AIRBAG PERFORMANCE SIMULATION USING FINITE ELEMENT AND IMPACT BIOMECHANICS METHODS FOR HUMAN INJURY PREVENTION DURING ACCIDENT OF VEHICLES

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ABSTRACT

Several people die every year due to vehicle accidents. The main aim of this study is evaluate the performance of airbag using Finite Element Methods (FEM). As FEM is a very advance tool to analyze stress-strain and acceleration response behaviour of the vehicle and its occupants. Out of several different directions of crashes front impact is very dangerous and common. In the frontal impact passenger vehicle hits to any other object. In this event velocity of vehicle abruptly reduces by zero within very short period of time. This causes sudden movement of occupant against the vehicle and damage to the passenger and sometimes death. This can be avoided by increase the time duration of the impact i.e. reducing the overall deceleration. Airbags are the life saving equipments of the vehicle. These devices play an imperative role to reduce the occupant acceleration at the time of crash or accidents. Finite Element Analysis is used to simulate crash event. This study includes the effect of Airbags and during crash. Hyper mesh (Product of Altair Engineering) is used to simulate and analyze the frontal impact scenario.

KEYWORDS

FEA, Frontal Accidents, Airbags, crash dummies

1. INTRODUCTION

The main aim of this study is to understand frontal injury mechanism and effect of airbags to reduce these injuries using Finite Element Methods (FEM). In frontal accidents occupants head, chest and pelvis are the most vulnerable site in the human body[1]. A head injury is any trauma that injures the scalp, skull or brain. The injury may be minor bump on the skull or a serious brain injury. Head injury can be either closed or open.

Lungs and hearts are protected by the ribs of the human being. High Rib acceleration can cause severe damage to these organs. This study includes the effects of airbags on these injuries using Finite Element Analysis. FMVSS208 is one the federal motor safety regulation to ensure the safety against frontal impact. In FMVSS208, vehicle with crash dummy is used to have frontal impact[3].

Crash dummies are mechanical device that act as a human body. This is also called Anthropomorphic Test Devices (ATC). several sensor and instrumentation are inserted into the dummy to measure injury parameters in terms of forces, deflection, acceleration etc.

The first crush test dummy is manufactured in 1971, by the Alderson research and sierra engineering with GM (General Motor). This dummy is called Hybrid I. GM improved Hybrid I, and offered Hybrid II dummy. Hybrid II dummy becomes the standard for frontal crush testing to adhere with regulation governing resultant system in 1972. The more improvement in Hybrid II dummy and created the Hybrid III dummy between1973 - 1977. . Hybrid II dummy becomes the standard for frontal crush testing to adhere with regulation governing resultant system in 1972. The more improvement in Hybrid II dummy and created the Hybrid III dummy between1973 - 1977 [4].

Table1. Comparison of weight, sitting height, and stature for Hybrid III Family

		12 month CRABI	3 YO child	6 YO child	5^{th} %ile Female	50^{th} %ile Male	95^{th} %ile Male
Weight	Ibs	22.0	34.5	46.00	108.7	171.3	22.3
Stature	in	29.4	37.2	47.30	59.0	68.7	73.4
Sitting height	in	18.9	21.50	25.00	31.1	34.80	36.8

Figure1: Hybrid Dummy Family[4]

Sled is one of the best simulator to analyze the crashes of the vehicle. in a typical sled, a vehicle & its dummies are moving at a constant velocity from prior to an actual crash they are decelerated very rapidly. The test vehicle & dummies are at zero velocity according to HYGE principle that situation simulates the constant velocity at an actual crash. During a deceleration of a moving automobile or aircraft the program, rapid acceleration of HYGE thrust column acceleration the sled with attached test articles(s) & produces an impulse similar to that generated. At any axis the crash loaded may be applied depending upon orientation of the test article[5]. Figure 2 below shows the typical sled configuration [6].

Figure2: Sled Test Configuration [6]

2. METHODS

As this study is mainly focused on airbags, sled and crash dummy, lets understand these three first. An airbag is a safety device used in the vehicles. It is a type of occupant restraint system having a fabric designed to inflate quickly during an automobile collision. Generally, air bags are designed to deploy in a crash that is equivalent to a vehicle crashing into a solid wall at 8 to 14 miles per hour. Air bags most often deploy when a vehicle collides with another vehicle or with a solid object like a tree. There are various types of airbags; frontal, side-impact and curtain airbags. Advanced frontal air bag systems automatically verify if and with what level of power the driver frontal air bag and the passenger frontal air bag will blow up. The suitable level of power is based upon sensor inputs that can typically sense: 1) occupant size, 2) seat position, 3) seat belt use of the occupant, and 4) crash severity [7].

Figure3: Frontal and Side Airbags [8]

Finite element analysis is often a favourable tool to analyze injury biomechanics of the occupants. Ls-Dyna which is a very advanced and matured software to simulate crash dummy kinematics [9]. Figure 4 below shows the FE model of crash dummy developed by LSTC. In frontal accidents occupants head, chest and pelvis are the most vulnerable site in the human body. Figure 4 also shows the locations which can be affected severely during frontal crash of any vehicle.

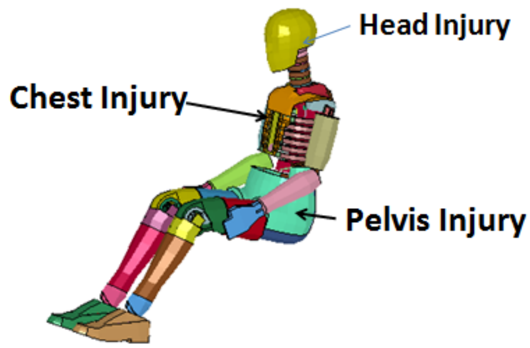

Figure4: Finite Element Model of Hybrid III Dummy [9]

Finite element model of sled environment is shown in figure 5. The acceleration impulse of 0.25mm/ms2 was applied to the system to simulate frontal impact scenario. Head, chest and pelvis injury parameters were measured with and without airbag to understand the performance of airbag.

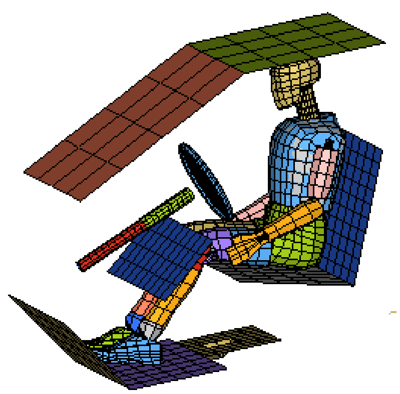

Figure5: Crash dummy and sled environment [9]

3. RESULTS

Figure 6 shows the different steps of the sled test simulation at different time points.

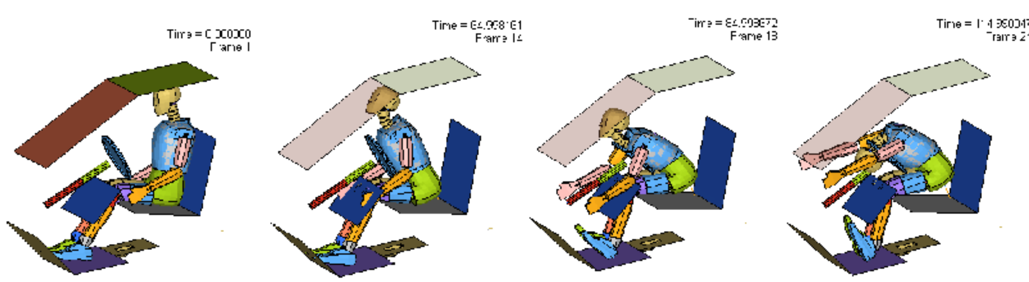

Figure6: Dummy movement during sled test simulation

It can be seen in the figure above how vehicle occupant can move during frontal crash and head and chest of the object can be impacted to the roof and steering system of the vehicle.

Figure 7 below shows the head acceleration time history of the occupant. Maximum head acceleration observed at time 34.375 ms with the value of 1.47 mm/ms2.

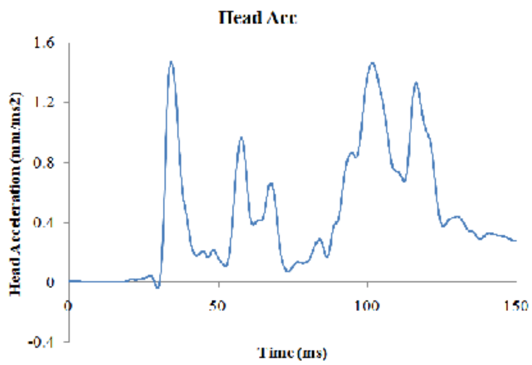

Figure 7: Head acceleration

Figure 8 below shows the chest acceleration time history of the occupant. Maximum chest acceleration observed at time 34.375 ms with the value of 1.08 mm/ms2.

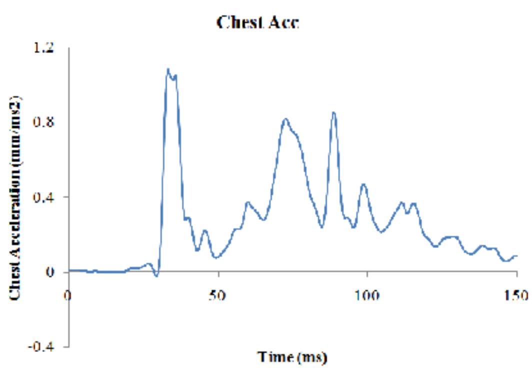

Figure 8: Chest acceleration

Figure 9 below shows the Pelvis acceleration time history of the occupant. Maximum chest acceleration observed at time 31.25 ms with the value of 2.3 mm/ms2.

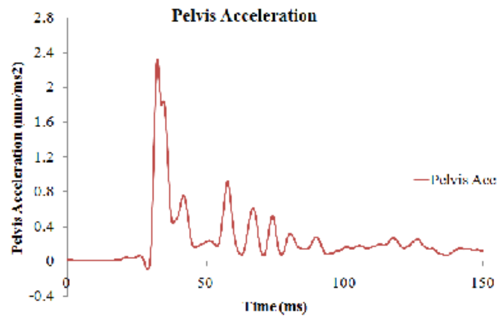

Figure 9: Pelvis acceleration

Figure 10 shows the different steps of the sled test simulation at different rime points with airbag.

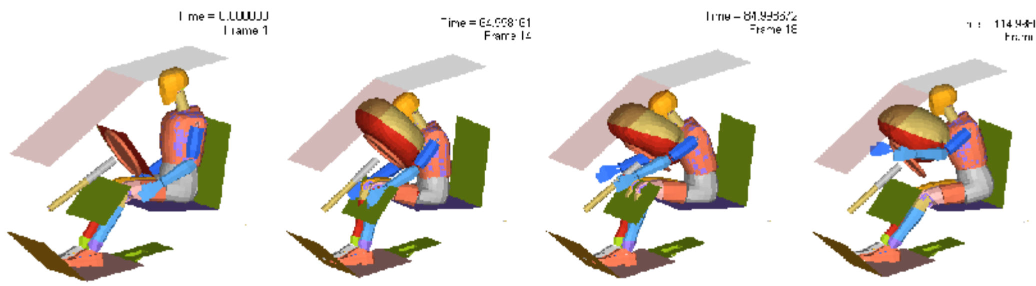

Figure10: Dummy movement during sled test simulation with airbag

It can be seen in the figure 13 that airbag can prevent occupant to hit directly with the vehicle subsystems.

Figure 11 below shows the head acceleration time history of the occupant. Maximum head acceleration observed at time 62.5ms with the value of 0.65 mm/ms2.

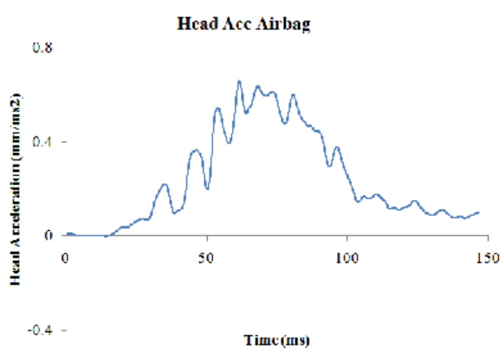

Figure 11: Head acceleration

Figure 12 below shows the chest acceleration time history of the occupant. Maximum chest acceleration observed at time 69 ms with the value of 0.47 mm/ms2.

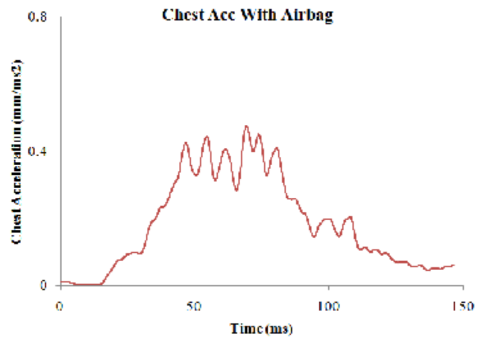

Figure 12: Chest acceleration

Figure 13 below shows the Pelvis acceleration time history of the occupant. Maximum chest acceleration observed at time 53.125 ms with the value of 0.46 mm/ms2.

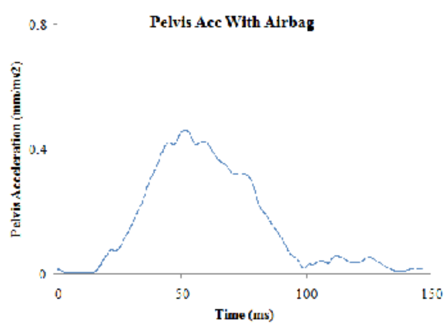

Figure 13: Pelvis acceleration

4. Conclusion And Discussion

Figure 14 shows the effect of airbag on head injury during frontal crash. It can be seen clearly that airbag can reduce the peak head acceleration with 55.783 %. Figure 15 shows the effect of airbag on chest injury during frontal crash. It can be seen clearly that airbag can reduce the peak chest acceleration with 56.482%. Figure 16 shows the effect of airbag on pelvis injury during frontal crash. It can be seen clearly that airbag can reduce the peak pelvis acceleration with 80 %.

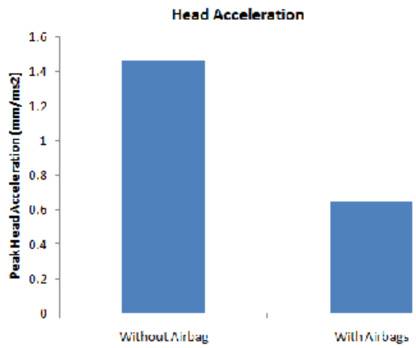

Figure14: Peak head acceleration comparison

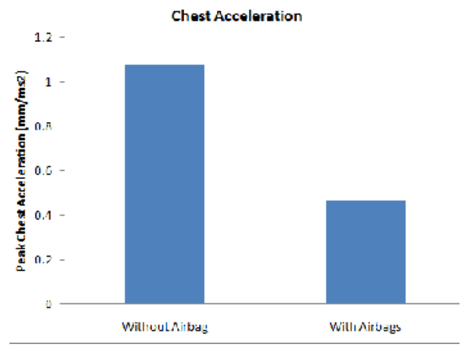

Figure15: Peak chest acceleration comparison

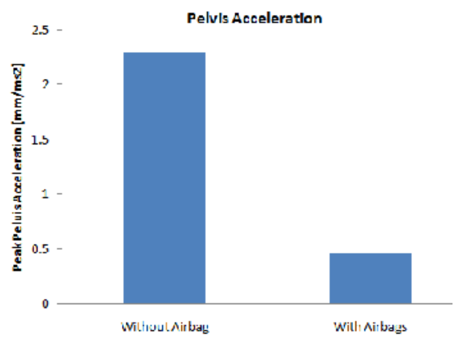

Figure16: Peak pelvis acceleration comparison

REFERENCES

[1] Bowleg D, Boffard K. ''pattern of injury in motor vehicle accidents'', 2002

[2] http://www.nlm.nih.gov/medlineplus/ency/article/000028.htm

[3] United States Department of Transportation. National Highway Traffic Safety Administration. Office of Vehicle Safety Compliance: Safety Assurance. Laboratory Test Procedure for FMVSS 208, Occupant Crash Protection Sled Tests. TP208S- 01. January 15, 1998.

[4] http://www.humaneticsatd.com/about-us/dummy-history

[5] http://www.trcpg.com/our-services/impact-laboratory/hyge-sled.aspx

[6] http://www.iihs.org/iihs/topics/t/neck-injury/qanda

[7] Zhang H. et al. Integrated Optimization System for Airbag Design and Modeling by Finite Element Analysis. Society of Automotive Engineers World C

[8] http://www.hamptonchevy.com/chevy-avalanche.htm

[9] LSTC, Livermore, CA, USA