CHALMERS
UNIVERSITY OF TECHNOLOGY

TME202 – Vehicle and Traffic Safety

Passive Safety Project Report – M4
CRASH ANALYSIS USING FE TOOLS

Submitted by:

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DESCRIPTION

For this project the students have been working in pairs of two. The students are employers of a small automotive company and each group has been assigned a specific task. Each task revolves around one central question. While these main questions are different, each group had to go through the same milestones and procedures. Depending on the assigned task the perspective and parameters for these milestones are different.

Commented [BS1]: Maybe change the structure here:
Talk about the test setup
Talk about LS Dyna
Move the Milestone description to the main parts??

The tools to answer this task given are sensor data and data extracted from a video of experiments as well as models to be used in simulations with the software LS Dyna.

Our group was assigned task 2:

What is the maximum Δv for the simulated "car" front structure?

To be able to answer this question the following questions had to be addressed as well:

- What is Δv? Why is it important? What happens at max Δv?
- How can we predict the velocity that causes bottoming out?

Milestone 1: Test selection

In this milestone the given datasets are being evaluated and the ones fitting the best to the assigned task are being selected for further processing.

Milestone 2: Benchmarking

The group is given the output of LS Dyna simulations with different mesh types and must evaluate which of those fulfil the requirements for simulations the best.

Milestone 3: In House Tuning

Based on the mesh chosen in the previous milestone a simulation must executed and the results must match one of the chosen datasets. The given files are incomplete and must be complemented before the simulation can be executed and the parameter tuning realised.

MILESTONE 1: TEST SELECTION

The test setup consists of a sled, which can be loaded with mass, and accelerates a mounted can constantly until it crushes a wall and the deformation of the can is measured.
There are two factors which can be changed in this setup: the mass and the impact velocity.
For our given task we are interested in the properties of the car regarding Δv. Δv is defined as the change of velocity **during** the crash while there is contact. Therefore, we want to have different impact velocities and a constant mass. These criteria are best fulfilled with Test 2, Test 4 and Test 5.

Experimental Dataset Selection for Task 2:

	Final Length	Mass	Initial velocity from Video tracking data	Initial velocity from Data acquisition systems
	mm	kg	m/s	m/s
Test1	74.0	49.9	2.8	2.82

Test2	108.5	45.1	1.9389	2.007
Test3	78.0	49.5	2.6736	2.773
Test4	80.5	45.0	2.6683	2.792
Test5	50.0	45.2	3.3165	3.451
Test6	76.0	46.9	2.7729	2.82
Test7	94	49.1	2.3681	2.475

The initial velocities of the DAQ systems are found from the light gate data by dividing the distance from the start of the third solid to the end of the first solid (163.6 mm) and the time taken for crossing that. The time has been acquired from the signal of the light gate as it changes from 1 to 0 when the laser is blocked. The initial velocities of the video tracking data are acquired from the excel sheet.

MILESTONE 2: BENCHMARKING

The second milestone is to evaluate different models for the simulation. It is in the interest of OEMs to have a model which is accurate enough and computationally cheap at the same time. To evaluate and compare each model with each other some information had to be extracted from the simulation. Namely the energy ratio, the deformed length, percentual change of deformation compared to the most accurate one, the percentage of hourglass energy to the total energy and the computational time. The contact forces have also been extracted but have not been considered in deciding which model suits the requirements the best. The most accurate model is the one with 1 mm mesh. This one is not suitable since the computational time is disproportionate, but it is used as the reference for the percentage change of deformation. Generally, the bigger the mesh is defined the higher the deviation of the maximum deformation from the reference. The models with 4 mm, 10 mm and variable meshes are computationally cheaper but sacrifice a lot of accuracy. At the same time, the energy is not balanced (indicated by the energy ratio), and the hourglass energy percentage is high. Therefore, they are not fulfilling our criteria. For the 2 mm mesh model the energy is quite balanced (close to 1), the percentage of the maximum deformed length compared to the reference is less than 5 percent, which, compared to the other models, is low. At the same time, the accuracy is relatively cheap when it comes to the computational time.

Data	Mesh	Energy ratio	Deformed Length	% change in max deformation	Hourglass Energy Percentage	Total Computational Time [s]
Mesh 1mm	1 mm	1.0003	-71.8	0	0.5	37020
Mesh 2mm	2 mm	1.0004	-69.2	3.76	1.29	5000
Mesh 4mm	4 mm	1.0012	-54.2	32.4	2.5	1078
Mesh 10mm	10 mm	1.0022	-40.2	78.6	3.01	227
Mesh Variable	variable	1.068	-45.8	56.8	5.45	531

$\% \, change \, of$

$$maximum\ deformation = \frac{\text{maximum deformation of reference (1mm)} - \text{value of deformation of other model}}{value\ of\ deformation\ of\ the\ other\ model}$$

$$\%\ of\ hourglass\ energy = \frac{hourglass\ energy}{total\ energy} * 100$$

MILESTONE 3: IN HOUSE TUNING

The 2mm mesh which was previously chosen for simulation is used to simulate the experiment (test 4). The inputs given for the simulation were,

Density of sled= 1.042e-4 kg/m^3

Can Shell thickness= 0.25 mm

Initial velocity= 2.6683 m/s

Simulation time=85 s

The mass obtained for the sled was equal to 45.018 kg which is very close to the given mass for experiment 4 which is 45 kg. The results of the simulation for both displacement and acceleration are given below after offsetting.

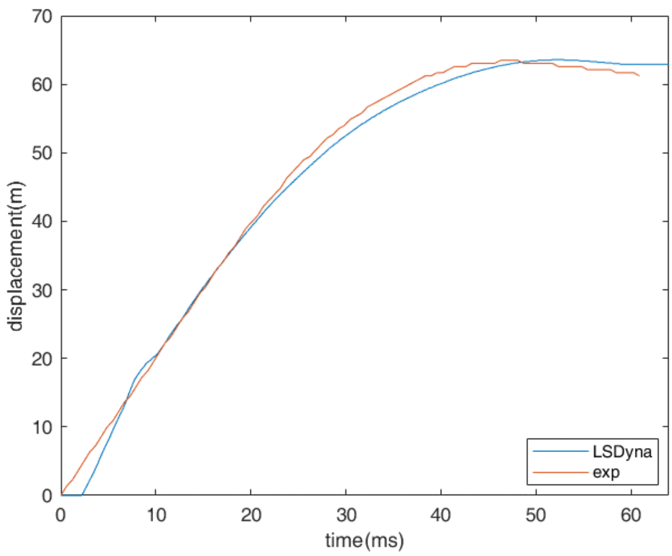

Figure 1 Offsetted displacement

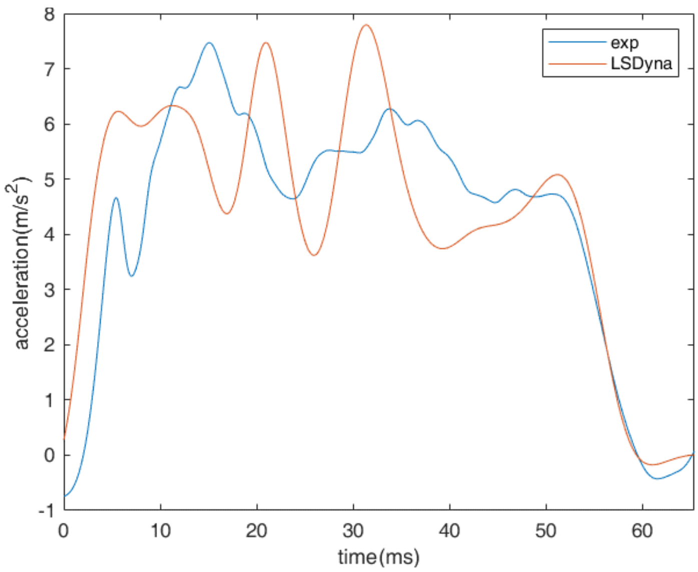

Figure 2Offsetted acceleration

The model is tuned to properly predict the experimental data. From the graphs we can observe that both the displacement and the acceleration curves for the simulation and the test are similar and further predictions will give a reasonable result. Therefore, it is inferred that the model captures the physics of the test. The deformation percentage for experiment is 44.1% and obtained value is 44.9%.

MILESTONE 4: PROJECT OBJECTIVE SIMULATION

The remaining tests (test 2 and 5) were also run in LS Dyna with the changed parameters and their respective graphs were also observed for the deformation lengths.

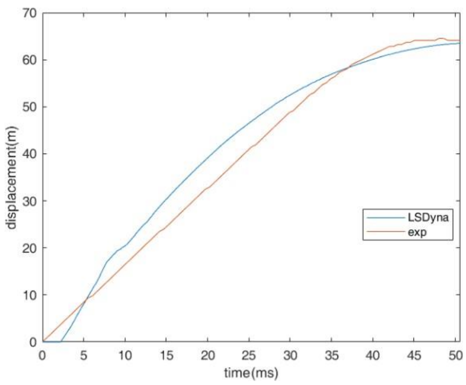

Figure 3 Test 2 displacement comparison

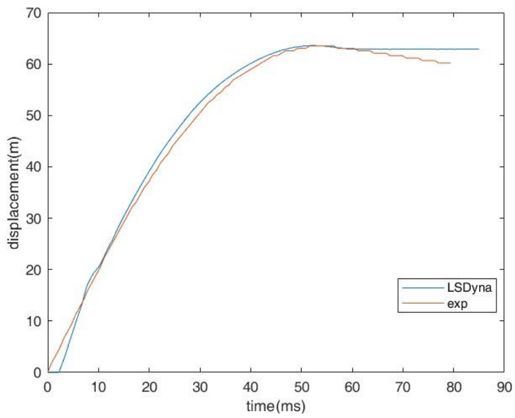

Figure 4 Test 5 displacement comparison

Both the impact speed and delta V values are calculated from 2 different sources(EXPERIMENTAL AND SIMULATION). The light gate data is obtained from the digital plot obtained from the given data by finding the time taken and the distance covered and passing through the pores which provides an interval. The simulation values are obtained from LD Dyna.The values obtained are

TEST No.	Simulation velocity (m/s)	Light gate data (m/s)
Test 2	1.9389	1.87
Test 4	2.6683	2.63
Test 5	3.3165	3.20

TEST No.	Simulation delta V(m/s)	Light gate delta V (m/s)
Test 2	1.948	1.936
Test 4	2.686	2.721
Test 5	3.3317	3.44

Test no.	Simulation deformation length (mm)	Expt deformation length (mm)
Test 2	32.5	35.5
Test 4	69.2	63.5
Test 5	98.1	94

With the values which were found earlier present in the above three tables, plots are drawn for impact velocity and delta V against the deformed length.

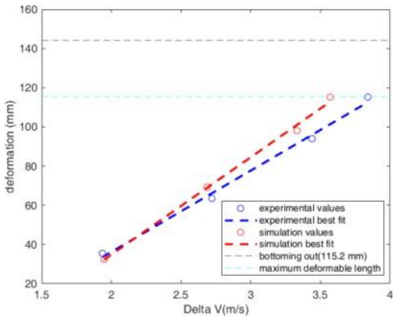

Figure 5 Delta V vs Deformation

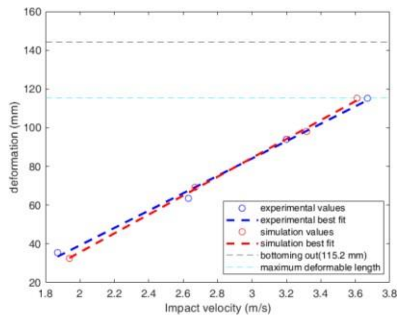

Figure 6 Impact velocity vs deformation

By extending the best fit line drawn to the test results of the 3 selected tests (2,4 and 5), the maximum approximate delta V was calculated to be 3.57 m/s. When the theoretical impact velocity of 3.6 m/s is used in the simulation, the simulated delta V is found to be 3.83 m/s which is close to the experimental delta V with a difference of 0.25 m/s.

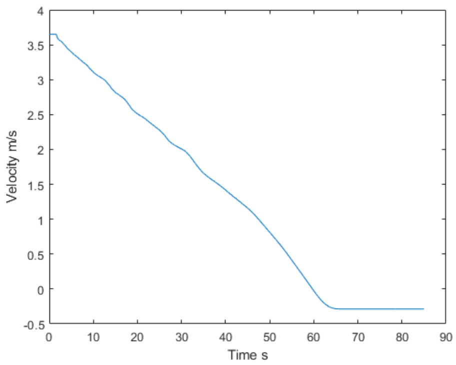

Figure 1 simulated delta V

CONCLUSION:

Hereby, in this project, the experiment is carried out in both real time and in simulation and the simulation results are looked to agree with the real time experiment results. The cost and time invested in setting up a real time test experiment can be removed by performing reasonable simulations obtaining agreeable results. In our experiment, it is observed that the test data agrees with the simulation data and can be used for further purposes.