REPUBLIC OF TURKEY

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GRADUATE SCHOOL OFNATURAL & APPLIED SCIENCES

INVESTIGATION OF THE EFFECTS OF POLYESTER YARN PRODUCED FROM STAPLE FIBERS HAVING DIFFERENT CROSS SECTIONAL SHAPE ON DIFFERENT WEAVING STRUCTURES

M.Sc.THESIS

IN

TEXTILE ENGINEERING

BY

ALİ IBRIKCI

SEPTEMBER 2019

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M.Sc. in Textile Engineering

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Ali IBRIKCI

ABSTRACT

INVESTIGATION OF THE EFFECTS OF POLYESTER YARN PRODUCED FROM STAPLE FIBERS HAVING DIFFERENT CROSS SECTIONAL SHAPE ON DIFFERENT WEAVING STRUCTURES

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Each fiber cross section gives a different characteristic to the yarn. By changing the fiber cross-sectional structure, studies of adding different functional properties in fibers are rapidly increasing. Examples include; such as cold-holding fibers, hot-holding fibers, anti-static fibers. With these features, the use of functional fibers developed in textile fields such as technical textiles and medical textiles is rapidly increasing.Inspired by this, in this thesis, weaving and fiber cross section structures are changed to reveal different fabric characteristics and to create inspiration for new special fabrics in different textile areas.In this study, the performance and comfort features, water vapor permeability, abrasion resistance, drape and brightness of the fabrics woven from different cross sectional shaped polyester fibers were examined. A total of sixteen woven fabrics were produced in four different weave patterns (plain, twill, sateen and basket) from polyester yarns of four different fiber cross sectional shapes (oval, scalloped oval, blending scalloped oval and hollow, hollow). Polyester yarns were produced in the same number by using fibers in different cross sections. Fabrics were produced in different weaving structures with these yarns and fabrics woven with yarns having these different cross-sections were examined to give which characteristics on the fabric structure and fabric surface.

KeyWords : Cross Section of Fibers,Weave Pattern, Polyester Yarn

ÖZET

FARKLI KESİTLERE SAHİP KESİK ELYAFLARDAN OLUŞAN POLYESTER İPLİKLERİNİN FARKLI DOKUMA YAPILARI ÜZERİNDEKİ ETKİLERİNİN İNCELENMESİ

IBRIKCI, Ali
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86 sayfa

Her bir lif kesiti, ipliğe farklı bir özellik kazandırmaktadır. Elyaf kesit yapısını değiştirerek elyaflarda fonksiyonel farklı özellik katma çalışmaları hızla artmaktadır. Bunlara örnek; soğuk tutan lifler, sıcak tutan lifler, ve antistatik lifler gibi. Bu kazandırılan özelliklerle de teknik tekstiller, medikal tekstiller gibi tekstil alanlarında geliştirilen fonksiyonel elyafların kullanımı hızla artmaktadır. Esin kaynağı olarak bu tezde, farklı dokuma özelliklerini ortaya çıkarmak ve farklı tekstil alanlarındaki yeni özel kumaşlarda ilham oluşturmak için farklı dokuma yapıları ve elyaf kesit yapıları kullanılmıştır.Bu çalışmada, farklı kesit şekilli polyester liflerden dokunan kumaşların performans ve konfor özellikleri, su buharı geçirgenliği, aşınma direnci, dökümlülük ve parlaklığı incelenmiştir. Dört farklı elyaf kesit şekli (oval, taraklı oval, taraklı oval ve içi boş karışımı, içi boş) polyester ipliklerden dört farklı dokuma deseninde (düz, dimi, saten ve panama) toplam on altı dokuma kumaş üretildi. Farklı kesitlerde elyaflar kullanarak aynı numarada polyester iplikler üretilmiş, bu üretilen ipliklerle farklı dokuma yapılarında kumaşlar üretilmiş ve bu farklı kesitlere sahip ipliklerle dokunan kumaşların, kumaş yapısı ve kumaş yüzeyinde hangi özellikler verdiği incelenmiştir.

Anahtar Kelimeler: Elyaf Kesit Yapıları,Dokuma Deseni, Polyester İplik

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LIST OF ABBREVIATIONS

PES	Polyester
PET	Polyethylene terephthalate
PCDT	Poly-1,4-cyclohexylene-dimethylene terephthalate
PSF	Polyester staple fiber
SD	Semidull
HCS	Hollow conjugate siliconised
SDOB	Semidull optical bright
HCSNS	Hollow conjugate slick non siliconised
SMD	Geometrical roughness
OP	Oval plain
BSOHP	Blending scalloped oval and hollow plain
SOP	Scalloped oval plain
HP	Hollow plain
OT	Oval twill
BSOHT	Blending scalloped oval and hollow twill
SOT	Scalloped oval twill
HT	Hollow twill
OS	Oval sateen
BSOHS	Blending scalloped oval and hollow sateen
SOS	Scalloped oval sateen
HS	Hollow sateen
OB	Oval basket
BSOHB	Blending scalloped oval and hollow basket
SOB	Scalloped oval basket
HB	Hollow basket

CHAPTER 1

INTRODUCTION

1.1 Introduction

Synthetic fibers are one of the most widely used petroleum-derived fibers in the textile field and their manufacture amounts are growing rapidly. In 2010, 45 million tons of synthetic fibers were manufactured annually. The global market size of synthetic fibers is expected to expand at an annual compound growth rate of 7.25% between 2018 and 2023 [1]. Trading synthetic fibers are usually oval cross-sectional structures. Additionally, changes in spinneret systems can be made to modify the fiber cross-sectional structure to impart some different performance properties to these fibers [2].

Various studies have shown that changing the shape of the fiber cross-sections causes some differences in fiber propertiessuch asdrape and liquid transfer, luster, strength, pilling propensity, moisture,stiffness, bulkiness, flexibility, frictional and surface properties, soiling, flexuralrigidity, heat, handle, acoustic insulation properties [3-5]. Thus, synthetic fibers can provide new implementation fields both in classic textile products and smart textiles. Today, fibers produced with non-oval cross-sectional shapes roll in different textile products such as upholstery, carpets, thermal insulation products, sports wears, technical products, and sound absorption products, silk-like fabrics. Polyester fibers are one of the raw materials of these products where it is used in its non-woven, knitted, and woven [6].

Polyester (PES) is in a very important position among synthetic fibers. The significance of polyester arise from both the indispensable properties it integrates to products (resistance to sunlight, high strength etc.) and it is common, easy and cheap production technology [7]. Various development studies are realized in the process of production regarding functional specialties. Headlines like improving products with new properties by using fibers with diverse cross-sectional structures, improvements of polymer colored filament can be shown as an example of these development activities [8].

The utilization of textile fibers with diverse cross-sectional form in textiles structures for some specific request such as bulkiness, abrasion resistance, handle, brightness, dyeing, coefficient of friction, thermal comfort, tenacity, surface properties, and bending rigidity. It is of great importance in recent times. The cross-sectional shape of the fibers has a major influence on the mechanical properties of the fibers. It also affects the features of yarns and fabrics produced from them. The cross-sectional forms of a synthetic fiber manufactured by the melt bending process can be easily changed by changing the shape of the spinneret head. Without the round cross-sectional shape, the trilobal cross-sectional shape is the most commonly used one in textile implementation, particularly in the production of fabrics with a silk-like touching [9-13].

Cross-sectional shapes other than round cross-section polyester fibers; fibers with round, trilobal, squareand hollow cross-section are also used.These fibers are widely used for cleaning and separating artificial kidneys, various fluids and gases, carpets, garments and pillows [14-16]. Hollow fibers have different appearance, brightness, large volume and thermal insulation. The hollow fiber is more rigid and resists more twist than oval fibers of the same fineness [17,18].

Most of the studies on fiber cross-sectional form focus on its impacts on fiber processing behavior and fiber features [19]. Fewer studies show the effect of fiber cross-sectional shape on different fabric features like thermal comfort features, surface properties, moisture and liquid transfer properties,microwave absorbent properties,sound properties, abrasion resistance, bearing properties, gloss properties [20].

The tensile strength test in the fabric is utulizied both for quality control of the fabric and for the establishment of performance standards [21]. The tensile behavior of woven fabrics is known to be affected by its sett and construction. This influence, when clearly understood, would make the engineering of fabrics for tensile properties easier. In a study, tensile properties of polyester woven fabrics were characterized by fabric breaking load and elongation. According to statistical analysis, filling yarn density and weave structure was found to have a significant influence on the breaking load of fabrics woven from polyester fibers. An increasing trend is detected confirming that as the weft density increases, the breaking load of the fabric samples follow the same trend. It is also shown that weave structure has a profound effect on fabric breaking load. Polyester fabrics woven from plain structure showed the highest breaking load followed by fabrics with twill weaves and satin weaves respectively. Fabric samples with plain structure showed a higher breaking load; this is because the higher intersections associated with this structure . It is also apparent that woven micro polyester fabrics with weave structure plain 1/1 are associated with higher breaking elongation followed by twill weave and satin weave respectively. The higher elongation of plain fabrics can be ascribed to the higher intersections between warp yarns and weft, yarns in the fabric structure. The lower breaking elongation of satin weave fabrics may be related to the higher float length of the weft yarns in this type of fabrics [22].

Tear strength is one of the tests that demonstrates the most important physical properties of a fabric. The tearing can be described as successive breakage of yarns or groups of yarns along a fabric [23]. Tearing Strength (warp & weft both ways) sequence from lower to higher in the plain to twill weave. In a study, Plain weave performs less tearing strength where as 2/1 and 2/2 twill are stronger in tearing behavior. It is clear that due to lose constructions and fewer interlacing, where the yarns can easily move and bunch together, twill weave shows higher resistance to the applied force than plain weave because several yarns are broken simultaneously [24].

Abrasion is the mechanical deterioration of fabric components by rubbing them against another surface. One of the results of abrasion is the gradual removal of fibres from yarns. Therefore, the factors that affect the cohesion of yarns will influence their abrasion resistance. The float length in woven fabrics can affect their resistance to abrasion. Long floats in a weave are more exposed and will abrade faster, usually breaking the yarns. For example, a satin weave fabric will abrade more easily than a twill weave [25].

One of the comfort measurements that greatly affects the user is the air permeability, defined as the flow rate of the fabric per unit area when there is a certain pressure difference across the two sides [26]. Many factors, such as, thickness, yarn twist, yarn curl, fabric weave, porosity, fabric cover factor, fiber cross-section, and the amount of finish and coating applied to the fabric, can affect air permeability. Thermal properties are mainly affected by air permeability [27, 28].

A number of studies have been found examining the drape characteristics in the literature. The drift coefficients of twill fabrics are lower than plain fabrics. It can be stated that this situation occurs due to the fact that yarns have less intersection point compared to plain weave in twill weave structure and therefore, the yarns can move more easily and easily [29].

Water vapor transfer features of textile fabrics are of great importance in determining thermal comfort features of garment systems. Water vapor permeability is the skill to transfer vapor from the body [30]. Water vapor diffusion in fabric could be realized through inter-fiber spaces, inter-yarn spaces, and through the fiber substance itself. Fiber content,percentage fiber volume, thickness, and fabric geometry are the main factors that may affect the water/moisture vapor transmission of textiles.Water vapor resistance varies depending on the air permeability of the fabric and is the most significant factor in specified thermal comfort [30-32].

1.2 Objective of the Study

The purpose of this thesis is to examine the effects of woven polyester fabrics having different weaving structures in relation to different fiber cross-sectional shapes. Four diverse cross-sectional forms (oval, scalloped oval, blending scalloped oval and hollow, hollow) are used to weave the fabric. Also, four different weaving structures are used to examine in relation to fibers. Our aim is to examine the effects of polyester yarn on the different structure weaving. Inspired by this, in this thesis, weaving and fiber cross section structures are changed to reveal different fabric characteristics and to create inspiration for new special fabrics in different textile areas. In this light of the developments, it is our main aim to introduce new, commercial value-added products for our country.

1.3 Structure of Thesis

Chapter 2 is related to the polyester as a textile material. In this chapter, the definition of raw material, manufacturing process, properties of the polyester staple fiber, cross-section structures in polyester were explained. Chapter 3 is related to the structures of weaving fabric. Structural parameters of woven fabrics were also given in this chapter. The relationship between fabric structures and surface properties were explained. The materials used and the methods that were followed during the thesis were given in Chapter 4. All practices carried out, problems and their solutions were explained in this section. Also, the procedures of all tests carried out within the scope of the project were explained in this stage. Chapter 5 involves the results of fabrics with respect to their strength, air permeability, drape, brightness, water vapor permeability properties. The thesis was finally concluded in Chapter 6.

CHAPTER 2
POLYESTER AS TEXTILE MATERIAL

Polyester is a synthetic fiber derived from petroleum, water, air, and coal derivatives. The polyester fiber developed in the 20th century consists of a chemical reaction between acid and alcohol. As a result of this reaction, two or more molecules form a large molecule repeating along the length of the structure. With polyester fibers, very long molecules which are very stable and strong can be developed.

Polyester is utilized in the production of numerous products like garments, household goods, industrial fabrics. Polyester has many benefits over natural fabrics like cotton. Does not absorb moisture, absorbs oil; With this material, a perfect structure for forming water and fire resistant surfaces is created. It ensures resistant to stains due to the low absorbency [33].

2.1 History of Polyester

In 1926, the United States-based E.I. Du Pont de Nemours and Co. started to research on very large molecules and synthetic fibers. This early research led by W.H Carothers focused on the first synthetic fibers that became nylon. Soon after, between 1939-1941, British researcher chemists showed interest in du Pont's work and did their own research at the laboratories of Calico Printers Association, Ltd. This work led to the emergence of polyester fiber known as Terylene in the UK.

In 1946 DuPont acquired the right to manufacture these polyester fibers in America. The company did a little more developmental work and in 1951 started to market fiber under the name of Dacron. In the following years, several companies were interested in polyester fiber and manufactured their own model of the yield for diverse uses. Today, Polyester has two basic types model: PET (polyethylene terephthalate) and PCDT (poly-1,4-cyclohexylene-dimethylene terephthalate).The more popular PET can be applied to a wider range of uses. PCDT, although more elastic and flexible, is stronger than PCDT. PCDT is suitable for heavier consumer uses like furniture covers and sheathed. PET can be utilized alone or in compound with other fabrics to produce garments resistant to wrinkles and stains and retains shape [33].

2.2 Raw Material

Polyester is a chemical period that can be divided into a number of poly which express an ester, a basic organic chemical composition (see in Figure 2.1). The main substance used in the production of polyester is ethylene from petroleum. In this operation, ethylene is polymer, the chemical building block of polyester and the chemical process that manufactures the finished polyester is called polymerization.

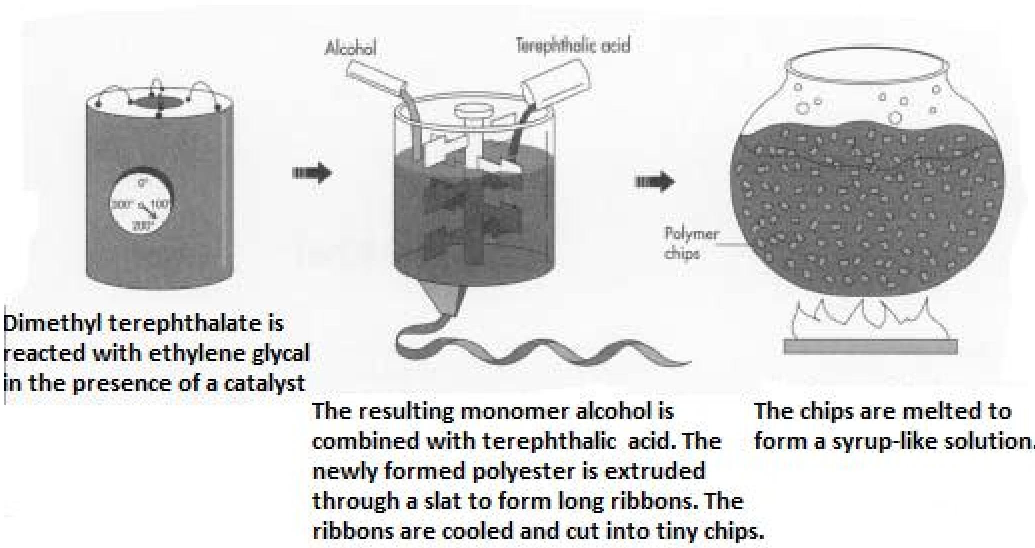

Figure 2.1 Formation of the polymerization [34]

2.3 The Manufacturing Process

Polyester is produced by one of several production methods. The four basic forms are staple, tow, fiberfill and filament. In the form of filaments, each polyester fiber yarn produces fabrics with a continuous surface and a straight surface. In the form of staples, filaments are cut into short form, predetermined lengths. In this form, polyester is easier to blend with other staple fibers. The tow form is formed by loosening the continuous filaments together. The fiber filling is formed from a quilt voluminous form. Used in the production of pillows and outerwear. The two most commonly used forms are filament and staple [35].

2.3.1 Manufacturing of Filament Yarn

i. Polymerization

To initiate the reaction in polyester formation, dimethyl terephthalate is first reacted with ethylene glycol with a catalyst at a temperature of 302-410° F (150-210 ° C).

The resulting chemical is combined with terephthalic acid, a monomer (single, non-repeating molecule) alcohol, and raised to 472° F (280° C). The newly formed, clear and molten polyester is squeezed through a slit to form long strips.

ii. Drying Process

When the polyester is removed from the polymerization, the long melt strips are allowed to cool to the breaking point. The material is cut with small chips and completely dried to prevent consistency irregularities.

iii. Melt Spinning Process

The polymer chips are melted at 500-518° F (260-270° C) to form a syrup-like solution. The solution is placed in a metal container called a spinneret and passed through small holes which are generally round but may be pentagonal or any other shape to produce special fibers (see in Figure 2.2). If the number of holes is more or less determines the diameter of the fibers, then the drawn fibers are brought together to form the yarn. During the drafting process, different chemicals may be added to the solution to impart properties such as flame retardant, anti-static or easy dyeing [36].

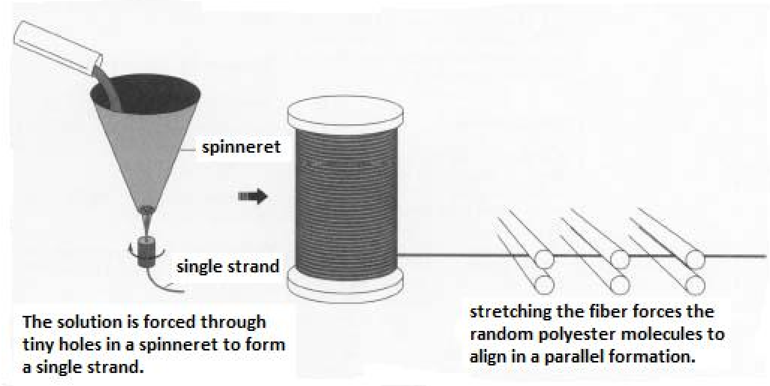

Figure 2.2 Formation of the filament yarn

iv. Drawingthe Fiber Process

The polyester is soft and can be extended up to five times its original length when it comes out of the spinneret. The strain forces the dispersed polyester molecules to be arranged in the same direction. This process increases the strength, flexibility and resistance of the fiber. This time, when the filaments dry, the fibers become solid and strong, rather than brittle.

The drawn fibers can change greatly in diameter and length depending on the requested properties of the finished article. In addition, when tis process is applied , fibers can be textured or twisted to form soft or dull fabrics.

v. Winding Process

After the drawing process of polyester fibers, it is wound into large bobbins or flat packages according to the next process such as weaving and knitting [37].

2.3.2 Manufacturing Staple Fiber

Polymerization, melting and drying processes are the same as in filament fibers production. Furthermore, the number of nozzle in the spinneret is higher during the melt spinning stage. The resulting rope-like bundles are called tow.

i. Polymerization

To initiate the reaction in polyester formation, dimethyl terephthalate is first reacted with ethylene glycol with a catalyst at a temperature of 302-410° F (150-210° C).

The resulting chemical is combined with terephthalic acid, a monomer (single, non-repeating molecule) alcohol, and raised to 472 ° F (280° C). The newly formed, clear and molten polyester is squeezed through a slit to form long strips.

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iii. Melt Spinning Process

The polymer chips are melted at 500-518° F (260-270° C) to form a syrup-like solution. The solution is placed in a metal container called a spinneret and passed through small holes which are generally round but may be pentagonal or any other shape to produce special fibers. The number of holes in the nozzle determines the size of the yarn as the resulting fibers are brought together to form a single yarn.

iv. Drawing Tow Process

Newly-formed tow is rapidly cooled in cans which combine thick fibers. Several lengths of tow are collected and then drawn three or four times the original length onto the heated rolls (see in Figure 2.3 and Figur 2.4).

Figure 2.3 Water bath drafting bath [38]

Figure 2.4 2nd and 3rd drafter[38]

The material is drawn about 4 times and the actual drawing or drawing takes place in the steam room or in the case of hot water. After drawing process, each filament has the required denier and all of the underlying microscopic chains are arranged parallel to the fiber axis, thus increasing the crystallinity of the fiber structure and perform a certain strength [38].

v. Crimping Process

Drawn tow is then brought up into pressing cabin, which strain the fibers to ply like an accordion, at a rate of 9-15 crimps per inch (3-6 crimps per cm). This improves to hold the fibers together during next production steps (see in Figure 2.5) [38].

Figure 2.5 Crimber[38]

vi. Setting Process

After the crimping process, it is heated at 212-302°F (100-150°C) to entirely dry the fibers and set the crimp. A part of the crimp will inevitably be drawn from the fibers during the behind operations.

vii.Cutting Process

After the setting process, tow fiber is divided into shorter lengths. Polyester that will be blended with cotton is divided in 3.2-3.8 cm pieces; for rayon blends,5 cm lengths are divided (see in Figure 2.6). For heavier fabrics, such as carpet, polyester filaments are divided into 15 cm lengths [38].

Figure 2.6 Cutter [38]

The tow fiber is wrapped on a cutter roller, at one side of the reel is a squeezer wheel which squeeze the tow on to the knives and the tow is divided.

Figure 2.7 Cyloid machine, tower spreader, relaxing heat setting machine [38]

The divided fibers come down by force of gravity and is usually partly opened up by a few air jets and eventually the fiber is baled.

Some bale machines have pre-weighting arrangements that allow bale to produce all bale with a predetermined weight.

Figure 2.8 Baler[38]

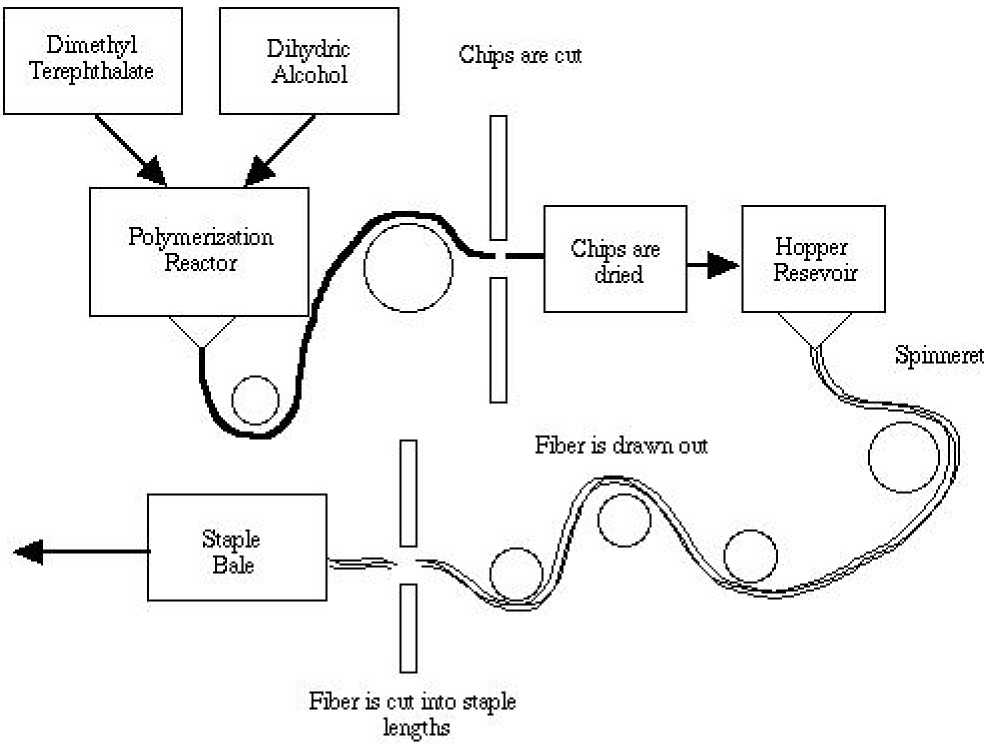


Figure 2.9 Polyester staple fiber production line [39]

2.3.2.1 Properties of the Polyester Staple Fiber

Polyester Fiber is a wide variety of fibers used in the production of many staple yarns. PSF is widely utilized for fiber fillings in pad and lounge. It is also widely used in the production of polyester yarns of knitted or woven fabrics.

PSF, except for oval horizontal sections; It is also produced as polyester fiber with hollow section. Hollow PSF can also have some features like conjugated, siliconized, lubricious and dry PSF. These features are generally symbolizied as HSC (hollow conjugated siliconized), HCNS (Hollow conjugate non-siliconized) or lubricious PSF that has a fluent finish. Depending on the brightness, PSF can be categorized as semi dull and bright. By integrating color master-batch, dope dyed PSF can also be procured in, black, optical white and variant colors.

Polyester staple fiber is existing in diverse deniers with diverse cut-lengths. It is mainly available in 1.4D, 1.5D, 3D, 6D, 7D, 15D and cut lengths like 32mm, 38mm, 44mm, 64mm. PSF is mainly produced in Indonesia, Vietnam, India, China, Malaysia, Korea and Taiwan [39].

Table 2.1 Properties of the staple fiber [40]

DENIER	CUT LENGTH (mm)	LUSTER	APPLICATION
1.2, 1.4, 1.5	32, 38	SD	Non Woven Spinning
2, 2.25, 2.5, 3, 6.15	32, 38, 51, 64	SD	Non Woven Spinning
1.2, 2	38, 51	BRIGHT	Sewing Thread
1.2, 1.4	38	SDOB	Luxury Spinning
6, 7, 15	32, 38, 51, 64, 76,102, 128	HCS	Filling
2, 7, 15	32, 38, 51, 64, 76, 102, 128	HCSNS	Filling
6, 7, 15	32, 38, 51, 64, 76, 102, 128	HOLLOW SILICONISED	Filling
6, 7, 15	32, 38, 51, 64, 76, 102, 128	HOLLOW SILK NON SILICONIZED	Filling
1.5, 2, 3, 4	32, 38, 51, 64, 76, 102, 128	SOLID NON SILICONSED	Spinning Non-woven Fabric
6, 7, 9, 15	32, 38, 51, 64, 76, 102, 128		
6, 7, 9, 15	32, 38, 51, 64, 76, 102, 128	HOLLOW DRY	Non-woven Fabric
6, 7, 9, 15	32, 38, 51, 64, 76, 102, 128	HOLLOW CONJUGATE DRY	Filling

2.4 Cross Section Structures in Polyester

Man-made fibers must also show a textile character if they are to be used in the textile field. They are therefore often formed with non-round sections such as indented, star-shaped, triangular, polygonal, etc. They can also be made hollow-formed. The fibers section mainly influences the yarn volume, feel, insulating ability, luster, and working performance in processing [41].

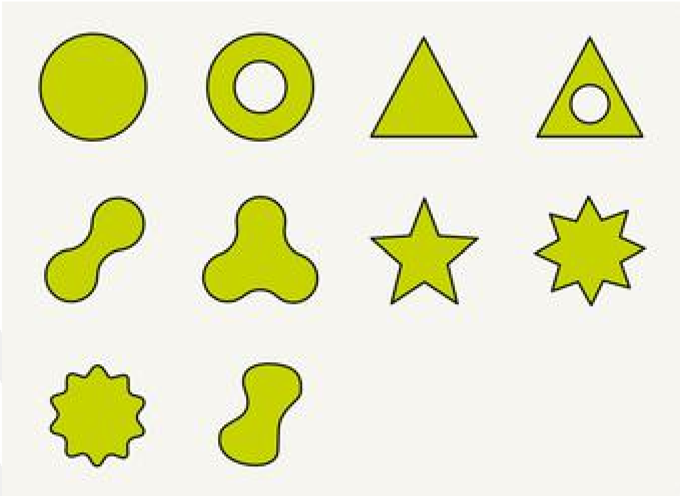


Figure 2.10 Some types of man-made-fiber cross-sections [41]

The simplest and common shape is a round, but by modifying the shape of the spinneret, oval, square, and bean-shaped fibers can be set up. One can even make a hollow fiber. The different shapes influence the strength and hand of the fiber.

Today, the round fiber cross-section is the most extensive form produced by synthetic fiber manufacturers. Other shapes are performance, comfort, pilling tendency, size, tactility, processing etc. As it has begun started to exist for various reasons.

In this article, we will analyze the contribution of fiber cross-sectional shape to the physical features of the fabric surface.

Fabric which are affected by the shape of the cross-section has many special features. Bulk, pilling, crease recovery, abrasion resistance, luster, handle, dyeing are just a few of the features that the user should consider in his decision making for the choice of a clothing. Specified cross-section has not all the desired properties for every user. One of the most important advantages of using changed cross-sectional fibers is possibly rigid stiffness. Different degrees of fabric softness, drape, clarity and stiffness are possible with fiber cross-section [42].

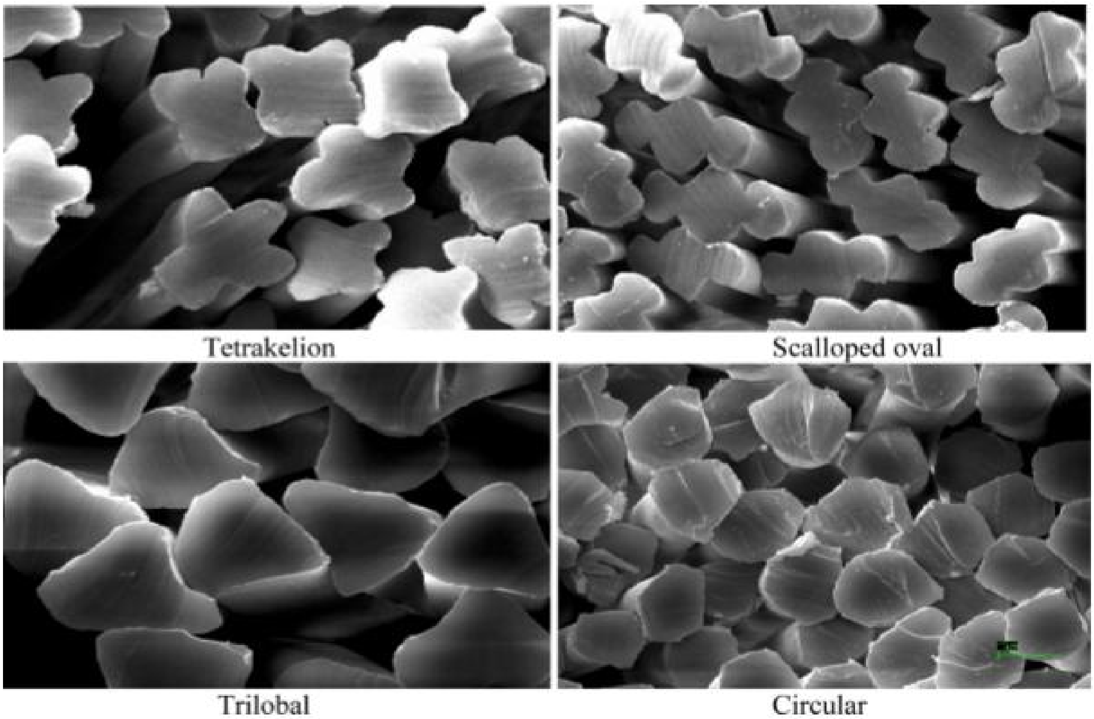
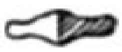
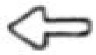


Figure 2.11 Scanning electron micro graphs of cross-sections of different polyester fibers [42]

Table 2.2 Examples of specialized cross-section [43]

Cross-section	Basic technology	Specialities of the product
	Hollow, triangular, thick and thin	Higher bending stiffness, mild color
	W-shaped, self crimping	Bulky, crispy, dry and cool hand
	Pentagonal cross section	Mild luster, dry hand and water-absorbent
	U-shaped cross-section, thick and thin.	Mild luster, dry, spun-yarn like and bending stiffness
	Flat cross-section, self-crimping	Deep color, bulky and higher bend-ing stiffness
	Arrow-like cross-section.	Dry and cool hand
	Random and multi-shaped cross-section	Dry hand, natural appearance, higher bending stiffness

CHAPTER 3

STRUCTURES OF WEAVING FABRIC

Fabric structures have a significant effect on their physical properties. Therefore, the fabric structural properties are widely referred to under three subtopics as follows:

1. Estimation of physical and mechanical properties of weaving fabric
2. Education and understanding related to the weaving fabric structural design
3. The area related to the fabric and clothing CAD systems

Among these, many textile scientists have researched the fabric structure together with the physical and mechanical properties of the fabric. However, only the theoretical aspects of education and understanding of fabric structure design were emphasized [44]. In this section, structural properties of fabrics, some fabric structures and some technical calculations will be mentioned.

3.1 Characteristics and Properties of Fabric

To form the fabric, first it is necessary to form yarn from the fibers. The yarns consisting of fibers are intertwined (in woven, knitted or non-woven forms). By combiningthese yarn forms, fabrics with different properties are obtained.

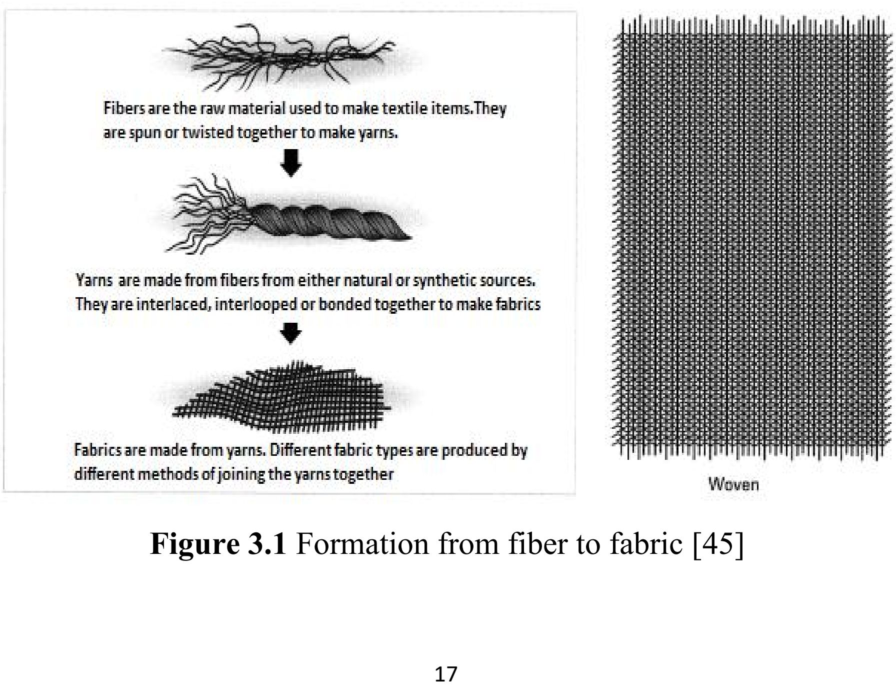


Figure 3.1 Formation from fiber to fabric [45]

Woven fabrics are formed by combining interlaced yarns at an angle of 90 degrees using weaving machines. The most powerful fabrics in terms of structural properties are woven fabrics. To start the weaving process with yarns, the loom is first installed with yarns extending from the top of the loom to the bottom. These are called warp yarns. A second yarn is then threaded from side to side, over and underneath warp yarns, to weave fabric. This is called the weft yarn [45].

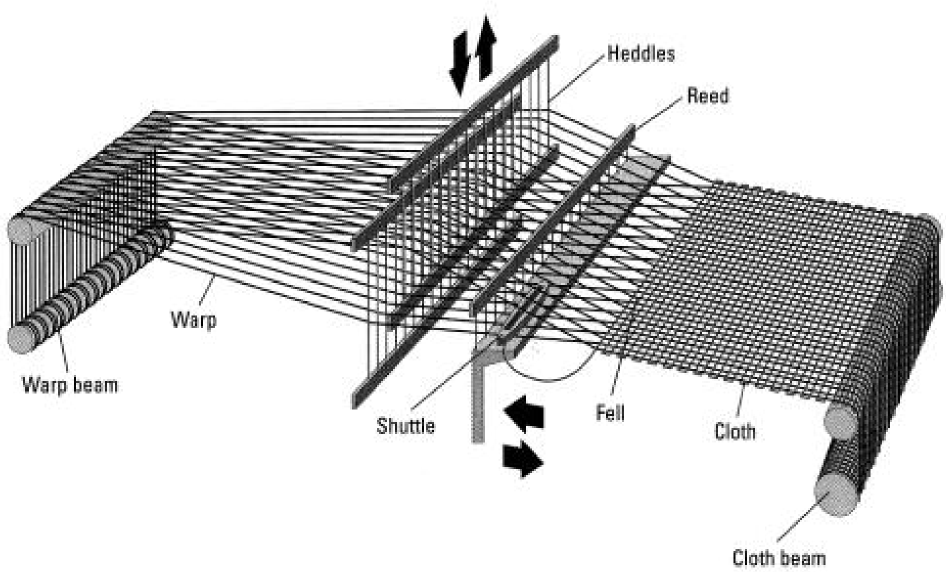


Figure 3.2 Weaving loom

In the weaving process, the so-called weft thread is thrown by the shuttle to the bottom of the warp thread at an angle of 90 degrees. For each weft insertion, the warp threads connected to the frame are open. This is called opening the mouthpiece. The weft is passed through the opened shed, then the weft is pressed with a reed. This completes a weft insertion.

When the weft insertion process is finished, the position of the warp yarns connected to the frames for the second repeat step is changed, and the same process is repeated. This process continues until the fabric according to the specified weaving report. Weaving types can be changed to add different appearance and characteristics to the fabrics. These types are woven types such as satin, twill, plain, sateen. The weft and warp yarns may vary depending on the selected weaving type [45].

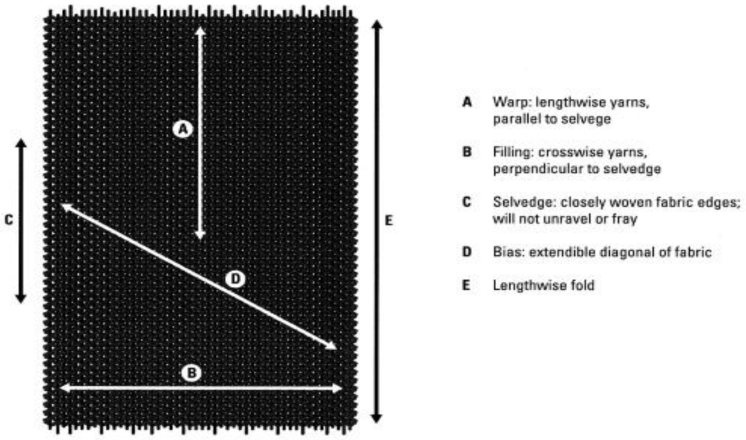


Figure 3.3 The parts of a piece of woven fabric [45]

3.2 Plain Weave

It is the most economical and easy to produce weave. In a plain weave, each warp yarn passes alternatively over one weft and then under the second weft yarn. They need only two heald shafts or harnesses because the weave repeats every two ends and two picks. When one heald shaft is raised the other is lowered, and then the sequence is reversed for the next pick [46].

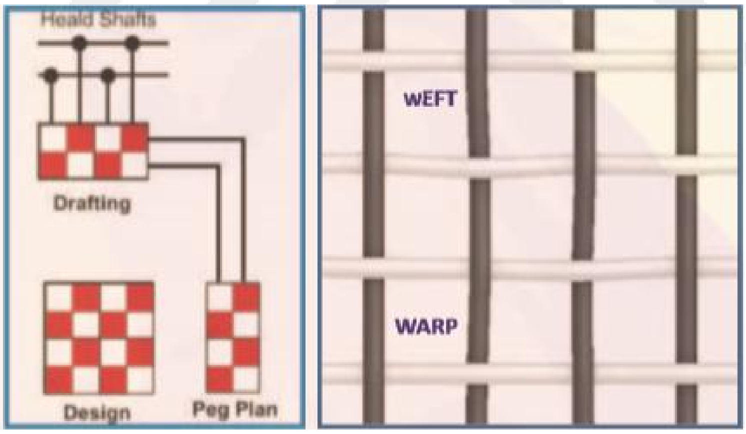


Figure 3.4 Interlaced 1 of warp & weft [46]

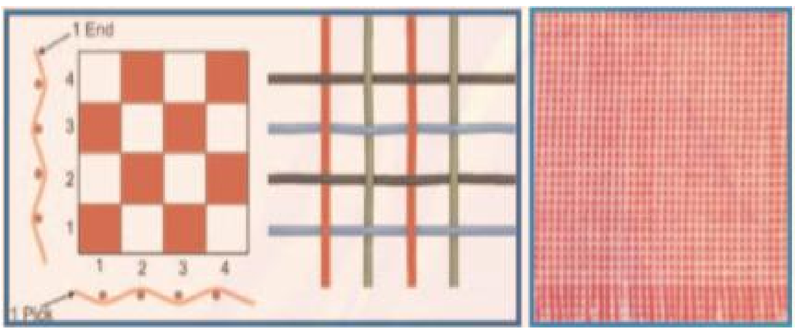


Figure 3.5 Interlaced 2 of warp & weft [46]

Plain weave is the fluency of interlacing, thereby producing a fabric of firm structure. The yarns in this weave are not easily displaced and are more resistant to slipping.

3.2.1 Derivatives of Plain Weave

Plain weave has the simplest form of interlacing and many variations of weaves could be produced from the simple plain weave by extending it either horizontally, 0 they may be called regular warp or weft rib or irregular warp or weft rib, similarly regular matt or irregular matt weave depending upon the ratios of warp and weft is selected for the construction of the weave [46].

3.2.1.1 Warp Rib

The Warp rib weaves are constructed in which each end passes alternately over and under two or more than two picks. Effect of the warp rib can be seen prominently from both the sides of the fabric.

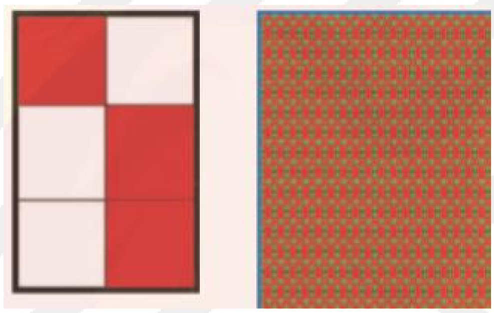


Figure 3.6 2 x 1 warp rib, the rib effect is produced in weft direction [46]

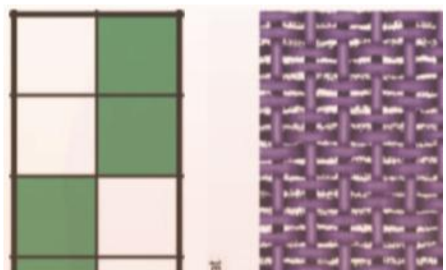
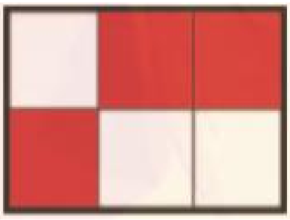


Figure 3.7 Warp rib weave [46]

3.2.1.2 Weft Rib

The weft rib weaves are constructed in which each end passes alternately over and under two or more than two ends. When the 2 ends are lifted alternately the result would be 2 x 2 weft rib. If the lifting is done by 3 ends and 4 ends the resultant weaves would be 3 x 3 and 4 x 4 weft rib respectively. The weft rib can be identified by the fact that the formation of the rib is always in warp direct which can be seen very prominently [46].



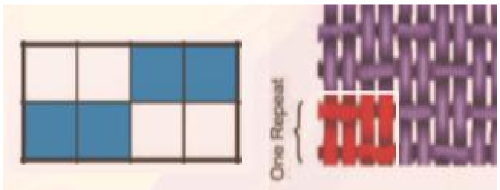


Figure 3.8 2 x 1 weft rib and 2 x 2 weft rib [46]

During the weaving, the warp rib or weft rib effect can be obtained by using one thick pick or one coarse end instead of two or more picks in a shed or two ends taken up in single eye of the drafting in the heald shaft during weaving as one respectively Figure 3.8.

3.2.1.3 Matt or Hopsack or Basket Weave

Matt weave is also the most popular weave as one of the derivatives of plain weave in the textile industry. They are made by extending a plain weave structure both warp way and weft direction. If the two or more ends working as one single ends and two or more picks in a shed then a Matt weave is produced. The simplest and most commonly used weave is 2 x 2 Matt also known as Basket or Hopsack weave as depicted in Figure 3.9. Grouping of the yarns in an irregular manner in warp direction or weft direction will produce the effects that are known as irregular Matt weave. Similarly 3 x 3, 4 x 4 or more Matt weaves can be constructed.

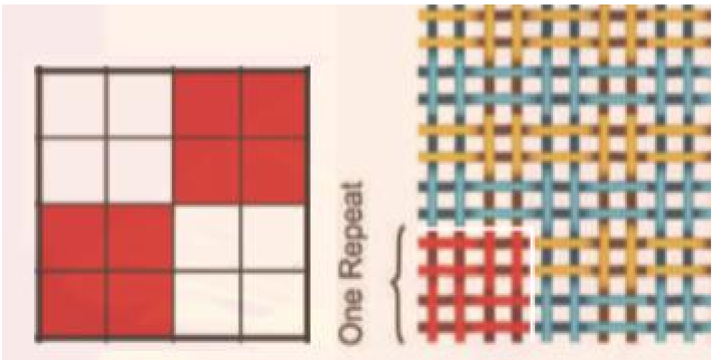


Figure 3.9 2x2 matt weave [46]

3.3 Twill Weaves

Twill weaves can easily be identified by its general characteristic of more or less pronounced diagonal lines in either warp or weft direction. The most commonly known twill is the denim fabric.

3.3.1 Characteristic of Twill Weaves

Twill weaves can easily be identified by its general characteristic with its series of more or less pronounced diagonal lines in either warp or weft direction, or in equal or quantities on both sides of the cloth. Twill with 3 ends and 3 picks with lifting of 1 /2 twill or 2/1 twill Figure 3.10 is the smallest twill weave repeats. The twill lines can be made continuously either from left to right in / direction as shown in Figure 3.11 and is called ‘Right Hand Twill’ or ‘Z Twill’ and a twill which runs from right to left in \ direction as shown in Figure 3.12 and is called ‘Left Hand Twill’ or ‘S Twill’ [46].

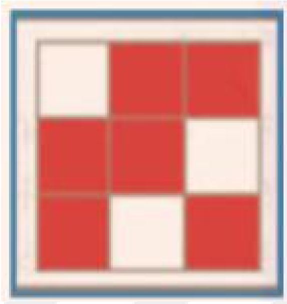
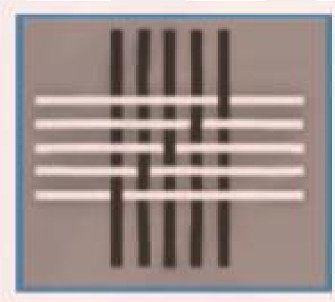


Figure 3.10 2/1 Twill weave [46]



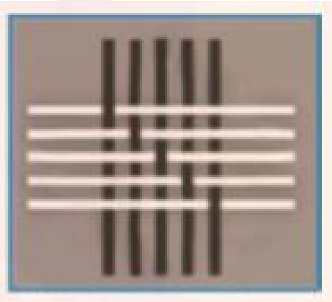
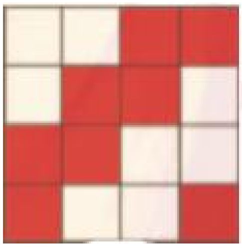


Figure 3.11 Right Hand Twill **Figure 3.12** Left Hand Twill [46]

3.3.2 Balanced Twills and Un-balanced Twill

In a balanced twill (Figure 3.13) the number, size and distribution of the warp or the weft floats are similar, and whereas in Un-balanced (Figure 3.14) twill either warp or the weft floats may be very prominent.



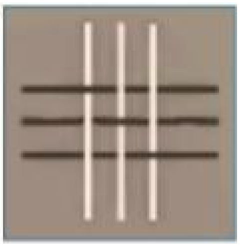


Figure 3.13 Balanced twill **Figure 3.14** Un-balanced twill

There are other classes of twill weaves derived from the basic twills known as Regular twills, Steep Twill, Flat and Elongated twills, Combination of twills, Broken twills, Pointed twill, Wavy or Zigzag twill, Herringbone twill, and Fancy twill weaves. A 3-ends twill with 2/1 lifting is represented in Figure 3.15 with its naturalistic interlacement for easy identification [46].

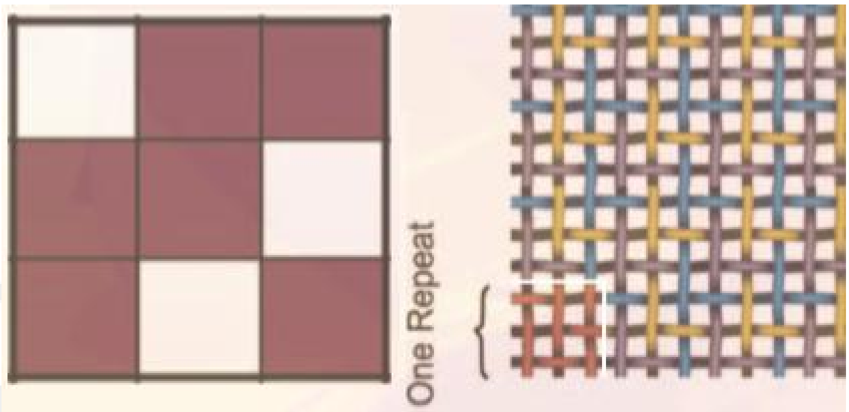


Figure 3.15 3-Ends twill weave

3.4 Sateen and Satin

The Sateen fabric has a characteristic luster, sheen on the surface. This chapter introduces the sateen weave design. It will teach the students the ways of representing the same on the design paper. The production of sateen requires certain rules. The chapter will introduce the students to these rules. It will teach them to make various regular and irregular structures of sateen. At the end of the chapter the student will be ready for weaving the sateen and satin weave swatch [46].

3.4.1 Construction and Characteristics of Sateen / Satin Weave

A sateen weave is predominantly a weft faced weave, whereas satin is a warp dominant fabric. It is constructed by choosing a move number. Selection of move number (intervals of selection) depends upon various factors to get a regular sateen and satin.

Principles of construction of sateen and satin are dependent upon the following rules:

1. A move number selected should not be less one of a repeat size.
2. A move number cannot be allotted as one move.
3. A move number should not be divisible by the number of ends and picks in a repeat.
4. A move number cannot be half of the number of a repeat size.

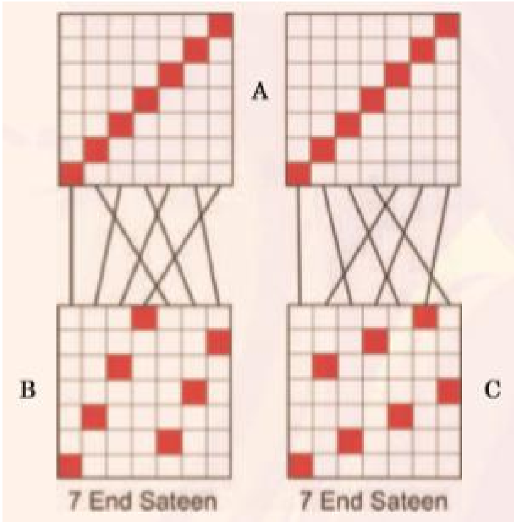


Figure 3.16 7-end Sateen at 2 and 5 intervals

A sateen weave when re-arranged can be made into twill, likewise a twill weave can be rearranged and converted into a sateen weave (weft face satin)

The simplest system of rearranging ordinary continuous twill weaves produces a class of weaves known as 'satin' or 'sateen' weaves. These sateen or satin weaves are characterized by an even and smooth surface of either warp or weft, resulting from a perfectly regular distribution of intersection of those threads [46].

In the Figure 3.16.B a 7-end weft faced satin (sateen) weave is produced from 7-end weft faced twill (Figure 3.16.A) by re-arrangement. Exactly reverse of this is when sateen is converted into warp faced and is called satin weave. The interval of selection for rearrangement may be either of two complementary numbers whose sum equals the whole number, but which have no common measure. Therefore, for 7-end sateen the interval of selection might be 5 and 2 or 4 and 3. In Figure B the interval of selection is 4 and in Figure 3.16.C it is 2. Similarly, sateen weaves of higher number of ends per repeat can be constructed by-arranging ordinary twill.

If we reverse the selection in sateen as given above by following the principles of same construction, we will get satin weave which is a warp dominant weave. In Figure 3.17. the examples of 7 ends satin with 2, 3 4 and 5 moves is given [46].

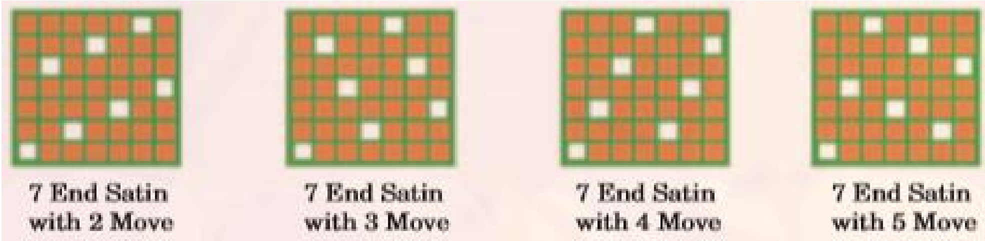


Figure 3.17 7-ends satin with 2, 3, 4, and 5 moves

3.5 Structural Parameters of Woven Fabrics

From prior research on the geometric theories given above, various parameters can be derived to characterize fabric geometry. In this stage, a commondefinition of every parameter will be introduced. Any parameters do not be essential to be calculated, but can only be measured.

3.5.1 Yarn diameter Parameter

In Peirce's 1937 study, according to the round yarn section, and the number of diameters per inch in the cotton system:

$$\frac{1}{d} = \frac{29.3\sqrt{N}}{v} \quad \text{and} \quad \frac{1}{d} = 28\sqrt{N}$$

$$d = \frac{1}{28\sqrt{N}} = \frac{0.0357}{N}(inch) = \frac{36}{\sqrt{N}}(mils) = \frac{0.91}{\sqrt{N}}(mm)$$

where , the specific volume is the ratio of the volume occupied by a material to the same weight of water under compression. For cotton yarn in woven structure [47].

3.5.2 Thickness Parameter

Fabric thickness, whichever is greater, is given by and , where

,

Assuming the yarn diameters are circular:

Fabric thickness to flatten cross-section yarns

The condition that the two yarns project equally produces a smooth surface and gives the minimum thickness, tmin.

where . So the minimum thickness is tehefore the sum of the yarn diameters.

The maximum thickness is obtained when one or other of the yarns is straightened as much as possible. In an open cloth, where either may be straightened to zero crimp, this thickness should be ;

is the diameter of the thicker yarn, and it is obtained by straightening the thinner threads. If :

3.5.3 Cover factor Parameter

Fabric cover is defined geometrically as the ratio of the fabric area covered by real yarns.Covering factors are calculated independently for warp and weft yarns. For instance, a fabric having 50 warp yarns per centimetre, each 0.01 cm in major diameter, would have a warp cover factor of 0.5 or 50 %. In the case of circular section yarns, warp and weft cover factors are given by Hamilton [48].

For flattened yarns, warp and cover factors for plain weave are thus given by

And total cover factor is calculated from and as follows:

The cover factor thus shows the degree of closing or cover. Increasing the projection of the area covered by yarns through using yarn with greater 'ooziness', or by flattening in finishing and more regularity will advance the cover of cloth [48].

3.5.4 Crimp Parameter

The crimp is the percentage of the length of the thread axis over the fabric length:

and

The first geometric parameter is the crimp size.Stress-strain relationships provide a well basis for the examination of many complex phenomena such as hand and wrinkle. And, in particular, crimp has been used as a fundamental parameter for calculating other geometrical parameters such as crimp height or weave angle which are hard to measure.Therefore, it is important that the fabric crimp is measured in the fabric to examine the fabric structure or related problems.However, the real challenge of measuring this parameter may be that it has not been fully solved or recognized by many researchers [49].

3.6 Relationship Between Fabric Structure and Surface Properties

The properties of a fabric surface are very important in terms of both psychological and physical influences when a person appreciates this fabric. For example, sensations perceived from skin contact with clothing can greatly affect our overall comfort. The KES system has a test machine specially designed to evaluate fabric surface properties.

The KES instrument is a height gauge in which a surface of a fabric advances 2 cm in length (front and back) in the main direction. This gives two values for geometrical roughness, SMD1 and SMD2. Geometric roughness (SMD) is a measure of the surface contour of the fabric, an increase in SMD indicates an increase in surface change of the fabric. Figure 3.19 shows the principles of the measurement process [50].

Interest in studying the geometry of fabric surfaces by objective means goes back to 1955, when Butler reported the design and implementation of their instrument known as the cloth profile recorder [50]. The main purpose of the design was to evaluate the fabric faults such as repping and the differences in pick spacing along the warp direction. Since this early work, there has been no reported work that describes the objective measurement of surface roughness until the KES system was introduced by Kawabata (1980). Then in 1985, an instrument was introduced in which the fabric was moved in a rotatable manner to measure heights around the 360 ° rotation. At the same time by Amirbayat designed a multi-purpose tester measuring the surface properties and changes during abrasion, in addition to measuring the hardness of the curtain or bending of the fabrics. Having realized that there is a force imposed when testing, which affects the measurement of the roughness in the KES surface tester, Ramgulam reported a non-contact method of surface assessment using laser triangulation techniques in 1990 [51].

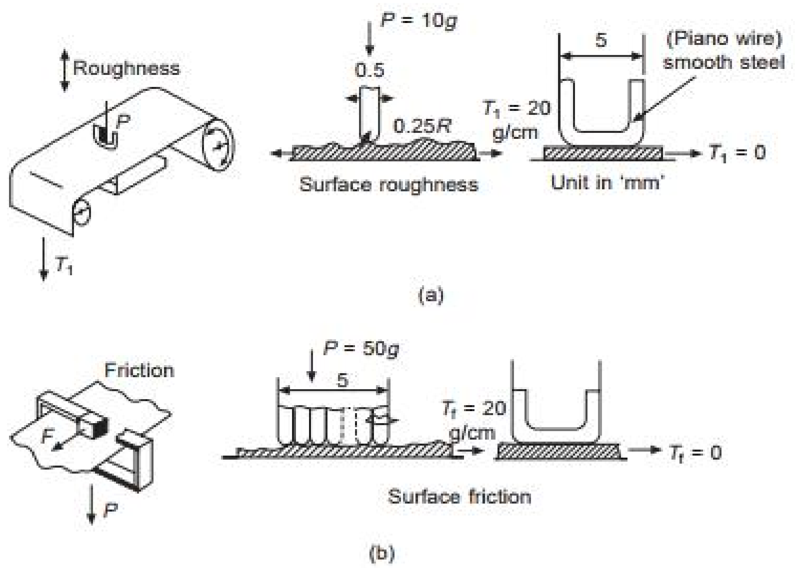


Figure 3.18 (a)Principles for the measurement of geometrical roughness SMD
(b)Principles for the measurement of fabric friction coefficient MIU [51]

CHAPTER 4

MATERIALS AND METHODS

4.1 Materials

Two different studies have been conducted here. In the first study, yarn production was produced using staple polyester fibers with different cross-sections. In the second study, woven fabrics included different weaving structures were produced with these yarns. As the next steps, some structural and comfort properties of the fabrics were tested. Therefore materials used in the production of woven fabrics are;

Polyester staple fibers ;

*PES fibers with round cross- section

*PES fibers with blending scalloped oval & hollow cross - section

*PES fibers with scalloped oval cross - section

*PES fibers with hollow cross- section

Polyester staple fibers were obtained from sources;

PES fibers with round cross-section, PES fibers with blended scalloped oval and hollow cross-section, PES fibers with scalloped oval cross-section, PES fibers with hollow cross-section were supplied by Kipas Textile Company.

PES yarns were produced by using these fibers in the first stage. As the second stage, the fabrics were produced in different weaving structures by using these yarns. Test values of fabrics produced from different cross sections were compared with each other. All the work as methods were determined below in order.

4.2 Method

The method of producing polyester staple fibers were described in the above chapter. For the study, polyester fibers having different properties of cross sections were produced by using this production method. In these studies, two different productions were carried out. In the first stage, PES yarn production were made by using *rieter ring spinning machine*. The second stage is the fabric production by using the *dornierrapier weaving machine*s.

i. Preparation of Fibers

PES fibers with four different cross section structures were obtained. These fibers were examined under a microscope and the structures examined again. Plans were made for each fiber yarn production.

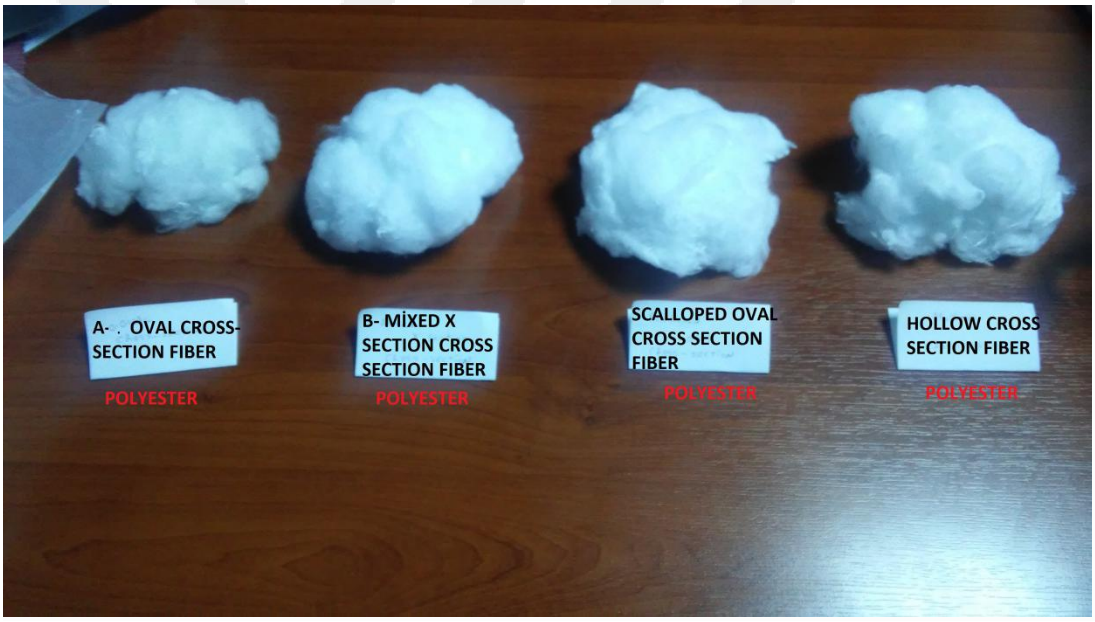


Figure 4.1 The Polyester fibers

As seen in Figure 4.1, fibers having the same color, different cross sections (oval, blending scalloped oval & hollow, scalloped oval, hollow) were used in the same lengths (38 mm).

Table 4.1 Properties of the polyester fibers

FIBER TYPE	FINENESS	FIBER LENGTH	COLOR	CROSS - SECTION
PES	1.6 dtex	38 mm	white	Oval
PES	1.6 dtex	38 mm	white	Blending Scalloped Oval & Hollow
PES	1.6 dtex	38 mm	white	Scalloped Oval
PES	1.7 dtex	38 mm	white	Hollow

The properties of the fibers used above were indicated. Fibers were examined again with a Leica DM500 microscope before production.

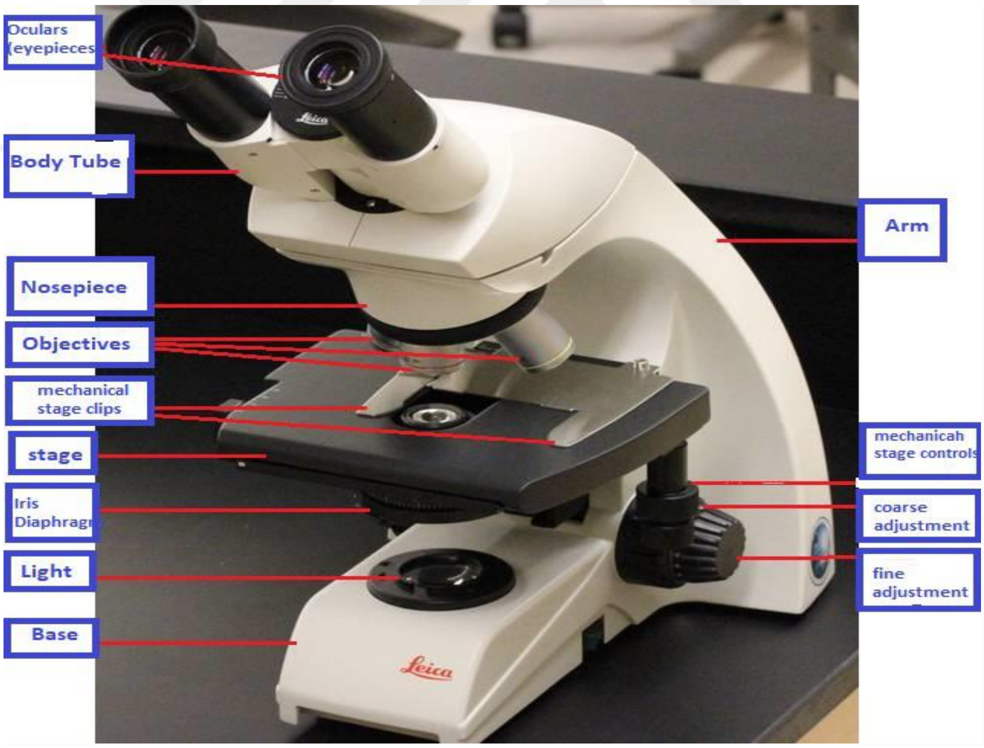


Figure 4.2 Leica DM500 microscope

The cross section views of the fibers to be used were illustrated as follows;

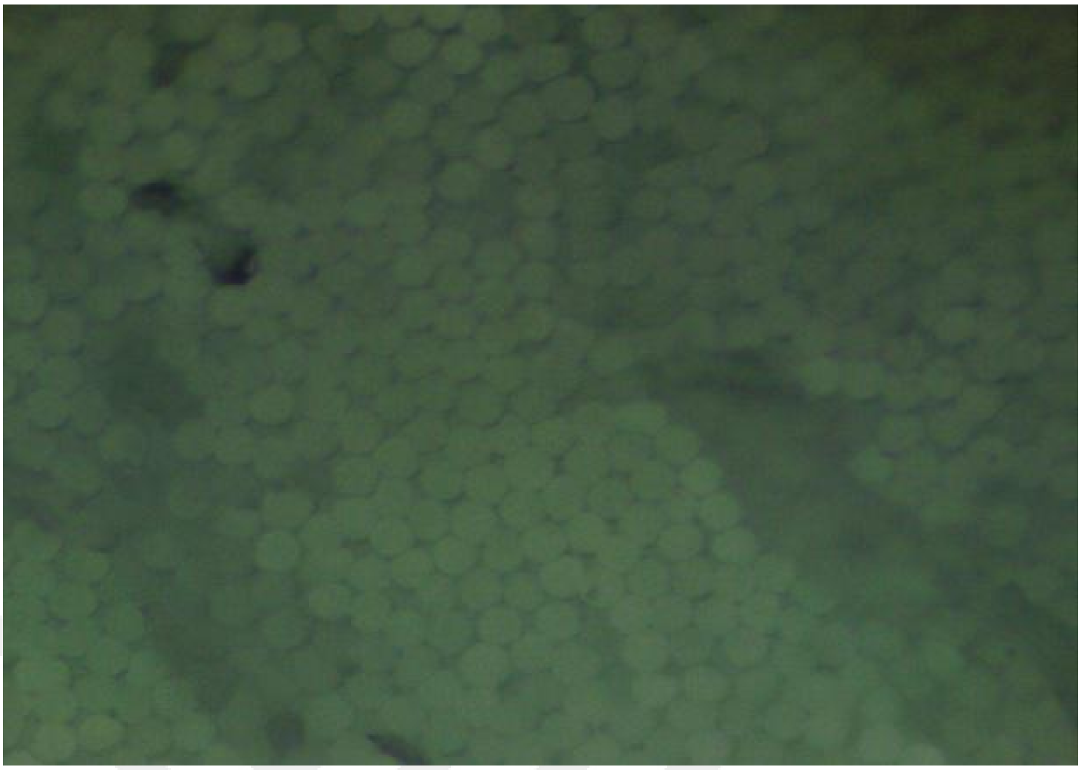


Figure 4.3 Pes fiber oval cross-section microscope image

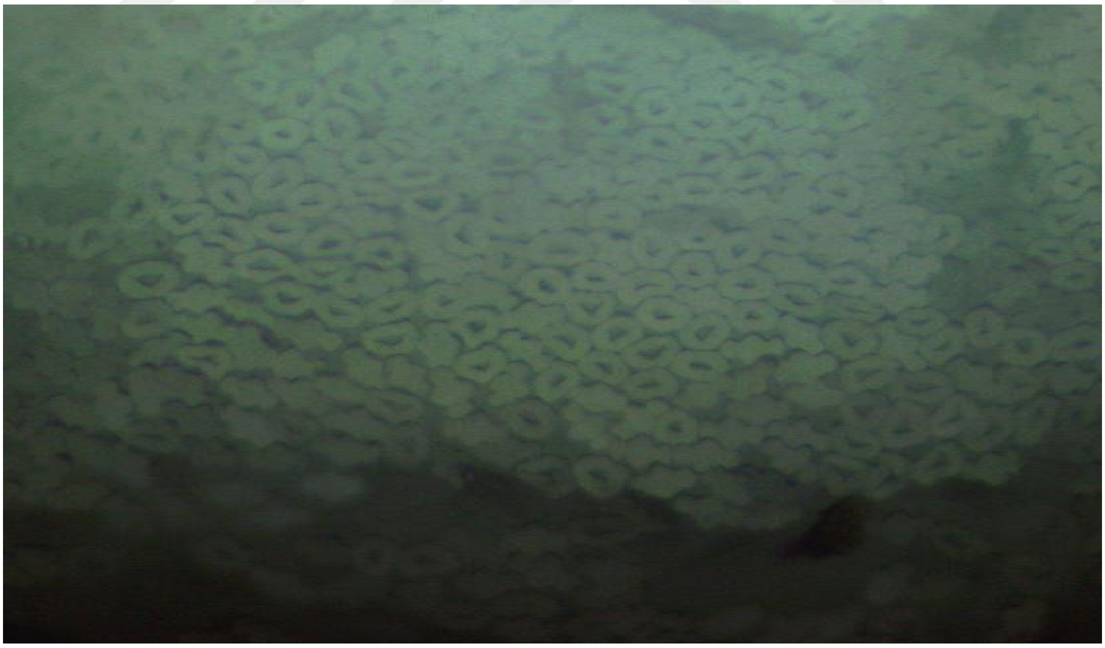


Figure 4.4 Pes fiber blending scalloped oval & hollow cross-section microscope image

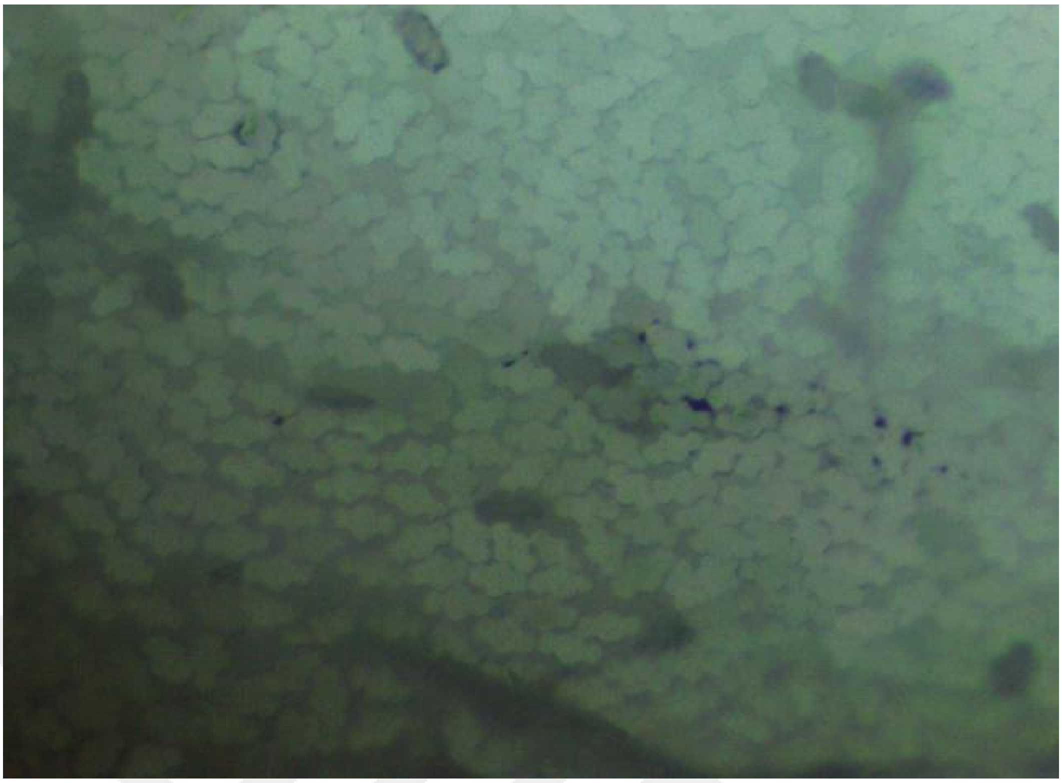


Figure 4.5 Pes fiber scalloped oval cross-section microscope image

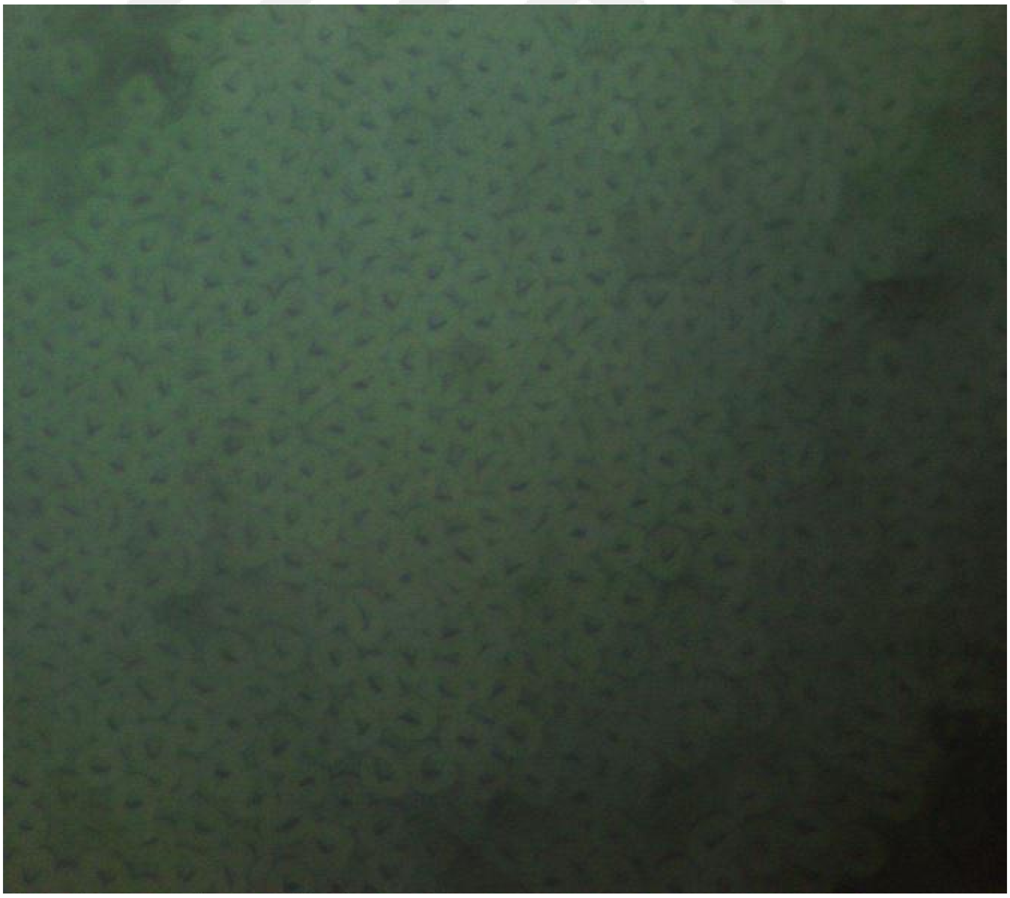


Figure 4.6 Pes fiber hollow cross-section microscope image

ii. Yarn Production by Using Ring Spinning

We mentioned above that we have produced four yarns with different cross-sections. We have produced yarn numbers the same so that we could examine the fabrics woven from these yarns in a more concrete way. These four yarns were composed of 100% PES, each with different structures and manufactured at Ne 20 of linear density.

In the following, we have described what preparatory stages these yarns have gone through for their production. We described what setting values are going from *Carding* to *Draw frame*, from *Draw frame* to *Roving Frame*, from *Roving Frame* to *Ring Spinning.*

First, the fibers were fed to a mixer called *B-34 Mixer Machine.* From here, the fibers were sent to the *carding machine* by air. As shown in Figure 4.7 in the following, the carding setting values were adjusted to 38 mm for synthetic fibers. Licker-in and drum revolution were adjusted to the fibers. Webs were turned into sliver in the carding machine.

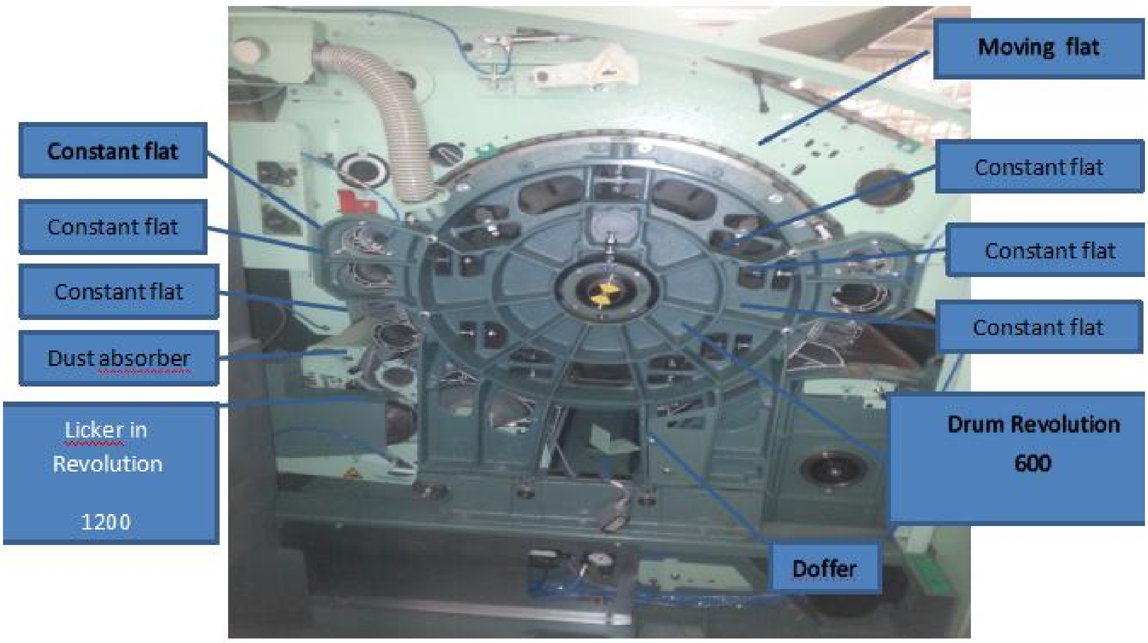


Figure 4.7 Side view of a carding machine

Table 4.2 Carding settings for fibers

MACHINE SETTING PLACES	*1,6dtex 38mm*
DRUM REVOLUTION rev/min	600
LICKER IN REVOLUTION rev/min	1200
MOVING FLATSETTINGS (from back to front)	30-25-25
FEED DENSITY SETTING	22
TIME NEEDED FOR CHANGE SETTINGS	5 hours

After carding operation, the slivers were passed through the draw frame-1 and draw frame -2 processes in Cans. In the *draw frame machines*, a certain draw was applied to the sliver and the fibers were smoothed. Settings of the draw frame for the sliver were shown at the following Figure 4.8 and Table 4.3.

Figure 4.8 Settings place of draw frame

After the draw frame operations, the slivers were brought to the roving frame.The aim of this machine is to convert the sliver into a roving with a certain draw and a false twist. The slivers were numbered whatever we wanted. The following settings were provided with the Figure 4.9 and Table 4.4.

Table 4.3 Draw frame settings for sliver

	MACHINE SETTING PLACES	FIBER DIMENSIONS 1,6dtex 38mm
1.DRAW FRAME	CRUSHING DRAW	1,4
	SPINNIG POSITION GAUGE(A-B)	51-43
	COILERSLİVER FUNNEL ENTRY	10,5
	COILERSLİVER FUNNEL EXIT	4,2
TIME NEEDED FOR CHANGE SETTINGS		40 MİN
2.DRAW FRAME	CRUSHING DRAW	1,4
	SPINNIG POSITION GAUGE(A-B)	50-43
	COILERSLİVER FUNNEL ENTRY	10,5
	COILERSLİVER FUNNEL EXIT	4,2
TIME NEEDED FOR CHANGE SETTINGS		40 MİN

Figure 4.9 Roving frame setting places for fiber

Table 4.4 Roving frame settings for fibers

MACHINE SETTING PLACES	FIBER DIMENSIONS 1,6dtex 38mm
CRUSHING DRAW (GEAR)	29
SPINNIG POSITION GAUGE EXIT - ENTRY	40-50-60
APRON IRONMIRROR	24
APRON CAGE NUMBERI	34,5
APRON DIMENSIONS	84,1X44X1,1
TIME NEEDED FOR CHANGE SETTINGS	30 MİN

As a final step for yarn production, the rovings were brought to the ring machine. Values were entered in the ring machine according to the number of the roving to obtain the desired number yarn. The data were described in more detail in the method section. Machine setting locations were illustrated as below and the settings used were shown in Table 4.5.

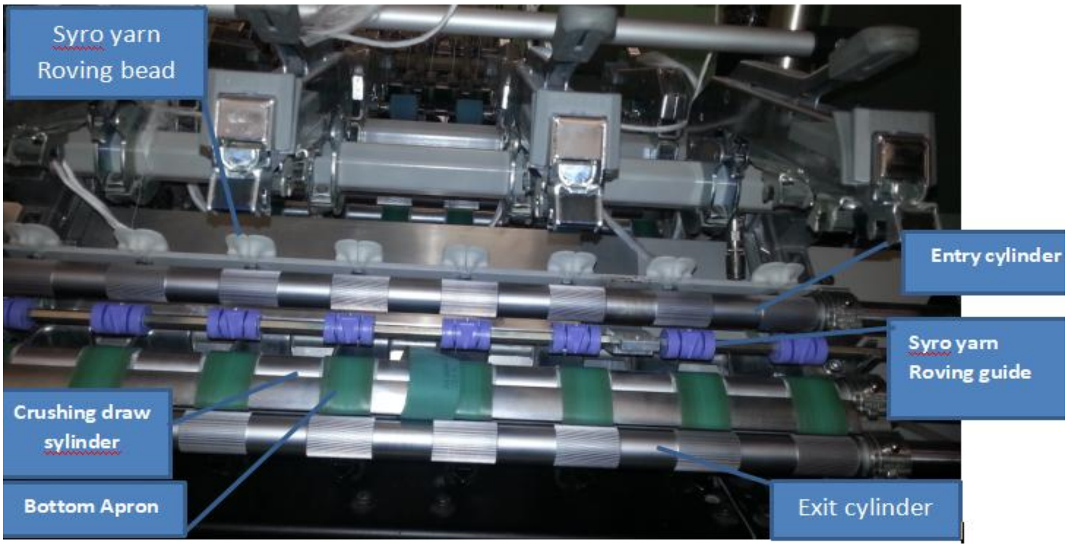


Figure 4.10 Ring spinning setting places for fiber

Table 4.5 Ring machine settings for fibers

MACHINE SETTING PLACES	FIBER DIMENSIONS
	1,6dtex 38mm
SPINNIG POSITION GAUGE CYLINDER(ENTRY-MIDDLE),(MIDDLE-EXIT)mm	40-13
PRESS SPINNIG POSITION GAUGE (ENTRY-MIDDLE),(MIDDLE-EXIT)mm	73-66
APRON IRONMIRROR(mm)	13
BOTTOM (ENTRY)MUFF STIFFNESS (sha)	70
FRONT (ENTRY) MUFF STIFFNESS(sha)	83
APRON (Length - Width - Thickness)	72,6X30X1,1
TIME NEEDED FOR CHANGE SETTINGS	20 HOUR

4.2.1 Practices for the production of polyester yarn

Polyester production has been done in four different practice. 100% polyester yarns were produced. The following practices have been described.

Firstly, Each Fibers with four different cross-section were provided. Approximately five kg of fibers were prepared for each fiber. A total of 20 kg of fiber was used.

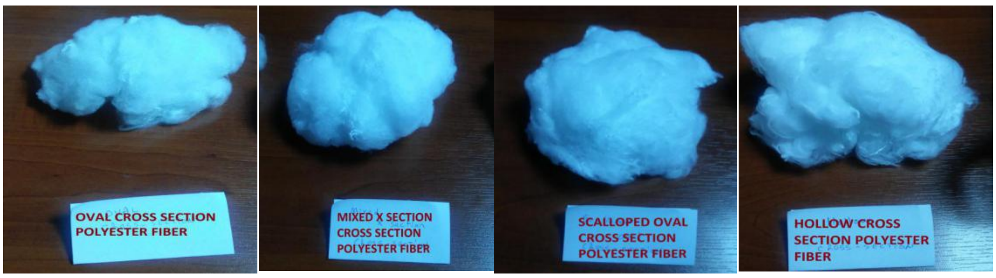


Figure 4.11 Oval, blending of scalloped oval and hollow, scalloped oval and hollow cross-section polyester fiber

These fibers were stepped through the process at the determined number values.

- ✓ Carding; Card Slivers were obtained at Ne 0,100 at a speed of 30 kg / h. This process was repeated for each fiber. A total of 4 different studies were performed.

✓ Draw Frame 1; Slivers were obtained at Ne 0,100 at a speed of 1000 m/min. One-can was produced from compound of six-can. This process was repeated for each fiber. A total of 4 different studies were performed.

The Amount of Drawing	=	**Ne (out)/Ne(in) x number of dubbing**

Drawing specified according to the above formula: Drawing = **[0,100 / 0,100] x6 = 6**. This value was entered to the screen and the machine was started.

✓ Draw Frame 2 ; Slivers were obtained at Ne 0,120 at a speed of 600 m/min. One-can was produced from compound of five-cans. Drawing specified according to the above formula: Drawing=[0,120 / 0,100] x6 = 6. This value was entered to the screen and the machine was started. This process was repeated for each fiber. A total of 4 different studies were performed.

✓

Figure 4.12 Production of carded sliver in carding machine

Figure 4.13 Production of polyester sliver with 5-cans at draw frame

- ✓ Roving Frame;Slivers were obtained at Ne 0,80 at a speed of 120 m / min Drawing specified according to the above formula : Drawing=[0,80 / 0,120] x 1 = 6,6. This value was entered to the screen and the machine was started.Roving with Ne 0,80 was produced from sliver with Ne 0,120. This process was repeated for each fiber. A total of 4 different studies were performed.

Figure 4.14 Production of pes roving(oval, blending of scalloped oval and hollow, scalloped oval and hollow cross-section) at roving frame

- ✓ Ring Spinning; Polyester yarns with NE 20 oval, blending of scalloped oval and hollow, scalloped oval, hollow cross-sections were manufactured in a R*ieter ring machine* with 15.000 rotation and 48 rings.

The Amount of Drawing for Ring = Ne (out)/Ne(in) x drawing gear

Drawing specified according to the above formula; Drawing= [20 / 0,80] x 1,08 = 27. This value was entered to the screen and the machine was started. Polyester yarns with Ne 20 were manufactured from Roving with Ne 0,80. This process was repeated for each fiber. A total of 4 different studies were performed.

Figure 4.15 Produced %100 pes Ne 20 (oval, blending of scalloped oval and hollow, scalloped oval and hollow cross-section)

4.2.2 Practices for the Production of Weaving Fabric

In this section, practices on fabric production were given. Using four different types of polyester yarns, sixteen fabrics were produced with four different weaving structures. In order to compare sixteen fabrics, all the fabric specifications were done the same.

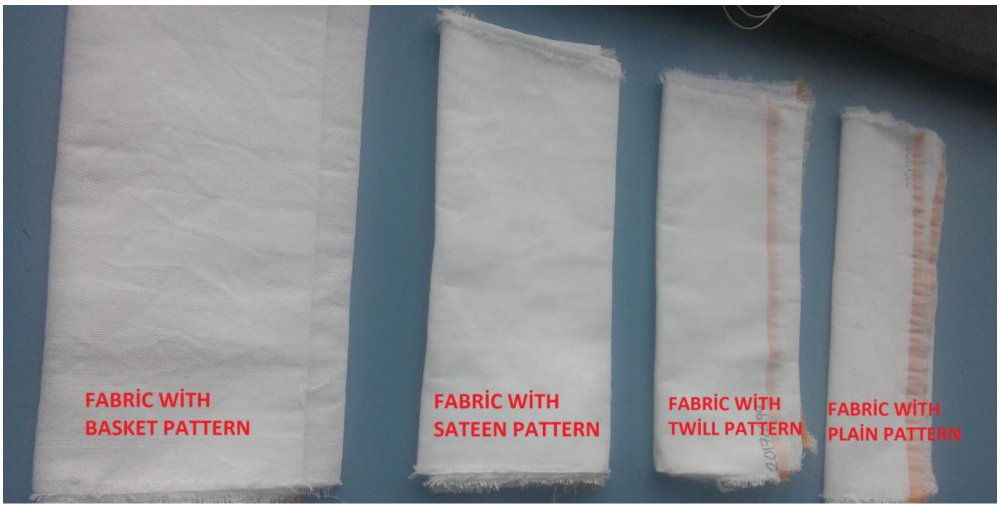


Figure 4.16 Produced different weaving fabrics

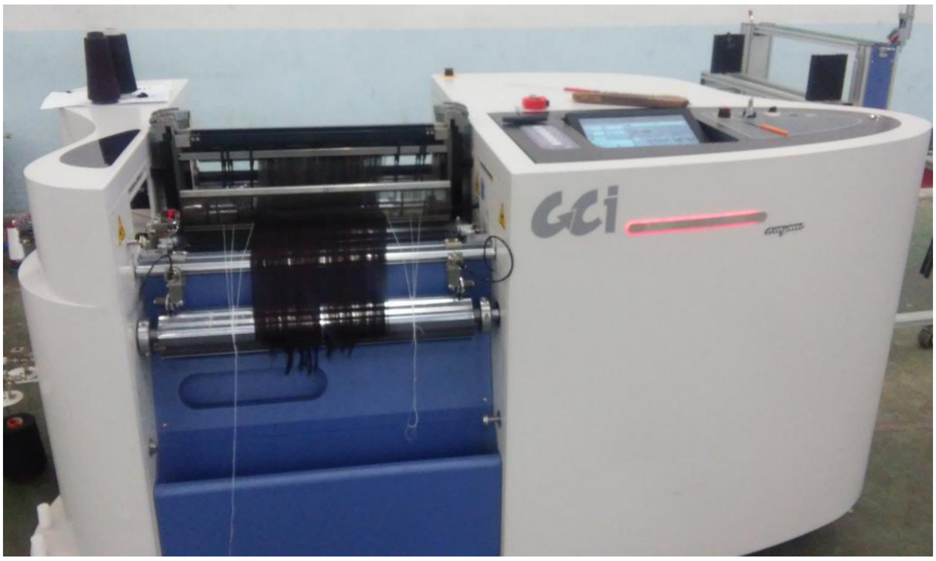


Figure 4.17 Fabrics produced with different weaving structures by *CCI machine*

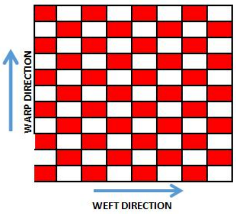
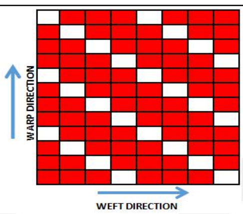
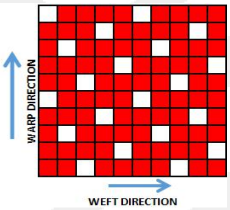
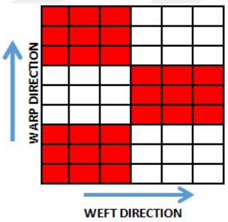
As shown in the picture above, sixteen different fabrics were produced at the parameters determined in *the CCI sampling machine*. Fabric production was carried out in the following practices.

Warp preparation, sizing, weaving draft and weaving operations of fabrics (1-16) were made according to parameters of weaving values give in Table 4.6. Sample fabrics with 3 m of length and 30 cm of width were produced. Settings of weft density, frame, draft plan and reed were kept constant, only the cross-section properties and weaving structures were changed.

Table 4.6 (Fabric 1-16) Parameters of weaving

Practice No	Pattern	Weft Yarn	Warp Yarn	Weft Density	Frame	Draft Plan	Reed No
Fabric 1 (O.P.)	1/1 Plain	20 Ne PES (Oval cross section)	20 Ne PES (Oval cross section)	23/cm	8	Ordered	110 /3
Fabric 2 (O.T.)	3/1 (S) Twill	20 Ne PES (Oval cross section)	20 Ne PES (Oval cross section)	23/cm	8	Ordered	110 /3
Fabric 3 (O.S.)	4/1 Sateen	20 Ne PES (Oval cross section)	20 Ne PES (Oval cross section)	23/cm	8	Ordered	110 /3
Fabric 4 (O.B.)	3/3 Basket	20 Ne PES (Oval cross section)	20 Ne PES (Oval cross section)	23/cm	8	Ordered	110 /3
Fabric 5 (S.O.H.P.)	1/1 Plain	20 Ne PES (Blending Scalloped Oval & Hollow)	20 Ne PES (Blending Scalloped Oval & Hollow)	23/cm	8	Ordered	110 /3
Fabric 6 (S.O.H.T.)	3/1 (S) Twill	20 Ne PES (Blending Scalloped Oval & Hollow)	20 Ne PES (Blending Scalloped Oval & Hollow)	23/cm	8	Ordered	110 /3
Fabric 7 (S.O.H.S.)	4/1 Sateen	20 Ne PES (Blending Scalloped Oval & Hollow)	20 Ne PES (Blending Scalloped Oval & Hollow)	23/cm	8	Ordered	110 /3
Fabric 8 (S.O.H.B.)	3/3 Basket	20 Ne PES (Blending Scalloped Oval & Hollow)	20 Ne PES (Blending Scalloped Oval & Hollow)	23/cm	8	Ordered	110 /3
Fabric 9 (S.O.P.)	1/1 Plain	20 Ne PES (Scalloped Oval)	20 Ne PES (Scalloped Oval)	23/cm	8	Ordered	110 /3
Fabric 10 (S.O.T.)	3/1 (S) Twill	20 Ne PES (Scalloped Oval)	20 Ne PES (Scalloped Oval)	23/cm	8	Ordered	110 /3
Fabric 11 (S.O.S.)	4/1 Sateen	20 Ne PES (Scalloped Oval)	20 Ne PES (Scalloped Oval)	23/cm	8	Ordered	110 /3
Fabric 12 (S.O.B.)	3/3 Basket	20 Ne PES (Scalloped Oval)	20 Ne PES (Scalloped Oval)	23/cm	8	Ordered	110 /3
Fabric 13 (H.P.)	1/1 Plain	20 Ne PES (Hollow)	20 Ne PES (Hollow)	23/cm	8	Ordered	110 /3
Fabric 14 (H.T.)	3/1 (S) Twill	20 Ne PES (Hollow)	20 Ne PES (Hollow)	23/cm	8	Ordered	110 /3
Fabric 15 (H.S.)	4/1 Sateen	20 Ne PES (Hollow)	20 Ne PES (Hollow)	23/cm	8	Ordered	110 /3
Fabric 16 (H.B.)	3/3 Basket	20 Ne PES (Hollow)	20 Ne PES (Hollow)	23/cm	8	Ordered	110 /3

Table 4.7 Pattern type of weaving fabrics

Practice No	Pattern Types	Pictures
Fabric 1,5,9,13		
Fabric 2,6,10,14		
Fabric 3,7,11,15		
Fabric 4,8,12,16		

4.2.3 The Tests Applied within the Scope of the Thesis

The fabrics produced from PES yarns obtained in each practices were tested simultaneously and discussed. Woven fabrics obtained from such fibers were also tested with respect to their comfort properties. The tests used in thesis were given below;

* Determination of physical properties of obtained PES staple yarns on fabric by using a tensile tester

* Determination of physical properties of obtained PES staple yarns on fabric by using a tearing tester
* Determination of physical properties of obtained PES staple yarns on fabric by using a abrasion resistance tester
* Determination of physical properties of obtained PES staple yarns on fabric by using a air permeability tester
* Determination of physical properties of obtained PES staple yarns on fabric by using a drape tester
* Determination of physical properties of obtained PES staple yarns on fabric by using a brightness tester
* Determination of physical properties of obtained PES staple yarns on fabric by using a water vapor permeability tester

4.2.3.1 Determination of Physical Properties of Obtained Staple Yarns on Fabric by Using a Tensile Strength Tester

Sample fabrics were conditioned at 20 ± 2 °C and 65% relative humidity for 24 hours prior to testing. Tensile Strength test was performed to determine the physical properties of the conditioned sample fabrics.

The tensile strength tests of the samples were made according to the (ISO 13934-1) standard of James H. Heal-Titan tester (see in Figure 4.18). Test samples were prepared in dimensions of 30 cm x 5 cm in weft and warp directions. The prepared samples were placed between the jaws for the measurement of tensile strength and 5N pre-tension was applied. The test was continued until the fabric weft and warp yarns were broken using a 3000 N load cell. Average values were obtained from each fabric sample by measuring 5 inch in weft and warp directions.

Figure 4.18 The device used for fabrics strength tests (*James H. Heal Titan universal strength tester 2)*

4.2.3.2 Determination of Physical Properties of Obtained PES Staple Yarns on Fabric by Using a Tearing Tester

Tear strength tests of fabrics were also performed according to the (ISO 13936-1) standard of *James H. Heal - Titan Apple Tear Tester* (see in Figure 4.19). Samples of sizes 20 cm x 5 cm were prepared in the weft and warp directions. The sample was cut 5 cm from the middle of the fabric to the inside of the fabric to the parallel 20 cm edge of the fabric. It was pointed 5 cm ahead of this cut with a pencil.The experiment was started by placing the sample between the jaws of both sides of the machine. As the fabric continues tearing, the machine was stopped manually when the marked part was reached and the measured tear strength value was recorded. Average values were obtained from each fabric sample by measuring weft and warp directions five times. The tests were carried out in Kipaş Textile Laboratory.

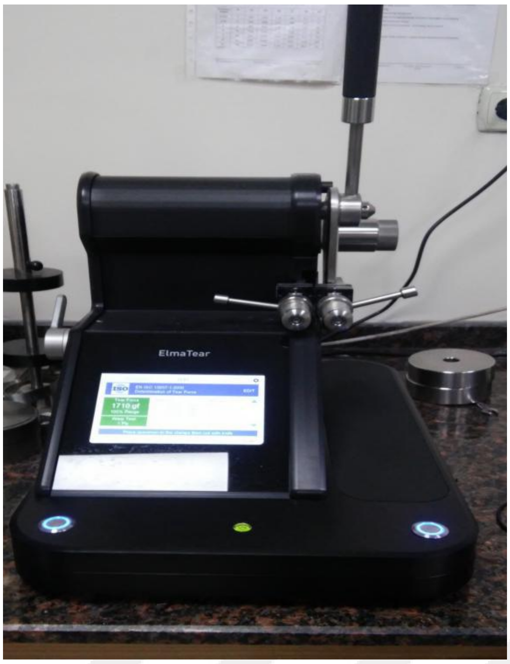


Figure 4.19 The device used for fabrics abrasion resistance test (*James H. Heal elma tear strength tester*)

4.2.3.3 Determination of Physical Properties of Obtained Staple Yarns on Fabric by Using an Abrasion Resistance Tester

Abrasion resistance tests of the fabric samples was performed on a Martindale abrasion tester according to the ISO 12947-2 standard (see in Figure 4.20). The samples were conditioned for 24 hours under standard atmospheric conditions (20 ± 2 º C temperature and 65% relative humidity) before testing began. Six samples were taken from the selected fabrics according to the standard. Each of the samples was weighed on a precision scale and their initial weights were recorded. After the samples and abrasive fabrics were placed in the device, 9 kPa of weight was placed on each sample according to the standard. After 30,000 cycles in the abrasive machine, samples were taken from the machine and weighed on the precision scale. The cumulative weight loss amount (mg) and the cumulative weight loss ratio were calculated according to the sample weights recorded.The tests were carried out in Kipaş Textile Laboratory.

Figure 4.20 The device used for fabrics abrasion resistance test (*James H. Heal martindale abrasion tester*)

4.2.3.4 Determination of Physical Properties of Obtained PES Staple Yarns on Fabric by Using a Air Permeability Tests

Air Permeability Tests of the fabric samples was performed on SDL ATLAS Air Permeability Tester according to the BS 5636:1990 standard (see in Figure 4.21). The samples were conditioned for 24 hours under standard atmospheric conditions (20 ± 2 º C temperature and 65% relative humidity) before testing began. A clamping arm was used to attach 16 fabric samples to the device.To start the test, press the clamping collar to evacuate the air inside the test head with a strong vacuum pump. The air permeability of the test sample is measured in mm / s while the preset test pressure is maintained automatically and regularly. Ten tests were done for each fabric. In the two separate studies, air pressures of 100 kPa was applied to fabrics of 20 cm^2, and air permeability of the fabrics was recorded separately. The average values of 10 tests for each fabric were taken.The tests were carried out in Gaziantep University Textile Engineering Department.

Figure 4.21 The device used for fabrics air permeability test (SDL ATLAS air permeability tester)

4.2.3.5 Determination of Physical Properties of Obtained PES Staple Yarns on Fabric by Using a Drape Tester

Drape Tests of the fabric samples was performed on James Heal Drape Tester according to the BS 5058 standard (see in Figure 4.22). The samples were conditioned for 24 hours under standard atmospheric conditions (20 ± 2 º C temperature and 65% relative humidity) before testing began. The paper ring was placed on the top of the tester. The fabric was allowed to drape under its own weight. With the help of a light and a parabolic mirror underneath the specimen, the drape image of the fabric was reflected on to the paper ring. After tracing the drape image, the paper ring was cut to separate the shadowed and non-shadowed area. The drape coefficient was then calculated. Firstly, 24 cm diameter template was selected. The selected template was placed on the specimen and mark round it. It was pushed the marker pin trough the template center in order to make a small hole in the middle of the specimen. Then, the specimen was cut and switch on the light. The tester was raised and locked the lid in the open position. The specimen was placed on the disc inside the instrument, so that the vertical locating pin passes through the central hole, made previously with the marker pin. Then a paper ring was placed on the lid around the locating disc and the shadow outline was drawn on the paper.The tests were carried out in Gaziantep University Textile Engineering Department.

Figure 4.22 The device used for fabrics drape test (*James Heal Drape Tester*)

Calculation of the drape coefficient in the formula (see in Figure 4.23):

Drape=(C/A) x 100%

A; weight the inner part of the ring to the nearest, C; symbolize weight the paper ring to the nearest

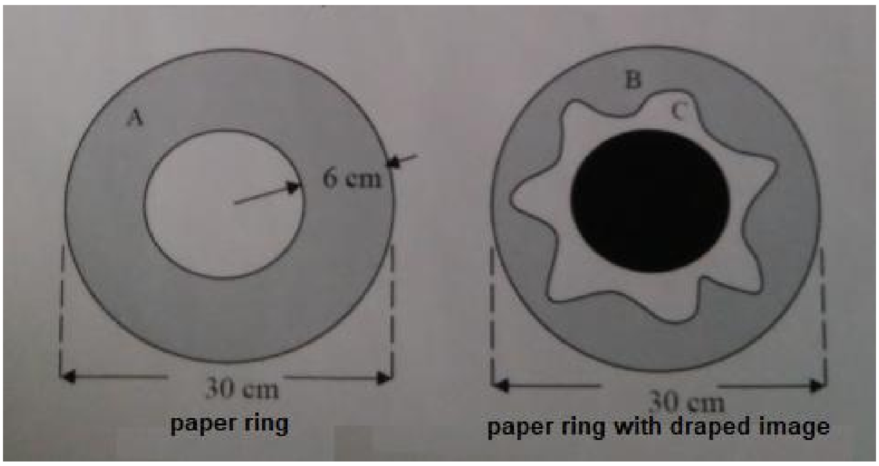


Figure 4.23 The analysis between the shape factor and the drape coefficient

4.2.3.6 Determination of Brightness Properties of Obtained PES Staple Yarns on Fabric by Using a Brightness Index

Brightness Tests of the fabric samples was performed on *Color Quest II Spectrophotometer* according to the TS EN ISO 105-J01 standard (see in Figure 4.24). The samples were conditioned for 24 hours under standard atmospheric conditions (20 ± 2 º C temperature and 65% relative humidity) before testing began. Each fabric sample was measured at four different locations and averaged. Brightness comparisons of fabrics were made using *Universe Color Quest®* software using the obtained data.

Figure 4.24 The Spectrophotometer device used for fabrics brightness Index (*Color quest II*)

4.2.3.7. Determination of Physical Properties of Obtained PES Staple Yarns on Fabric by Using a Water Vapor Permeability Tester

Water vapor permeability tests of the fabric samples was performed on SDL *ATLAS Water Vapor Permeability Tester* according to the *BS 7209:1990* standard (see in Figure 4.25). The samples were conditioned for 24 hours under standard atmospheric conditions (20 ± 2 º C temperature and 65% relative humidity) before testing began.

The test fabrics and reference fabrics were conditioned for at least 1 hour in the test chamber. The each fabrics were cut to be tested. Three test specimens and one specimen from the reference fabrics were obtained. Then , A volume of water at 20 ± 2 º C to each open dish was transferred. Predetermined from the dimensions of the dish to give a 10 ± 1 mm deep layer of air between the surface of the water and the underside of the supported specimen.

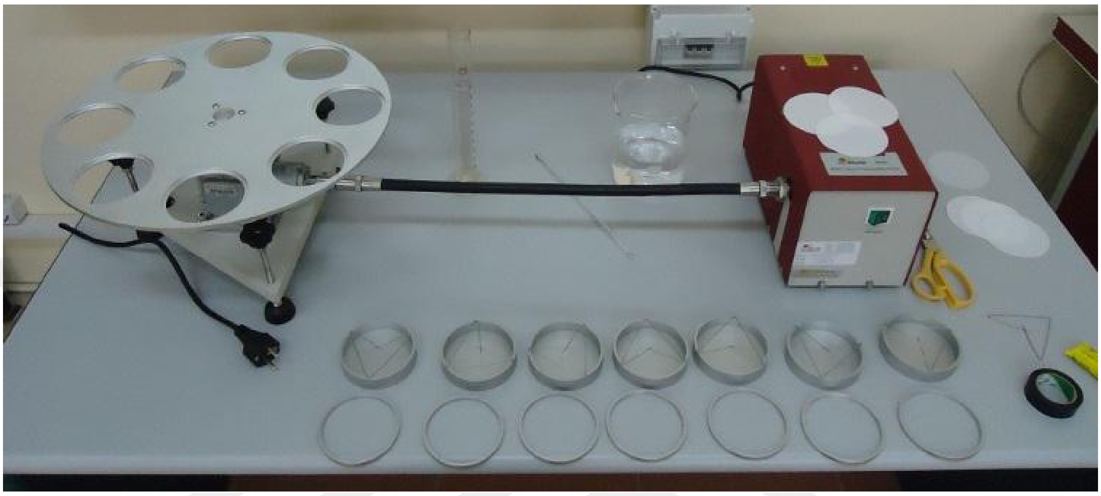


Figure 4.25 The device used for fabrics water vapor permeability test (*SDL ATLAS water vapor permeability tester*)

Carefully, the fabric specimen onto the rim of the dish was placed. Each assembly(dish,complete with specimen), in turn, onto its corresponding position on the turntable, e.g. eight station turntable, triplicate specimens from each of two test fabrics (A and B) were arrange, the reference fabric clockwise in the following dish sequence : A1, A2, A3, reference ; B1, B2, B3, reference. Then, the turntable with assemblies were rotated in the chamber for a period of not less than 1 hour to establish equilibrium of the water vapor gradient for each assembly. At the end of the equilibration period, each assembly were weighed on the balance to the nearest 0,001 g. Note the mass of each assembly and the time at which each assembly was weighed and the dishes were replaced on the turntable. After that, the turntable was rotated within the controlled atmosphere for a further period of at least 5 hours, The assemblies were reweighed and noted the mass and time of weighing.The tests were carried out in Gaziantep University Textile Engineering Department.

The water vapor permeability(WVP) in g/m2/day was given by equation :

$$WVP = 24M/At$$

M is the loss in mass of the assembly over the time period t (in gram);

t is the time between successive weighings of the assembly(in hour)

A is the area of the exposed test fabric (equal to the internal area of the test dish) (in m2) ; where A is given by the equation :

$A = (\pi d^2 / 4) X 10^{-6}$ where d is the internal diameter of the test dish (in mm)

The water vapor permeability Index is given by means of the following equation:

$$I = [(WVP)_f / (WVP)_r] X 100$$

4.2.4 Statistical Analysis

As well as so as to evaluate the statistical significance of woven fabric properties analysis of variance (ANOVA) was performed breaking strength and elongation, abrasion resistance, tear resistance, air permeability, drape,brightness, water vapor permeability between fabric properties from statistical method. For this purpose the statistical software package SPSS 15.0 was chosen to use in order to give information about experimental data. All test results were evaluated significance levels of $\alpha \leq 0.05$ and $\alpha \leq 0.01$.

CHAPTER 5

RESULTS AND DISCUSSION

In the following this section, the results which were obtained from the evaluation of the samples formed by using an experimental study which was given as in Chapter 4.

First of all, the result of performance properties were given and discussed, secondly different graphics were prepared about weaving structure effect on performance properties and cross-section effect performance properties, after that read the data discussed relationship between weaving structures and fiber cross-sections. Thirdly, the statistical analysis result were given by ANOVA Tables and discussed the significance level of performance properties.

In this study, the performance properties of weaving fabrics having different weaving structures which were produced by polyester fibers having different cross-section shapes were investigated. For this purpose, influence of four different cross-section fibers and four different weaving structures were examined on woven fabric.

In this thesis tests was determined as below experiments

- ✓ Tensile strength and elongation at break
- ✓ Tear strength
- ✓ Abrasion resistance
- ✓ Air permeability
- ✓ Drape
- ✓ Brightness
- ✓ Water vapor permeability

5.1 Tensile Strength and Elongation at Break Test Results

The tensile behavior of woven fabrics is known to be affected by its sett and construction. This influence, when clearly understood, would make engineering of fabrics for tensile properties easier. In this study, tensile properties of polyester woven fabrics were characterized by fabric breaking load and elongation, as shown in Table 5.1.

Table 5.1 Test result of tensile strength and breaking elongation

Weaving Structure	Sample Codes	TENSILE STRENGTH (N)		BREAKING ELONGATION (%)	
		Warp	Weft	Warp	Weft
Plain	O.P.	1463	971	38,29	26,87
	B.S.O.H.P.	1479	1003	37,01	25,32
	S.O.P.	1445	952	37,35	25
	H.P.	1398	918	36,45	24
Twill	O.T.	1293	810	36	25,5
	B.S.O.H.T.	1320	830	35	25,3
	S.O.T.	1310	820	34,8	24,5
	H.T.	1328	871	34,5	23
Sateen	O.S.	973	723	33	21,45
	B.S.O.H.S.	1009	758	31	21,05
	S.O.S.	997	725	32,85	20,84
	H.S.	1112	782	30,23	20
Basket	O.B.	1214	815	35,42	22,45
	B.S.O.H.B.	1287	808	33,8	24,2
	S.O.B.	1247	820	35,02	24
	H.B.	1189	817	33,98	24,5

Tensile strength results in warp and weft obtained from tensile tests were presented in Figures 5.1 and 5.2. When all the fabric samples were considered, it was observed that the highest tensile strength values both in warp and weft directions were obtained in plain fabric produced from blending scalloped oval and hollow (B.S.O.H.P). It was observed that the tensile strength of plain fabrics (O.P./ B.S.O.H.P./ S.O.P./ H.P.) were higher than the twill and sateen fabrics when considering the tensile values in the warp and weft direction. And also, when the relationship between basket and plain weave were compared, plain weave had more higher values. *Gadah Ali Abou Nassif* [22] *a*lso found similar results in his study. The polyester yarns used in the studies were produced according to the same production parameters, but the fiber cross-sectional shapes were different. For this reason, the differences between the yarn strengths can only be caused by the difference between the fiber cross-sectional shapes.

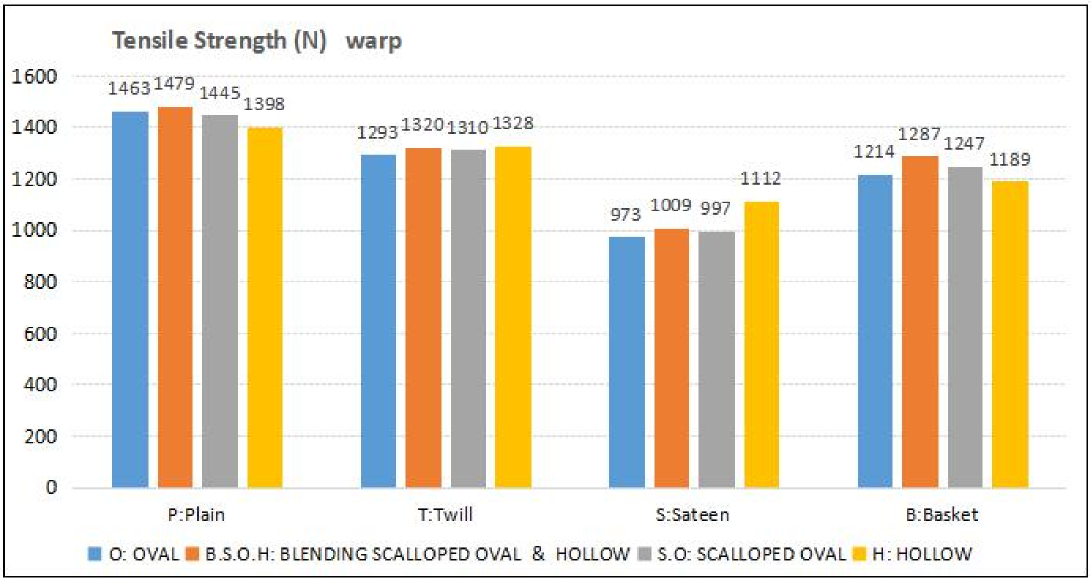


Figure 5.1 Tensile Strength exchanges in different weaving structure in warp

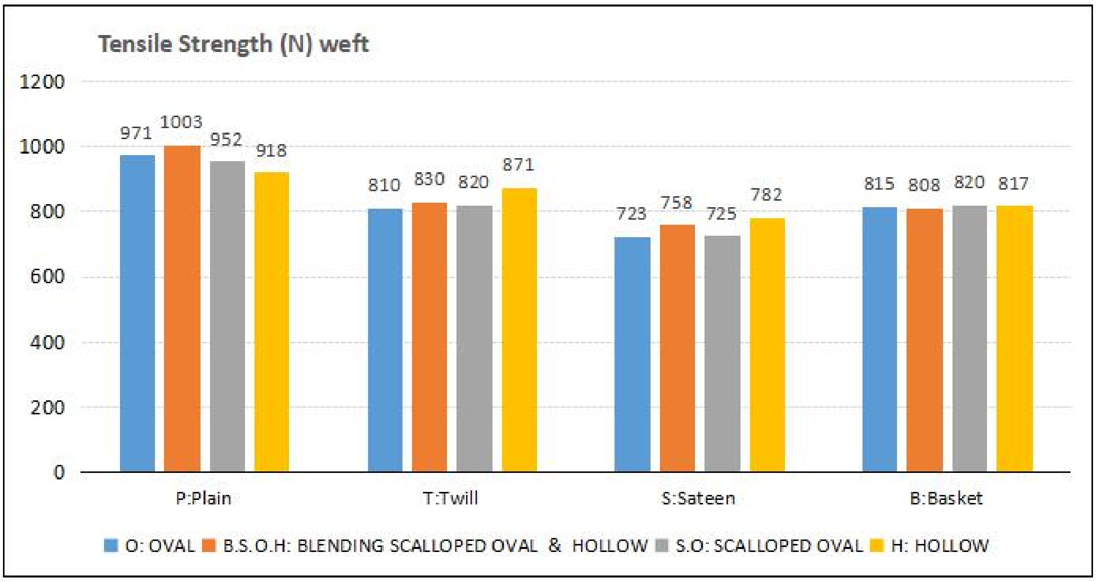


Figure 5.2 Tensile Strength exchanges in different weaving structure in weft

Considering the tensile strength of yarns having the same weaving structures (O.P./ B.S.O.H.P./ S.O.P./ H.P.) in general all results were found to be almost close values. Small differences in the tensile strength of the staple yarns from fibers having different cross-sectional shapes did not cause significant differences in the tensile strengths of the fabrics due to interactions resulting from fabric structural characteristics.

When the tensile strengths of B.S.O.H. fabrics were considered in Figure 5.1 and Figure 5.2, the same behavior was observed in fabrics. Although the hollow fibers had not the highest tensile strength in some samples, when the hollow fiber was blended with the scalloped oval fiber, B.S.O.H. fiber had an increased tendency.

In addition, Plain fabrics have the most yarn interlacing point in the unit fabric area. As a result of this two directions, the fibers compress each other under the applied force during the pulling test and cause an effect which reduces this load.

The breaking elongation values of fabrics in weft and warp structures were shown in Figure 5.3 and Figure 5.4.

The plain woven fabrics (O.P./ B.S.O.H.P./ S.O.P./ H.P.) in warp had the highest breaking elongation compared to the other fabrics. The sateen weaving fabrics (O.S./ B.S.O.H.S./ S.O.S./ H.S.) in warp had the lowest values in all the different sections. When we examined elongation at break of the woven fabrics in weft, it was illustrated that plain woven fabrics had highest values. *As Gadah Ali Abou Nassif* [22] mentioned in his study, the lowest values in weft direction were caused in sateen to higher float length of the warp yarns in this type of fabrics

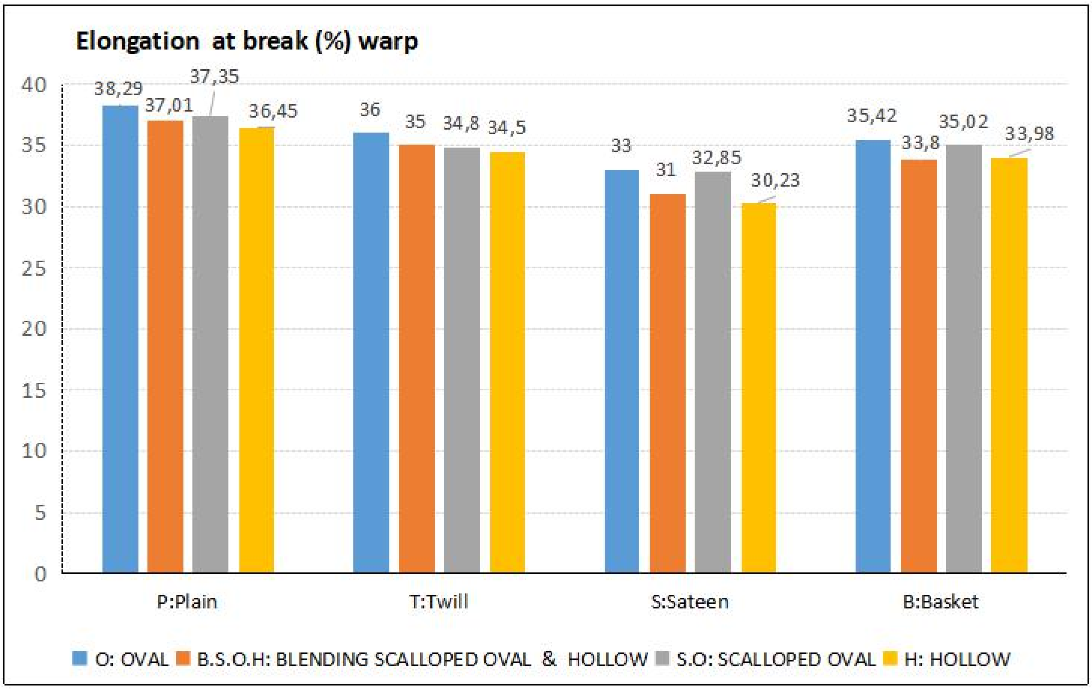


Figure 5.3 Elongation at break of the woven fabrics in warp

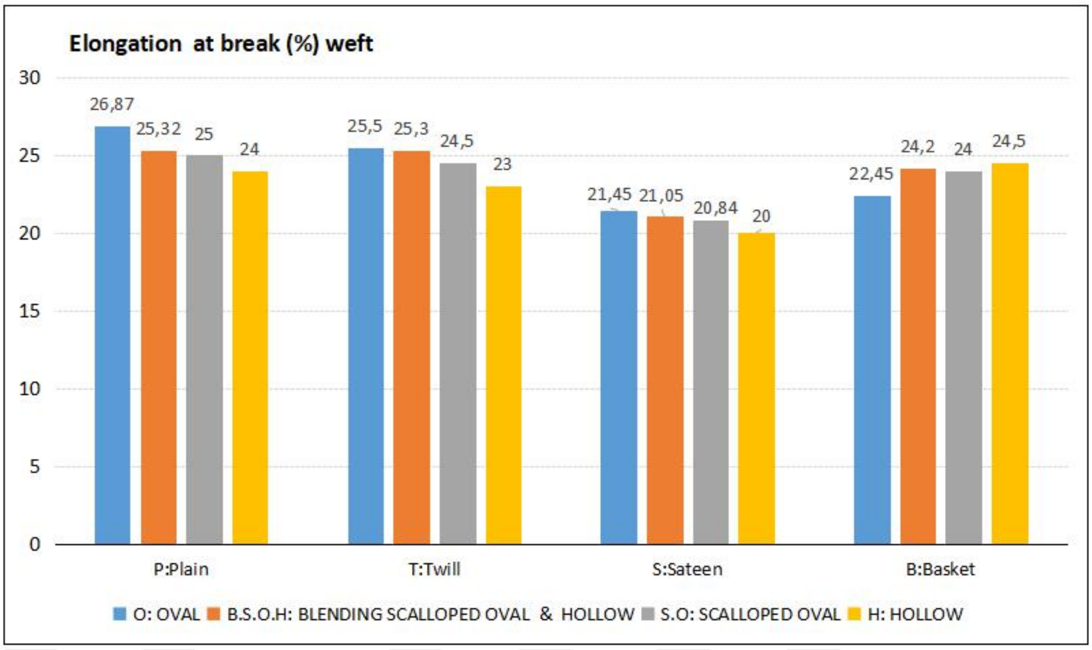


Figure 5.4 Elongation at break of the woven fabrics in weft

The effect of different weaving structure on tensile strength in warp and weft direction values were found to be significant ($p \leq 0.01$) 1% significance level based on the ANOVA table (Table 5.2).

Table 5.2 ANOVA Table w. structure effect on tensile strength in warp and weft

Oneway

ANOVA

TensileStrengthWarp

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1486245,313	3	495415,104	482,300	,000
Within Groups	61631,625	60	1027,194		
Total	1547876,938	63			

TensileStrengthWeft

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	738816,125	3	246272,042	501,375	,000
Within Groups	29471,625	60	491,194		
Total	768287,750	63			

The effect of different cross-section on tensile strength in warp and weft direction values were not found to be significant ($p \leq 0.01$) 1% significance level based on the ANOVA table (Table 5.3).

Table 5.3 ANOVA Table cross-section effect on tensile strength in warp and weft

Oneway

ANOVA

TensileStrengthWarp

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	14078,063	3	4692,688	,184	,907
Within Groups	1533798,875	60	25563,315		
Total	1547876,938	63			

TensileStrengthWeft

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6010,500	3	2003,500	,158	,924
Within Groups	762277,250	60	12704,621		
Total	768287,750	63			

The effect of different weaving structure on elongation at break in warp and weft direction values were found to be significant ($p \leq 0.01$) 1% significance level based on the ANOVA table (Table 5.4).

Table 5.4 ANOVA Table w. structure effect on elongation at break in warp and weft

Oneway

ANOVA

BreakingElongationWarp

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1095,357	3	365,119	317,116	,000
Within Groups	69,083	60	1,151		
Total	1164,439	63			

BreakingElongationWeft

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	818,645	3	272,882	68,067	,000
Within Groups	240,542	60	4,009		
Total	1059,187	63			

The effect of different cross-sections on elongation at break in warp and weft direction values were not found to be significant ($p \leq 0.01$) 1% significance level based on the ANOVA table (Table 5.5).

Table 5.5 ANOVA Table crosssection effect on elongation at break in warp and weft

Oneway

ANOVA

BreakingElongationWarp

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	33,538	3	11,179	,593	,622
Within Groups	1130,901	60	18,848		
Total	1164,439	63			

Oneway

ANOVA

BreakingElongationWeft

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	15,909	3	5,303	,305	,822
Within Groups	1043,278	60	17,388		
Total	1059,187	63			

5.2. Tear Strength Test Results

The test results of tear strength was given in Table 5.6.

The graphical representation of the results obtained as a result of the tear strength tests made on the basis of TS EN ISO 13937-1 was given in Figure 5.5 and Figure 5.6.

Table 5.6 The result of tear strength

Weaving Structure	Sample Codes	TEAR STRENTGH (gf)	
		Warp	Weft
Plain	O.P.	5054	3125
	B.S.O.H.P.	3850	2712
	S.O.P.	4291	2819
	H.P.	3800	2618
Twill	O.T.	7784	6124
	B.S.O.H.T.	7325	5801
	S.O.T.	7542	5889
	H.T.	7321	5715
Sateen	O.S.	9745	8212
	B.S.O.H.S.	9345	7801
	S.O.S.	9530	7845
	H.S.	9214	7771
Basket	O.B.	6856	4404
	B.S.O.H.B.	6388	4311
	S.O.B.	6415	4537
	H.B.	5900	4185

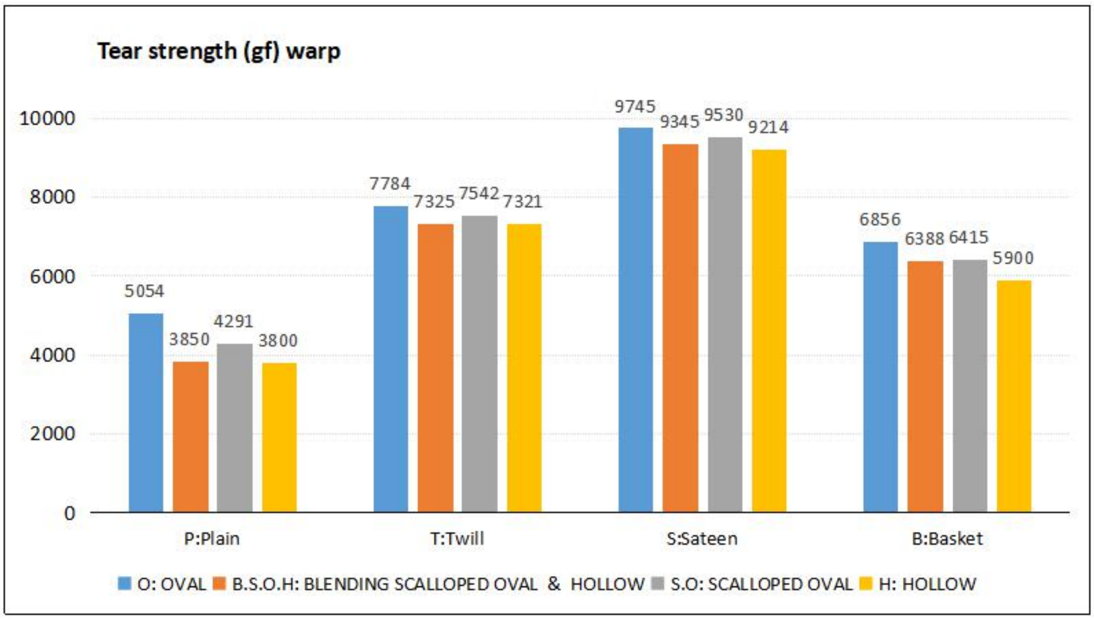


Figure 5.5 Tear strength exchange in different woven fabrics for cross-section in warp direction

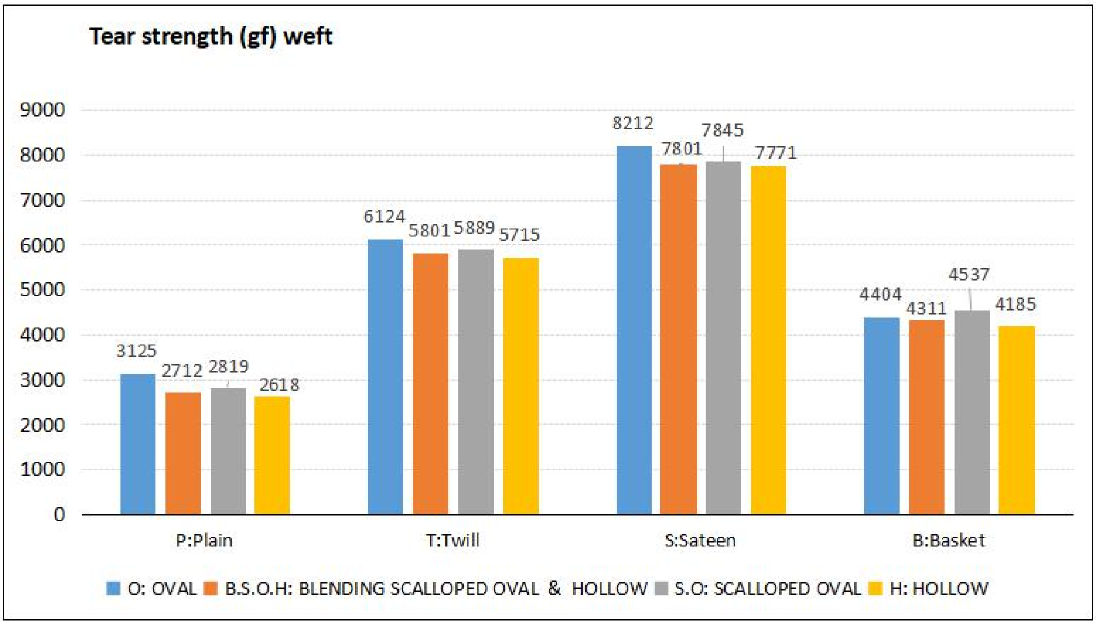


Figure 5.6 Tear strength exchange in different woven fabrics for cross-section in weft direction

When we firstly examined at warp and weft charts of the graph, it was illustrated that the warp tear values are higher in weft values. When it was examined the warp direction in terms of weaving structures, it was illustrated that sateen woven fabrics had the highest tear strength (O.S./B.S.O.H.S./ S.O.S./ H.S.). It was seen that the structures with the lowest tear strength were plain structures (O.P./ B.S.O.H.P./ S.O.P./ H.P.) in warp and weft directions. The results of the tear strength in the weft direction Figure 5.6 were similar to those of the warp result Figure 5.5. There was a significant relationship between the highest and lowest tear strengths originating from these different weaving structures. We could explain this relation in the following way; as the tear strength increased, the strength of the fabric increased. *As Booth JE's* [24] mentioned in his study that the low number of interlacing caused to increasing tear resistance of the fabric. Because, during the tear operation, the yarns slide over each other and riding on top of each other and gathering in the tear zone. This situation increased the tear strength. In the above figure, the sateen woven fabrics had the highest tear strength. There was clear relationship between basket (B) and twill (T), in the Figure 5.5 and Figure 5.6. As for the comparison of fiber cross-sectional structures,significant relationship was found. When examined in terms of fiber cross sections, when the hollow fiber (H) was blended with the scalloped oval fiber (S.O.), blending of scalloped oval and hollow (B.S.O.H.) fiber caused an decreasing tendency.

The effect of different weaving structure on tear strength in warp and weft direction values were found to be significant ($p \leq 0.01$) 1% significance level based on the ANOVA table (Table 5.7).

Table 5.7 ANOVA Table weaving structure effect on tear strength in warp and weft

Oneway **ANOVA**

TearStrengthWarp

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	108178362,4	3	36059454,13	40,948	,000
Within Groups	52836399,63	60	880606,660		
Total	161014762,0	63			

TearStrengthWeft

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	180802831,2	3	60267610,39	60,998	,000
Within Groups	59281349,06	60	988022,484		
Total	240084180,2	63			

The effect of different cross-sections on tear strength in warp and weft direction values were found to be significant ($p \leq 0.01$) 1% significance level based on the ANOVA table (Table 5.8).

Table 5.8 ANOVA Table cross-sections effect on tear strength in warp and weft

Oneway

ANOVA

TearStrengthWarp

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	12404839,13	3	4134946,375	1,669	,000
Within Groups	148609922,9	60	2476832,048		
Total	161014762,0	63			

TearStrengthWeft

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	17328573,92	3	5776191,307	1,556	,000
Within Groups	222755606,3	60	3712593,439		
Total	240084180,2	63			

5.3 Abrasion Resistance Test Results

Abrasion resistance tests of the fabric sampleswere performed on a martindale abrasion tester according to the ISO 12947-2 standard. The graphical representation of the results is shown in Figure 5.7 and Figure 5.8 and the mass values of samples after 30,000 rubbing cycles were shown in Table 5.9. This value was taken to happen the average brakes at 30,000 cycles.

The following table was shown the weights of sample fabrics before and after the test.

Table 5.9 Mass loss ratio values of samples after 30.000 rubbing cycles

Weaving Structure	Sample Code	Mass of samples before	Mass of samples after 30.000 cycles, g	Mass Loss Ratio, %
PLAIN	O.P.	0,2115	0,2063	2,5
	B.S.O.H.P.	0,2275	0,2205	3,1
	S.O.P.	0,2246	0,2133	5,0
	H.P.	0,2147	0,2066	3,8
TWILL	O.T.	0,2163	0,2037	5,8
	B.S.O.H.T.	0,2255	0,2141	5,1
	S.O.T.	0,2134	0,2054	3,7
	H.T.	0,2221	0,2126	4,3
SATEEN	O.S.	0,2225	0,2057	7,6
	B.S.O.H.S.	0,2216	0,2035	8,2
	S.O.S.	0,2273	0,2076	8,7
	H.S.	0,2141	0,1947	9,1
BASKET	O.B.	0,2134	0,1954	8,4
	B.S.O.H.B.	0,2185	0,1985	9,2
	S.O.B.	0,2223	0,2025	8,9
	H.B.	0,2231	0,2031	9,0

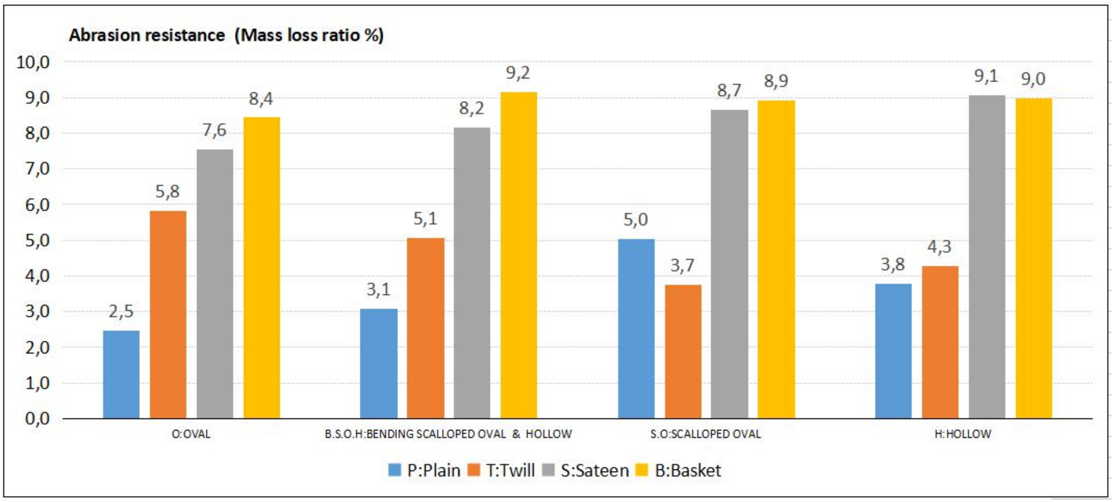


Figure 5.7 Mass loss ratio exchange in different woven fabrics for cross-section

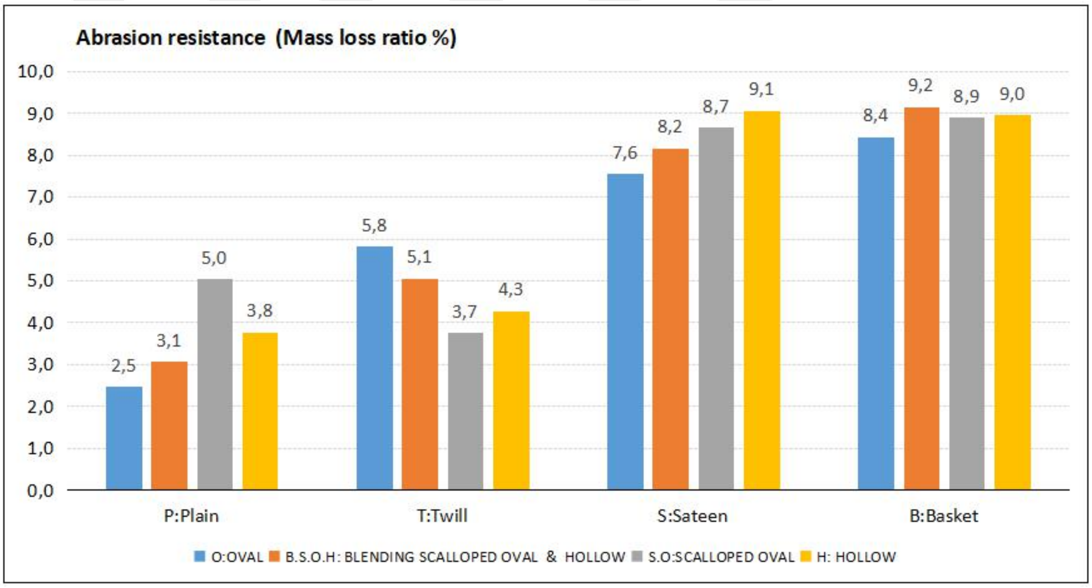


Figure 5.8 Mass loss ratio exchange in different cross-sections for weaving structures

When we examined Figure 5.7 in terms of weaving structures; it was illustrated that sateen (S) and basket (B) fabrics had low abrasion resistance. Low abrasion resistance is a high sign of mass loss. As shown in the Figure 5.7, sateen (S) and basket (B) fabrics had the highest mass loss ratio. We could say that this is due to the long jumps in the sateen and baskets. In twill (T) and plain (P) fabrics, mass loss ratio was illustrated to be less, this is because of the small number of interlacing points short jumps and interlacing points in the twill and plain structure. *As Hatice Kübra Kaynak, Mehmet Topalbekiroğlu* [25]stated similar results in their studies.

When we examined the abrasion values in terms of fiber cross-section structures, no statistical evaluation of the results was found.

The effect of different weaving structure on abrasion resistance was found to be significant ($p \leq 0.01$) 1% significance level based on the ANOVA table (Table 5.10).

Table 5.10 ANOVA Table weaving structure effect on abrasion resistance

Oneway

ANOVA

Abrasion

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	248,422	3	82,807	117,742	,000
Within Groups	30,945	44	,703		
Total	279,367	47			

The effect of different cross-sections on abrasion resistance value was not found to be significant $p \leq 0.01$) 1% significance level based on the ANOVA table (Table 5.11).

Table 5.11 ANOVA Table cross-sections effect on abrasion resistance

Oneway

ANOVA

Abrasion

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2,064	3	,688	,109	,954
Within Groups	277,303	44	6,302		
Total	279,367	47			

5.4 Air Permeability Test Results

Air permeability tests were carried out on 16 different fabrics produced according to *BS 5636: 1990 standards.* Ten tests were performed on each fabric and the average values of these values are shown in the Table 5.12. Weaving and cross section structures, air permeability averages were given as follows.

Table 5.12 Air Permeability values of samples after test

Weaving Structure	*Sample Code*	Air Permeability Trials (mm/s)
Plain	O.P.	40,1
	B.S.O.H.P.	34,97
	S.O.P.	36,62
	H.P.	34,2
Twill	O.T.	350,2
	B.S.O.H.T.	288,9
	S.O.T.	310,2
	H.T.	275,9
Sateen	O.S.	564,5
	B.S.O.H.S.	507,2
	S.O.S.	545,9
	H.S.	516,2
Basket	O.B.	342,5
	B.S.O.H.B.	297
	S.O.B.	307,7
	H.B.	242,5

Figure 5.9 and Figure 5.10 show air permeability test results of samples. The first figure showed the relationship between weaving structures and permeability, and the second figure showed the relationship between permeability and cross-sectional structures.

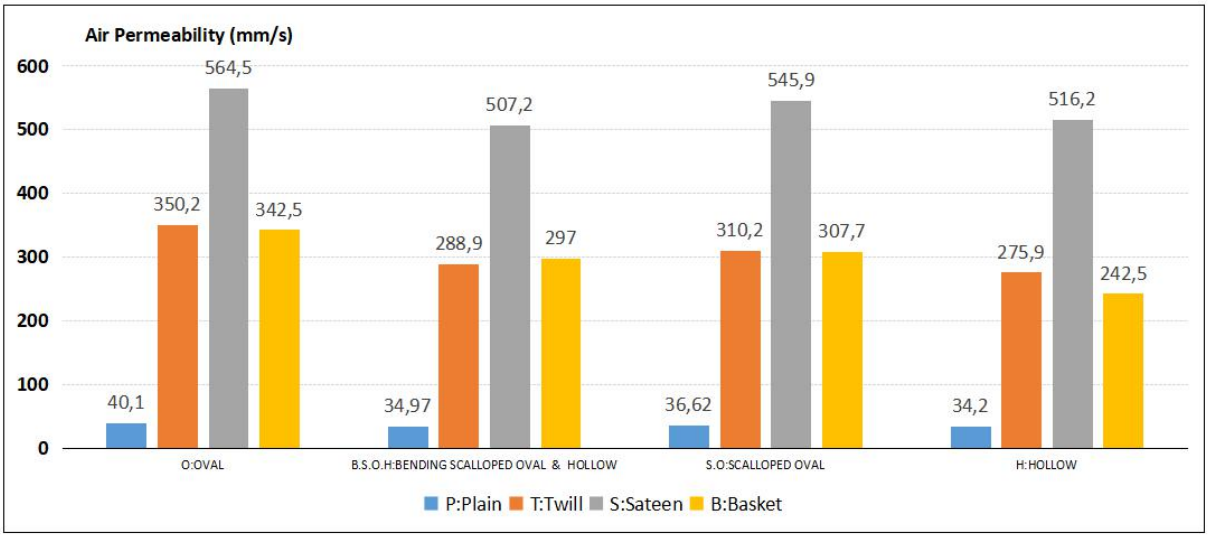


Figure 5.9 Air permeability exchange in different weaving structures for cross-sections

As shown Figure 5.9, the highest values of air permeability were showed in the fabric of sateen (S) fabric. The lowest air permeability values were available in plain

(P) weaving structures. Looking at these results; it was observed that the highest values of air permeability were attained because the skipping ratios in the sateen weaving were higher than in other weaving structures and the number of interlacing points was less. It could be said that the air permeability was low due to the fact that the interlacing point was a very tight structure.

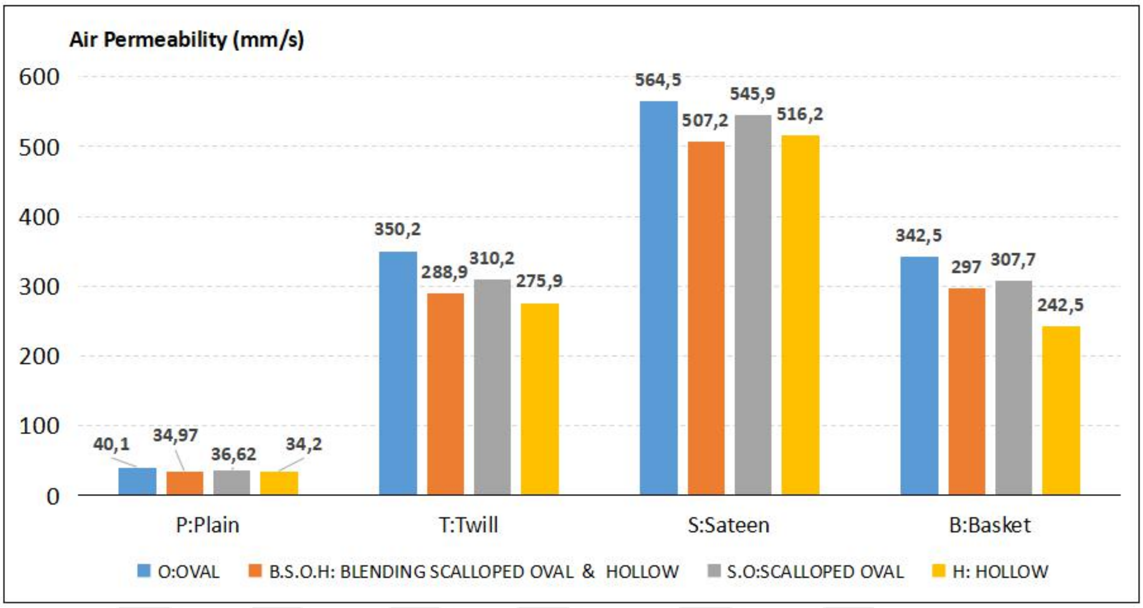


Figure 5.10 Air permeability exchange in different cross-sections for weaving structures

In the above figure, air permeability was shown in different cross-sectional structures. The measured permeability values were very close to each other but it seems that there was a statistical relation between the samples. It seems that the hollow cross section fabric with the same weaving structure had lower air permeability than the other sections, while the oval cross section fabrics had the highest air permeability. When the scalloped oval structure and the hollow oval structure were blended, the air permeability decreased. It has been seen that the permeability increased slightly with the removal of the hollow structure.

The effect of different weaving structure on air permeability was found to be significant ($p \leq 0.01$) 1% significance level based on the ANOVA table (Table 5.13).

Table 5.13 ANOVA Table weaving structure effect on air permeability

Oneway

ANOVA

AirPermeability

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2037470,995	3	679156,998	617,908	,000
Within Groups	65947,392	60	1099,123		
Total	2103418,387	63			

The effect of different cross-sections on air permeability value was not found to be significant ($p \leq 0.01$) 1% significance level based on the ANOVA table (Table 5.14).

Table 5.14 ANOVA Table cross-sections effect on air permeability

Oneway

ANOVA

AirPermeability

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	26375,694	3	8791,898	,254	,858
Within Groups	2077042,693	60	34617,378		
Total	2103418,387	63			

5.5 Drape Test Results

BS 5058 drape value test performed by applying conventional processes according to the standard were given in the table following. The first and the last weights of the paper rings, the coefficient of drape were given by using the cut - weight method.

Table 5.15 Drape coefficient of samples fabric

Weaving Structure	Sample Code	Weight of the paper ring (g)	Weight of the shaded area of the ring (g)	Drape Coefficient of specimens
Plain	O.P.	4,382	1,996	45,5%
	B.S.O.H.P.	4,382	1,988	45,4%
	S.O.P.	4,307	1,942	45,1%
	H.P.	4,375	1,982	45,3%
Twill	O.T.	4,399	1,946	44,2%
	B.S.O.H.T.	4,346	1,938	44,6%
	S.O.T.	4,352	1,944	44,7%
	H.T.	4,338	1,902	43,8%
Sateen	O.S.	4,358	1,813	41,6%
	B.S.O.H.S.	4,396	1,881	42,8%
	S.O.S.	4,383	1,857	42,4%
	H.S.	4,362	1,837	42,1%
Basket	O.B.	4,361	1,888	43,3%
	B.S.O.H.B.	4,363	1,875	43,0%
	S.O.B.	4,346	1,923	44,2%
	H.B.	4,349	1,932	44,4%

The relationship between the drape coefficients and the weaving structures was also shown in Figure 5.11 and Figure 5.12. In the statistical study, it was found that there was a significant relationship between drape and weaving structures. Plain (P) weaving structures had the highest coefficient of drape, while sateen (S) fabrics had the smallest coefficient values. Twill (T) structure fabrics had higher coefficient

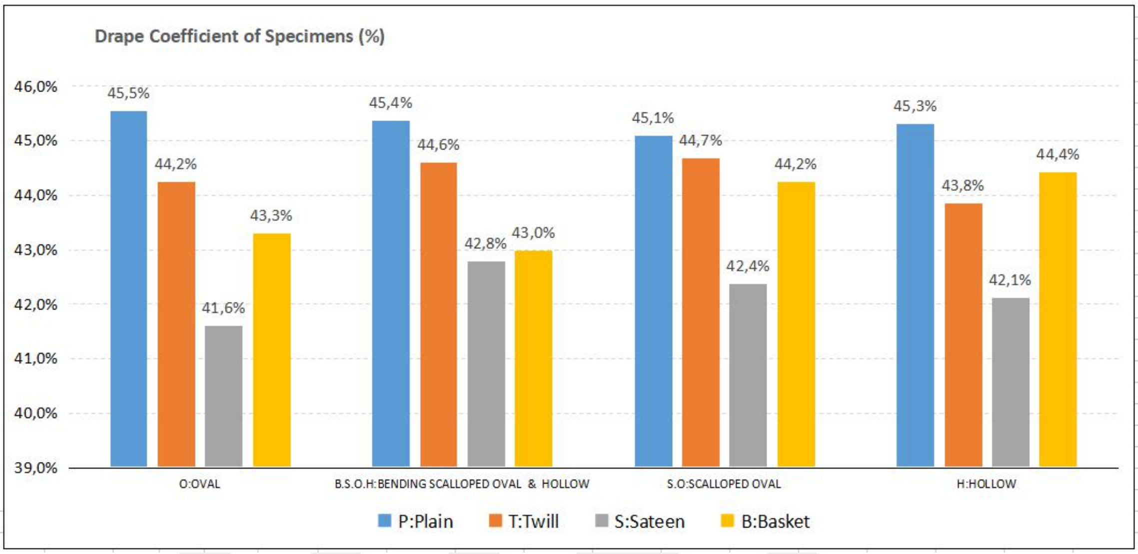


Figure 5.11 Drape coefficient exchange in different weaving structures for cross-sections

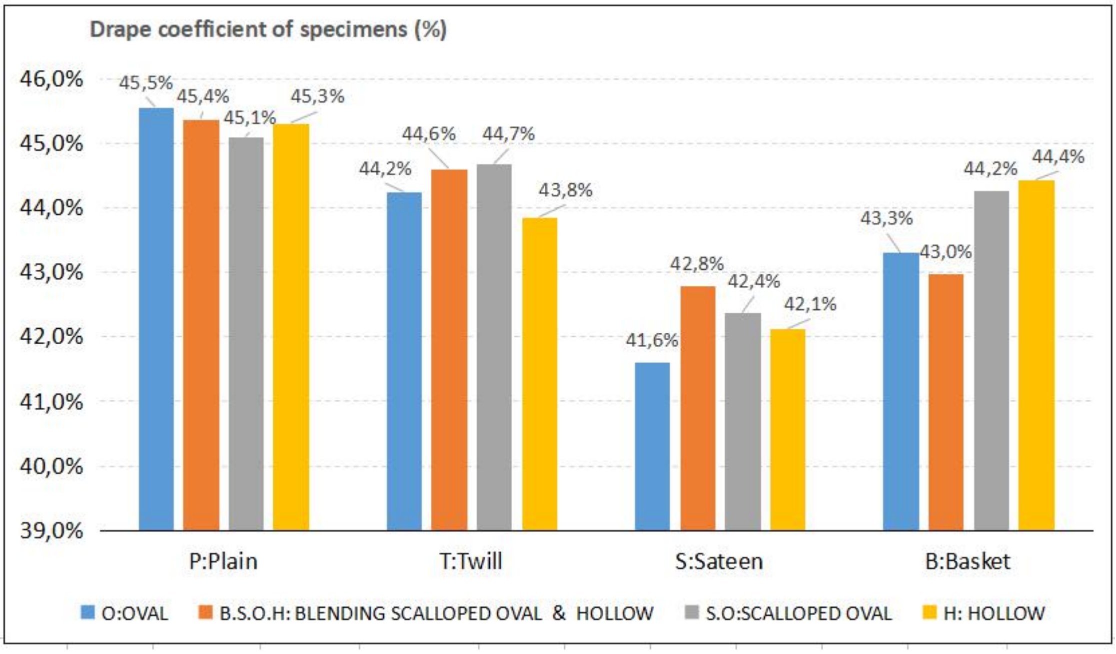


Figure 5.12 Drape coefficient exchange in different cross-sections for weaving structures

values than sateen fabrics and smaller values than plain (P) fabrics. Basket-structured fabrics (B) had higher values than sateen (S) fabrics. When we compared it with fabric made of twill; it was observed that some cross sections had high values and some sections had low values. These indications showed us that the yarns in the fabrics were directly proportional to the drape at the interlacing point. When compared to the plain structure with the sateen structure, it could be said that there were fewer interlacing points in the sateen structure, so that the threads could move more easily and easily. *Nazan Erdumlu* also found similar results in her study [29].

If we examined the relationship between cross-sections and drapes, it was seen that no statistically significant results were obtained. For example; When we compared the fabrics having four different cross sections, the oval structured fabric had the highest value in the plain fabric, on the other hand, the oval structured fabric had the lowest coefficient values in the sateen fabrics having four different cross sections.

The effect of different weaving structure on drape coefficient was found to be significant ($p \leq 0.01$) 1% significance level based on the ANOVA table (Table 5.16).

Table 5.16 ANOVA Table weaving structure effect on drape coefficient

Oneway

ANOVA

Drapeability

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	60,980	3	20,327	33,116	,000
Within Groups	27,007	44	,614		
Total	87,987	47			

The effect of different cross-sections on drape coefficient value was not found to be significant ($p \leq 0.01$) 1% significance level based on the ANOVA table (Table 5.17).

Table 5.17 ANOVA Table cross-sections effect on drape coefficient

Oneway

ANOVA

Drapeability

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1,073	3	,358	,181	,909
Within Groups	86,914	44	1,975		
Total	87,987	47			

5.6 The Result of Brightness Test

The test result of brightness was given in Table 5.18, Figure 5.13 and Figure 5.14 illustrates the effect of weaving structures and cross-sections on the brightness index.

Table 5.18 Brightness index value of samples fabric

Weaving Structures	Sample Code	Brightness Index
Plain	O.P.	80,29
	B.S.O.H.P.	81,59
	S.O.P.	84,18
	H.P.	78,50
Twill	O.T.	80,39
	B.S.O.H.T.	84,09
	S.O.T.	84,90
	H.T.	78,99
Sateen	O.S.	81,10
	B.S.O.H.S.	85,30
	S.O.S.	85,45
	H.S.	79,61
Basket	O.B.	79,48
	B.S.O.H.B.	82,10
	S.O.B.	83,61
	H.B.	79,17

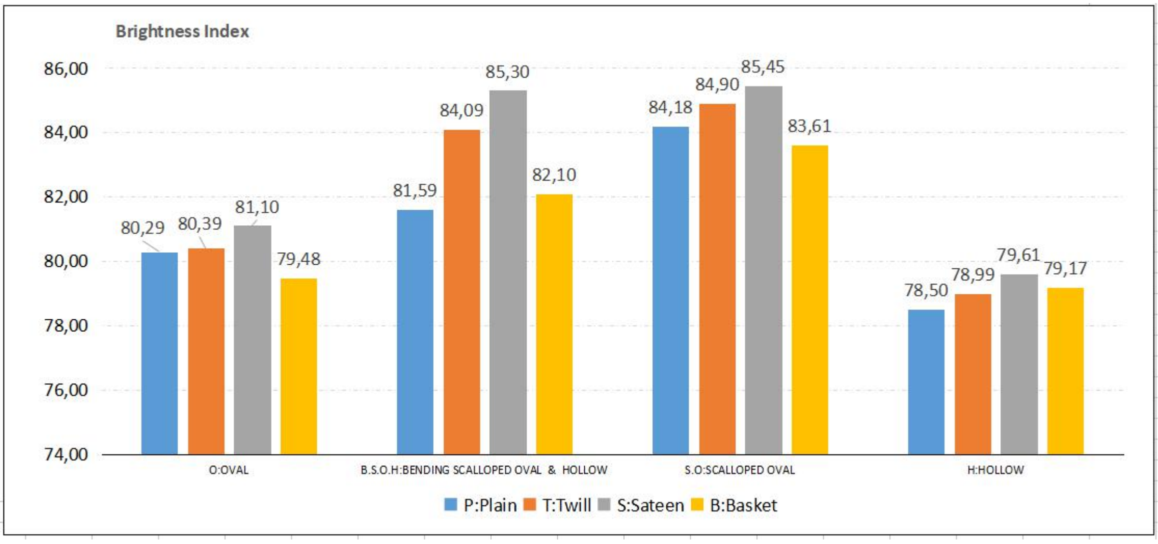


Figure 5.13 Brightness index exchange in different weaving structures for cross-sections

When we examined Figure 5.13, there was an increasing trend in the brightness towards the sateen weave structure (O.S./ B.S.O.H.S./ S.O.S./ H.S.) from the plain weave structures(O.P./ B.S.O.H.P./ S.O.P./ H.P.). However, this increasing tendency reduced in basket weaving patterns.This showed us that sateen weave had the most brilliant values. When twill weave and plain weave structures were compared, it was illustrated that the twill weaves (O.T./B.S.O.H.T./S.O.T./H.T.) were brighter than the plain weave (O.P./ B.S.O.H.P./S.O.P./ H.P.) at pillar graphics.When the relationship between plain weave and basket weave was examined, the plain structure was brighter than the basket weave in the structures woven with oval and scalloped oval cross-section . The basket weaving structure was brighter than plain weave in the structures woven with hollow and blending scalloped oval & hollow cross-sections. Therefore, no significant difference was found between plain and basket weave structure.

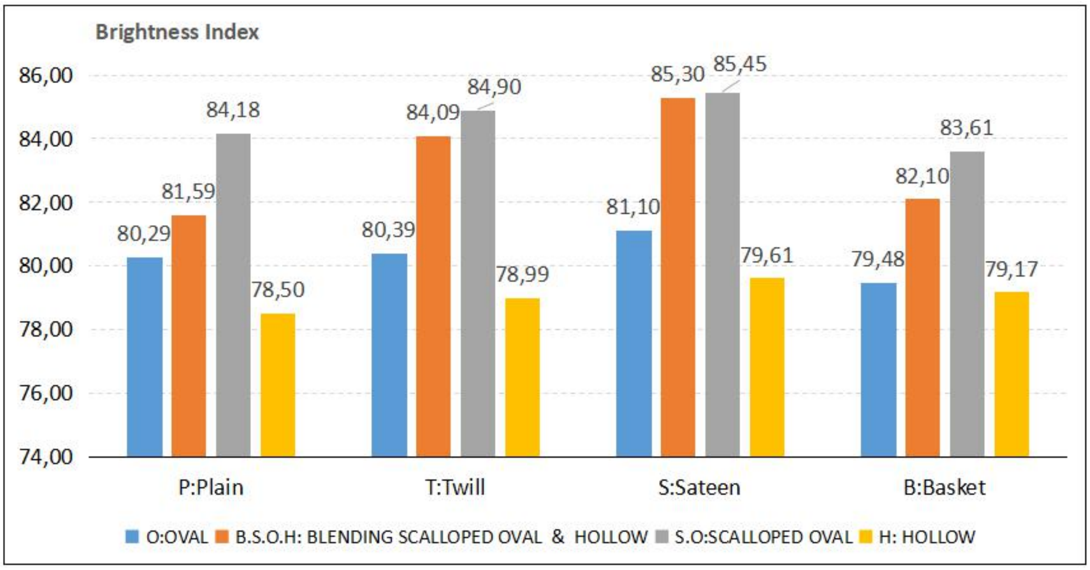


Figure 5.14 Brightness index exchange in different cross-sections for weaving structures

When we examined Figure 5.14, the relation between the different fiber cross-section and the brightness index was given. As it was illustrated, scalloped oval cross-sections weaved with four different weaving structures(S.O.P./ S.O.T./ S.O.S./ S.O.B.) gave the highest brightness values. While the scalloped oval structure had the highest brightness values (S.O.), hollow cross-section (H.) had the lowest brightness values. From the oval cross section (O.) to the scalloped oval cross sections (S.O.), an increasing tendency was illustrated in the brightness values, on the other hand, with using the hollow cross sections (H.), the lowest brightness values occurred.The scalloped oval structure showed a decreasing tendency by mixing the hollow oval cross-section in the brightness values (B.S.O.H.). When the Oval cross-section was compared with the hollow cross-section, it was illustrated that the hollow cross-section (H.) was duller.

The effect of different weaving structure on brightness was not found to be significant ($p \leq 0.01$) 1% significance level based on the ANOVA table. (Table 5.19)

Table 5.19 ANOVA Table weaving structure effect on brightness

Oneway

ANOVA

BrightnessTest

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	26,572	3	8,857	1,503	,227
Within Groups	259,382	44	5,895		
Total	285,954	47			

The effect of different cross-sections on brightness value was found to be significant ($p \leq 0.01$) 1% significance level based on the ANOVA table. (Table 5.20)

Table 5.20 ANOVA Table cross-sections effect on brightness

Oneway

ANOVA

BrightnessTest

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	233,074	3	77,691	64,645	,000
Within Groups	52,880	44	1,202		
Total	285,954	47			

5.7 The Result of Water Vapor Permeability Test

The weight changes in the fabric and test plan during the water vapor permeability test were shown in the following Table 5.21. and Figure 5.15. and 5.16.

According to Figure 5.15, the highest water vapor permeability value was seen in sateen weaving structures (O.S./ B.S.O.H.S./ S.O.S./ H.S.).When we examined the lowest water vapor permeability values, it was seen that there were plain fabrics (O.P./ B.S.O.H.P./ S.O.P./ H.P.). For this reason, a tight structure had been formed due to high interlacing points. When we compared the weaving structures, it seems that a meaningful relationship had emerged. Sateen fabrics (O.S./ B.S.O.H.S./ S.O.S./ H.S.) were the highest, plain woven fabrics (O.P./ B.S.O.H.P./ S.O.P./ H.P.) were the lowest, twill (O.T./ B.S.O.H.T./ S.O.T./ H.T.) and basket fabrics (O.B./ B.S.O.H.B/ S.O.B./ H.B.) had the intermediate scale values.

Table 5.21 Water vapor permeability values of sample fabrics

Weaving Structures	Sample Code	Weight Loss Occured in the Vessel (gr)	Water Vapor Permeability (g/m2/day)
Plain	O.P.	0,8541	757,64
	B.S.O.H.P.	0,8595	762,40
	S.O.P.	0,8550	758,41
	H.P.	0,8529	756,52
Twill	O.T.	0,8697	771,48
	B.S.O.H.T.	0,9009	799,10
	S.O.T.	0,8877	787,39
	H.T.	0,8934	792,48
Sateen	O.S.	0,9240	819,62
	B.S.O.H.S.	0,9377	831,74
	S.O.S.	1,0180	903,00
	H.S.	0,9322	826,86
Basket	O.B.	0,8580	761,07
	B.S.O.H.B.	0,8598	762,67
	S.O.B.	0,9633	854,51
	H.B.	0,9216	817,46

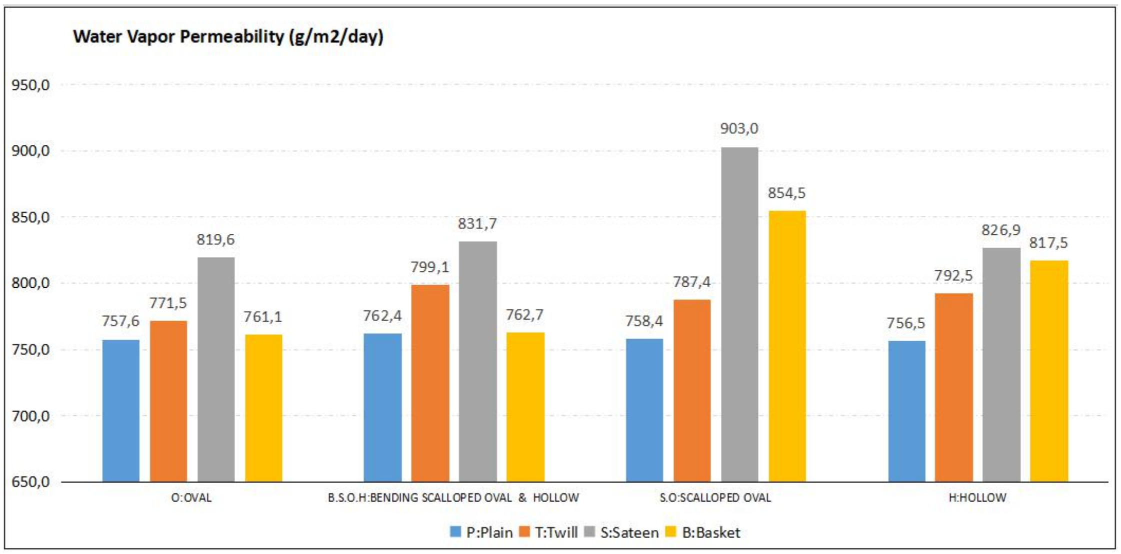


Figure 5.15 Water vapor permeability exchange in different weaving structures for cross-sections

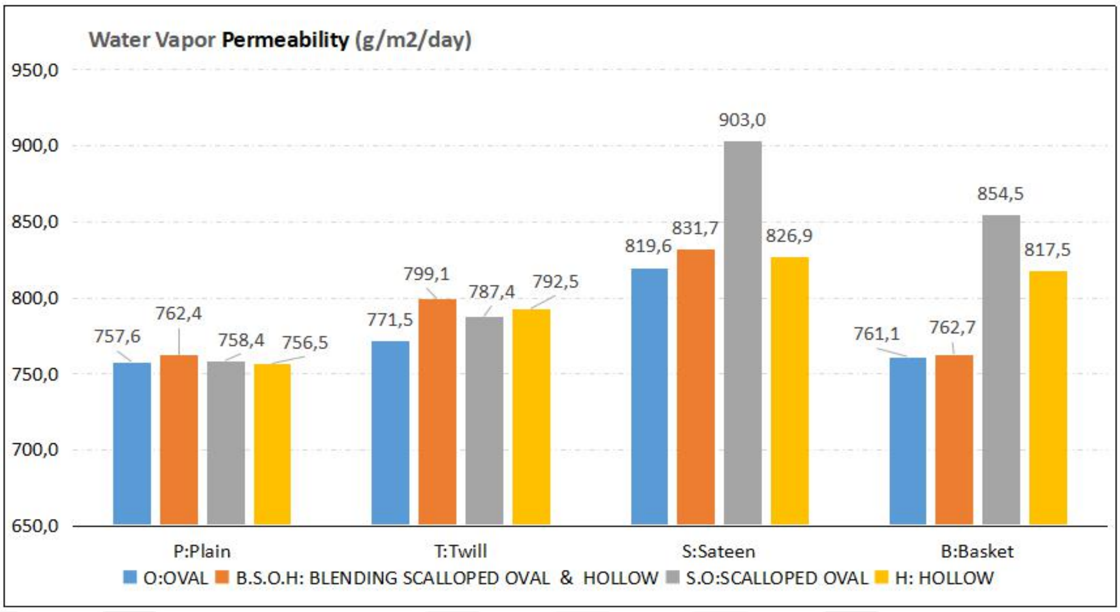


Figure 5.16 Water vapor permeability exchange in different cross-sections for weaving structures

When we examined according to the cross-sectional shapes Figure 5.16, a statistical value was not observed. For example; the scalloped oval with sateen and basket weave had the highest water vapor permeability, while the plain and twill structures showed lower values than the other cross-section structures. Therefore, the contribution of the cross-sections to the water vapor permeability could not be exactly determined.

The effect of different weaving structure on water vapor permeability was found to be significant ($p \leq 0.01$) 1% significance level based on the ANOVA table (Table 5.22).

Table 5.22 ANOVA Table weaving structure effect on water vapor permeability

Oneway

ANOVA

WaterVaporPermeability

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	46643,806	3	15547,935	8,071	,000
Within Groups	84761,938	44	1926,408		
Total	131405,744	47			

The effect of different cross-sections on water vapor permeability value was not found to be significant ($p \leq 0.01$) 1% significance level based on the ANOVA table (Table 5.23).

Table 5.23 ANOVA Table cross-sections effect on water vapor permeability

Oneway

ANOVA

WaterVaporPermeability

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	15329,725	3	5109,908	1,937	,138
Within Groups	116076,020	44	2638,091		
Total	131405,744	47			

CHAPTER 6

CONCLUSION

In this study, many production processes were carried out from yarn production to fiber production. We have produced Ne 20 and 100% polyester yarn using four different cross-section having staple polyester fibers with ring spinning technology. Fiber supplies, yarn and fabric productions were carried out in Kipas Textile Company.

Produced polyester yarns with four different cross sections; oval, hollow, scalloped oval, blending scalloped oval & hollow (O./ B.S.O.H./ S.O./ H.) were produced using four different weave structures ; plain, twill, basket, sateen (P./ T./ B./ S.).In this study, sixteen fabrics were produced by fabric production in different weaving structures of each section. Fabric productions were carried out in Kipas Textile Company. For statistical studies between fabrics; the same weaving density, the same weft and warp threads, the same reed number, production parameters are kept constant.

6.1 Conclusion of Studying

6.1.1 Conclusion of Statistical Analyzes

Regarding with statistical analyzes, all performance properties were examined by statistical analyzes through SPSS 15.0 program. All experimental result was investigated the influence on terms of weaving structure and cross-section shape through ANOVA table. According to ANOVA Table all performance of properties fabric was obtained the of $p \leq 0.05$ and $p \leq 0.01$ at 1% and 5% significance level and non-significance level in weaving structure and cross-section shapes effect on performance properties.

6.1.2 Conclusion of the Effect Performance Properties of Weaving Structure and Cross-sections

The yarns and fabrics were tested for their SEM , performance properties and comfort properties.

In this study it was examined as following.

- ✓ The effect of different weaving structures on performance and comfort properties.
- ✓ The effect of different cross-sections on performance and comfort properties

6.1.2.1 Tensile Strength Analysis

The Result of the tensile strength was the highest tensile strength values both in warp and weft directions were obtained in all lain fabrics produced from oval, blending scalloped oval and hollow, scalloped oval and hollow cross-section fibers (O.P./ B.S.O.H.P./ S.O.P./ H.P.). The tensile strength of sateen fabrics were lower than the plain, twill and sateen fabrics when considering the strength values in the warp and weft direction. On the other hand, small differences in the tensile strength of the staple yarns from fibers having different cross-sectional shapes did not cause significant differences in the tensile strengths of the fabrics.

6.1.2.2 Tear Strength Analysis

The highest tear strength was obtained by sateen weaving structures containing woven fabric (O.S./ B.S.O.H.S./ S.O.S./ H.S.). It was seen that the structures with the lowest tear strength were plain structures (O.P./ B.S.O.H.P./ S.O.P./ H.P.). According to the result, there was a significant relationship between the highest and lowest tear strengths originating from these different weaving structures. The sateen woven fabrics had the highest tear strength. As for the comparison of fiber cross-sectional structures, a significant relation was found. When examined in terms of fiber cross sections, when the hollow fiber (H) was blended with the scalloped oval fiber (S.O.), blending of scalloped oval and hollow (B.S.O.H.) fiber caused an decreasing tendency.

6.1.2.3 Abrasion Resistance Analysis

The results showed that the abrasion resistance of sateen and basket fabrics were low. We had known that less abrasion resistance was a sign of mass loss. According to the results, sateen and basket fabrics had the most mass loss. In twill and plain fabrics showed the least mass loss.

When we examined the abrasion results in terms of fiber cross-section structures, no statistical evaluation of the results was found.

6.1.2.4 Air Permeability Analysis

The Results showed the relationship between weaving structures,cross-sectional structure and air permeability, The sateen fabric showed the highest values of air permeability. The plain weaving structures showed the lowest air permeability values.

According to the relationship between different cross section structures and air permeability, the measured permeability values were very close to each other but it was seen that there was a statistical relation between the samples. It was seen that the hollow cross section fabric with the same weaving structure had lower air permeability than the other sections. However, oval cross section fabrics showed the highest air permeability. When the scalloped oval structure and the hollow structure were blended, the air permeability decreased. It showed that the permeability increased slightly with the removal of the hollow structure.

6.1.2.5 Drape Analysis

According to the results, there was a significant relationship between drape and weaving structures. Plain weaving structures showed the highest coefficient of drape, when sateen fabrics showed the smallest coefficient values. Twill structure fabrics showed higher coefficient values than sateen fabrics and smaller values than plain fabrics. Basket-structured fabrics showed higher values than sateen fabrics. When we compared it with fabric made of twill. It was showed that some cross sections had high values and some sections had low values.

According to the results between cross sections and drapes, it was seen that no statistically significant results are obtained. For example; When we compared the fabrics having four different cross sections, the oval structured fabric showed the highest value, on the other hand, the oval structured fabric showed the lowest coefficient values in the sateen fabrics having four different cross sections.

6.1.2.6 Brightness Analysis

According the results, there was an increasing trend in the brightness towards the satin weave structure from the plain weave structures. However, this increasing tendency reduced in basket weaving patterns. The results of sateen weave showed the most brilliant values. The twill weaves were brighter than the plain weave. The plain structure was brighter than the basket weave in the structures woven with oval and scalloped oval cross-section. The basket weaving structure was brighter than plain weave in the structures woven with hollow and blending scalloped oval & hollow cross sections.

The relationship between the different fiber cross-section and the brightness was examined, the results showed that polyester yarns with scalloped oval cross sections woven with four different weaving structures given the highest brightness values. While the highest brightness values were in the scalloped oval structure, the lowest brightness values were seen in hollow cross-section fabrics. The scalloped oval structure with high brightness showed a decrease in the brightness values in the woven fabrics by mixing the hollow oval section. When the oval cross section was compared with the hollow cross section, it showed that the hollow cross section was more dull.

6.1.2.7 Water Vapor Analysis

According the results, there was a significant relationship between water vapor permeability and weaving structures. Sateen weaving structures showed the highest WVP, when plain fabrics showed the smallest values. Twill structure fabrics showed higher values than plain fabrics and smaller values than sateen fabrics. Basket-structured fabrics showed higher values than fabrics.

According to the results between cross sections and water vapor permeability, it was seen that no statistically significant results were obtained. For example; the scalloped oval with sateen and basket weave has the highest water vapor permeability, while the plain and twill structures show lower values than the other section structures.

According to Figure 5.15, the highest water vapor permeability value was seen in sateen weaving structures (O.S./ B.S.O.H.S./ S.O.S./ H.S.). The reason for this result was that the sateen weaving fabric was loose and the float rate was high.

When we examined the lowest water vapor permeability values, it was seen that there were plain fabrics (O.P./ B.S.O.H.P./ S.O.P./ H.P.). For this reason, a tight structure had been formed due to high interlacing points.

6.2 Recommendations for Further Studying

In this study we examined different cross-section of polyester fibers and effects of some structural and comfort properties on different woven fabrics endeavored to have scientific research about different woven fabric performance and physical characterization and properties, however this studying might not be satisfied or give answer directly for further purposes, for this reason we can give some recommendation for further studying.

- ✓ Different fibers may be used rather than polyester fibers such as viscose
- ✓ Different shaped structures may be used than cross-sectional structures used to detect different properties.
- ✓ Different finishes such as flame retardant and antimicrobial can be applied to reveal different properties.
- ✓ Different tests can be performed in which the effect of cross-sections is more visible such as thermal heat comfort test.

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