ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

A REVIEW ON TEXTILES IN SPACE PROTECTION EQUIPMENTS

SUNTER EROGLU Nilsen[1], YUKSELOGLU Sevhan Muge[2], CANOGLU Suat[3]

[1] Marmara University, Institute of Pure and Applied Science, Goztepe, Istanbul, Turkey
E-Mail: nilsensunter@gmail.com

[2] Marmara University, Faculty of Technology, Department of Textile Engineering, Goztepe, Istanbul, Turkey,
E-Mail: myukseloglu@marmara.edu.tr

[3] Marmara University, Faculty of Technology, Department of Textile Engineering, Goztepe, Istanbul, Turkey,
E-Mail: scanoglu@marmara.edu.tr

Corresponding author: Canoglu, Suat, scanoglu@marmara.edu.tr

Abstract: *Astronauts need the lander for decelerate and bridle the speed when they land on the space surface slowly. This lander could be controlled velocity magnitude in any direction or orientation and provide protection. The landers consist of airbags and parachutes. The airbag is a type of vehicle safety device, have a soft cushioning and is an occupant restraint system. The parachute provides to slow the motion of an object through an atmosphere by the hauling. Space protection equipments must have some properties because of astronaut's entry, descend and landing in safely. Textiles in airbags provide these properties especially which are light weight, low gas permeability, high strength, low cost, low temperature flexibility and low coefficient of friction. For textiles in parachutes must have properties such as smooth, porosity, air permeability, high strength, cost-effective, stability light weight and good in drag and lift. Airbags and parachutes in space protection equipment's are improved in systems provide easy stability. Recently, inflatable technologies for space protection equipments plays a fundamental role in building re-entry capsule. It can be performed a variety of pre-flight analyses to ensure the success of the tests of protection systems from day to day. In this review, space protection systems, their textile materials and properties, their advantages and disadvantages are presented.*

Key words: *Airbag, Parachute, Space lander, Bridle, Protection*

1.INTRODUCTION

Space is defined as located the remaining portion of the universe infinite emptiness, outside the earth's atmosphere and between celestial bodies. For space exploration, space travel must be organized. Space travel generally begins with rocket firing on the earth, passing to gravity, go out of atmosphere and then return after a while. After space travel, astronauts need a safe entry, descent and landing for returning to earth. So, they need to use space protection equipments such as airbags and parachutes.

2.AIRBAG

An airbag is a type of vehicle safety device, have a soft cushioning and is an occupant restraint system. The airbag module inflates extremely rapidly then quickly deflates during a collision and in this way, it prevents impact-caused injuries [1]. Airbags should have a chemical explosion to inflate the airbags immediately. The chemicals used such as the nitrogen gas finally inflates the airbags in 30-40 milliseconds [2].

2.1. Textiles Used in Airbag

Airbags fabrics must have some characteristic properties such as low air permeability, light fabric weight, low fabric thickness and high fabric breaking strength and breaking extension [3]. Generally, [3], [4], [5], [6] airbag fabrics are made of a synthetic yarn. The airbags used in are mostly a rubberized polyamide fabric because of low level of air permeability. Instead of polyamide yarns, it can also be used polyesters, vinyl polymers, polyolefins, rayon, polyoxymethylene, polysulfones, carbon fibers, glass fibers, ceramic fibers and metal fibers which must be rubberized. Rubberizing production is very important because it makes the fabrication of the airbag complicated and expensive, and increases the space required by the folded airbag [3]. Mostly used rubberizing polyamide yarns for the airbag fabric woven from nylon 6, 6 ranging from 420 to 840 deniers [5], [6]. The fabric which is used to make passenger airbag is normally uncoated and its weight is about 170 and 220g/m² [6], [7]. Airbag fabrics 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 [5]. Initially, airbags were coated by neoprene rubber, but recently silicon coated and uncoated varieties have been used in a lot because of both lighter and thinner to fold up into a compact pack [6], [7]. Coated airbags are preferred for driver seats because of slow wearing off, good resistance for burn, easily to cut and sewn, air porosity precisely controlled. Non-coated fabrics are lighter, low in cost, softer, smaller package and easier for recyclability [5], [6], [7].

2.2. Airbags Used in Space Protection Equipments

The Mars Pathfinder (MPF) airbag system firstly was landed in 1997 and landing was achieved with a combination of bridle-mounted retro-rockets and an airbag impact attenuation system [9]. Airbags must be strong enough for descent to land on rocks or rough terrain and must be inflated in seconds before contact to surface [10]. MPF airbag system consisted of four separate airbags, each with six lobes (hold the airbag to lander) (see in Figure 1) and a gas generator [11], [12]. Connection between lobs is important, because it provides to landing forces for keeping the airbag system flexible and responsive to ground pressure. Materials in MPF airbags must have some characteristic properties to reliable fabrication processes for assembly. (see in Table 1). Airbag fabrics are generally [9], [10], [11], [12] produced from high strength of Vectran HS. Vectran with liquid crystal polymer has a better property for flex-crack/abrasion resistance. For the Vectran HS fabric, Kevlar 29, Technoro T-240 and Spectra 1000 can be used. The bridle consisted of a Kevlar tether [9], [10], [11. For the non-coating fabric structure, it is generally suggested to use an adaptable fabric [9], [12], [13] which is suitable for a smooth topography, has lightest gas retaining coating with a 50 × 50 plain weave of 200 denier in fineness (details in Table 2). For coating material, the low temperature silicone is selected [9], [13] because of constrain from gas with a thin coating and provide to lend itself well to assembly processes [9].

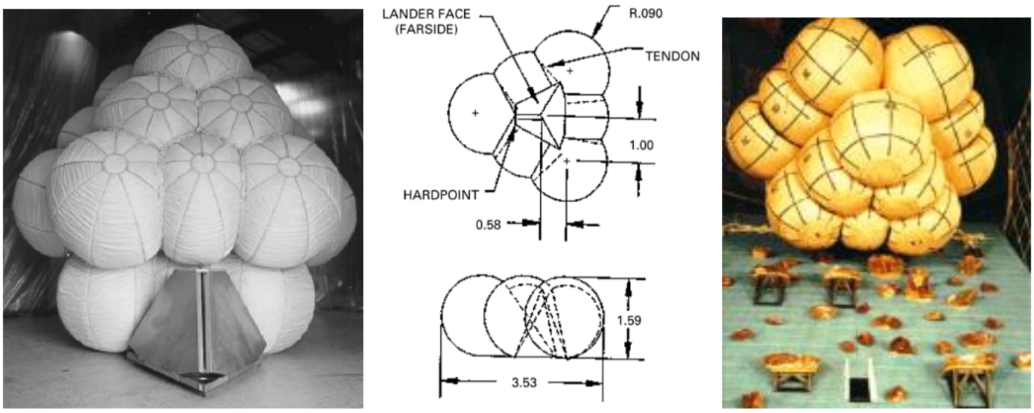

Fig. 1: *MPF airbag six lobes, MPF geometry and drop test in MPF airbags [9],[10,[11],[12]*

Table 1: *Fabric for MPF Airbag*

Fabric requirements of MPF Airbag	
Light weight	Low temperature flexibility
High tensile strength	Retention of strength after flex/crease
High tear strength	Low coefficient of friction
Low gas permeability	Low cost

Table 2: *Fabric Construction of MPF Airbag*

Type of MPF Airbag	**Fabric Construction**	
	Coated	**Non-coated**
Yarn Type	Vectran	Vectran
Yarn Denier	400-750	200
Weave	50x50 plain	
Tensile (lbs/inch)	485	485
Weight (oz/yd²)	4,3	2,7

3. PARACHUTE

A parachute provides to slow the motion of an object through an atmosphere by the hauling [14]. There are three principal stages in a parachute drop: deployment, inflation, and descent. The deployment means that eliminating of the payload from the aircraft and ends when the suspension lines and canopy could be transferred from deployment bag [15]. Parachutes rocket burns to motor in 3,5 seconds before launching the flare and flare burns for about 40 seconds while slowly descending [16].

3.1. Textiles Used in Parachute

Parachute fabrics must have some characteristic properties such as smooth, porosity, air permeability, high strength, cost-effective, stability light in weight, good in drag and lift [15], [16], [17], [18]. For parachute design, actuating and sensing technologies for feasibility of implementation are improved. These systems provide that very high mechanical flexibility, light weight, excellent bond between parachute canopy and sensor and very high strain limit [18]. Parachutes are usually made from silk or most commonly nylon [14]. Because the silk is so expensive for the use in parachute canopy, other fibres can be used either in whole or in admixture with silk [17] Nylon parachute fabrics are generally in 50-75 µm thickness [19]. Parachute fabrics could be woven [17] or knitted [20] structure. Parachute woven fabric has both adjacent warp and weft threads where a binder thread interlaces arbitrarily with other threads so it could be increase the permeability and tearing resistance of the fabric [17]. Parachute knitted fabric make from a combination of metallized polyester ribbons and synthetic plastic polymeric filaments knitted together. Polyester ribbons have a metallic coating thereon and metallic coating is aluminum [20].

3.2. Parachutes Used in Space Protection Equipments

Orion's parachute system helps to slow the spacecraft down during entry, descent and landing and ensure a safe landing for astronauts returning to earth [21], [22] Parachute loads are used with atmospheric density, velocity, parachute drag area, and mass. Parachutes must be produced with a high strength material and must be reasonably lightweight so it can be fit in well to a very small area. Before the space travel, they must be pressure packed and folded several times. Parachutes generally [21], [22] are made from Kevlar or Nylon fibers. For parachute's bridle Zylon and Kevlar fibers are used. Zylon bridles are sewn specifically in a webbing pattern, provides deployment and increased stability [21]. Parachutes are in four types which have different gauges, materials and properties (details in Table 3) (see in Figure 2)

Table 3: *Types of Orion Parachute Systems [22]*

Types of Orion Parachute System	Gauge	Material	Speed
1.Forward Bay Cover Parachutes	7 feet in diameter and 8 lbs.	100% Kevlar	475 feet per second
2.Drogue Parachutes	23 feet in diameter and 80 lbs.	Kevlar/Nylon hybrid material	450 feet per second
3.Pilot Parachutes	11 feet in diameter and 11 lbs.	Kevlar/Nylon hybrid material	190 feet per second
4.Main Parachutes	116 feet in diameter and 310 lbs.	Kevlar/Nylon hybrid material	265 feet per second

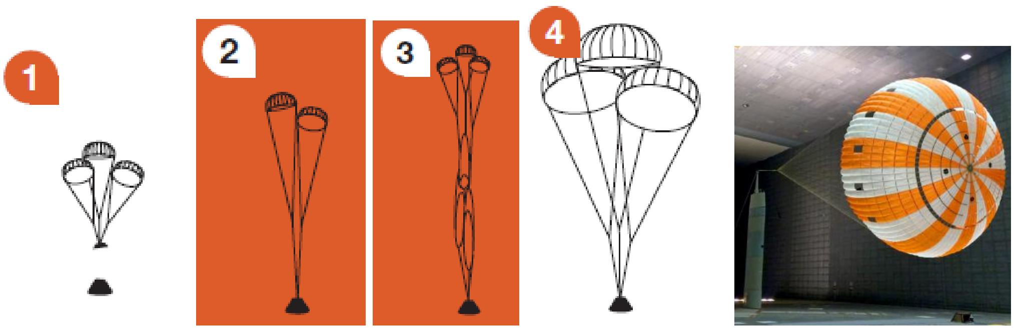

Fig. 2: *Types of Orion Parachute Systems and Parachute Testing [22]*

4.ADVANTAGES AND DISADVANTAGES OF SPACE PROTECTION EQUIPMENTS

Airbags and parachutes in space protection equipment's are improved in systems provide easy stability. The engineers performed a variety of pre-flight analyses to ensure the success of the tests of protection systems [23]. Recently, inflatable technologies for space protection equipments plays a fundamental role in building re-entry capsule [24]. These technologies have advantages such as low volume and mass, easily reconfiguring [24], high strength, good resistance [5],[18]. However, inflatable re-entry capsule has some disadvantages about design process such as aero-thermodynamics, material sciences, shield design, multi-body mechanics, inflatable structures blow up simulation and stress analysis. In re-entry and descent times, high stress in capsule can be affect easily to design. Structure of the re-entry capsule could be deformed and stressd when it imposed to loads, stiffness and strength [24].

5. CONCLUSIONS

Airbags and parachutes in which space protection equipments have offered highly important criteria for space travel because of safe entry, descent and landing. Textiles in space protection equipments must have light weight, high strength, low cost, flexibility, stability, foldable and good resistance to provide successful performance. Their performances can be improved by using advanced textiles and designs in airbags and parachutes from day to day.

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