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AIRBAGS: AN OVERVIEW

ABSTRACT

Over the last decade, safety restraint systems in automobiles have progressively gained attention. Airbags are the most important automotive safety products, since they have proven to increase the safety of passengers in a variety of ways. There is no doubt that airbags save lives and the number of lives saved has increased year by year. Aside from saving lives, the airbag has also led to a new market in automotive safety. The airbag module consists of an inflator with an initiator, a textile cushion and housing. The role of the textile material which constitutes the airbag is vital. The performance of the airbag cushion is expected to remain essentially unchanged over many years, and in consequence, reliable and predictable behavior of the cushion's constituent materials is essential. In this paper historical background of airbags, detailed explanations of fabric types used for airbags and their properties, and finishing processes are overviewed.

Keywords: Airbags, Automobile Safety, Airbag Fabrics

HAVA YASTIKLARI: GENEL BİR BAKIŞ

ÖZET

Son on yılda otomobillerdeki güvenlik sağlama sistemleri kademeli olarak dikkat kazanmıştır. Yolcuların güvenliğini farklı açılardan artırdığını ispatlamasından dolayı hava yastıkları en önemli otomobil güvenlik ürünleridir. Hiç şüphe yoktur ki hava yastıkları hayat kurtarır ve kurtarılan hayatların sayısı yıllar geçtikçe artmaktadır. Hayat kurtarmanın yanında hava yastığı ayrıca otomobil güvenliğinde yeni bir pazara da öncülük etmiştir. Hava yastığı modülü; reaksiyonu başlayan şişiriciden, bir tekstil yastığından ve tekstil yastığının içine yerleştirildiği bölümden oluşmaktadır. Hava yastığını oluşturan tekstil materyalinin rolü hayatidir. Hava yastığının kumaşının performansının uzun yıllar boyunca özellikle değişmeden kalması beklenmektedir ve neticede hava yastığını meydana getiren birleşenlerin güvenilir ve tahmin edilebilir olması gerekir. Bu makalede, hava yastıklarının tarihsel geçmişi, kullanılan kumaş tipleri ve bitim işlemleri ayrıntılı olarak açıklanmaktadır.

Anahtar Kelimeler: Hava Yastıkları, Otomobil Güvenliği,
Hava Yastığı Kumaşları

1. INTRODUCTION (GİRİŞ)

Over the last decade, safety restraint systems in automobiles have progressively gained attention. Federal, national, and international safety regulations have become increasingly severe, with consumer awareness of safety issues at an all time high. There is a movement in the marketing of vehicle safety in which selling arguments and negotiation tactics are focused around the crash star rating of the vehicle. Based on this trend, vehicle manufacturers are continually working on applying new technologies and refining their restraint systems. One area of restraints with a focus on refinement is inflatable systems, known as airbags [1]. The airbags are spreading in use with several now being fitted to each vehicle-for driver, passenger, thorax, knee side and side curtain airbags- and it is expected that in Europe alone approaching 100 million modules will be required by 2006 [2]. In Figure 1, for driver and passenger, frontal airbags are shown.

Figure 1.Frontal airbags [3]
(Şekil 1. Ön hava yastıkları [3])

According to a research executed by The US National Highway Transportation Safety Authority (NHTSA) and Insurance Institute for Highway Safety (IIHS), through airbags almost 10000 potential fatalities have been prevented in the US alone since 1985. There is no doubt that airbags save lives and the number of lives saved has increased year by year. Aside from saving lives, the airbag has also led to a new market in automotive safety representing $4 bn annually with continued double-digit annual growth expected through the next decade [4].

2. RESEARCH SIGNIFICANCE (ÇALIŞMANIN ÖNEMİ)

Airbags are the most important automotive safety products, since they have proven to increase the safety of passengers in a variety of ways [3]. The evolution in demand for airbag systems has been accompanied by significant technical development. The key driver for this development is the maximizing the protection of vehicle occupants and thus reducing potential risk of injury. The global influencing factor in the foreground of these developments has been competitive pressure to enhance vehicle safety as measured in crash test series such as the National Highway Traffic Safety Administration New Car Assessment Program NCAP, and the European equivalent EuroNCAP. Locally, in North America, changes in the Federal Motor Vehicle Safety Standard have mandated improvements, while changes in product liability legislation in North America and Europe have driven manufacturers into more cautious behavior in relation to systems design and materials specification [4]. It is clear that, while the airbags certainly saves the lives of the drivers and passengers, they also create a big market in automotive safety. In this paper, firstly historical background of airbags are introduced, then the detailed explanations of fabric types used for airbags and their properties are given in part 4; in part 5 finishing processes are given.

3. THE AIRBAG PROCESSES - A TEXTILE PERSPECTIVE (HAVA YASTIĞI İŞLEMLERİ - TEKSTİL AÇISINDAN)

3.1. Background and Functions (Geçmiş ve Fonksiyonlar)

Airbags were first introduced in the late 1960s [5]. During the 1970-80s, automakers resisted airbags. Only when the US Supreme Court intervened did regulators finally complete a frontal airbag rule specifying 100 percent compliance by the 1990 model year. By the late 1990s frontal airbags were standard in new cars in the US market, and automakers quickly began offering optional side airbags. Now head-protecting side airbags are in nearly 70 percent of new cars, and some manufacturers offer knee airbags [6].

Airbags save the lives but in the case of incorrectly usage, they can cause deaths. In the mid-1990s that inflating airbags were causing some deaths and serious injuries, efforts have been aimed at reducing the problem. As it is seen in Figure 2, the worst years were 1997, when 56 deaths occurred, and 1998 with another 47 deaths.

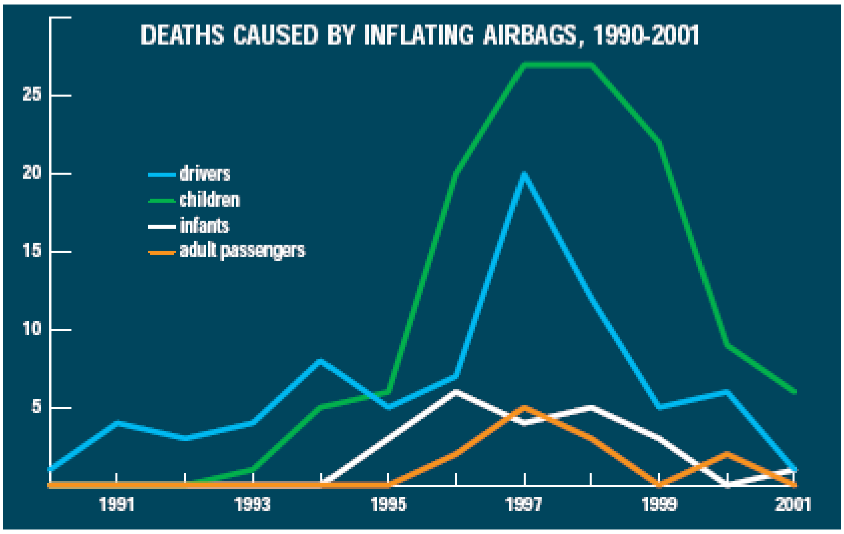

Figure 2. Deaths caused by inflating airbags [7]
(Şekil 2. Şişen hava yastıklarının neden olduğu ölümler [7])

In contrast, 8 deaths were attributed to airbags in 2001, even as more cars on the road were equipped with airbags. The problem is on the wane, a major effort is given to educate drivers and the change in airbag design made a difference. The national effort has included not only educating motorists but also amending child restraint laws. Delaware, Louisiana, New Jersey, New Mexico, North Carolina, Rhode Island, South Carolina, and Washington have changed their laws to require children to ride in the back seats of vehicles if available. Another approach involves the airbags themselves. Beginning with 1998 models, National Highway Traffic Safety Administration changed the rules for compliance testing so manufacturers could install airbags with less power (but still enough to protect people in serious crashes). Since then improvements beyond depowering have been introduced [7].

The airbag module consists of an inflator (or gas generator) with an initiator, a textile cushion, housing and, for driver bags, a cover for the steering wheel [8]. A modern frontal airbag system consists of an electronic control unit (ECU) and one or several airbag modules, if the vehicle has a passenger bag, side-impact bag, etc. The electronic control unit is usually installed in the middle of the car or in the steering wheel. The sensor (an micro-machined accelerometer) continuously monitors the acceleration and deceleration of the vehicle and sends this information to a micro processor where the crash algorithm of a vehicle is stored. The algorithm, which is specific for each car model, is determined by crash tests. When the micro processor "recognizes" the crash pulse from the sensor, an electrical current is sent to the initiator (or squib) in the micro gas generators of the seat belt pretensioners and/or to the inflator of the airbag that should be deployed. Capacitors in the ECU are used as back-up energy, in case the main battery of the vehicle is disconnected during the crash. An electro mechanical safing sensor prevents cellular telephones and other electro magnetic interference from setting off the airbags inadvertently [8].

3.2. Properties of Airbag Fabric (Hava Yastığı Kumaşının Özellikleri)

In 2005 approximately 325 millions square meters of fabrics and 83 million tons of yarn is used [9]. Airbags operate by a triggering device, which sets of explosive chemicals when it senses an impact at above approximately 35km/h is about to happen. This causes the bag to inflate, which cushions and restraints the human body from hitting a harder object. In inflates and deflates all within a fraction of a second-less than the time to blink an eye. The fabrics from which the bag is made must be able to withstand the force of the hot propellant chemicals and more importantly they must not penetrate through the fabric to burn the skin of the car occupant. Polyester is not used for airbags because its thermal properties are not suitable. Compared to nylon 6.6, about 40% less heat is needed to melt polyester and the fabric could allow the penetration of hot gasses [10]. Traditionally, nylon 6.6 has been the material of choice for safety airbags. In general, the nylon fiber exhibits high specific strength, abrasion resistance, and toughness or energy-absorption properties. The aging characteristics of nylon are also very good. Nylon's greater biaxial elongation due to lower stiffness offers a unique advantage in airbag application by providing more uniform biaxial stress distribution [11]. Moreover, nylon 6.6 has lower density. For fabrics made with yarns of identical diameter and in the same construction, polyester fabric is 20% heavier than the fabric made from nylon 6.6. Lower mass has key advantages reducing the mass of the cushion lowers the kinetic energy of impact on the occupant in out-of-position situations thus enhancing safety, while allowing the overall weight of the vehicle to be reduced. Of course, this also has the effect of increasing the cost of material in the polyester fabric relative to nylon 6.6 [4]. Airbags are made of compact, plain woven fabrics. Generally nylon 6.6 filament yarns are used to make the fabric [9].

Table 1. Comparison of key properties of nylon 6.6 and polyester [4]
(Tablo 1. Naylon 6.6 ve polyesterin önemli özelliklerinin karşılaştırılması [4])

	Nylon 6.6	**Polyester**
Density (kg/m^3)	1140	1390
Specific heat capacity (kJ/kg/K)	1.67	1.3
Melting point (°C)	260	258
Softening point (°C)	220	220
Energy to melt (kJ/kg)	589	427

Table 2. Typical yarns and constructions being used in airbags [9]
(Tablo 2. Hava yastıklarında kullanılan tipik iplikler ve konstrüksiyonlar [9])

Yarn counts (denier)	Warp yarns per cm	Weft yarns per cm
210	72	72
315	60	60
420	49	49
525	43	44
630	41	41

The amount of fabric needed to construct an airbag depends upon on its position in the car and the market that it serves [12]. The size of the cushion varies from 35 to 70 liters for the driver side airbag and from 60 to as much as 160 liters for the passenger side airbag [8]. Fabric weights, uncoated are about 170 and 220 g/m^2 [10].

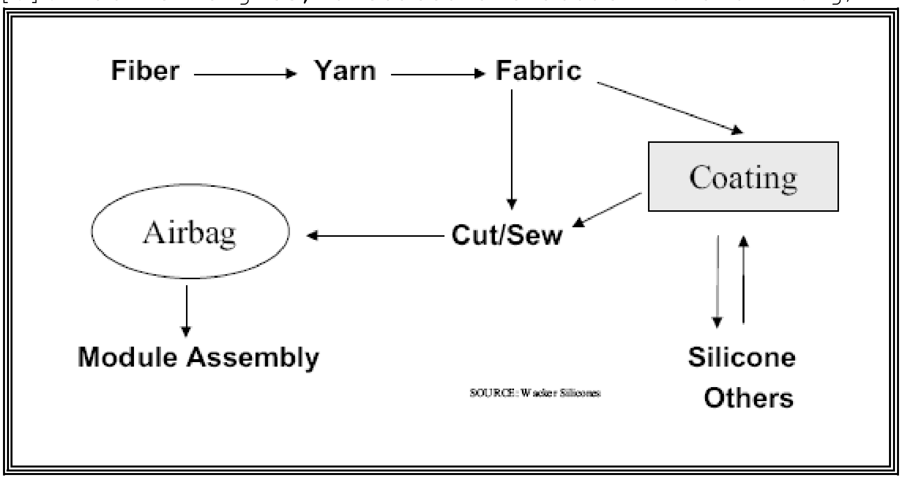

Figure 3. The airbag processes-a textile perspective [9]
(Şekil 3. tekstil açısından hava yastığı prosesleri [9])

The airbag fabric must be strong with high tear strength, high anti seam slippage and needs to have controlled air permeability [10]. In addition to the demanding functionality, the systems are constrained further as the airbag cushions are designed to be stored in steering wheels, under instrument panels or inside the roof rails with replacement periods of up to 15 years. The performance of the airbag cushion is expected to remain essentially unchanged over this period, and in consequence, reliable and predictable behavior of the cushion's constituent materials is essential [4].

3.3. Finishing Processes (Bitim İşlemleri)

To facilitate weaving nylon fabric contains about 10% acrylate size and 1.5% mineral oil. After weaving the fabric is subject to scouring process to move away these deposits since an airbag fabric of serviceable quality should hold 0.3% or less of these deposits [12].

Permeability of airbag fabrics can be controlled by coating. When a coating is applied as a continues layer, any route through the fabric pores is blocked [12]. In first airbags neoprene rubber was used but in efforts to make bags both lighter and thinner to fold up into a compact pack, silicone coatings soon followed [10].

In recent years, uncoated airbags have been developed to supersede the popular coated airbags with their inherent drawbacks such as excessive thickness, an inability to be folded and packed into small spaces and degradation over time. Uncoated airbags rely on permeable woven fabrics as their principal material of construction and release gas through the fabric pores. In this regard, the air permeability of airbag fabrics will significantly influence the performance and safety of uncoated airbags. During inflation, low permeability is absolutely necessary for uncoated airbags to deploy promptly to cushion the occupant. However, facial burns due to excessive leakage of hot gas through airbags still occur and so precise control and prediction of the permeability of airbags are essential [13].

However there are advantages and disadvantages for both coated and uncoated fabrics. Coated fabrics do not fray, are easier to fray, are easier to cut and sew and air porosity can be controlled better. Non coated fabrics are lighter, softer, less bulky and can be recycled easily [10].

When airbag material has been finished, it is cut into panels, which are then sewn together. The best method of cutting coated and uncoated airbag material is by using a laser [12]. Lasers have the potential for faster joining rates and increased productivity. A laser welded seam; it is instantaneous so that the airbag material is not melted by the high temperature gas released by the explosion when an airbag is activated, in contrast to the gradual failure of "cut and sew" joints that can melt the material [2].

When a bag has been sewn it is folded inside its cover. The fabric is folded with extreme care to ensure smooth deployment. A variety of folds are suitable including the accordion fold, reversed accordion fold, pleated accordion fold and overlapped folds. Lastly a cover can be fitted over the bag to protect it from abrasion [12].

4. RESULT (SONUÇ)

Airbags were first introduced in the late 1960s. During the 1970-80s, automakers resisted airbags. By the late 1990s frontal airbags were standard in new cars in the US market, and automakers quickly began offering optional side airbags. Now head-protecting side airbags are in nearly 70 percent of new cars, and some manufacturers offer knee airbags. There is no doubt that airbags save lives and the number of lives saved has increased year by year. Aside from saving lives, the airbag has also led to a new market in automotive safety representing $4 bn annually with continued double-digit annual growth expected through the next decade.

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REFERENCES (KAYNAKLAR)

1. Witteman W.J. and Shuler S., (2004). Development Process of Seamless Airbag Covers, TU/e Internship Report. July, pp:1-77.
2. Rooks B., (2004). Laser Processing of Plastics, Industrial Robot. Volume:31, Number:4, pp:338-342.
3. http://www.autoliv.com, (accessed November 2007). Autoliv Homepage.
4. http://www.dupont.com, (accessed December 2007). Materials Selection for Airbag Fabrics, Dupont Technical Report.
5. Horrocks, A.R. and Anand, S.C., (2004). Handbook of Technical Textiles. England: Woodhead Publishing Limited.
6. How Airbags Went from Controversial to Commonplace, Insurance Institute for Highway Safety Status Report, Volume:42, Number:1, pp:7.
7. Deaths Caused by Inflating Airbags Have Declined Dramatically, Insurance Institute for Highway Safety Status Report, Volume:37, Number:4, pp:7.
8. http://www.carseatscolorado.com, (accessed December 2007). Technical Update, November 2003, pp:2.
9. Smith W.C., (accessed December 2007). Automotive Airbags, What Now?, http://www.intexa.com.
10. Fung, W. and Hardcastle, M., (2001). Textiles in Automotive Engineering. England: Woodhead Publishing Limited.
11. Keshavaraj, R., Tock, R.W., and Nusholtz, G.S., (1996). A Realistic Comparison of Biaxial Performance of Nylon 6,6 and Nylon 6 Fabrics Used In Passive Restraints-Airbags. Journal of Applied Polymer Science, Volume:61. pp:1541-1552.
12. Mukhopadhyay, S.K. and Partridge, J.F., (1999). Automotive Textiles. England: Alden.
13. Wang, X.H., Kainuma, M., Bao, L.M., and Nakazawa, M., (2006). A Novel Approach for Evaluating the Air Permeability of Airbag Fabrics. Textile Research Journal, Volume:76, Number:1, pp:66-70.