CORELLATIONS BETWEEN REQUIREMENTS, FUNCTION AND QUALITY CHARACTERISTICS OF AIRBAG TYPE TECHNICAL PRODUCTS

Lecturer PhD. **Liliana LUTIC**

„Gheorghe Asachi" Technical University, Faculty of Industrial Design
and Bussiness Management, Iasi, Romania

REZUMAT. Echipamentele auto de securitate a pasagerilor (*Sisteme de Retinere Suplimentară* – SRS), în speţă airbagurile, vizează asigurarea şi îmbunătăţirea protecţiei şi siguranţei pasagerilor din autovehicul, detectând în timp util accidentele, monitorizează continuu circulaţia şi diagnostichează în timp util eventualele avarii sau accidentări. Lucrarea prezintă principalele aspecte avute în vedere la realizarea şi perfecţionarea airbagurilor, o dezvoltare a corelaţiei cerinţe – caracteristici de calitate ale acestora, precum şi principalele tendinţe de dezvoltare.

Cuvinte chele: produs, siguranţă, airbag, cerinţe, caracteristici, calitate.

ABSTRACT. Passenger safety equipment (Supplemental Restraint System - SRS), specifically airbags, aim to ensure and improve the protection and safety of the vehicle passengers through timely detection of accidents, continuous monitoring of traffic and early diagnosis of possible damage. This paper presents the main aspects to be taken into consideration during airbag manufacture and improvement, the correlation between requirements and quality characteristics, as well as the main development trends.

Keywords: product, safety, airbag, requirements, characteristics, quality..

1. GENERAL CONSIDERATIONS

Lately the textile industry has undergone revolutionary changes with some of the most remarkable innovations. These have led to the expansion of high-performance technical textiles, with multifunctional destinations, of those with special properties considered passive systems, and of products that "feel" and react to external stimuli of a mechanical, thermal, chemical, magnetic and so on nature. The Mobiltech branch represents the most important field of technical textile applications, accounting for approximately 20% of the total production.

Airbags are safety devices for vehicles consisting of pillows, made of thin and durable materials, recessed in the steering wheel, dashboard or seats and which, in the event of an impact (collisions) swell instantly, protecting the people in the car [1]. These passenger safety equipment's are electronically controlled and are also known as **Supplemental Restraint System (SRS)**. In case of collision, the airbag automatically activates, a pyrotechnic charge filling with gas (nitrogen), almost instantly, a special cushion of flexible material, in order to protect the **occupants** of the vehicle from possible contusions and / or injuries with the hard objects inside it. [1]. Airbags are one of the most important passive safety systems in cars and operate together with the seat belts. However, unlike the latter who are effective only if they are worn properly, the airbags are activated automatically. The early version of the airbag was developed about 70 years ago (in the 1950s [2, 3]). In 1955 an airbag similar to the ones of today was patented, but it had many disadvantages. One of which was the fact that the driver had to trigger the airbag by pushing a button. On series cars however, the standard airbags started to be used only in the 1970s. The first vehicles to benefit from the use of airbags were Oldsmobile Toronado and Cadillac, produced by General Motors. Following were the models designed by Mercedes-Benz, which used satisfactory airbags in regards to performance, similar to the ones used currently. In 1987, the Porsche 944 Turbo became the first car to have driver and passenger airbags as standard equipment. In the same year the option became available for the first time on a Japanese car - Honda Legend. Other manufacturers

followed the trend, generalizing the use of this safety system.

2. THE STRUCTURE AND FUNCTION OF THE PROTECTION AND SAFETY SYSTEM

A passive system of protection and safety complete system has the following components:

- ✓ Seat belts;
- ✓ Seat belt tensioner units;
- ✓ Airbag module;
- ✓ Diagnostics and control unit;
- ✓ Sensors for impact, position, weight and safety.

The airbag module (figure 1) consists of:

- The inflator device located on the steering wheel, above the glove compartment or close to the airbag bracing compartment;
- The airbag (made out of lightweight and resistant material) is folded inside the steering wheel, in the seat or even in the car door [2, 4, 5];
- The inflator unit contains capsules with chemical substances (sodium acid), that during burning (produced by a pyrotechnical generator) produce nitrogen gas. The later fills the textile pillow in case of impact.

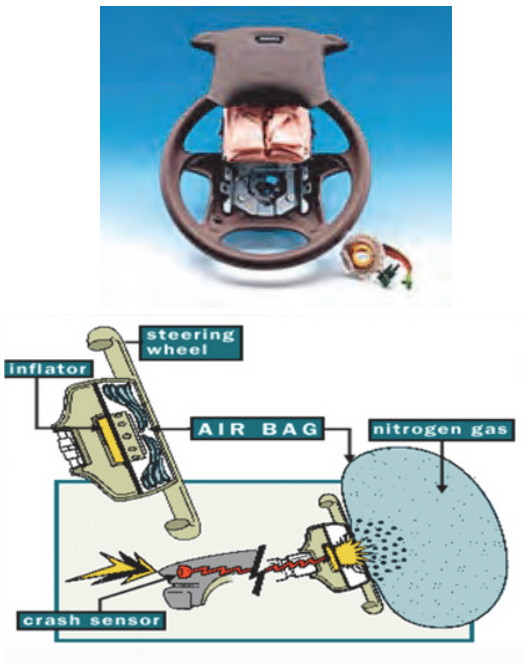
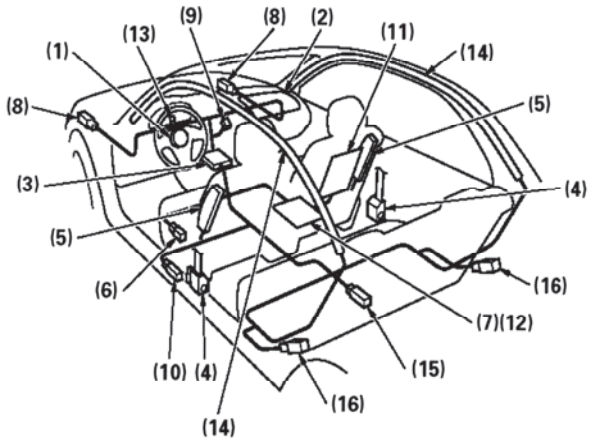


Fig. 1 Airbag module – functioning mode

The diagnostic and control unit monitors continuously the operation of the vehicle. In case of malfunction, this is optically signalled on the instrument dashboard panel. **Damage and impact sensors**, generally mounted on the front bumper of the vehicle but also in the binnacle can detect the sudden deceleration of the vehicle or the severity of the impact in case of an accident, triggering the airbags along with the diagnostic and control unit. During a collision or a strong impact with a speed of at least 24 km / h [5, 6, 7] (which occurs in about 0,125 seconds, according to the specialty literature [5, 8]), the sensors placed on the vehicle activate the control unit that triggers the combustion of a gas which rapidly inflates the air cushion (figure 1). These sensors are placed in positions that are easily compromised in the event of an accident, but they can also receive data from the accelerometer or wheels (figure 2).



Legend:
(1) Driver's Front Airbag; (2) Passenger's Front Airbag; (3) Control Unit; (4) Automatic Front Seat Belt Tensioners; (5) Side Airbags; (6) Driver's Seat Position Sensor; (7) Front Passenger's Weight Sensors; (8) Front Impact Sensors; (9) Passenger Airbag Off Indicator; (10) Side Impact Sensors (first); (11) Occupant Position Detection System (OPDS) Sensors; (12) Front Passenger's Weight Sensors Control Unit; (13) SRS Indicator; (14) Side Curtain Airbags; (15) Safing Sensor; (16) Side Impact Sensors (Second).

Fig. 2 The components of the protection and safety system inside a vehicle

The seat belt and airbag operate in tandem in regards to the protection offered. In case of impact, the seat belts restrain the driver / passengers, while the airbag protects them against collision with the steering wheel, the dashboard or the other hard surfaces inside the vehicle. The airbag is automatically triggered in the event of a collision between two or more vehicles and has been continuously improved, so that depending on the weight of the occupant and the severity of the impact, it can be opened in several stages with various intensities [9]. Many manu-

facturers have programmed airbags not to open unless the seat belt is attached. The latest safety requirements specify that a car must be equipped with at least two frontal airbags and several more for the other passengers, with the possibility to deactivate one or more airbags. The protection and safety system is designed so that the airbags activate and inflate at a speed of approximately 300 km / h, in 0,03 seconds. As such they become energy absorbing buffers, damping the shock suffered by passengers in contact with the hard surfaces inside the vehicle. After inflation, the airbag cushion deflates in a controlled manner through the tiny holes in the material from which the airbag is formed.

3. AIRBAG CASSIFICATION

The classification of these passive safety systems can be done based on several criteria, as presented in table 1.

Table 1. **Airbag classification**

No. crt.	Classification criteria	Groups (types of airbags)
1.	**Airbag type**	Interior airbags for the passengers
		Exterior airbags for the pedestrians
		Exterior partial airbags for the vehicle
		Exterior airbags for the whole vehicle
2.	**Number of protected passengers**	Interior airbags for the frontal passengers
		Interior airbags for all passengers
3.	**Destination**	Interior airbag for the driver
		Interior airbag for front-right passenger
		Interior airbags for backseat passengers
		Children airbags
4.	**Placement (position) inside the vehicle and the anatomical parts to be protected**	Driver's front airbag
		Passenger's front airbag
		Central airbag for the frontal passengers
		Knee airbags
		Side airbags
		Rear window airbags
		Curtain airbags
5.	**Impact type (gravity of collision)**	Interior airbags for frontal impact
		Interior airbags for side impact
		Interior airbags for rear-end collision
		Interior airbags for flip collisions
6.	**The manner of fastening**	Steering wheel recessed airbag
		Dashboard recessed airbag
		Seat airbag
		Airbag incorporated in the seat belt
		Airbags incorporated in the side compartments
		Airbag recessed in the car doors
		Curtain airbags fixed to the roof
7.	**Constituent material**	Airbags manufactured with material using Nylon 6.6 yarns (weave or warp knitted)
		Airbags manufactured with material using Nylon 6 yarns (weave or warp knitted)
		Airbags manufactured with Nylon 4.6 yarns
		Airbags manufactured using PES fibres
8.	**The type of finish of the used material**	Airbags manufactured using coated materials
		Airbags manufactured using uncoated materials

4. THE CORRELATION BETWEEN REQUIREMENTS – FUNCTIONS – QUALITY CHARACTERISTICS FOR THE PROTECTION AND SAFETY

In accordance to the purpose for which they were created, the main requirements and functions for these safety products are:

- ✓ Ensuring and improving the protection and safety of passengers in the vehicle against collision and / or injuries caused by the hard surfaces inside it (steering wheel, dashboard, windshield, bonnet, rear window, doors, etc.), in the event of a vehicular accident;
- ✓ Correct and timely detection by the sensors of impact, speed, braking, position, weight and safety (impact, collisions) and of the hazard warning signals;
- ✓ Quickly run-through of self-diagnosis for the entire protection and safety system;
- ✓ Appropriate tensioning of the seat belts to prevent impact / injury of the passengers;
- ✓ Activation of the control unit that triggers the combustion of chemical substances and the production of gas that rapidly inflates the airbag cushions;
- ✓ Quick and easy release of folded airbag cushions;
- ✓ Airbag inflation under controlled speed (approximately 200 - 300 km / h [2, 5]) and in the expected time (it is recommended that full inflation should be achieved in about 0.03 seconds from impact [2]);
- ✓ Recording the errors of the car's computer memory and activating the hazard lamps;
- ✓ Manufacturing the airbag cushions according to pre-determined dimensions and capacities depending on their destination (airbag capacity varies between 30 - 200 litres);
- ✓ Reduction of manufacturing costs.

4.1. Relevant characteristics for the airbag constituent materials

The principal requirements and relevant characteristics for the airbag constituent materials are presented in table 2:

Table 2. **Relevant characteristics of the components**

Constituent materials	Relevant characteristics
Yarns	Length count controlled according to its destined function (420 – 840 den for nylon 6 and nylon 6.6 fibres) [5]
	High uniformity
	Extremely low number of frequent defects
	High tenacity (7,5 – 9 cN / den) [8]
	High breaking elongation (16 – 25 %) [5, 8]
	Resistance to high temperatures (200 – 250^{0}C) [5, 8]
Flat surfaces (weave or warp knitted)	Low thickness, variable according to its destined function (0,25 mm for driver seat airbag – made out of coated textile surfaces); (0,32 – 0,44 mm for passenger airbags – made out of uncoated materials) [5, 7]
	Low and variable surface unit weight (≈ 175 g/m^2 – for coated textile surfaces) (220 – 260 g/m^2 for uncoated materials) [5, 6]
	High traction resistance (2300 – 3300 N) [5]
	High resistance to bursting (higher than 60 daN/cm^2) [5]
	Resistance to aging
	Breaking elongation (12 – 45 %) [5]
	High flexibility
	Increased adherence
	Increased resistance and stability to high temperatures (up to 200^0 C);
	Increased pliability
	Low air permeability (6 – 10 dm^3/min) [5]
	Controlled gas permeability
	High adherence to coating
	Increased reliability
	Nice touch

5. CHARACTERISATION AND ILUSTRATION THE AIRBAG TYPES

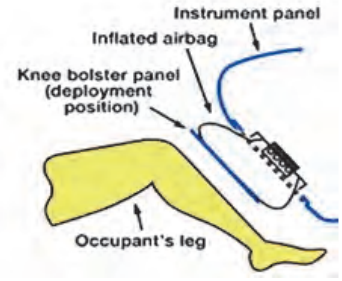
5.1. Frontal interior airbags

Table 3. **Relevant characteristics of the frontal interior airbags**

Relevant characteristics / Illustration
- Ensure protection of the frontal passengers from impact and / or injury against the steering wheel, dashboard or windshield, in the event of a frontal collision between two vehicles. - Generally they are folded inside the steering wheel and / or dashboard; - During an impact it inflates instantly with a speed of about 300 - 350 km / h [2, 5]; - The airbag is fully inflated at 0.03 seconds from impact [2]; - The capacity of the front airbags (for the driver and right passenger is 65 litres [7,10]; - The dimensions of the frontal airbags are smaller compared to those of the back seat passengers; - The driver's airbag is usually made of thin, coated materials (with silicone or other types of substances) in order to improve the resistance to breaking, aging and high temperatures, increase adhesion and low air permeability; - If the airbags are incorrectly triggered, the life of the passengers is endangered.
    

5.2. Central interior airbags and airbags for knees

Table 4. **Relevant characteristics of the central interior airbags**

Relevant characteristics / Illustration
- Ensure protection of the front passengers against striking and / or injuring during a frontal and lateral collision or overturning; - It is placed between the front passengers offering protection to their heads, shoulders and arms [14]; - The airbag is generally fixed to the right side of the driver's seat; - In case of an impact, it inflates immediately with a speed of approximately 300 km / h [2]; - The airbag is fully inflated at 0.03 seconds from impact [2]; - The dimensions and capacity of the central airbags (between the driver and right passenger) are generally smaller than the frontal airbags - the capacity can be about 30 litres. - Knee airbags provide protection for the driver and / or front passenger against hitting and / or injury with lower area of the dash board; - The size and capacity of the knee airbags are reduced.
   

5.3. Interior airbags (lateral, for the rear window, panoramic and curtain airbags) for passengers

Table 5. **Relevant characteristics**

Relevant characteristics / Illustration
- Side interior airbags, for the rear window, provide protection of the passengers against impact and / or injury with hard surfaces or objects inside the car, in case of collision between two or more vehicles; - Interior rear airbags provide protection for the rear window and backseat passengers in the event of an accident; - They can be recessed inside the seats or side compartments of the vehicles for added protection against side collision or overturning; - They can be opened in several stages and with various intensities [9]; - The dimensions of the side airbags are larger compared to the front ones, thus having higher inflation times; - Airbags usually made of uncoated textile surfaces, with an increased thickness and mass (0,32 – 0,44 mm thick and 220 - 260 g / m2 mass) are used for the passengers; - The capacity of the side airbags (for passengers) varies between 100 - 300 litres [7,10]; - Special baby seats have been designed and manufactured with airbags incorporated inside [9, 13]; - Panoramic airbag - is installed in the panoramic roof and looks like an air mattress that covers the entire roof of the vehicle [3, 9]. It can unfold in just 0,08 seconds and it stretches from the rear of the vehicle to the front.
  
 

5.4. Exterior airbags for pedestrians

Table 6. **Relevant characteristics**

Relevant characteristics / Illustration
- Provides pedestrian protection in the event of a car accident [4]; - Vehicles should be equipped with a special radar and sensors capable of accurate and timely detection of a collision, triggering full airbag inflation (placed under the hood of the car) before impact, thus minimizing the extent of pedestrian injury, or saving their life.


5.5. Exterior airbags for the vehicle

Table 6. **Relevant characteristics**

Relevant characteristics / Illustration
- External side airbags were created to ensure the protection of the vehicle and passengers inside it, in case of a side collision; - Manufactured from the same types of textile surfaces as the interior airbags; - The cars are equipped with a special radar and sensors able to accurately and quickly detect an imminent collision, triggering in 100 milliseconds the full inflation of the airbag, before the impact; - External airbags have been created and manufactured for the entire vehicle, which ensures both the protection of the car and the passengers in it, in case of collision, or overturning [11, 12]; - The system is called External Vehicle Protection (EnVeloP) [12, 15] and detects any impact in a timely manner, causing a special airbag (folded inside the roof of the vehicle) to open and inflate, thus covering the entire car, minimizing the effects of the collision on the passengers.
 


6. TRENDS AND CONCLUSIONS

Airbags are an integral part of the passive safety equipment for passengers and were created in order to ensure and improve their protection and safety during traffic. They are triggered automatically in the event of a collision, between two or more vehicles, and underwent continuous improvement so that depending on the weight of the occupant and severity of the impact, they can be deployed in several stages with various intensities [9].

The continuous diversification of beneficiary requirements in the automobile industry, in regards to the protection and safety of the traffic participants, has led to the emergence of the most remarkable innovations to the **Supplemental Restraint System (SRS**). These innovations include the development of **intelligent restraint systems** that adapt to the geometry of the passenger compartment, position and height of the seats, passenger type and weight (adults, children) and severity of collision, etc.

An intelligent restraint system must be capable of updating and deciding:

• What types of airbags should be activated;

• The inflation degree of the airbags and the time required for their complete activation;

• Proper pre-tightening of the seat belts.

As possibilities for detection and activation of passive safety systems, along with the full range of sensors mounted on and inside the vehicle, video systems, biometric detection, or different types of radars can also be considered [5].

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About the author

Lecturer PhD. **Liliana LUTIC**
„Gh. Asachi" Technical University, Faculty of Industrial Design and Bussiness Management, Iasi, Romania

Graduate of "Gheorghe Asachi" Polytechnic Institute of Iasi, Faculty of Industrial Design and Bussiness Management, specialization "Technology of Knitted and Clothing" in 1984; doctor of engineer since 2004; lecturer at the Faculty of Industrial Design and Bussiness Management 2004. Competence domains: structure and technologies of Knitted; processes and Knitting machines; metrology in textiles and leather; ensuring quality in knitted – clothing; quality engineering.