Study concerning the loads over driver’s chests in car crashes with cars of the same or different generation

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Abstract. Reducing occupant injuries for cars involves in traffic accidents is a main target of today cars designers. Known as active or passive safety, many technological solutions were developing over the time for an actual better car’s occupant safety. In the real world, in traffic accidents are often involved cars from different generations with various safety historical solutions. The main aim of these papers are to quantify the influences over the car driver chest loads in cases of same or different generation of cars involved in side car crashes. Both same and different cars generations were used for the study. Other goal of the paper was the study of in time loads conformity for diver’s chests from both cars involved in crash. The paper’s experimental results were obtained by support of DSD, Dr. Steffan Datentechnik GmbH - Linz, Austria. The described tests were performed in full test facility of DSD Linz, in “Easter 2015 PC-Crash Seminar”. In all crashes we obtaining results from both dummy placed in impacted and hits car. The novelty of the paper are the comparisons of data set from each of driver (dummy) of two cars involved in each of six experimental crashes. Another novelty of this paper consists in possibilities to analyse the influences of structural historical cars solutions over deformation and loads in cases of traffic accidents involved. Paper’s conclusions can be future used for car passive safety improvement.

1. Introduction
Chest injury risk is evaluated on the basis of sternum deflection, sternum deflection rate, viscous criterion, and thoracic spine acceleration. A sternum deflection of 60 mm marks the border between an Institute rating of acceptable and marginal. This is near the same limit used to evaluate compliance with the U.S. advanced airbag rule (NHTSA, 2000) [1].

Another rate-dependant injury criterion, viscous criterion, also is calculated from sternum deflection measurements. Viscous criterion is the product of sternum deflection, normalized by chest depth, and the sternum deflection rate [1].

A thoracic spine acceleration of 60 g (during 3 ms) marks the border between an Institute rating of good and acceptable. This value also is used to evaluate compliance with the U.S. advanced airbag rule (NHTSA, 2000). According to NHTSA (2001), this represents a 20 percent risk of AIS 4+ chest injury. However, the value of whole-body thorax acceleration as a predictor of injury was highly debated through the development of the advanced airbag rule because the injuries observed among crash-involved occupants generally are associated with rib cage deformation [1].

Only driver’s chest acceleration was used in this paper for evaluate injuries risk.

The paper’s experimental data were obtained by support of DSD, Dr. Steffan Datentechnik GmbH - Linz, Austria. The follow described tests were performed in full test facility of DSD Linz, in “Easter
2015 PC-Crash Seminar” [2], [3]. Seven crash experiments were made for estimate the accelerations over the car driver head using cars and crashes design showed in the figures 1 - 7.

Figure 1. First crash details and vehicles involved specification.

Figure 2. Second crash test and vehicles characteristics.

Figure 3. Third test details and vehicles involved specification.

Figure 4. Fourth crash test and vehicles characteristics.

Figure 5. Fifth crash details and vehicles involved specification.

Figure 6. Sixth crash test and vehicles characteristics.
Figure 7. The seventh crash test details and vehicles involved specification.

2. Experimental research

Seven 90° side-impact collision tests were performed according with EN1317 and EN12767. In each of them, except of last one was used dummy as car driver in both in crash cars. Complex accelerometers were mounted for dummy’s head, chest, neck and pelvis. Accelerations, velocities and rotations of the cars were also measured (figure 8).

Figure 8. Dummy instrumentation for all side-impact collision tests [3].
For all side-impact crashes in the figures 9 – 21 see evolution of chest decelerations.

Figure 9. Chest acceleration of P02 driver.

Figure 10. Chest acceleration of P01 driver.
Figure 11. Chest acceleration of P03 driver.

Figure 12. Chest acceleration of P01 driver.
Figure 13. Chest acceleration of P01 driver.

Figure 14. Chest acceleration of P03 driver.
Figure 15. Chest acceleration of P05 driver.

Figure 16. Chest acceleration of P02 driver.
Figure 17. Chest acceleration of P06 driver.

Figure 18. Chest acceleration of P03 driver.
Figure 19. Chest acceleration of P07 driver.

Figure 20. Chest acceleration of P07 driver.
3. Results, discussions and conclusion

In the real world, crash tests are strong tools for improve both occupants and road vehicle safety. Compatibility between cars has for a long time been reduced to the simple image of heavy against light cars. Over the past years vehicle stiffness has been increased thanks to improved restraint systems. We also have a better understanding of the front end design energy absorption. Front end design is at the cross road of numerous contradictory constraints: self-protection of occupants, protection of vulnerable users such as pedestrians, reparable styling, aerodynamics, engine cooling and so on. Therefore, each manufacturer has developed its own solution to solve this difficult equation which resulted in a wide variety of front end designs, structure and stiffness regardless of the overall mass of the vehicle. Solutions however have been optimized against a rigid wall or soft obstacle but not in car to car configuration [3], [4], [5].

Using for each crash case cars with or without technical/age compatibility, we can write the followers main conclusions:

A. First crash test:
1. Cars crash was at low impact speed(19.4 km/h) between vehicles from different generation (Fiat Punto 55 – from year 1996 versus Chrysler PT Cruiser from year 2006);
2. The cars are dissimilar weights(Fiat Punto 55-895 kg, Chrysler PT Cruiser-1470 kg);
3. For 2006 year car generation the car side from neighborhood of “B” pillar is more stiffness compared with stiffness of the same zone from a cars made in 1996;
4. The Fiat Punto car is made with a low absorber of crash energy in the car front structure;
5. The maximum absolute amounts of accelerations of Fiat Punto car driver chest were 7.6 g on “Z” direction and 9.6 g on “X” direction;
6. The maximum absolute amounts of accelerations of P01 car driver chest were 4 g on “Z” direction and 2.85 g on “Y” direction.

B. Second crash test:
1. Cars crash was at low impact speed (19.3 km/h) between vehicles from different generation (Fiat Punto 55 – from year 1994 versus Chrysler PT Cruiser from year 2006);
2. The cars are dissimilar weights (Fiat Punto 55 - 850 kg, Chrysler PT Cruiser - 1470 kg);
3. For 2006 year car generation the car side from neighborhood of “C” pillar and rear axle is more stiffness compared with stiffness of the same zone from a cars made in 1994;
4. The Fiat Punto car is made with a low absorber of crash energy in the car front structure;
5. The maximum absolute amounts of accelerations of Fiat Punto car driver chest were 5.5 g on “Z” direction and 7.2 g on “X” direction;
6. The maximum absolute amounts of accelerations of P01 car driver chest were 12.3 g on “Y” direction.

C. Third crash test:
1. Cars crash was at relatively low impact speed (40.7 km/h) between vehicles from the same generation (Fiat Punto 55 – from year 1996 versus Fiat Punto 55 – from year 1997);
2. The cars are similar weights (Fiat Punto 55, 1997 - 830 kg, Fiat Punto 55, 1996 - 895 kg);
3. For 1996 year car generation the stiffness of front door is the same compared with stiffness of the front door of a cars made in 1997;
4. Both Fiat Punto cars are made with a low absorber of crash energy in the car front structure;
5. The maximum absolute amounts of accelerations of Fiat Punto 1996 year car driver chest were 16.1 g on “X” direction;
6. The maximum absolute amounts of accelerations of P02 car driver chest were 9.8 g on “X” direction and 28 g on “Y” direction.

D. Fourth crash test:
1. Cars crash was at relatively low impact speed (40.7 km/h) between vehicles from the same generation (Fiat Punto 55 – from year 1994 versus Fiat Punto 55 – from year 1996);
2. The cars are similar weights (Fiat Punto 55, 1994 - 890 kg, Fiat Punto 55, 1996 – 895 kg);
3. For 1994 year car generation the neighborhood of “C” pillar and rear axle have the same stiffness compared with stiffness of the same zone from a cars made in 1996;
4. Both Fiat Punto cars are made with a low absorber of crash energy in the car front structure;
5. The maximum absolute amounts of accelerations of Fiat Punto 1994 year car driver chest were 10.6 g on “X” direction;
6. The maximum absolute amounts of accelerations of P02 car driver chest were 43 g on “Y” direction.

E. Fifth crash test:
1. Cars crash was at medium impact speed (59.4 km/h) between vehicles from very different generation Opel Astra from year 2014 versus Fiat Punto 55 – from year 1994);
2. The cars are dissimilar weights (Opel Astra from year 2014 – 1440 kg, Fiat Punto 55 from year 1994 - 850 kg);
3. For 1994 year car generation the front side door is less stiffness compared with stiffness of the same zone from a cars made in 2014;
4. The Opel Astra car is made with a high absorber of crash energy in the car front structure;
5. The maximum absolute amounts of accelerations of Fiat Punto car driver chest were 13.4 g on “Z” direction and 14 g on “X” direction;
6. The maximum absolute amounts of accelerations of P03 car driver chest were 360 g on “Y” direction and 21 g on “X” direction.

F. Sixth crash test:
1. Cars crash was at relatively medium impact speed (60.7 km/h) between vehicles from the same generation (Fiat Punto 55 – from year 1997 versus Fiat Punto 55 – from year 1994);
2. The cars are similar weights (Fiat Punto 55, 1997 - 890 kg, Fiat Punto 55, 1994 - 830 kg);  
3. For 1997 year car generation the stiffness of the side in place of rear axle is the same compared with stiffness of the side rear axle from a car made in 1994;  
4. Both Fiat Punto cars are made with a low absorber of crash energy in the car front structure;  
5. The maximum absolute amounts of accelerations of Fiat Punto 1996 year car driver chest were 3 g on “Y” direction and 19.2 g on “X” direction;  
6. The maximum absolute amounts of accelerations of PO4 car driver chest were 15.8 g on “Z” direction and 44.2 g on “Y” direction.

G. The seventh crash test:  
1. Cars crash was at relatively high impact speed (80 km/h) between vehicles from the same generation (VW Golf 1.4 – from year 1998 versus Honda Accord 4D – from year 2002);  
2. The cars are similar weights (VW Golf 1.4, 1998 - 1137 kg, Honda Accord 4D, 2002 - 1272 kg);  
3. For 2002 year car generation the stiffness of the side in B pillar area is comparable with stiffness of the side from a car made in 1998;  
4. The maximum absolute amounts of accelerations of VW Golf (P09) year car driver chest were 25 g on “X” direction and 6 g on “Z” direction.

4. References  
[1] Insurance Institute for Highway Safety 2001 Frontal Offset Crashworthiness Evaluation Guidelines for Rating Injury Measures  
[2] Ispas N and Năstăsoiu M 2016 Crash Tests and the Loads over Driver Head in Different Side Impact Cases Current Solutions in Mechanical Engineering pp 181-186  
[3] Ispas N and Năstăsoiu M 2015 A Study Concerning the Loads Over Drivers Heads in the Cases of Cars Crashes with Involved Cars of the Same or Different Generation Proceedings of the European Automotive Congress EAEC-ESFA 2015 Springer pp 325-336  
[4] 54th GRSP 2013 Research on Chest Injury Criteria  
[5] Thorsten A, Eggers A, Thomson R and Koji M 2014 Comparison of the Dummy Response in two different Restraint System Crash Tests IRCOBI Conference 2014 pp 545-561

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