness. To address this issue, the agency is developing advanced simulation models of vehicles that could be used as tools to understand crash behavior and interactions between incompatible vehicles and to assess safety implications of these vehicles fleet wide.

This research could lead to the development of suitable countermeasures for occupant protection in crashes of incompatible vehicles by transferring loads through structural members which interact better in crashes and through energy management while maintaining occupant compartment integrity. Bumpers should be designed to protect car bodies from damage in lowspeed collisions, absorbing crash energy without significant damage to the bumper itself. Lowspeed crashes occur by the thousands every day on congested streets and parking lots — the kind of impacts in which effective bumpers can mean the difference between lots of costly damage and none at all. A 2002 Institute study of vehicles brought to 5 insurance drivein claims centers in a major metropolitan area found that about 14 percent of all claims for auto damage involve parking lot collisions. Bumpers on today's cars generally consist of a plastic cover and underneath, a reinforcement bar made of steel, aluminum, fiberglass composite, or plastic. A bumper system also should include mechanisms that compress to absorb crash energy — polypropylene foam or plastic honeycomb, also called "egg crate," is often used. For a bumper to be effective, there must be some distance between the reinforcement bar and the sheet metal it should protect. This is true among cars of similar size and type and among cars from the same automaker. Some bumper designs put more emphasis on style than protection. For example, some car designers object to bumpers projecting beyond body parts — sometimes referred to as bumper overhang. As a result, even the most minor collisions can mean expensive damage. Lights built into bumpers may be stylish, too, but they can sustain damage in lowspeed crashes. It applies to front and rear bumpers on passenger cars to prevent the damage to the car body and safety related equipment at barrier impact speeds of 2 mph across the full width and 1 mph on the corners.