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Air Bag: A Safety Restraint System of an Automobile.

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Abstract:
The present paper represents a brief review of life saving system in roll- over accidents, while driving on the road by a four wheeler. An Airbag is an automotive safety restraint system for an occupant as well as passengers. The system consists of a flexible fabric envelope or cushion, designed to inflate rapidly during an automobile collision. Its purpose is to cushion occupants during a crash and provide protection to their bodies when they strike interior objects such as the steering wheel or a window etc. Thus it lowers the number of injuries by reducing the force exerted by steering wheel, windows and the dashboard at any point on the body. Continuing research and developments are going on in its module design, combustible material, air bag fabric design and material, coating etc. in making this life saving safety device further efficient. However, success of any safety restraint device depends on its correct implementation and certain safety rules to be followed.
Key Words: Air bag, Collision, Occupant, Fatal injury, Safety, Passenger.

I. Introduction

A car becomes an essential feature for any service class as well as businessman to meet with the stringent demand of hectic lifestyle. Safety of the driver as well as passengers becomes an important feature along with comfort and performance of any family car. Airbags have even been suggested from the beginning of the motor vehicle safety. It has been used for the protection of head, knees and legs. Rear passenger airbags and side airbags in addition to driver air bag [figure 1] are developed for providing protection in roll- over accidents by shielding the occupants and passengers from side window glass and protecting the head [1-9].

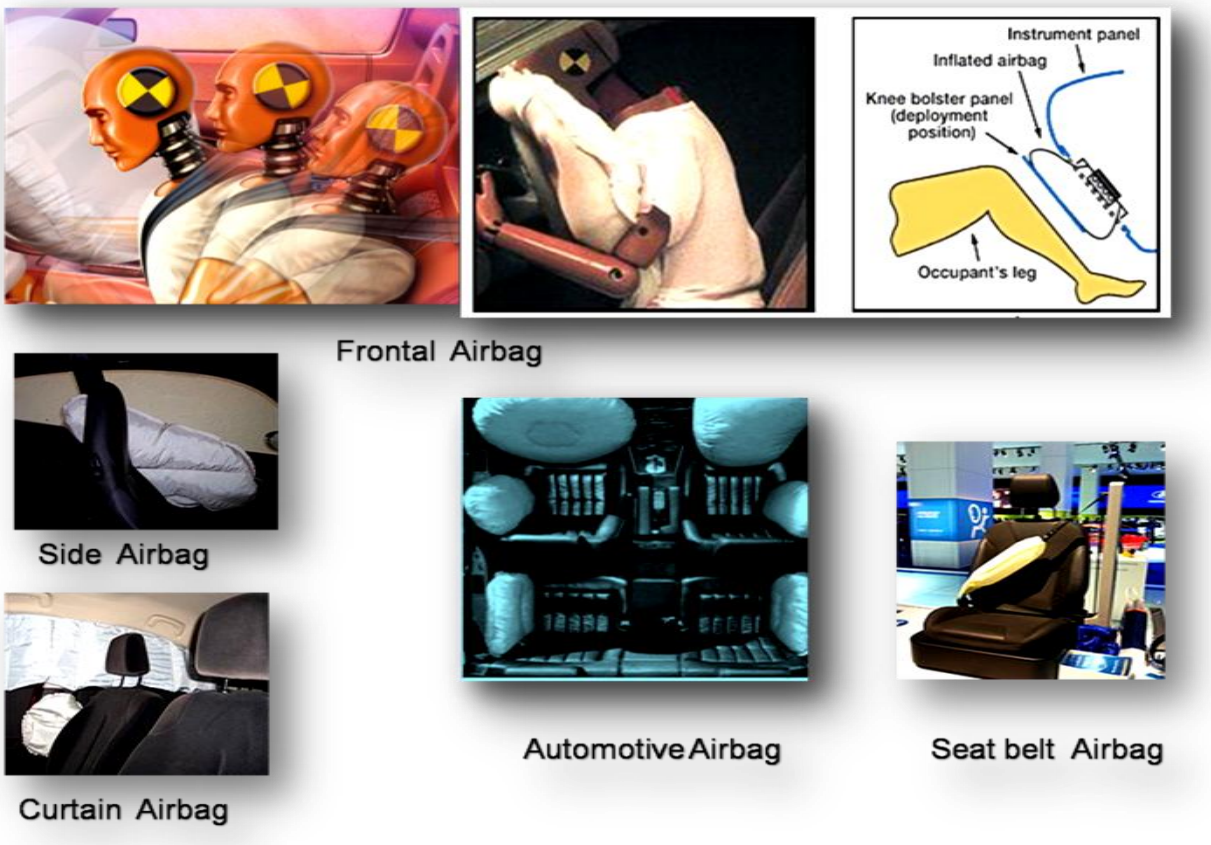

Figure 1: Different types of air bags

II. Airbag

An Airbag is an automotive safety restraint system. It is an occupant restraint system consisting of a flexible fabric envelope or cushion designed to inflate rapidly during an automobile collision. Its purpose is to cushion occupants during a crash and provide protection to their bodies when they strike interior objects such as the steering wheel or a window. Thus it lowers the number of injuries by reducing the force exerted by steering wheel and the dashboard or any point on the body. This is accomplished in two ways, viz; i) by increasing the interval over the force being applied or ii) by spreading the fore over a large area of the body [1 -14].

III. Brief History of the Airbag systems development

The first concepts for an automatically inflating "air cushion" used as an impact protection for car passengers were discussed in the sixties, approximately 10 years after corresponding patents had been granted [9]. John HETRICK'S [1] patent describes a general airbag system in which a self-opening airbag is automatically inflated following a sudden deceleration of the vehicle.

In the USA ordinances "FMVSS 208" was passed in the middle of the sixties against the background of increasing numbers of accidents, to improve vehicle safety, thereby it called "Safety Act"[1, 6, 15-19]. A bundle of new ordinances were planned to improve safety in traffic. It was not until 1984, following long and controversial discussions, that an agreement could be reached on the introduction of a passive restraint system on September 1, 1989 for all new vehicles registered in the USA. These automatic restraint systems could be automatically closing seat belts or the airbag. In order to be able to comply with the new ordinances (FMVSS 208) immediately after they come into force, airbag developments were also initiated and intensified by European automobile manufacturers; primarily by Mercedes-Benz. The basic development of "passive restraint systems" stepped up at Mercedes-Benz from 1967 onwards. This first development stage from 1967 to 1972 is referred to as "the principle functional proof [5-8, 20-23].

However, General Motors has also introduced its first airbags in the early 1970s but consumer did not readily accept them. The market for airbag was assured by US when the Department of Transportation (DOT) implemented the "Federal Motor Vehicle Safety Standards (FMVSS) 208" in 1984 as mention above. Because of this law, the US leads the commercialization of airbag [2, 24-25].

The airbags of initial phase were inflated using compressed-gas canisters. However, the pressure canisters could only be accommodated in the instrument panel. Connection to the steering wheel proved problematic since it could only be sealed with great difficultly[22, 25]. In the next development phase experiments were carried out with liquefied gas and solid fuels. The solid propellant should supply the thermal energy needed to expand the liquid Fringe. Although the necessary inflation time of 1/30 second was reached this system was still too heavy[20-25]. A neoprene-coated polyamide fabric was initially determined as a suitable material for the airbag. After 1970, research concentrated on an inflator filled with solid fuel to inflate the airbag. Together with development partners from the chemicals and automotive industries, this method of producing the gas was perfected for series production as of 1974. In December 1980, the first vehicle with a driver airbag was launched by Mercedes Benz. Seat belt tensioner were also offered for the driver and front seat passenger. As of 1988 front-seat passengers were also protected by an airbag. Since the beginning of the nineties, all automobile manufacturers have been offering airbags as a standard feature or optional extra, even in compact class cars[1-10].

However, the world-wide use of the airbag system didn't proceed harmoniously since on the US-American market it is specified as the only restraint system (passive system) whereas in Europe it has been developed as an additional safety device (SRS: Supplemental Restraint System) to the seat belt system. These different developments have affected the size of the airbag and inflator. As a sole passenger protection system the airbags must be much bigger and must inflate earlier since the unprotected passenger collides faster with the instrument panel. The number of persons, driver and passenger killed in traffic has dropped continuously since 1970. Table1 represents the same statistics for belted, non belted and over all[3-7].

Table 1: Effectiveness of Frontal Air bag

Percent Reductions in Driver and Passenger Deaths with Airbags
(Data from Insurance Institute for Highway Safety – IIHS, 2000)

	Crash Type			
	Frontal		All	
	P	D	P	D
All	18	23	11	14
Belted	14	26	8	12
Unbelted	23	32	14	19

As a result of which air bag penetration in the market has also get hiked from 1999 to 2005 [figure 2]. Airbag growth has also increased accordingly in every region of the vehicle with the stringent demand of the safety [figure 3][5, 9].

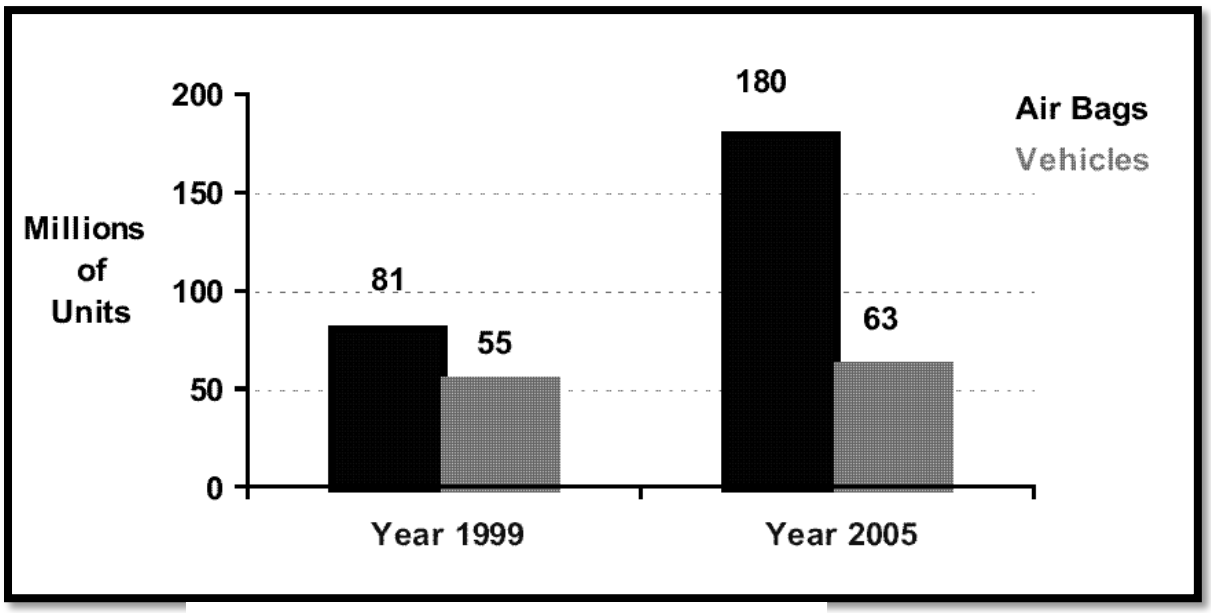

Figure 2: Statistics for Airbag Application in Vehicles

Thus development of Federal rules, increased public awareness for safety and concern for safety has enhanced the growth of air bags in the market [7].

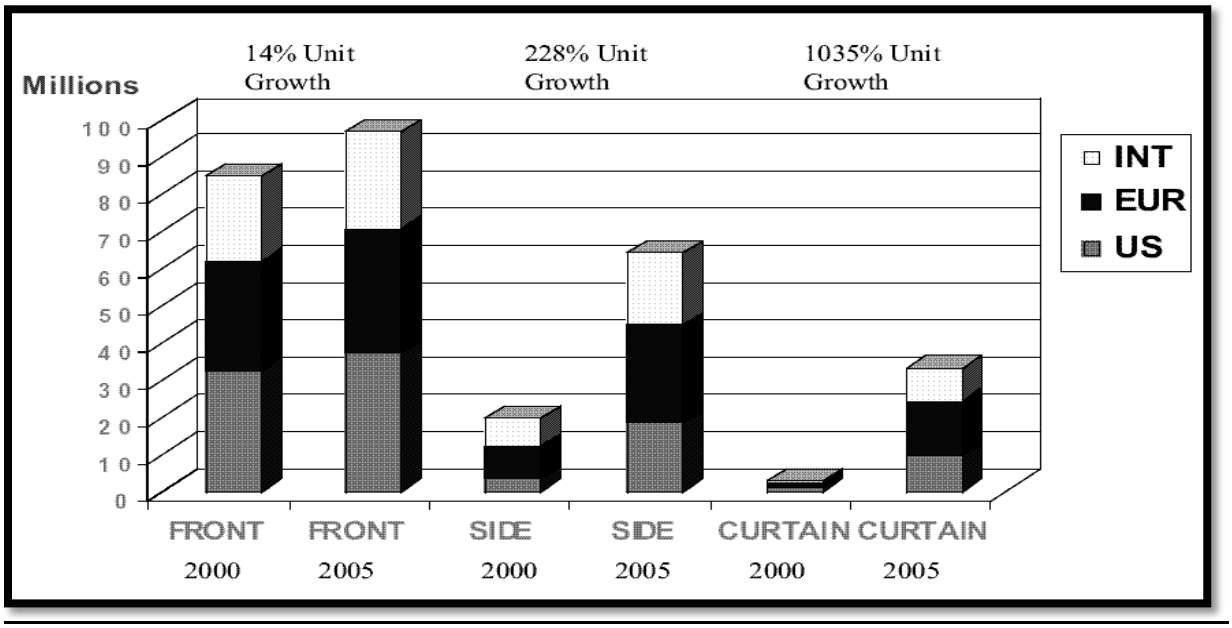

Figure 3: Airbag Unit growth in Vehicles, by Region- 2000 to 20005.

IV. Air bag Production Process

Typical manufacturing line for air bag has been shown in figure 5. Airbags can be manufactured by either of the mechanisms of fabric manufacturing, viz; weaving and non- woven fabric manufacturing process [4, 14, 18].

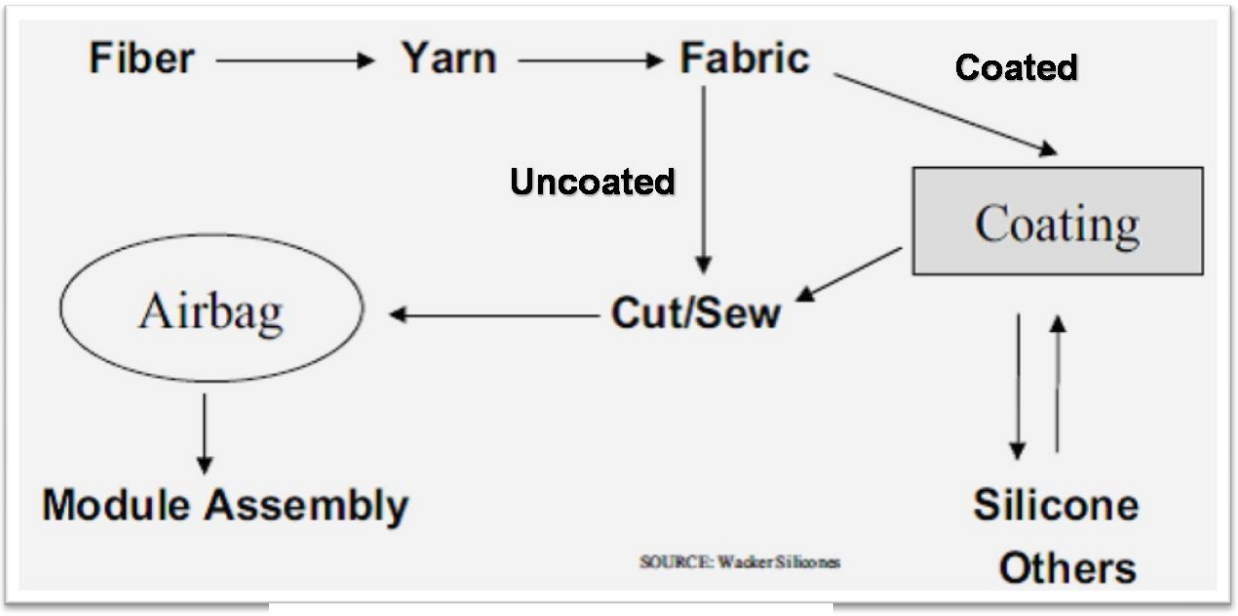

Figure 5: Air bag fabric productions flow-chart

V. Materials used in Air bag

Mostly used raw material for the airbag fabric is nylon 6, 6 yarns in the deniers ranging from 420 to 840. The side impact airbags used 1880 D nylon- 6.6[1, 6-9, 25]. Table 3 shows the important properties of these commercially used fabrics. They are generally woven, with the construction of either 840 X 840 D, 98 X 98 /dm plain weave, 60" width or 420 X 420 D, 193 X 193 /dm plain weave, 60" width[22-25].

Usually Rapier with insertion rate of 400 m/min has been found most suitable for weaving airbags. Since, it can maintain warp tension with accuracy of 1 CN per warp[12-14]. Even water jet and air jet with insertion rate of 600 m/min are being used[15]. Commonly, the airbag made were coated by neoprene, but recently silicon coated and uncoated varieties have become popular. Coated airbag are generally preferred for driver seats. The weight per unit length uncoated one is higher than coated bags[4], i.e. 244 - 257 Vs 175 g/m^2. Today, the latest research on potential airbag

materials includes High tenacity polyester, Nylon 4, 6, etc. apart from Nylon 6, 6. However Nylon 6, 6 has the most superior quality in all[8-12].

Air bag fabric has to keep a balance between two extreme conditions [1-2]. It has to be sufficiently flexible to fold into relatively small volumes. At the same time it should be sufficiently strong to withstand the deployment at high speed, e.g. under the influence of an explosive charge, and the impact of passengers or other influences when inflated[21-25]. To play this role successfully airbag fabric should possess following quality parameters[3, 8, 25]:

1. Small fabric thickness.
2. Low specific fabric weight.
3. High tenacity in warp and weft direction as well as toughness.
4. High tenacity for furthers tearing.
5. High elongation.
6. Good resistance to aging.
7. Heat resistance up to 190 ^{0}C.
8. Good resistance to UV light.
9. Low and very even air permeability.
10. Reduced cost.
11. Precisely controlled gas permeability.
12. Excellent seam integrity.
13. Reduced value or burn through resistance.
14. Improved pliability and pack height

Airbag system

The air bag system consists of three basic parts- an air bag module, crash sensor and a diagnosis unit[1-6]. Some systems have ON/OFF switch to deactivate air bag system [figure 4]. The air bag module contains both an inflator unit and the lightweight fabric air bag. The driver air bag module is located in the steering wheel hub, and the passenger air bag module is located in the instrument panel. When fully inflated, the driver air bag is approximately the diameter of a large beach ball. The passenger air bag can be two or three times larger since the distance between the right-front passenger and the instrumental panel is much larger than the distance between the driver and steering wheel[1-9].

Table 3: Constructional details of Airbag fabric.

Type of airbag	Neoprene coated		Non- coated		Silicone coated
Yarns	**Nylon 6,6**	**Nylon 6,6**	**Nylon 6,6**	**Nylon 6,6**	**Nylon 6,6**
Denier	**840**	**420**	**840**	**420**	**420**
EPI	**98**	**193**	**32**	**57**	**46**
PPI	**98**	**793**	**32**	**51**	**46**
GSM	**280**	**260**	**252**	**238**	**175**
Thickness(mm)	**0.38**	**0.34**	**0.4**	**0.35**	**0.25**

Figure 4: ON/OFF switch of air bag system

The crash sensors are located either in the front of the vehicle and/or in the passenger compartment. Vehicle can have one or more crash sensors. The sensors are activated by forces generated in significant frontal or near-frontal crashes only and not during sudden braking or while driving on rough or uneven pavement.

The diagnostic unit monitors the readiness of the air bag system. The unit is activated when the vehicle's ignition is turned on. If the unit identifies a problem, a warning light alerts the driver to service the air bag system before use. Most diagnostic units contain a device, which stores enough electrical energy to deploy the air bag if the vehicle battery is destroyed very early in a crash sequence[5-12].

Vehicles like pickup trucks do not have rear seats; have manually operated ON/OFF switches for the passenger air bags[2-3].

VI. The mode of operation of the airbag system

The first stage of the airbag deployment is the accident itself. The collision, be it frontal or lateral, activates an array of sensors in the vehicle, including accelerometers, impact sensors, side pressure sensors, brake pressure sensors, and seat occupancy sensors. All these sensors are in intimate connection with the ACU (Airbag Control Unit). The unit decides if and how to deploy the airbags. When the ACU detects that the deployment threshold has been reached, it initiates the inflation stage. As the

compressed air system would have been impractical and quite inefficient, engineers came up with an idea quite similar to the working principle of the solid rocket booster. Each airbag incorporates a pyrotechnic device, known as an initiator or electric match, consisting of an electrical conductor cocooned in combustible material. A current pulse heats up the conductor, which in turn ignites the combustible material. This igniter triggers the chemical reaction that actually fills the nylon fabric airbag with gas. The large volume of gas then forces the airbag out of the steering wheel and/or dashboard at a speed of up to 200 mph or 322 mph, the whole process taking about 0.04 seconds. Considering that the blink of an eye is approximated at 0.2 seconds, one could say it's quite a speedy process [1-10].

The last stage of the airbag process is the deflation, which occurs almost immediately after the inflation is completed. The gas escapes through special vents. They also prevent the occupants from suffering major impact injuries. Another effect of the deflation is the release of dust-like particles, mostly cornstarch and talcum powder that are used to lubricate the airbag. Small amount of Sodium hydroxide may initially be present. This chemical can cause minor irritation to the eyes and/or open wounds; however, with exposure to air, it quickly turns into Sodium bicarbonate (common baking soda). Depending on the type of air bag system, potassium chloride (a table salt substitute) may also be present. Initially, the chemicals used in airbags were a major health concern, but present systems will only produce a mild irritation of the throat and eyes for most people, as an outcome of dust released. Generally, these minor irritations continue up to the time occupant remains in the vehicle with the windows closed and no ventilation. However, person with asthma may develop an asthmatic attack from inhaling the dust; need to immediately seek medical treatment[6-14].

Once deployed, the air bag cannot be reused and should be replaced by an authorized service department.

VII. Air bag contact injuries

Air bags must inflate very rapidly to be effective, and therefore come out of the steering wheel hub or instrumental panel with considerable force, generally at a speed over 100 mph. Due to this very high initial force, contact with a deploying air bag may cause injury. Properly restraint occupant along with applied due seat belt receives very minor abrasion or burns. However, very serious or fatal injuries can occur when someone is very close to, or in direct contact with an air bag module when the air bag deploys. Even never attach objects to an air bag module or place loose objects on or near an air bag module, since they can be propelled with great force by a deploying air bag, potentially cause serious or fatal injuries. Thus safety restraint system must be utilized with due care and regulation to get best results [12, 16-22].

An unrestrained or improperly restraint occupant can be seriously injured or killed by a deploying air bag. The National Highway Traffic Safety Administration (NHTSA) recommended certain rules for the safety of occupant and passengers[23-26]. They are as follows:

1. Never put a rear-facing infant restraint in the front seat of a vehicle with a front passenger air bag.
2. Children 12 and under should be properly restrained in a rear seat.
3. Driver should sit with at least 10 inches between the centre of their breast bone and the steering wheel.
4. Always apply seat belt, it retain occupant and passenger rightly positioned and minimizes risk of serious injuries.

VIII. Conclusion

The number of persons killed or injured in traffic has dropped continuously since the development of air bag system. Over the time, the development of seat belt becomes an indisputable matter of course. Today, the 3-point automatic seat belt, seat belt tensioner and airbag constitute a carefully matched passenger protection system. Implementation of these safety restraint systems with due care and regulation can further drop the fatality rate and serious injuries at the time of road accidents.

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