RECENT DEVELOPMENTS IN AIRBAG TECHNOLOGY

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Abstract: *Airbags reduce the impact of high speed collisions by cushioning effect and thereby significantly bring down chances of head, knee and leg injuries to occupants. Unfortunately, airbags can also cause fatal injuries during relatively minor vehicle collisions. Airbags require high-performance engineered materials and careful design considerations to withstand high mechanical stresses and temperatures during impact. The aim is to get good balance between high impact resistance and reduced aggressivity of air bags. The recent advances air bag systems include changes in inflator characteristics, newer shapes, sizes, fabrics, venting systems and venting levels, occupant size and location sensors, seat position sensors and crash severity sensors. The present article review the recent developments in the air bag sector.*

Keywords: *Airbag, High performance engineered materials, Cushioning effect, sensors.*

1. Introduction

Airbags are one of the most advanced car safety technologies that have revolutionized the car industry in the recent years. Air bags are supplemental restraints, designed to work best in combination with safety belts. These are flexible and inflatable cushions built into the car interiors mainly on the steering wheel or the dashboard designed in a way to rapidly expand in case of a car accident. The concept of airbags was proposed by John W Hetrick, a former naval engineer in 1950s. Ford Motors took around two decades to convert the Airbag concept into reality. The Airbag technology in passenger car was used on commercial scale by General Motors in 1973[1]. The first generation airbags caused lot of causalities due to poor design and very high deployment force. To check the alarming rate of fatalities due to airbag, NHTSA proposed the modification in occupant crash protection standards. This was done to ensure that vehicle manufacturers could depower all air bags so that they inflated less aggressively [2]. The NHTSA regulation 2006 required all passenger cars and light-duty trucks to be equipped with sensors for identifying children and very short adults and deploying the airbag with less force or not at all for them. The introduction of such frontal airbag has saved 25,782 lives between 1987 and 2008. By the early 2000s, advance airbags systems were introduced, which not only changed the force of deployment, but also the size and shape of the airbag according to the occupant. Initially use of airbags for occupant's safety in vehicles was a concept restricted to western countries only. In the recent years, airbags have made a quick and gentle move to India through luxury cars tagged to Mercedes-Benz, Audi, and BMW. Although, airbag technology has also shifted to all the car segments in India, but a recent survey [3] conducted by London car-safety watchdog Global NCAP (New Car Assessment Programme) failed all the five popular small cars (Tata Nano, Maruti Suzuki Alto 800, Hyundai i10, Ford Figo and Volkswagen Polo) on the Indian market in crash test and rated them as zero on a scale of 1-5. It is expected that a new era in vehicular safety year 2014 will usher in a whole new era in vehicle safety with a whopping 10 or more standard airbags popping up in many vehicles.

2. Working principle of airbag

Airbags work on a crash testing technology that enables the installed sensors to detect an accident. These sensors further send an electric current to a wire that heats up and charges the inflator. Charging of the inflator undergoes a chemical reaction to create gas and inflate the flexible cushions positioned on the steering wheel or the dash or rear compartment in case of side-impact airbags. As the gas expands and fully inflates the airbag, it starts deflating, thereby cushioning the impact.

3. Air bag manufacturing

Airbags fabric is produce by simple textile manufacturing process. Air bags fabric can be woven/nonwoven structure with or without the coating of some elastomeric material depend upon the location of installation of airbag in the car. Thereafter, airbag fabric is cut according to design by using laser cutter to avoid fabric waste, selvedge fraying and maintain integrity of woven fabric. Finally, sewing of airbag is done using special sewing machines.

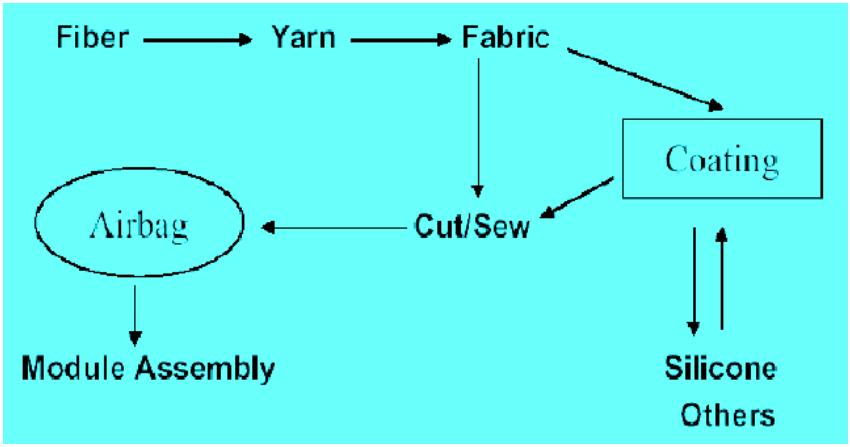

Figure 1: Steps in manufacturing of a typical airbag [4]

4. New developments in airbag system

4.1 Rear curtain airbag

In 2008, the Toyota iQ launched the rear curtain shield airbag to protect the rear occupants' heads in the event of a rear end impact. In the event of a crash, these airbags inflated between the glass of the rear window and the rear passenger's head restraints, protecting rear passengers from breaking glass and other debris.

4.2 Anti slide airbag (Seat Cushion)

In 2008 the Toyota iQ added a seat cushion airbag in the passenger seat. This is to prevent the pelvis from diving below the lap belt during a frontal impact or submarining. Anti slide airbag is not a fabric bag, but a thin metal envelope like structure that is mounted under the foam cushion of the front seats. The operating principle is identical to that of an airbag, except that the anti-sliding airbag never comes into direct contact with the occupant. A gas generator inflates the metallic envelope compressing the foam of the cushion up in the front portion of the seat, pushing the occupant back against the back rest, as the side foam forms around the pelvis. It also lifts the weight of the legs, preventing the downward force of the feet pushing into the floor.

4.3 Center airbag

In 2009, Toyota developed the first production rear-seat center airbag designed to reduce the severity of secondary injuries to rear passengers in a side collision. In late 2012, General Motors introduced a front center airbag. This air bag deploys from the right side of the driver's seat and positions itself between the front row seats near the center of the vehicle. This tethered, tubular air bag is designed to provide restraint during passenger-side crashes when the driver is the only front occupant, and also acts as an energy absorbing cushion between driver and front passenger in both driver- and passenger-side crashes. The air bag also is expected to be useful in rollovers.

Anti slide airbag Centre airbag Rear Curtain airbag

Figure 2: Antislide, Center and rear curtain airbags [5,6,7]

4.4 Carpet Airbags

They are mounted under the carpet and deployed by a stored gas inflator located over the center tunnel. The inflators are actuated by the frontal airbag sensors, but at a faster rate. They are multipurpose, providing cushioning for the occupant's feet and with the upward motion on the legs they hold the occupant's lower body in the proper position in the seat. These work in conjunction with another airbag mounted under the driver's seat that tilts the seat back when inflated. By tilting the seat back and the upward motion to the legs, the lower body is held in place and the upper body is moved further away from the deploying frontal airbag.

4.5 Combination head/torso airbags

This system protects the head and the body from the shoulders down to the hip and is typically provided for front seat occupants only. They are located in a similar position to the torso airbags, but are larger as they protect the head and torso. Side airbags that protect the head and torso for both front- and rear-seat occupants offer the best protection. Some vehicles are now being equipped with different types of designs, to help reduce injury and ejection from the vehicle in rollover crashes. More recent side airbag designs include a two chamber system; a firmer lower chamber for the pelvic region and softer upper chamber for the ribcage. Some cars, such as the 2010 Volkswagen Polo Mk.5have combined head and torso side airbags. These are fitted in the backrest of the front seats, and protect the head as well as the torso.

4.6 Inflatable Tubular Structure (ITS) head airbags

Working together with the side airbags, the ITS head airbags provide superior protection in the event of a side impact. They inflate diagonally across the side windows and protect your head from injury and from intruding objects. The intelligent deployment electronics measure a range of values and inflate the airbags within milliseconds across the side windows and over the seatbelt height adjuster, ensuring the best protection for the occupant, irrespective of their size or seating position. Together with the side airbags, the ITS head airbags lead to a 200 percent improvement in side-impact safety.

Carpet airbag | Side head and torso airbag | Inflatable tubular structure head side airbag

Figure 3: Carpet, Side torso and head side airbags [5,8,8]

4.7 Flexible venting technology

In 2013, GM developed flexible venting technology for deployment of the air bag more efficiently depending upon the type of crash as compared to more expensive and complex dual-stage air bags,. Crash tests have demonstrated that this single-stage driver air bag provides excellent cushioning for drivers of different sizes in low-and high-speed crashes.

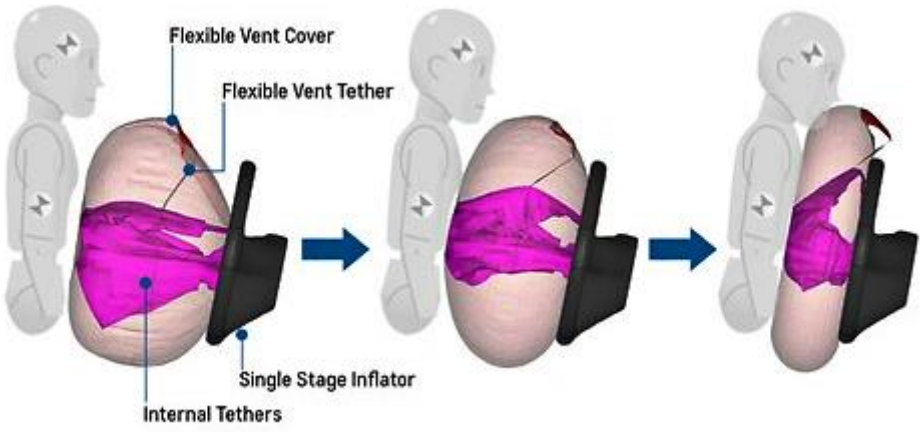

Figure 4: Flexible venting system of GM [9]

Current dual stage air bags have venting holes that are open at all times; they allow the gas to escape to help manage the energy when the air bags deploy. Since the venting holes are open at all times, the air bags can lose gas early in the deployment before the occupant has had time to hit the air bag. Therefore, it has to inflate using a stronger inflator and at a higher rate of inflation. While in flexible venting, the vents are closed early in deployment and open only when the driver hits the air bag using his or her momentum. Because the air bag retains the gas until the driver comes into contact with it, the air bag can inflate with lower pressure irrespective of the severity of the crash can maintain the pressure for a longer duration of time. The lower rate of inflation helps prevent inflation-related injuries to smaller drivers as well as drivers who sit closer to the steering wheel.

4.8 Volvo's external airbag technology

Volvo developed the External Vehicle Protection system (ENVELOP System), which consists of a small container built in the roof of the car, containing a folded-in, vacuum pulled balloon of material similar to existing airbags. In case of an unavoidable collision, whether it is with another car, a roadside object or even when coming into contact with surface water, the balloon unfolds within the blink of an eye around the car. By completely enveloping the car, the External Vehicle Protection system ensures that damage and personal injury as a result of the collision is minimized.

Figure 5. Volvo V40 air bag External Vehicle Protection system [10]

4.9 Airbag for Smartphone

Japanese car maker Honda has created a Smartphone case with built-in airbags designed to prevent damage and breakages of screen after hitting the ground.

Figure 6: Smartphone airbag system [11]

Dubbed Case N, the phone accessory acts like a protective shell and is equipped with the six airbags. Apple also holds a patent for a phone case that tracks how close a phone is to hitting the ground, using built-in accelerometers.

4.10 LASER sewing technology

The traditional sewing process has been replaced by laser welding by the airbag industry due to severe drawbacks of the sewing process, e.g. seam leakage behavior, occurrence of stitch errors as well as limited degree of automation. Laser transmission welding of PA 6.6 fabrics is a suitable way to join textile layers with sufficient seam strengths larger than 1,000 N/5 cm (tensile strength 1,000 N/5cm according to a tensile test specified by DIN EN ISO 13935-1) [12]. The highest average seam strengths of more than 1,200 N/5 cm have been obtained with calendared fine-woven PA 6.6 textile layers as absorbing interlayer material. Without polymeric interlayer material, the seam strengths for overlap geometry are in the range of 500 N/5 cm. laser welding fabric. The laser seams have qualitatively good external appearance, as they are clean, impermeable and the weld fume is minimal.

Thus it can be seen that airbags have come a long way from just being optional accessories to vital life saving components of motor vehicles. They have been instrumental in reducing the fatalities due to vehicular accidents. There are various types of airbags being used and a variety of materials are being explored to manufacture them. The quest for improvement continues in the hope to reduce fatalities and injuries during collisions.

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