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Frontal Crash Effect Analysis of Ads Vehicles with Rigid Wall Using Ls-Dyna

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Abstract
It's obviously known that most recently vehicle fates are pleasant a foremost difficult around the world, in our countries too, forcing engineers' efforts to identify measures to reduce the risk of injury. Here, the most important issue is to keep the occupant compartment space safe during a collision. The occupant compartment intrusion during vehicle collision is influenced by stiffness, crash speed, mass, and geometric interaction. Automated driving systems (ADSs) promise to make driving safer, more comfortable, and more efficient. However, the number of fatalities in vehicles equipped with ADSs is increasing like those existing vehicles. The full potential of ADSs will not be achieved unless the current state of the toughness skills is improved. The crash worthiness challenges with wall from front side and technological aspects of automated driving are discussed in this study. The ADS TRACTOR model used here was modeled using LSDYNA and simulated using LS-DYNA which is widely used by the automotive industry to analyze vehicle design and predict a car's behavior in a collision.

Keywords: Ads, Crashworthiness, Fatality, Lsdyna, Occupant.

Introduction

Automatic riding is one of the key present-day technologies. Further to supplying broader get admission to mobility, it can additionally assist to reduce the quantity of driving-associated injuries and crashes. When doing so, the protection of automated using motors is one of the maximum crucial elements.

According to the 2018 WHO Global Status Report on Road Safety, 1.35 million people worldwide died in road accidents in 2016. Road accidents are the eighth leading cause of death in the world, with 18.2 deaths per 100,000 and the leading cause of death for children and adolescents aged 529. Road traffic casualties are evenly distributed around the world, with 93% of deaths occurring in low- and middle-income countries, accounting for 41% of the world's automobiles. About 29% of these deaths are four-wheel drive drivers, 23% are pedestrians, and 3% are cycling [1].

Now a day on average approximately 1.3 million people die each year as a result of road traffic crashes until June 2021.

By reducing the number of crashes on U.S. roadways and highways, vehicles outfitted with software and hardware that executes the driving duty have the potential to drastically reduce fatalities and serious injuries. This new technology, on the other hand, may provide hurdles in terms of protecting occupants in the remaining crashes. New ADS vehicles are planned to include vehicles that are not designed to carry passengers. These new ADS vehicles would solely be used for deliveries. Most automobiles sold in the United States today must comply with occupant protection regulations set forth by the Federal Motor Vehicle Safety Standards (FMVSS), such as FMVSS No. 208, "Occupant Crash Protection," or FMVSS No. 214, "Side Impact Protection"[4].

However, because these criteria are focused on occupant safety, it's feasible that they'll be changed in the future to exclude occupant less ADS vehicles. Even if this were to happen, such occupant less ADS cars may be involved in collisions with current vehicles and roadside infrastructure. There is little research on crash scenarios that do not involve occupant safety but instead involve proper interaction with existing roadside hardware, such as guardrails and sign support. The US Department of Transportation is funding research initiatives to better understand the crash characteristics of ADS vehicles in order to develop safety considerations and rules for them.

NHTSA's mission is to save lives, prevent injuries, and reduce the economic costs of roadway crashes through education, research, safety standards, and enforcement activity. As automated vehicle technologies advance, they have the potential to dramatically reduce the loss of life each day in roadway crashes.

Given that a mix of vehicles with ADSs and those without will be operating on public roadways for an extended period of time, entities still need to consider the possible scenario of another vehicle crashing into an ADS-equipped vehicle and how to best protect vehicle occupants in that situation. Regardless of whether the ADS is operating the vehicle or the vehicle is being driven by a human driver, the occupant protection system should maintain its intended performance level in the event of a crash [3].

Entities engaging in testing or deployment should consider methods of returning ADSs to a safe state immediately after being involved in a crash. Depending upon the severity of the crash, actions such as shutting off the fuel pump, removing motive power, moving the vehicle to a safe position off the roadway (or safest place available), disengaging electrical power, and other actions that would assist the ADSs should be considered. If communications with an operations center, collision notification center, or vehicle communications technology exist, relevant data is encouraged to be communicated and shared to help reduce the harm resulting from the crash [2].

Additionally, entities are encouraged to have documentation available that facilitates the maintenance and repair of ADSs before they can be put back in service. Such documentation would likely identify the equipment and the processes necessary to ensure safe operation of the ADSs after repairs.

Various crash test

It's a form of destructive testing usually performed in order to ensure safe design standards in crashworthiness and crash compatibility for various types of vehicle like small, medium and heavy duty and its related systems and components for the sake of getting the performance of the vehicle under the different conditions of crash at different angles with taking certain objects like rigid wall, cables specially three strand cable, concrete barriers, guardrail system etc. It will be performed either by numerical simulations or experimentally. Here is different types of crash test generally used [6,7].

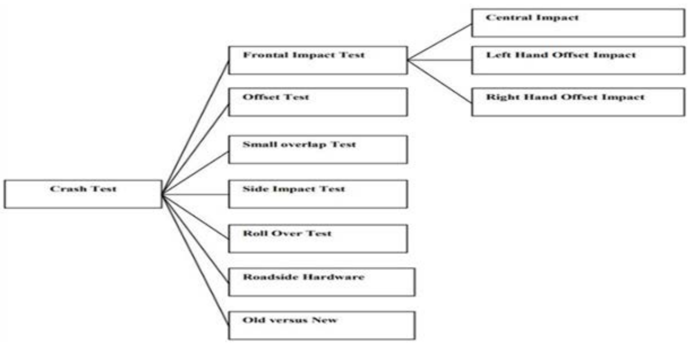

Figure 1: Types of Crash Test

As explained that, crash test is a type of destructive testing used to ensure that automobiles and related components meet safe design standards for crashworthiness and crash compatibility. Vehicle manufacturers crash test their automobiles from various angles, sides, and with various objects, including other vehicles, to test their safety performance under various conditions and during numerous sorts of crashes [8].

The most common types of crash tests are listed below.

- Front impact test.
- Front offset crash test.
- Side impact test.
- Roll over test

Vehicle description

- Tractor Automated Driving System (ADS) Vehicle.
- Weight: 3373 kg.
- Finite element model derived from a validated 2014 Chevrolet Silverado FE model.
- Dimensions similar to existing tractor ADS vehicle concepts.
- Resulting tractor ADS vehicle FE model was NOT validated against test data.

Model Information

Table 1: Vehicle Full Information

Number of parts	400
Number of nodes	192049
Number of solid elements	4899
Number of shell elements	301752
Number of beam elements	1515
Number of elements	308166
Model units	mm,s,t,N
Release date	Nov. 2019

Figure 2: Vehicle Structure

Model Development

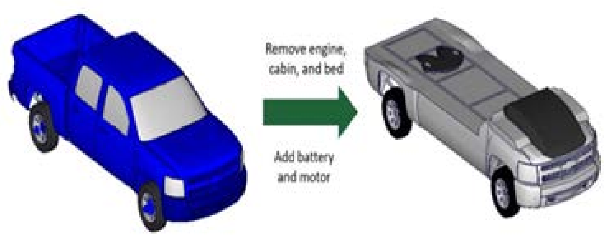

Figure 3: Existing FE model and Generic tractor ADS FE Model.

Accelerometers

Table 2: Accelerometer Specs Mounted.

Left Rear Seat	(Node 1167327)
Right Rear Seat	(Node 1167319)
Vehicle C.G. Local	(Node 1167332)
Vehicle C.G. Global	(Node 116733)

Simulation bench mark

Table 3: Simulation Benchmark Boundary

LSDYNA	
Platform	
Version	R11.1.0
Revision	R810
Precision	Double
Turnaround times (150ms)	
Number of processors	8

Mesh generation

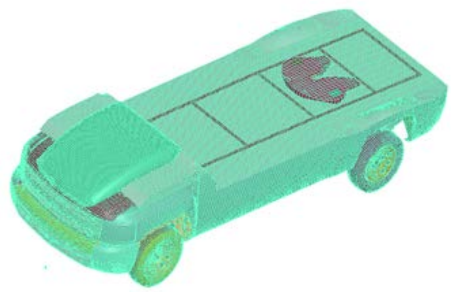

Figure 4: Meshed Vehicles Body

Part Material Properties and Thicknesses of the ads Components

LS-DYNA material library is used for the selection of materials for vehicle components. The windscreen and vehicle structures including chassis were modelled by MAT_PIECEWISE_LINEAR_ PLASTICITY. While The keyword used for the tire was modelled by MAT_ELASTIC. Since some parts are not subjected to deformation they were modelled by MAT_RIGID, these are axles and engine components representation.

The mechanical properties and thickness of the shell of the vehicle components are given in table below:

Table 4: Mechanical Properties of The Set Components for Analysis

Vehicle item	Mass density (kg/m^3)	Young's Modulus(pa)	Poisson's ratio	Yield Stress (pa)
Vehicle structure	7.890e-09	2.100e+05	0.30	270
Chassis				
Windscreen				
Tire				

Contact Definition

The contact between two parts is given to prevent penetration during the crash. There are a lot of contact types are available in the keyword manager. The contact types used on this paper is shown on table 3.

Table 5: Contact Between Different Parts of Ads

Contact type	Slave	Master
Automatic surface to surface	ADS	Wall
Automatic surface to surface	ADS	Wall
Automatic single surface	Whole vehicle	Non

When two bodies collide during the deformation process, contact occurs. During contact, a force is transmitted at the interface. The two components just pierce each other if there is no touch. Unless the user specifies otherwise, the software does not have any logic to detect the contact by default. When it comes to giving contacts, there are two factors to consider: master and slave.

The component with the highest stiffness and Young's modulus is the master. In our company, a stiff wall is regarded as the master. In comparison to the master, the slave component is deformable and has a lower stiffness and Young's modulus value.

Boundary Condition

To analyze the real crash event of ADS hitting a post or wall, an FEA model is set up in which the vehicle moves with a velocity of 65 km/h and then strikes the rigid pole at an angle of 90 degrees with the vehicle's longitudinal axis is adjusted. The rigid pole used for the simulation can be downloaded from [5].

The diameter of the rigid pole is 254mm and arranged vertically with 2150mm length. The direction of vehicle motion is such that the pole is always aligned with the CG of the head of the driver [8]. The LS-DYNA set-up of side crashworthiness test BPV model as per NACP regulation is shown in Figures 7 a and b.

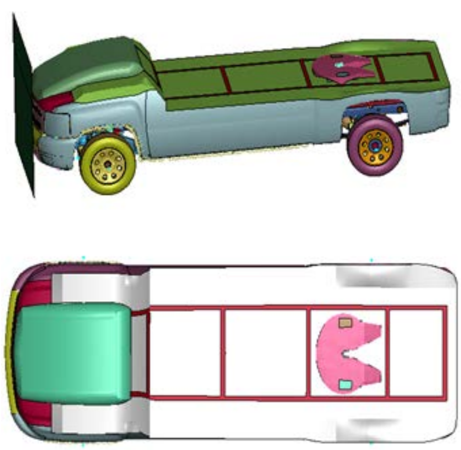

Figure 5: Front Crash Test Setup

Sets

To assign the vehicle velocity, the velocity must be applied to all nodes on the fascia. It's impossible to apply a velocity to each node individually. As a result, it is preferable to build a set for all nodes so that the velocity of all nodes on the fascia can be assigned at the same time.

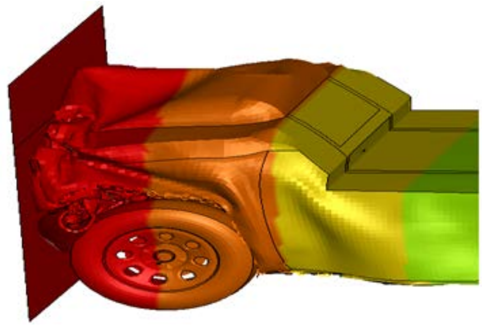

Figure 6: Sets on Lsdyna for Frontal Crash

Initial

The velocity is allocated to fascia in this section. The velocity is allocated to all of the nodes produced as a group. As a result, the allocated velocity is distributed evenly throughout the surface nodes. The fascia is given a velocity of 30 mm/ms, or 108 km/hr in +X-direction, because the vehicle moves in X-direction in reality.

Data Base

Database cards are offered to generate results and analyze charts, as well as to receive the output. The energy absorption is analyzed using database cards.

Result and Discussion

Frontal Crash and Body Deformation

The deformation values are obtained by measuring the relative displacement from two nodes (one at the right or left end of the beam and the other at the middle of the beam). With this measurement, the value of the deformation graph for different thicknesses of the beams with acceleration is shown in Figure 10 below. This does mean that abeam with less thickness is always better. Because more deformation means that there is the probability of intrusion to the vehicle main compartments.

The Front Longitudinal Panel Deformation and Dash Panel Intrusion Analysis

During a vehicle collision simulation, the front longitudinal beam is the primary kinetic energy absorber. The optimal front longitudinal beam deformation has a sufficient front deformation and a modest rear distortion, allowing the automobile to absorb kinetic energy efficiently, minimize rapid acceleration, and prevent dash panel invasion. It has enough room for the driver and front passenger to be safe. Figure 7 depicts the deformation of the front longitudinal beam at various times.

Figure 7 shows how the front longitudinal beam deforms from front to back as time passes. The absorption of energy is aided by the front of the front longitudinal beam entirely crushing first. The center and rear longitudinal beams of the front longitudinal beam appear to flex differently with time, which is hazardous to the dash panel intrusion.

The dash panel displacement contours can illustrate the amount of dash panel that has been directly invaded by the cab. The amount of the invasion is related to living space in the collision process, so the smaller amount of the invasion is beneficial to provide enough space for the front passenger.

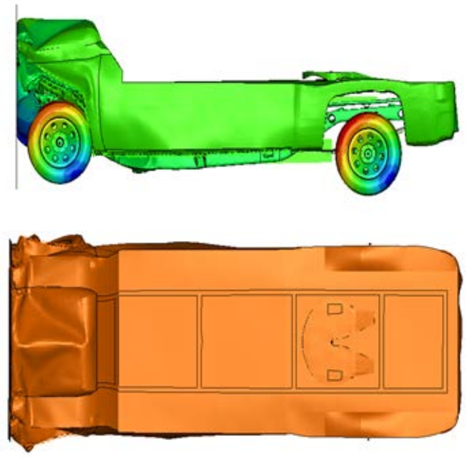

Figure 7: Front Longitudinal Beam Deforms from Front to Back

Energy Balance Curve

Energy cannot be generated or destroyed, but it can be transferred from one type of energy to another, according to the Law of Conservation of Energy. The quantity of kinetic energy lost during impact must be transformed to other forms of energy, such as internal energy, sliding energy, and hour glass energy, using the same method as in crash analysis. It should also be noted that there may be some inaccuracies in estimating energy ratios because all activities in the universe are irreversible, and certain losses are always included in, causing the energy ratio to diverge slightly from one.

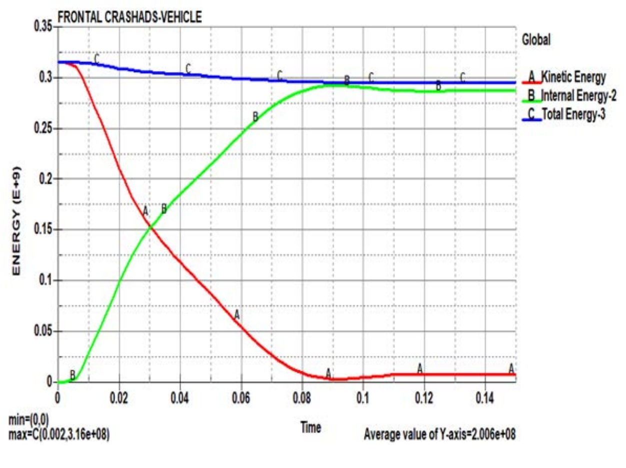

Figure 9: Change of Energy During the Crash

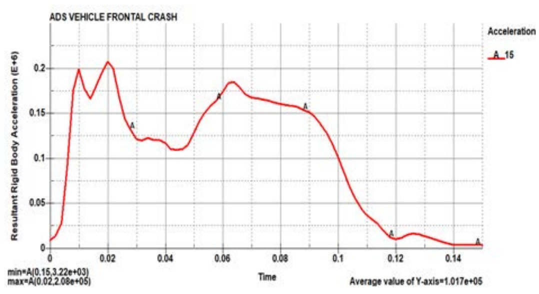

Figure 10: Rigid Body Acceleration Vs Time

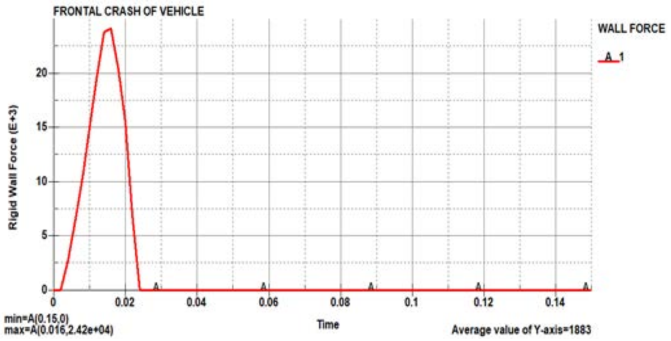

Figure 11: Rigid Wall Force Vs Time

Conclusion

- The overall objective of the work was to simulate a Frontal crash-test and analyse the results of the simulations obtained from the crash-test. Simulation was performed using the LS-DYNA software package.
- The outcomes of the simulations were collected from the results of the Tractor ADS model simulation.
- As was observed, the bumper, engine and the rails absorb most of the energy before the wheel impacts the wall. Almost half of the energy of the crash is absorbed by these components after about 0.08sec of the crash initiation.
- Due to the limited availability of computer resources, a simpler model of the test vehicle was chosen, which ultimately caused the inaccuracies of the results.
- For more accurate results a more accurate model would be required but the computer resources required for the simulations would have been much higher. Therefore, a compromise had to be found wherein the simulation could be performed without the result deviating too much.

References

1. Naheed Saba, Paridah Md Tahir (2014) "A Review on Potentiality of Nano Filler/Natural Fiber Filled Polymer Hybrid Composite" University Putra Malaysia, Malasia 6: 2247-2273.
2. Md Atiqur Rahman, D Praveen Babu (2019) Simulation of Car Frontal Fascia During Crash using LS-DYNA. International Journal of Engineering Research & Technology (IJERT) ISSN 8.
3. Chunke Liu, Xinping Song, Jiao Wang (2014) Simulation Analysis of Car Front Collision Based on LS-DYNA and Hyper Works. Journal of Transportation Technologies 4: 337-342.
4. Ghamarian A, Zarei HR, Abadi MT (2011) Experimental and Numerical Crashworthiness Investigation of Empty and Foam-Filled End-Capped Conical Tubes. Thin-Walled Structures 49: 1312-1319.
5. Zhang Y, Sun GY, Li GY (2012) Optimization of Foam-Filled Bitubal Structures for Crashworthiness Criteria. Materials & Design 38: 99-109.
6. Zarei HR, Kroeger M (2006) Multi-objective Crashworthiness Optimization of Circular Aluminum Tubes. Thin-Walled Structures 44, 301-308.
7. Tejasagar Ambati, KVNS Srikanth, P Veeraraju (2012) Simulation of Vehicular Frontal Crash-Test International Journal of Applied Research in Mechanical Engineering 1.
8. Deba MS, Mahendrakumara, C Chavan, J Karve, D Blankenburg, et al. (2004) "Design of an Aluminium-Based Vehicle Platform for Front Impact Safety", Journal of Impact Engineering 30: 1055-1079.