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Aspects of the passenger airbag E.C.U. location

A Soica¹

¹Automotive and Transport Engineering Department, Transilvania University of Brasov, Brasov, Romania

E-mail: a.soica@unitbv.ro

Abstract. Road accidents represent the dark side of road traffic, their consequences leading to material damage and often to vehicle occupant fatalities. Passive safety systems offer a high level of protection to vehicle occupants; yet, depending on a number of constructive factors and not only, these systems can not always ensure a high survival rate. The costs of road traffic accidents are to be borne by the whole society, with high amounts of money required. In this paper we analyze how the collision is felt in various points on the vehicle, at a given time and how this may affect the proper functioning of the passive safety systems, especially the airbag system.

1. Introduction

Personal vehicles are still the main mean of transportation for people. A wide range of vehicles are to be met on all roads, from premium class, equipped with the latest occupant safety systems, to low-cost vehicles of older generation, whose safety systems equipment is less studied. In this paper we studied how a frontal impact is felt in various points of the vehicle structure, including the interior. One of the goals of car manufacturers is to design deformable structures on certain areas of the vehicle in order to absorb the impact energy. At the same time the lowest possible levels of deceleration must be obtained in the passenger compartment and intrusions that may endanger the life of the occupants should be avoided.

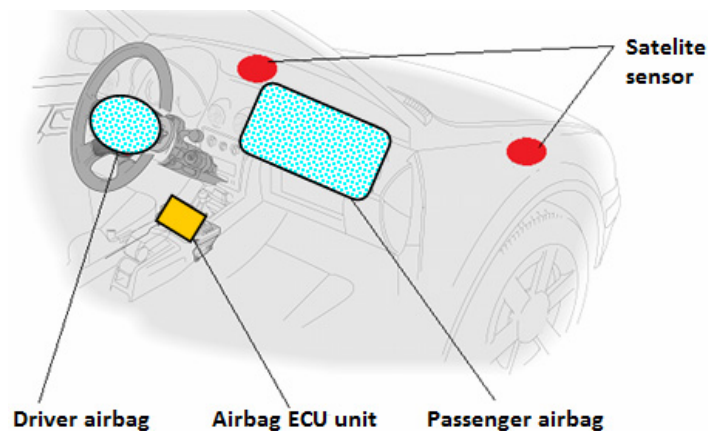


Figure 1. Component parts of the frontal airbag system.

The electronic unit of the airbag system, which determines the intensity of a collision and the need to trigger the airbags, is usually located on the central tunnel of the vehicle, in front of the gear shift, as seen in figure 1. Low cost or older vehicles have the decision to trigger an airbag based only on the sensors from the airbag ECU - Electronic Command Unit. State-of-the-art vehicles as well as older vehicles from the premium class are also equipped with additional sensors, called satellites sensors, which detect the impact and are mounted on the vehicle structure, as close as possible to the impact area. Researches on impact intensity in passenger compartment have also been mentioned in [1].

2. Research background

The injuries that an airbag can cause to the vehicle occupants can be severe in particular passenger positions called out of position or when the airbag receives the inflation command with delay. This situation may occur in the absence of satellite sensors, and in the passenger compartment the threshold deceleration required to inflate the airbag is delayed, due to the various factors or even impact configuration (e.g. impact angle according to Federal Motor Vehicle Safety Standards - FMVSS 208 [2]). As an example, figures 2(a, b, c) and 3(a, b, c) present the cases of two vehicles subjected to frontal collision. In the first case we notice that the driver's airbag is inflated with delay, the body already moving forward due to inertia. The airbag inflates and hits the dummy in the face, causing injury to the head/neck. In the second case the airbag inflates at the right time and the occupant's head is protected against the hit that may be produced during airbag inflation.

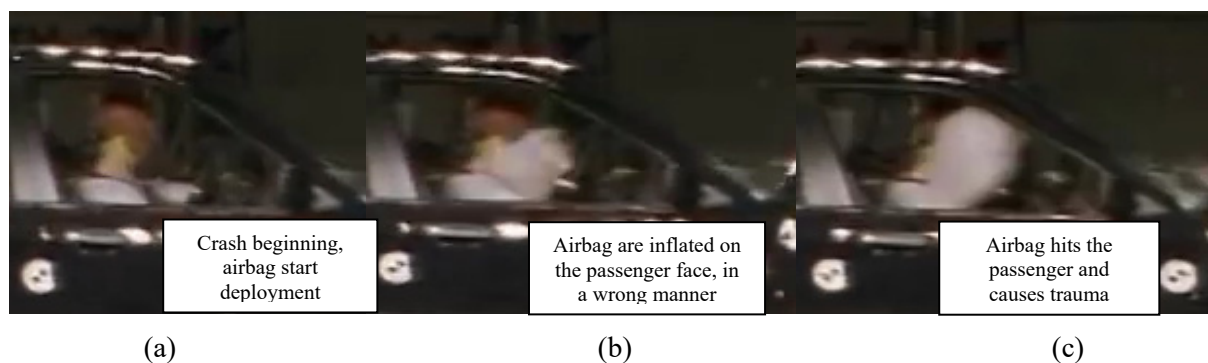


Figure 2. Airbag inflation with delay - the occupant has the body/head close to the dashboard [14].

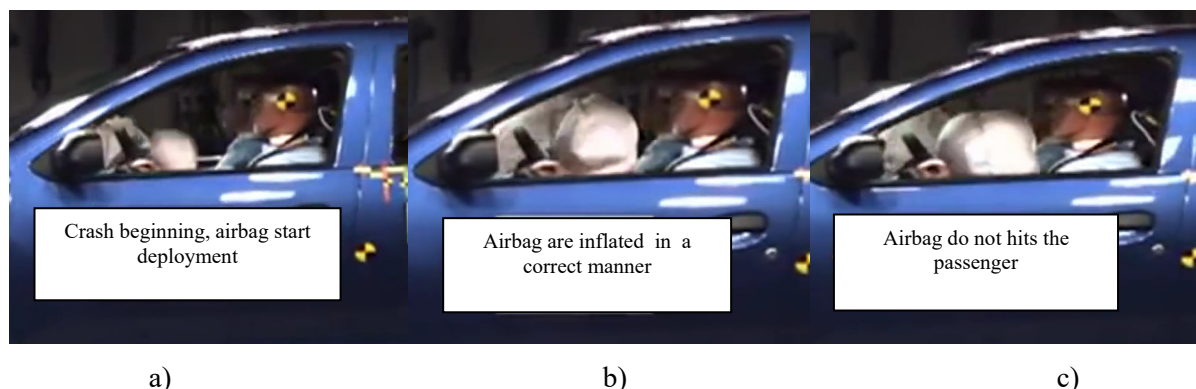


Figure 3. Proper airbag inflation – the occupant leans back against the chair back [14].

There have been multiple reports of head and neck injuries related to airbags. The head-neck area injuries include facial trauma [3], cervical spine fractures [4], [5], mandibular injury [6] and decapitation [7]. In addition, soft tissue injuries are also seen, including damage to the blood vessels

[8]-[10]. The eye seems to be vulnerable to injury. These injuries include orbital fractures, [11] retinal detachment [12] and lens rupture [13].

3. Results and discussion

Based on the above statements, measurements of impact intensity in the vehicle were made by mounting sensors at various points on the vehicle. In the example shown the sensors were mounted on the front wing support, in the pedals area, on the central tunnel in front of the gearshift as well as on the engine, as seen in figure 4. Data on deformation, velocity and acceleration may be recorded depending on the equipment complexity.

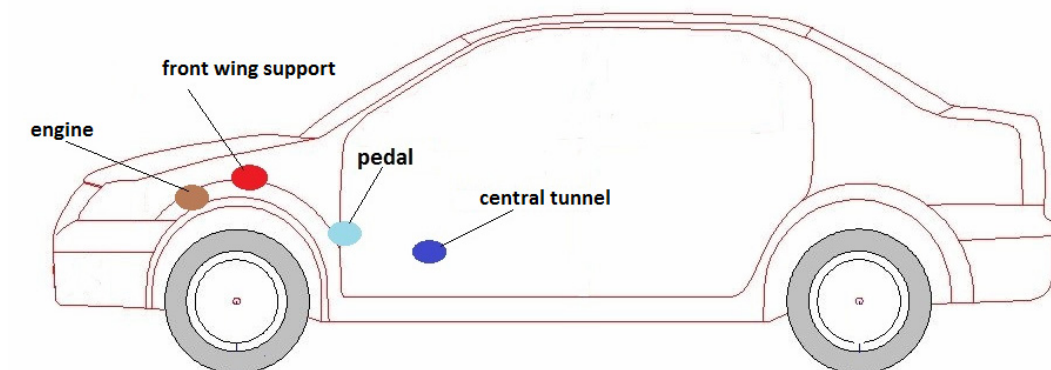


Figure 4. Sensors mounted to record data on the frontal impact.

The accelerometers are most commonly used; the integration algorithms are used to successively obtain the speed or the deformation. The data was processed in conformity with [15].

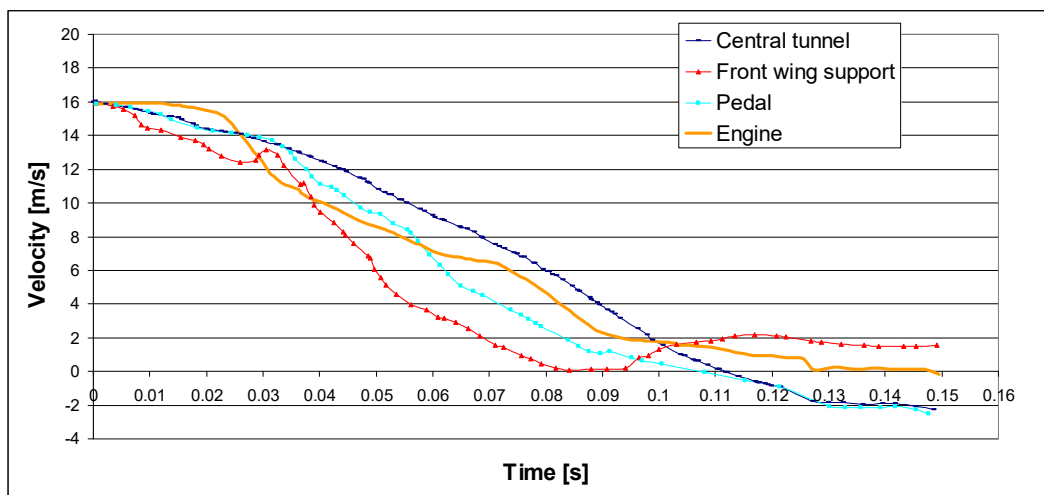


Figure 5. Speed variation in the measurement points.

Figure 5 presents the results following the measurements through a diagram of the speed variation according to time. Naturally, the impact is first felt in the front wing support, the speed at this point registering a sharper decrease within the first 20-30 milliseconds as compared to the other measurement points on the vehicle body. After 30 ms it is noticed that a decrease in speed occurs in the pedals area as compared to the area of the central tunnel.

At about 85 milliseconds from the beginning of the collision, the speed at the point on the front wing support is null, which means that the deformation ended on that area, while it continues to about 107 or 112 milliseconds for the pedals area and central tunnel.

A special case is the information from the sensor mounted on the engine. First, it is noticed that although the engine is the first element located, in terms of distance, from the impact site, it does not feel the impact, the speed variation is even lower than in the passenger compartment. This can be explained through the engine mounting on elastic damping vibration elements sent to the vehicle body. These elastic elements and the large mass of engine enable a continuation of its movement forwards, out of inertia, with relatively constant speed in the first moments of impact, approximately 15-20 milliseconds.

Throughout the impact an engine oscillation, marked by slower decreases which are then followed by some sharper decreases in engine speed is observed.

It is necessary to place particular sensors called satellite sensors in the crushable areas. These are coupled with acceleration sensors placed in the electronic control unit, usually mounted on the central tunnel. The existence of a single deceleration sensor mounted in the passenger compartment leads to a less accurate detection of frontal impacts in different angular configurations, as well as to possible severe traumas to passengers diverted from the normal position with the torso straight and tightly fixed in the chair. Thus, as shown in figure 1, the data of a collision are recorded on a motor vehicle where there is a sensor unit mounted in the airbag ECU, and a satellite sensor; these values are then represented in figure 6.

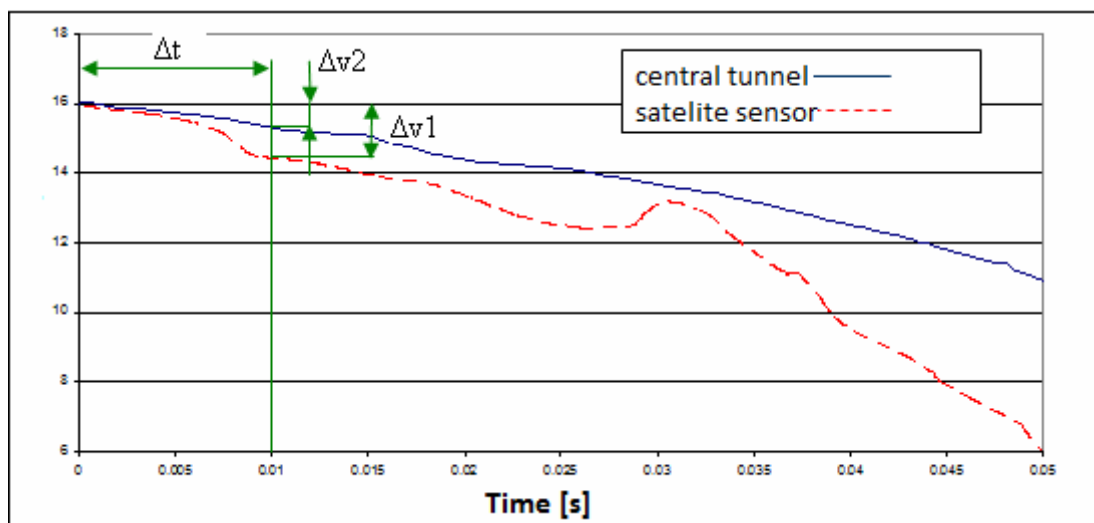


Figure. 6. Speed variation recorded by the satellite sensor and the ECU airbag sensor.

It is noticed that for the same period the average decelerations approximately measured within the vehicle passenger compartment and the satellite sensor are:

$$a_2 = \frac{\Delta v_2}{\Delta t} \quad (1)$$

$$a_1 = \frac{\Delta v_1}{\Delta t} \quad (2)$$

Therefore, in the first 10 milliseconds from the beginning of the impact, in the passenger compartment an $a_2=60 \text{ m/s}^2$ deceleration twice and half lower than $a_1=150 \text{ m/s}^2$ deceleration in the satellite sensor is recorded.

The control of airbag triggering devices is based on the numerical analysis of signals received from sensors. The decision-making process is difficult due to many factors that lead to similar variations of the output signals, with the possibility of taking wrong decisions.

4. Conclusions

Due to a time lag between the moment of impact and the decelerations recording in the passenger compartment, it is necessary to place sensors as closer as possible to the deformation zone. During the impact the vehicle structure deforms continuously, partially absorbing the impact energy; the absorption of impact energy is recorded with delay in the passenger compartment. All these considered, many safety equipment manufacturers agree that decelerations measured in the passenger compartment do not provide enough data to be used to establish an airbag triggering algorithm for various impact scenarios.

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