MARCH 2019

M. Sc in Textile Engineering

TUĞBA CAN

REPUPLIC OF TURKEY

GAZİANTEP UNIVERSITY

GRADUATE SCHOOL OF NATURAL & APPLIED SCIENCES

PERFORMANCE PROPERTIES OF FLAT KNITTED FABRICS PRODUCED BY DIFFERENT DESIGNS AND RAW MATERIALS

M. Sc. THESIS

IN

TEXTILE ENGINEERING

BY

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M. Sc. Thesis

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Supervisor

Assoc. Prof. Dr. Züleyha DEĞİRMENCİ

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This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

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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.

Tuğba CAN

ABSTRACT

PERFORMANCE PROPERTIES OF FLAT KNITTED FABRICS PRODUCED BY DIFFERENT DESIGNS AND RAW MATERIALS

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M. Sc in Textile Engineering
Supervisor: Assoc. Prof. Dr. Züleyha DEĞİRMENCİ
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In this study, 30 different fabrics were produced by 10 different patterns (single jersey, ribana, interlock, purl, half cardigan, full cardigan, lace, single lacoste, double lacoste and moss stitch) and 3 different raw materials (cotton, acrylic and polyamide). Since the aim of the study is investigating the effects of design on performance of the study, each raw material was evaluated within. All the production adjustments are selected as optimum. During the production the Performance tests (air permeability, bursting strength, pilling and abrasion resistance) and aesthetic tests (softness, drapability and wrinkle recovery) were applied to the fabrics produced. Through the graphical and statistical methods, the effects of structural, performance and aesthetic properties of patterned fabrics have been tried to be determined. It is also to determine the relationship between the design parameter and the raw material of the samples being done with different raw materials. At the end of the study, it is concluded that flat knitted patterns can not be produced by constant adjustments than it is the reason of the less study about this subject. Therefore the impoartance of the study increases that it will fill the lack of literature

Key words: Flat knitted, knitted pattern, aesthetic test

ÖZET

FARKLI DESENLERLE VE HAMMADDELERLE ÜRETİLEN DÜZ ÖRME KUMAŞLARIN PERFORMANS ÖZELLİKLERİ

CAN, Tuğba
Yüksek Lisans Tezi, Tekstil Mühendisliği
Tez Yöneticisi: Doç. Dr. Züleyha DEĞİRMENCİ
Mart 2019
93 sayfa

Bu çalışmada düz örme makinesi kullanılarak 3 farklı hammaddeden (pamuk, akrilik ve polyamid) ilmek-askı kombinasyonlarıyla 10 farklı desende (süprem, ribana, interlok, horoşa, yarım selanik, tam selanik, pirinç, tek lakost, çift lakost ve ajurlu) 30 farklı kumaş üretilmiştir. Çalışmanın ana amacı desenin performansa etkisi olduğu için her hammadde kendi içinde değerlendirilmiştir. Üretim sırasında iplik numara ve makine sıklık ayarları optimum olacak şekilde seçilmiştir. Üretilen kumaşlara performans testleri (hava geçirgenliği, patlama mukavemeti, boncuklanma ve aşınma dayanımı) ve estetik testler (yumuşaklık, dökümlülük ve buruşma dayanımı) uygulanmıştır. Grafikler ve istatistiksel metotlar aracılığıyla desenin kumaşların yapısal, performans ve estetik özeliklerine olan etkileri saptanmaya çalışılmıştır. Çalışmanın farklı hammaddelerle yapılmasının nedeni desen parametresinin hammaddeyle ilişkisini de tespit etmektir. Çalışma sonunda düz örme makinesi ile aynı parametrelerle farklı desenler üretmenin oldukça zor olmasının; bu konuda araştırma azlığının nedeni olarak görülmüştür. Bu durum çalışmanın litaratürdeki boşluğu kapatması bakımından önemini arttırmaktadır.

Anahtar kelimeler: düz örme, örme deseni, estetik testler

To My Sons

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In this work, sharing his valuable information with me, when I consulted him with his precious time and patience and with great interest to be useful to me every time I have problems to offer more than I can go without hesitation, smiling face and sincerity in my life and in my professional life that he gave me in my life My valued teacher Züleyha DEĞİRMENCİ, who I think will benefit from valuable information and who fulfills the status of consultant teacher,

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My mother and children Mustafa Agah and Mehmet Taha CAN, my precious husband Mehmet CAN, who did not support me in completing my thesis which I started a week after our marriage and completed two children,

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CHAPTER 1

INTRODUCTION

Knitted fabrics are frequently preferred because of their flexibility, softness, easy adaptation to the body and shorter production times than the woven fabric. In terms of production principles, weft knitting and warp knitting are generally divided into two main groups. In general, fabrics obtained by weft knitting are used for the production of fabrics (T-shirts, sweaters, tracksuits, socks, dresses) that we use more frequently in our daily lives. The fabrics obtained by warp knitting are mostly used in the production of fabrics (curtains, tablecloths, geotextiles, medical products) that we use for technical purposes. According to the principle of weft knitting, fabrics are produced by circular knitting, flat knitting and sock machines. According to the principle of warp knitting, fabrics are obtained with raschel and tricot machines. When we talk about weft knitting, we present circular and flat knitting machines. Circular knitting machines can be classified as industrial machines that enable the production of socks machines, seamless knitting machines and feature films. Flat knitting machines are likely to be classified as mechanical, electronic and automatic machines. These machines are usually machines that allow the production of everyday garments, the machine body is flat and electronically controlled by the pattern and the tension. Color, pattern and fashion cannot be discussed among the preference of outer garments which are frequently used in our daily lives. In relation to the user's knowledge levels, the raw material of the product is also one of the reasons to choose. Although many products purchased are used in terms of performance, they are out of use due to aesthetic losses in consumers. Therefore, aesthetic features, strength and comfort are important performance parameters for the fabrics produced. The aim of this study is to produce a sample fabric with different patterns (single jersey, ribana, interlock, purl, half cardigan, cardigan, single lacoste, double lacoste, lace, moss stitch) by using different raw materials (natural, semi-synthetic and synthetic), in flat knitting machines. And to determine the effects of the pattern parameter on the structural properties (thickness, unit weight, stitch density, loop shape factor and porosity), performance properties (air permeability, bursting strength, abrasion resistance, pilling resistance), and aesthetic properties (wrinkle recovery, bending rigidity, drapeability) of knitted fabrics necessary tests were applied.

1.1 Properties of Raw Materials Used in This Study

In this study, the raw materials are polyamid, acrylic and cotton. These fibers are selected to show the effect of pattern on the performance of knitted fabrics distinctly. Polyamid is the popular type of synthetic fibers, acrylic is the popular type of semi-synthetic fibers and cotton is the popular type of natural fibers. Then it is concluded that these fibers are quite different to each other and because of this difference pattern effect can be seen easily. Their yarn counts are closer to each other.

1.1.1 Polyamid

Polyamid is a synthetic fiber. It is produced by melt spinning technique. Using of polyamid in knitted structure is popular nowadays. The most important Polyamid are nylon 6 and nylon 6.6. Nylon 6 is made by polymerising caprolactam (a cyclic amide derived from aparticular amino acid) to polycaprolactam. Nylon 6.6, is made by condensation polymerisation of hexametilene diamine and adipic acid, through the intermadiate "nylon salt", to poly (hexamethylene adipamid). In this study Nylon 6 is used. The nylon 6 or 6.6 is melted and either extruded directly or converted into nylon chips for later use. After emerging from the spinneret, the filaments are cooled in a cold air stream and and drawn by three to fourfold in length [1].

Polyamides are linear macromolecules containing amide groups (-CO-NH-) at regular intervals. Different types of polyamid are made by using starting materials (monomers) of different sizes (different numbers of carbon atoms). Nylon 6 has six carbons in the repeating unit; Nylon 6.6 has to sets of six carbons [1].

Nylon 6 and nylon 6.6 are used in apparel, household, and technical fabrics. There are special types for particular end uses. Examples are high-bulk, antistatic, and high-lustre types. The newest polyamide types are the so-called aramids. These are polyamides which contain a large proportion of aromatic (phenyl) groups. Such fibres tend to have more highly oriented molecules and higher crystallinity; they are therefore stronger and more resistandt to high temperatures [1].

Comfort is quite important for textile materials. People prefer textiles according to generally their comfort properties. Today “thermal comfort” term is used to define the comfort of textiles in accordance with thermal absorptivity, warm-cool effect, water vapor permeability and next to skin performance. Insulation properties depend on whether the fibre is produced as flat flament, textured flament, or stable yarn. Flat flaments entrap very little air and have low insulation. Texturing İncreases the specific volume and allows more air to be enclosed for better insulation. Stable yarns may be either fine and smooth or more voluminous. Nylon absorb little water; between 3.5 and 4.5%. In textured yarns, the capillary spaces are capable of transporting liquid water effectively. Fine and soft nylon fibres are utilised for apparel fabrics [1].

Polyamid is very strong and has excellent abrasion resistance. The wet strength is 80 to 90% of the dry. Aramid fibres have about five times the tensile strength of apparel fibres. Breaking extension of polyamid is very high, either wet or dry. Depending on the fibre type it my be from 20 to 80%. Polyamid is very resilient and wrinkle-resistant. Electrostatic Charge of polyamid is very susceptiple, but can be reduced by special antistatic treatments [1].

Fineness of polyamid ranges from microfibres to coarse fibres. Fabrics may be fine and soft or firm, according to fibre fineness, fabric consturuction, and finishing. Lustre of polyamid is from matt to high lustre, depending on fibre cross-section and addition of delustrants. Polyamid is thermoplastic; can be permanently shaped under the influence of heat. This property is utilisied for texturing and heat setting. Polyamid is resistant to alkalis and many solvents. It is attacked by concentrated acids. Polyamid will yellow and lose strength on long exposure to sunlight. Resistance can be improved by including special chemicals in the spinning melt. Polyamid is resistant to moulds and fungi. It does not decompose. Polyamid is sensitive to dry heat [1].

There are many applications of polyamid. Filament yarns, usually textured, are about 80% of nylon production. They are utilised in sheer stockings, lingerie, foundation garments, swimming, sports and leisure wear, linings, dresses and blouses, weather-proof clothing and umbrellas, reinforcing yarns for knitted fabrics and carpets. Monofilaments are used for sewing yarns. Stable fibres are blended with wool, cotton, or other man-made fibres for apparel fabrics. They are used in knits, plush, carpet pile, and drapes. They are also used for fleece fabrics [1].

Microscobic view of polyamid is usually circular but depends on the spinneret. Polyamid shrinks and melts away from the flame with fibre-forming drips. Residue is hard and uncrushable. Polyamid is destroyed by 80% formic acid and concentrated mineral acids. Slightly degraded by dilute organic acids. Polyamid is machine washable, quick drying, and wrinkle-resistant but should be ironed with care [1].

1.1.2 Acrylic

Acrylonitrile, made from propylene and ammonia, is polymerised to form polyacrylonitrile powder. It is dissolved in dimethylformamid or dimethylacetamide, and either wet or dry spun to acrylic filaments. Polymerisation of the acrylonitrile can also be effected in the solvent, to form the spinning solution directly. The polyacrylic linear chain molecule is built from repeating units of CH2CHCN. There are three broad types of acrylic fibres: normal acrylics, modacrylics (modified acrylics), which are highly resistant to burning, and the porous fibre Dunova. Acrylics are produced almost exclusively as staple fibres. They have a wool-like handle, low density, and good resistance to light and chemicals. Like all synthetic fibres they are thermoplastic and wrinkle-resistant (though they are susceptiple to deformation in steam or hot water) [1].

Acrylic yarns are usually voluminous, and are very soft and warm; somewhat similar to wool in character. Heat will cause the fibres to shrink strongly. By mixing such fibres with stabilize fibres in a spun yarn, a subsequent heat treatment will induce bulking in the yarn, due to the shrinkage of the unstabilised fibres. Acrylic yarns have a high spesific volume, due partly to the low density of the fibres [1].

Applications of Acrylics are spun into staple yarns, either alone or blended, especially with wool. The yarns are made into knitted fabrics, outwear, blankets, imitation fur, drapes and furnishings, carpets and awnings. Modacrylics are modified acrylic fibres. Their properties include flame resistance. They are made into protective clothing and drapes. Porous acrylic fibre contains many micro-capilleries which are able to absorb liquids. It is used for warm and absorbent underwear. Acrylic shrink and burn with a sooty flame, with melting and dripping. The smell is pungent; the residue is hard and unbreakable. Acrylic **s**olvents are dimethylformamid, dimethylacetamide, and nitric acid. Acrylics are susceptible to heat and must be ironed carefully [1].

1.1.3 Cotton

The high strength of the cotton fibre is a consequence of its construction from highly organised cellulose chain molecules in the fibre interior (crystalline regions).Cotton fibres are relatively fine and flexible. Therefore they are often made into textiles which have a relatively low proportion of entrapped air (low specific volume). Warmer, more voluminous materials can be made, however, by appropriate choice of yarn and fabric constructions and through roughening (raising) the surface. Cotton can absorb up to 20% of water vapour without feeling wet. Cotton fabrics absorb liquid very rapidly and can contain up to 65% of their own weight without dripping. Cotton dries slowly. Cotton is very comfortable next to the skin because of its fineness and softness. The extensibilty of cotton is relatively low, at about 6-10%. Cotton has a very poor elasticity and therefore it wrinkles easily. It develops scarcely any eloctrostatic charge because it always contains Moisture, which conducts the charge anyway. Cotton fibres are fine and soft, they have a pleasant hande. There are some methods for the improvement of the properties by finishing [1].

1.1.3.1 Mercerising

Treatment of cotton under tension with caustic soda solution causes the fibre cross-section to become more circular. This results in higher strength and lustre [1].

1.1.3. Wrinkle-resist, Easy-care finish

The elasticity of cotton, and hence its resistance to wrinkle, can be improved by cross-linking the cellulose chains, using synthetic resins. However, there is a consequent reduction in its strength and absorptivity, although it will dry more quickly [1].

1.1.3.3 Anti-shrink finish

Shrinkage is deliberately induced in the fabric the avoid such shirinkage appearing after subsequent wet treatments. This process is important for improving the laundering characteristics of cotton textiles-especially when a household tumble dryer is used [1].

1.1.3.4 Water Repellent Finish

Cotton textiles can be made water repellent by treatment with special chemicals (e.g.silicones) [1].

Combuation of cotton is quick, bright, with afterglow. Cotton smells like burnt paper. Residue of cotton is pale grey, powdery ash [1].

Fibre blending allows the disadvantages of one fibre to be offset by the advantages of another, or special effects to be achieved. Cotton is usually blended with polyester but also with naylon, acrylic; viscose and modal fibres. Blending with synthetic man-made fibres improves the easy-care and durability of clothing. Blending with viscose and modal fibres is for their lustre and uniformity, whilst preserving good moisture absorption, but also to reduce the cost. Modal fibres are a good match for cotton in their strength and extensibilty. Blends with other fibres are also possible. The most common blends ratios are 50:50, 60:40,and 70:30[1].

Applications of cotton are apparel fabrics are shirts, blouses, underwear, nightwear, outwear, rainwear (water-repellent finishes), trousers (jeans, chinos), leisure wear, workwear. Handkerchiefs, laces, ribbons, trimmings, umbrellas. As household textiles bed clothes, tablet and kitchen cloths, decorative fabrics, furniture coverings, hand and bath towels are used. Workwear and protective clothing, awninhgs, tarpaulins, sewing threads are technical textiles. [1]

1.2 PURPOSE OF THESES

The purpose of this theses is to define the effect of the pattern on the structural, aesthetic and performance properties of flat knitted fabrics which are produced by polyamid, acrylic and cotton fibers.

1.3 STRUCTURE OF THESES

Chapter 1 describes the general description and classification of knitted fabrics. The fibers used in the thesis (polyamide, acrylic, cotton) are summarized in this part. Chapter 2 discusses previous studies that guide us to write the thesis. In Chapter 3, materials, methods and tests applied to sample fabrics are mentioned. In the material section, the technical properties and usage areas of the sample fabrics are examined. In the material section, the performance and aesthetic tests applied to the sample fabrics were examined. In Chapter 4, the structural properties of the sample fabrics were examined and the tests applied to the fabrics were examined and interpreted on the graphs. In this section, statistical analyzes of test results were made by using design expert and minitab package programs. Test results are explained with graphs and tables. And in the last Chapter 5, conclusions and further studies were presented and new reccomandations were added for the readers.

CHAPTER 2
LITERATURE SURVEY

In this section, literature review of knitted fabrics is made and the studies that guide the thesis study are tried to be summarized.

Marmaralı (2003), "Dimensional and physical properties of cotton / spandex single jersey fabrics" in the study of the use of elastomer in knitted fabrics the effect on the dimensional and physical properties of fabrics. For this reason, she produced 9 different jersey fabrics with 3 different frequencies, without elastane, semi-filled elite, fully filled elastane. According to the findings of the study, the air permeability values are highest in the lowest, non-elastic and loose fabric in the full and tight fabric. The effect of loop length on air permeability is very clear in non-elastic fabrics, it is not evident in the elastane fabrics but is still statistically significant. The use of elastane in the knitted fabric reduces the porosity since it has already tightened the fabric; this leads to reduced air permeability [2].

Oğlakçıoğlu and Marmaralı (2007), “Thermal comfort properties of some knitted structures” in their work 20 tex cotton and polyester ring yarn single jersey, Thermal comfort test was applied to 1 × 1 ribana and interlock knitted fabrics. Cotton and polyester knitted fabrics of the same characteristics gave close test results. Single jersey fabrics have low thermal conductivity and thermal resistance but high water vapor permeability value. Single jersey fabrics have a higher heat absorption rate than the cold. In addition, the thermal conductivity of the rib fabrics is lower than the interlock fabrics and the water vapor permeability is higher. The authors attributed this result to the amount of fiber in the unit area [3].

Mavruz and Oğulata (2009), “Pamuklu örme kumaşlarda hava geçirgenliğinin incelenmesi ve istatistiksel olarak tahminlenmesi” in their work in three different numbers, a total of 27 knitted fabrics were produced in three different tightnesses, single jersey, rib, and interlock structures. The thickness, loop length, loop density and weight of the fabrics were analyzed. Air permeability test was applied on these fabrics and it was tried to predict air permeability by determining the statistical relationship between the physical properties of the knitted fabrics and the air permeability. While the air permeability values are higher in the superstructure structures, they are less in double sided fabrics such as ribana and interlock. As the yarn in the fabric becomes thinner, the length of the loop yarn increases and the fabric density decreases, the air permeability increases [4].

Majumdar et al., (2010), "Thermal properties of knitted fabrics made from cotton and regenerated bamboo cellulosic fibres" in their work in three different numbers, cotton and bamboo fibers in four different mixture of ring yarns are produced and of these yarns, single jersey, 1 × 1 ribana and interlock 27 knitted fabrics were produced. When the thermal comfort properties of the produced fabrics were examined, as the bamboo ratio increased, the fabrics were thinner and lighter and the thermal conductivity of these fabrics decreased. Among the three fabric types, single jersey fabrics showed minimum thermal conductivity, thermal resistance and maximum water vapor permeability [5].

Kanakaraj, Ramachandran (2017). "Influence of Knit and Miss Stitches on Air and Water Vapour Permeability of Flat Knitted Rib Fabrics".In this study, the effects of the ribana fabric structure on the air and water vapor permeability of the filled needle and empty needle combinations were investigated by using knitted fabrics. According to the one-way anova and tukey test results, the needles are full or empty and have a significant effect on air and water vapor permeability [6].

Usha, Mohammed, Chin (2018). "Bursting Strength and Extension for Jersey, Interlock and Pique Knits". In this study, the bursting strength and elasticity of the seventeen knitted fabrics (single jersey, interlock and pique) were compared. Variance Analysis (ANOVA), correlation coefficient, regression analysis and t tests were performed by using IBM SPSS program. According to the results of the study, significant differences were found on the mesh structure and fiber content and bursting strength and flexibility [7].

Hossain et al (2018). “Factors of Weft Knitted Fabrics Related to the Bursting Strength”. In this study, the structural parameters of weft knitted fabrics such as stitch length, number of stitches, number of rows and number of courses and number of wales in the unit area, the effect of GSM and porosity on the bursting strength are explained. Burst strength is important for weft knitted fabrics. Due to their dimensional properties, the draw percentage is also noteworthy. In this study, the stitch density, stitch length and shrinkage percentage were found to be effective on the strength of weft knitted fabrics in addition to the literature [8].

Sultana, Ahmed, Maruf Bin Alam (2014). “A comparative study on conventional carded and compact combed yarn on spirality and bursting strength of various knitted fabrics”. This thesis presents a comparative study on the properties of knitted fabrics, between conventional carded and compact combed yarn. 30Ne carded and 30Ne compact combed yarn produced from the same batch were used. 6 types of fabric (single jersey, single jersey elastane, single lacoste, double lacoste, ribs and locks) are produced from both carded and compact combed yarn. Then the spirality and the burst strength of loop was tested on all raw fabrics. According to the test results; compact combed yarns are shown to be advantageous compared to traditional carded yarns. The strength values were better for fabrics produced from carded yarns. It was concluded that the presence of lycra for all fabrics had lower burst strength values [9].

Göktepe (2002), “Fabric Pilling Performance and Sensitivity of Several Pilling Testers” in his work, 100% cotton, PES / viscose and PES / viscose / lycra blended fabrics were studied. He made pilling test on Martindale and ICI test devices. As a result of the test, more pilling was observed in fabrics obtained from low twisted yarns. Fabrics containing PES at 15% showed less pilling than lycra-containing fabrics. The increase of the yarn number and the increase in the thickness of the fabric worsened the pilling result [10].

Dündar (2008), "Çeşitli Selülozik İpliklerden Üretilen Örme Kumaşların Performanslarının Karşılaştırılması" in his work, produced fabrics with cotton, bamboo and lyocell (tencel) fibers. Bursting strength test was applied to the produced fabrics. As the weight of grams decreased and the stitch density decreased, the burst strength decreased. Pilling test on ICI pilling tester. As the unit weight decreased, the pilling value increased. The Martindale device has been tested for abrasion. As a result of the analysis, it was observed that the abrasion resistance decreased with increasing density of stitches [11].

Candan and Önal, (2002), "Dimensional, pilling and abrasion properties of weft knits made from open-end and ring spun yarns" in their work, produced single jersey, lacoste and two yarn knitted fabrics with cotton and blend yarns produced by ring and rotor spinning principle. They examined the dimensional changes, pilling and abrasion resistance of the fabrics they produced. According to the findings of the study, fabric structure and fiber type play an important role in dimensional change. This change in the two yarn knitted fabrics depends on the lower yarn change. It is a type of knitted fabric that has the least abrasion resistance [12].

Wilbik-Halgas et al. (2006), "Air and water vapour permeability in double-layered knitted fabrics with different raw materials" in their work, applied air and water vapor permeability tests to 24 double knitted fabrics composed of different raw materials and correlated the test results with fabric thickness and porosity rates. In this study, the porosity was calculated by image analysis. Statistical data showed a high correlation between fabric thickness and porosity and air permeability, but showed that the relationship with water vapor permeability was negligible. It was concluded that the high porosity of the structure of the knitted fabric allowed free movement of the water vapor and therefore the effect of the thickness was not clearly observed [13].

Chidambaram et al, (2011), “The effect of loop length and yarn linear density on the thermal properties of bamboo knitted fabric” in their work, produced ring yarn in Ne 20/1, Ne 25/1 and Ne 30/1 of 100% bamboo fiber. These yarns are made of single jersey fabrics with three different stitches. Air permeability and thermal comfort tests were applied to the fabrics. Test results show that thermal resistance and thermal conductivity increase as the yarn thickens and air permeability decreases. In addition, the increase in the length of the loop thread has led to a decrease in the air permeability of the fabric [14].

Özdil et al. (2014), “Influence of yarn and fabric construction parameters on drape and bending behavior of cotton woven fabrics” in their work, 100% cotton fiber 50/1, 70/1 and 100/2 numbers and αe = 3.3.3.8, Yarn production with 4 twist coefficient and satin and plain fabric production with these yarns. They produced wefts of these fabrics at three different frequencies. They applied the draping and strength tests to the produced fabrics. They examined the effects of yarn number, twist, weft density and fabric pattern on bending strength and drapery. The fabrics produced with plied yarns have decreased their bending strength compared to the fabrics produced with single-ply yarns and their drape has decreased. Loose fabric was found to be more draped. They concluded that the fabrics produced with fine yarn had low bending strength and more draped fabrics. When compared to the fabric pattern, the drapability of satin fabrics is better than plain fabrics. The fabrics with the highest bending strength are satin fabrics made of thin and thin yarn [15].

Logjen, Jevsnik (2001), “some aspects of fabric drape” in their work in her work, applied the drape and bending strength tests to 5 different raw materials and 8 different fabrics obtained in different designs. Two-dimensional drift test was used to test the bending strength test, and the test on the drapery test device was accepted as three-dimensional drought test. They performed the tests at 0.2.4.6 and 24 hour intervals. The test specimens were 30 cm and 36 cm in diameter. As a result of the tests, it is observed that the test results for large sample fabrics are mostly draped. When the period is examined, it is seen that the drapability coefficient increases as the time increases. When examined in terms of raw materials, it is seen that the most draped fabrics are 100% cotton fabrics. As a result, yarn density, yarn type, weaving type were found to be effective on fabric drapability [16].

When the literature is examined, it is seen that aesthetic and performance tests are not performed systematically in fabrics with different patterns produced from different raw materials with flat knitting machines in available sources. Therefore, this thesis will be fill the lack of literature.

CHAPTER 3

MATERIALS AND METHODS

3.1 MATERIAL

In this study, 30 different fabrics were produced by 10 different patterns (single jersey, ribana, interlock, purl, half cardigan, cardigan, single lacoste, double lacoste, lace, and moss stitch) and 3 different raw materials (cotton, acrylic and polyamide). Since the aim of the study is investigating the effect of designs on the performance of the knitted fabrics; each raw material is evaluated within. For finding the most convenient design the yarn counts are selected closer to each other. (Polyamid yarn count Nm12/1; Acrylic yarn count Nm 11/1 and Cotton yarn count Nm 15/1). The machine parameters, loop lengths and tightness of the fabrics are adjusted optimum. The production of sample fabrics was carried out on the Shima Seiki NSSG122 model machine as seen in Figure 3.1.

Figure 3.1 Machine view of Shima Seiki NSSG122 [18]

Schematic view and the machine parts names are emphasized in Figure 3.2.

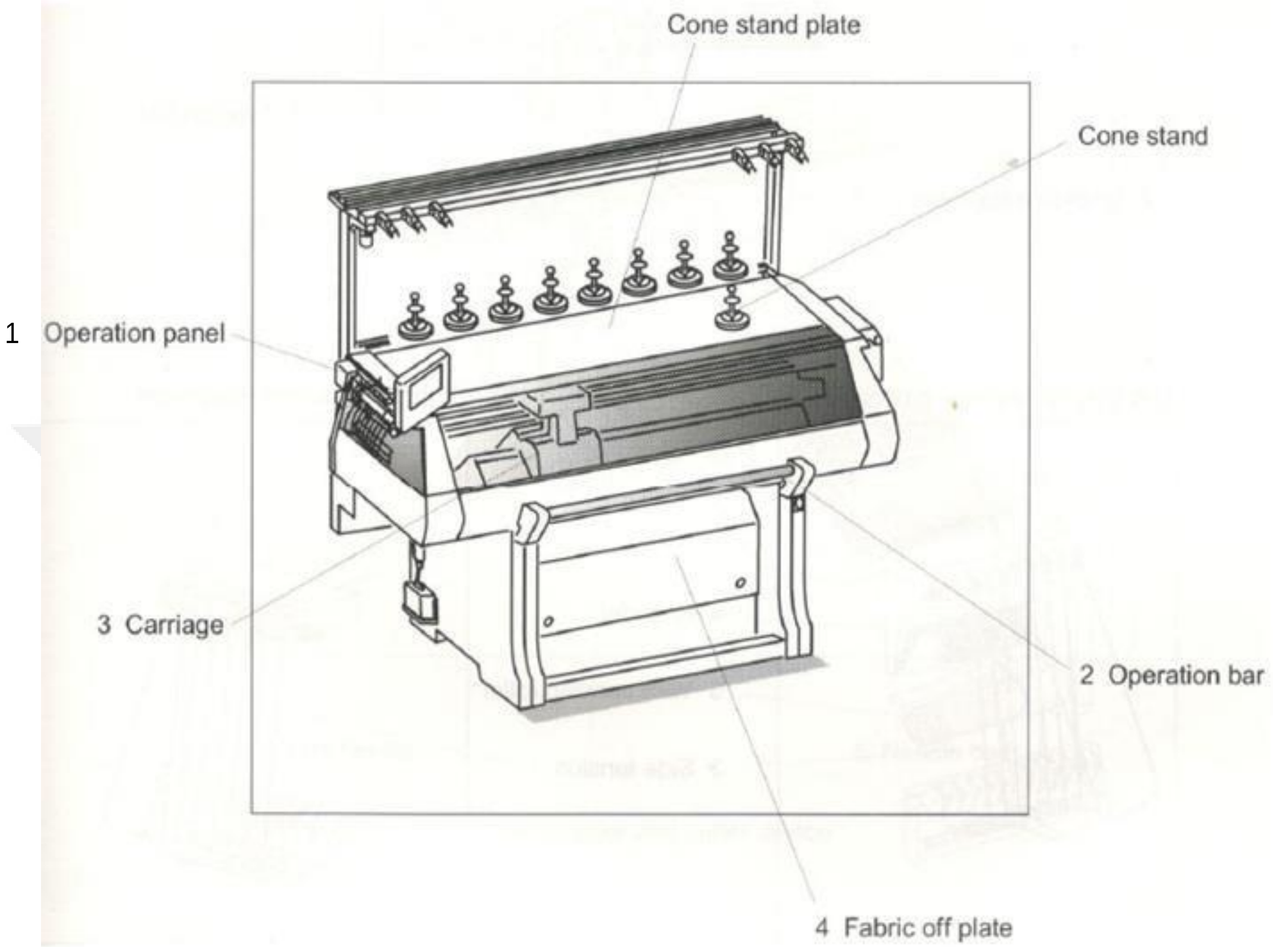

Figure 3.2 Machine shematic view of Shima Seiki NSSG122 [18]

Function of the machine parts are as following:

1. Operation panel: Displays the knitting data to confirm and modify.
2. Operation bar: Moves or stops the carriage and used to cancel the operation error. (Stop motion)
3. Carriage: Controls the motion of the needles and carriers.
4. Fabric off plate: Drives off and releases the knitting fabric downward to the front of the machine [18].

During the knitting of the fabrics tension is quite impotant. By adjusting the tension loop yarn lenght and accordingly tightness of the fabric are adjusted. In flat knitting machines tension is adjusted by yarn tension equipments as shown in Figure 3.3 and 3.4.

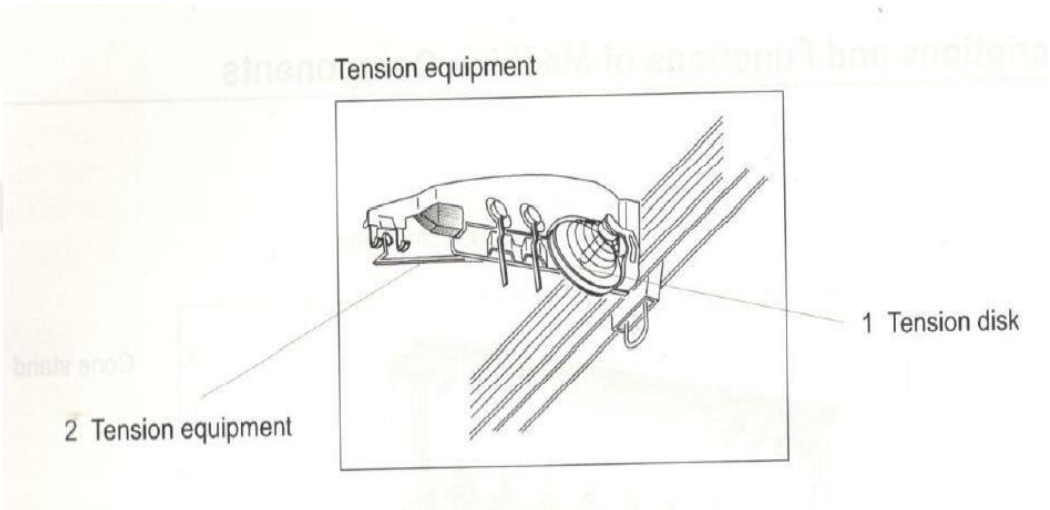

Figure 3.3 Yarn tension equipments [18]

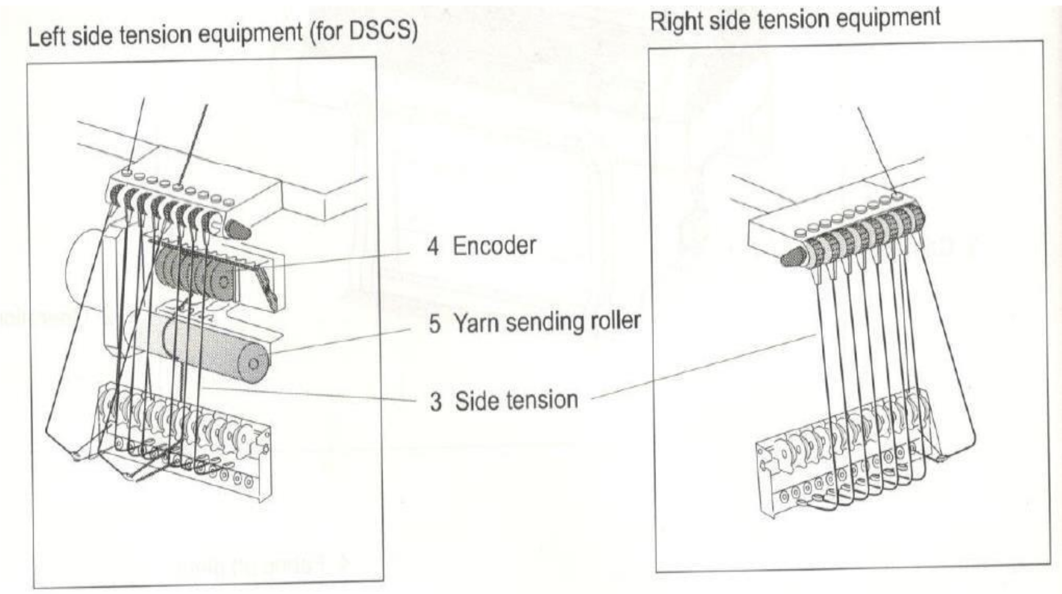

Figure 3.4 Left and right side tension equipments [18]

1. Tension disk: Adjusts the tension of the yarn.

2. Tension equipment: Detects the yarn breakage.
3. Side tension: Absorbs the slack of the yarn when the carriage reverses.
4. Encoder: Measures the lenght of provided yarn.
5. Yarn sending roller: Reduces the resistance for suppliying the yarn to yarn feeder by rotating at high speed [18].

Flat knitting machine knitting frame parts are presented in Figure 3.5 and the functions of the parts are expressed [18].

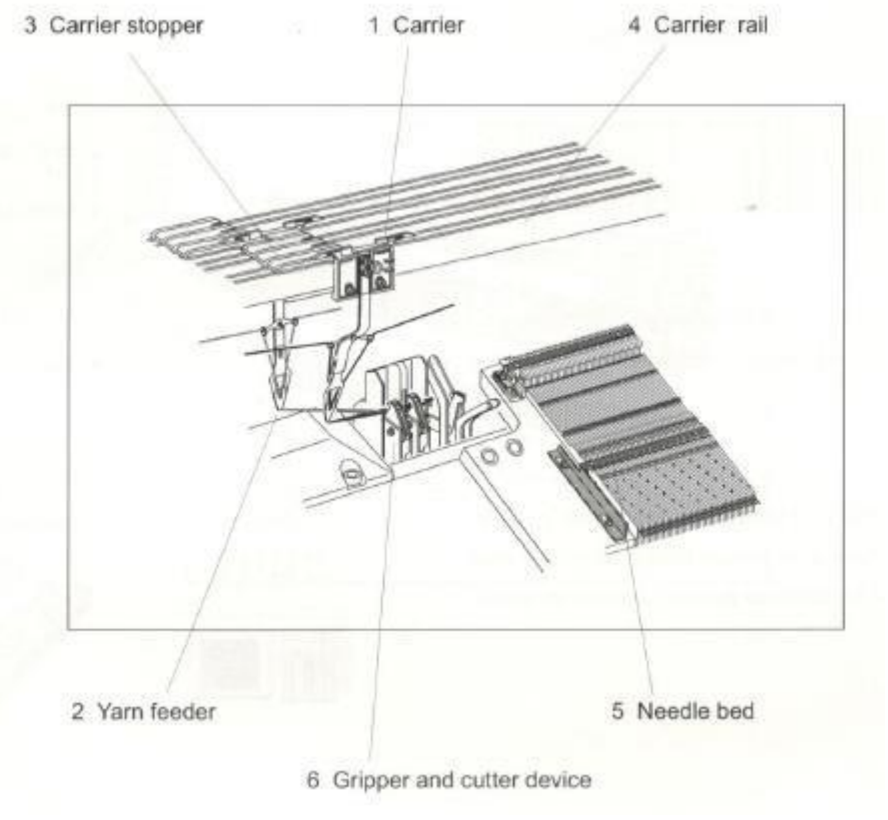

Figure 3.5 Knitting frame parts [18]

1. Carrier: Carries the yarn.
2. Yarn feeder: Feeds the yarn to the needle beds gap.
3. Carrier stopper: Stops the carriers at both ends of the carrier rails.

4. Carrier rail: Rail for the carriers.

5. Needle bed: Parts such as needles, jacks, and select jacks are arranged on this needle bed.

6. Gripper and cutter device: Device to cut and hold the yarn [18].

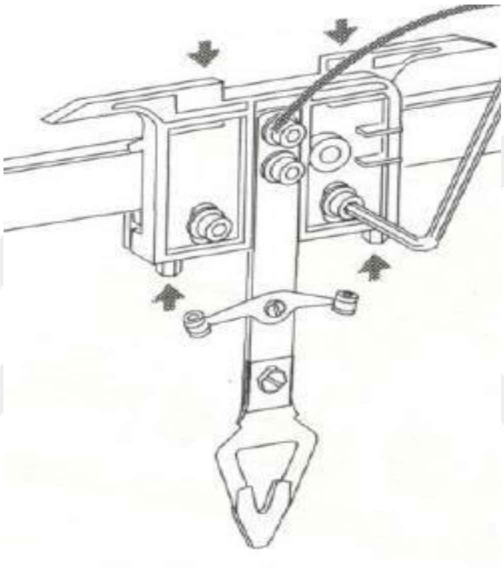

Figure 3.6 Yarn carrier, shuttle [18]

Flat knitting machines carriers are supplying the transmission of the yarn which is coming to the tension with the help of the solenoids or bobbins in the best way to the needles. The carriers are being relayed with the saddle head and they are the last point where the yarn is directed to the needles. There are being used different kinds of carriers in the flat knitting machines. Ordinary or regular carrier; The carrier is allowing the knitting process on the flat knitting machines. Loop formation by carriers is shown in Figure 3.7.

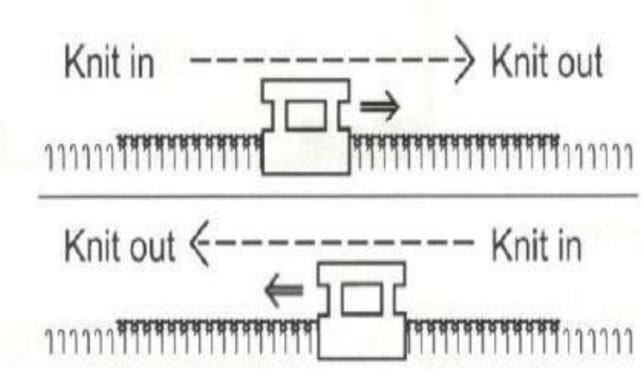

Figure 3.7 Loop formation by carriers movement [18]

During the knitting loops are formed by the selected needles. Needle selection system is shown in Figure 3.8.

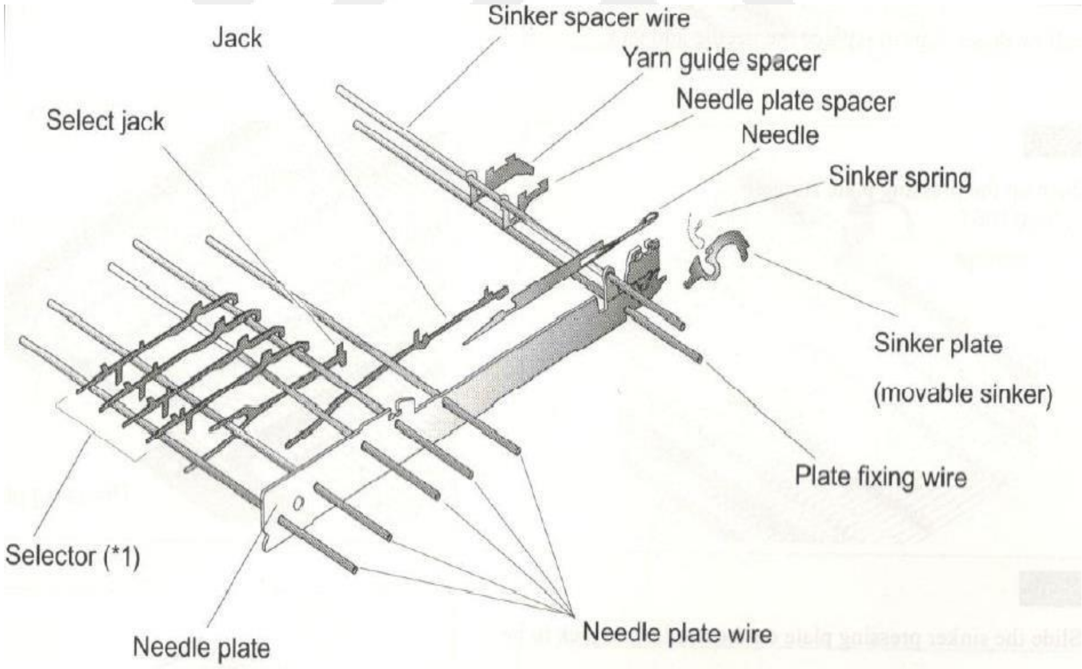

Figure 3.8 Selector type varies according to the knitting machine gauge [18]

There are three types of needles as bearded, latch and compound. In this study single sided latch needle is used as shown in Figure 3.9. [18]

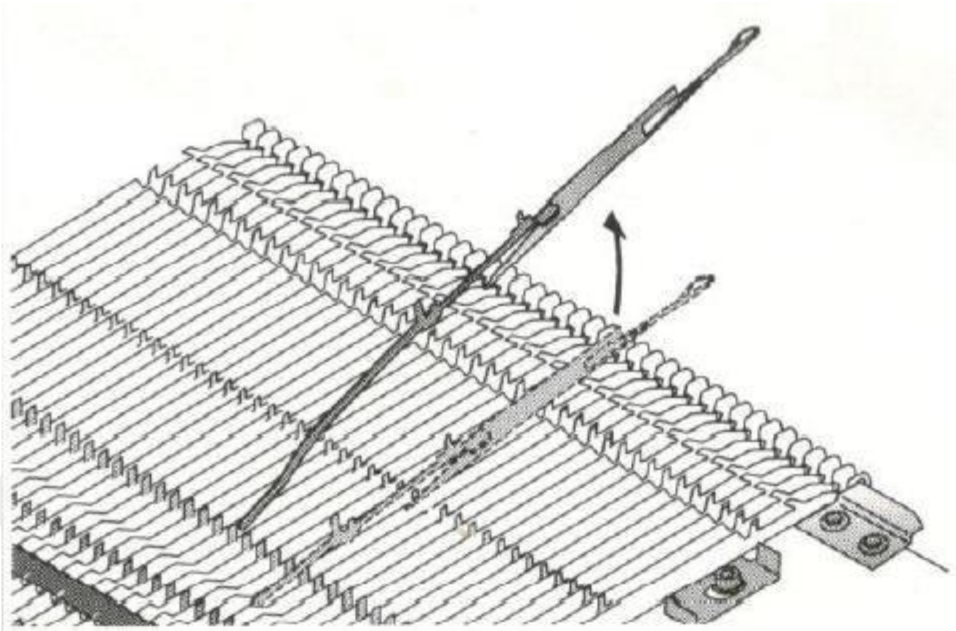

Figure 3.9 Needle bed and needle [18]

The main functions of a latch needle parts are;

1. Saw cut or slot receives the latch blade.
2. Rivet can be threaded or plain and pinched in the slot walls for retaining the latch blade.
3. Hook draws and retains the new loop.
4. Stem carries the new loop in the rest position or clearing position.
5. Tail is normally extensions which is below in the butt, gives additional support to the knitting needle and keep the needle in it is trick.
6. Latch blades situated in the blade.
7. Slot walls or cheeks are either riveted or punched to fulcrum in the latch blade.
8. Latch spoon is an extension of the latch blade which ultimately bridges between the stem and hook.
9. Butt enables the knitting needles to be reciprocated when contacted by cam profiles. [19]

The sinker is the second primary knitting element (the needle being the first). It is a thin metal plate with an individual or a collective action operating approximately at right angles from the hook side of the needle bed, between adjacent needles. It may perform one or more of the following functions, dependent upon the machine's knitting action and consequent sinker shape and movement:

1. Loop formation
2. Holding-down
3. Knocking-over [20]

Sinker bed and sinker used in this study are seen in Figure 3.10 and 3.11 respectively.

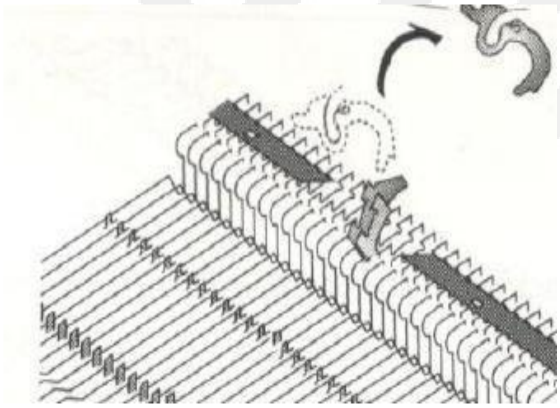

Figure 3.10 (a). Sinker bed [18]

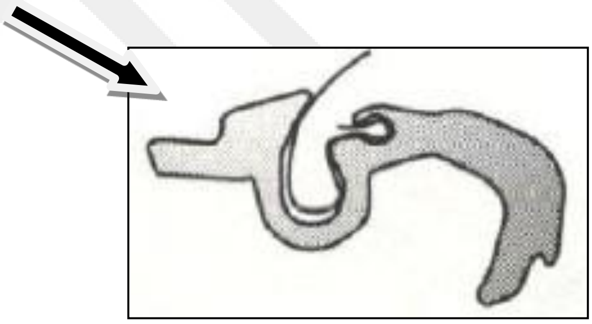

Figure 3.10 (b). Sinker [18]

Production of Sample Fabrics

3.1.1 Production of Weft Knitted Fabric on Flat Knitting Machine

Knitted structures are the surfaces formed by transforming the yarn into the loop form as seen in Figure 3.11.

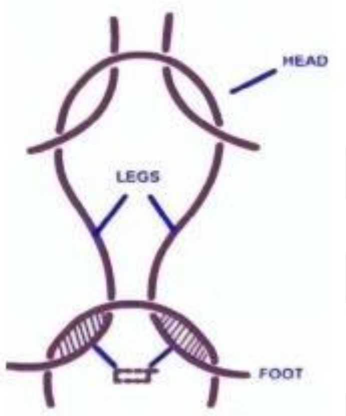

Figure 3.11 The parts of loop

When the loops come together and overlap and form a textile surface, the leg portions of the loops on the front face of the fabric are clearly visible, these loops R, called the face loop. On the back side of the fabric, the head and legs of the loops are clearly visible, and these loops are called L, reverse loops.

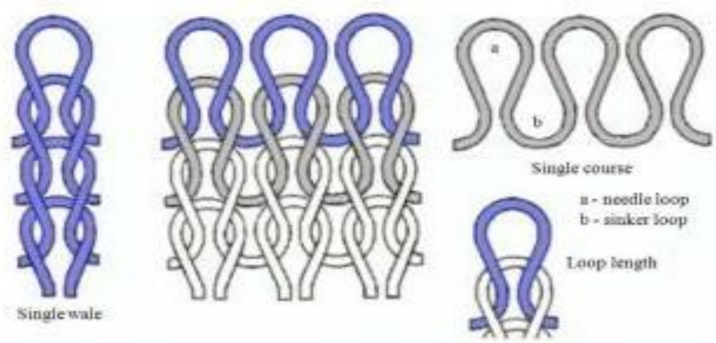

Figure 3.12 The parts of loop and settlement over fabric [24]

Properties of Sample Fabrics

3.1.1.1 Single jersey

In plain knitted fabrics, only the face loops (R) on the front side of the fabric are composed of only the opposite loops (L) on the back side. They are easily deformed in the transverse and longitudinal directions due to the regular and lateral overlap of the loops on the fabric surface. The ribana knitted fabrics can be stretched up to twice the width of the fabric when stretched in the transverse direction while stretching in the longitudinal direction according to the type of yarn being knitted and stretching in the longitudinal direction. In the design of RL knittings, various patterns are obtained by working with auxiliary knitting elements such as miss and tuck. Color patterns can be obtained with jacquard technique. Colored yarns can be applied to patterns such as lines in the transverse direction. It is also possible to obtain various patterns by arranging the needle and steel lines. More wide widths can be obtained in singular jersey fabrics according to rib and interlock fabrics. Their shape may deteriorate when stretched too much. When used as a garment, because of their low elasticity, it is worse to wrap the body than other weft knitted fabrics.

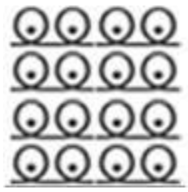

Figure 3.13 Single Jersey needle diagram

Figure 3.14 Single Jersey fabric front and back side

3.1.1.2 Ribana

Ribana fabrics are double-layered and R staple bars are seen on both sides. When the fabric is stretched transversely, L loops are seen between the R loops. It is typical of RR and the yarn is knitted in the front and back in order. These fabrics have high shrinkage and elasticity properties in the transverse direction. The fabric has a balanced structure. Therefore, no curl is seen on the edges of the fabric. The roller cover needles of ribana knitting machines are in cross position as seen in the Figure15.

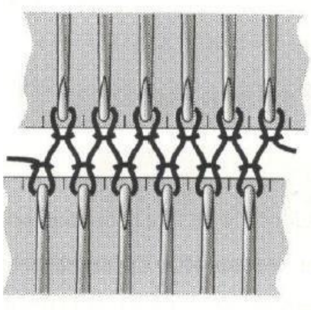

Figure 3.15 Ribana knitting machines are in cross position [18]

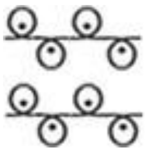

Figure 3.16 Ribana fabric needle diagram

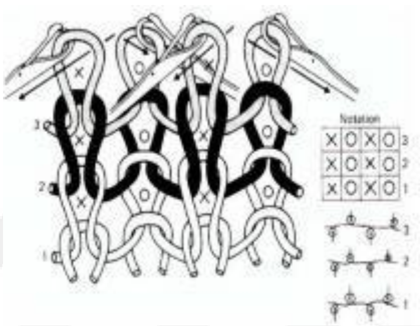

Figure 3.17 Ribana fabric construction [24]

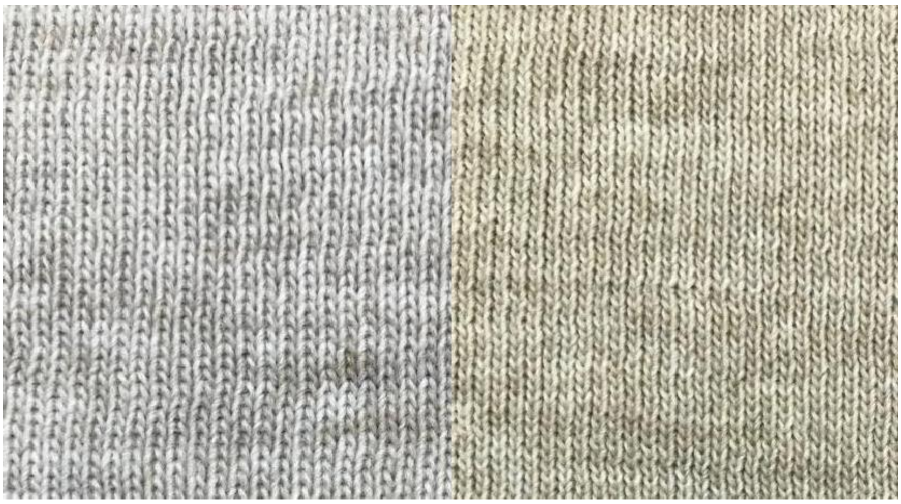

Figure 3.18 Ribana fabric front and back side

3.1.1.2 Interlock

Interlock fabrics have the same appearance on the front and back sides, double sided. Design and surface design is limited. Front and back face are smooth. It has a tight structure. Its dimensional stability and shape retention are high. According to the other knitted fabrics, weights with the highest weights can be obtained. Since there is air between the front and rear surface, it has better thermal insulation. Keeps warmer than other single-strand knitted fabrics. Interlock knitted fabrics have good dehumidification due to their bulky structure. The needle bearings of the double-bed knitting machines where interlock fabrics are produced are in opposite position with each other.

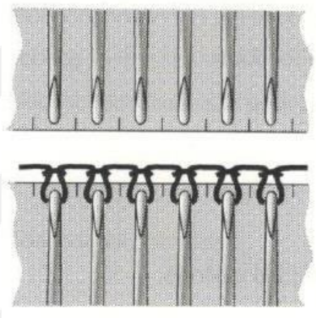

Figure 3.19 Interlock knitting machines are in opposite position[18]

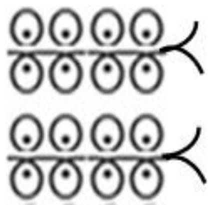

Figure 3.20 Interlock fabric needle diagram

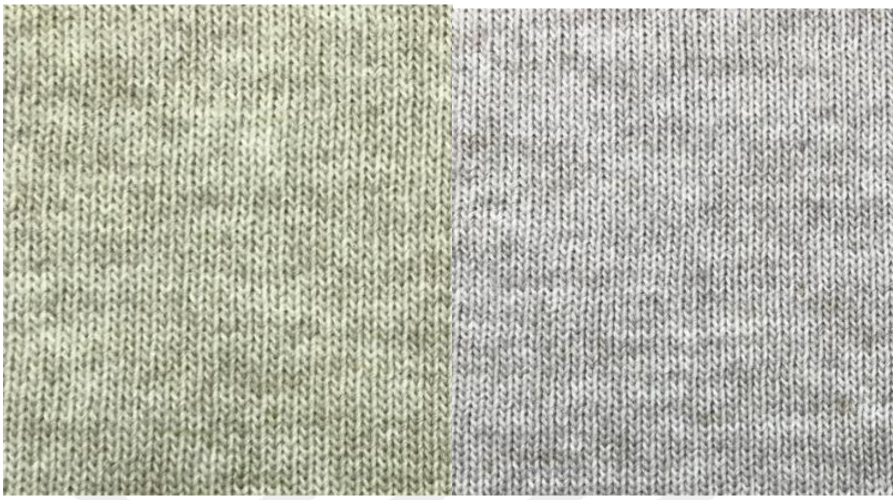

Figure 3.21 Interlock fabric front and back side

3.1.1.4 Purl

Purl fabrics are called LL fabric because L loops appear on both sides. It is knitted surfaces produced in links links machines with hooks on both ends. The longitudinal direction can be flexed twice as much as single jersey birds and the yarn consumption is twice as much as the single jersey fabric of the same length. They do not tend to curl from the edges at the starting and ending parts of the fabric. They are thick and soft in nature and because of the air gap they contain. They are used in the production of winter clothes and winter baby clothes and blanket.

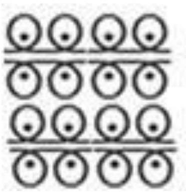

Figure 3.22 Purl fabric needle diagram

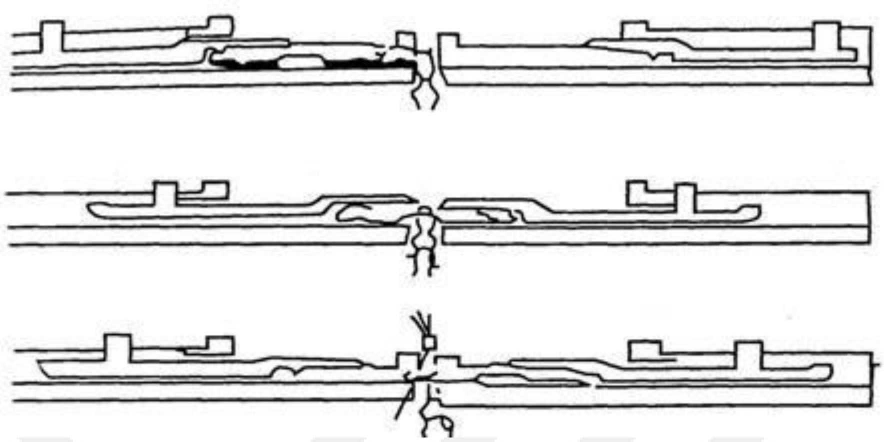

Figure 3.23 Fabric formation with two end hooks in purl machine [25]

Figure 3.24 Purl fabric front and back side

3.1.1.5 Half Cardigan

The schematic view of the half-cardigan structure used in sweater like outer garments and the braid report can be seen in the Figure The black thread as shown in the illustration is the tuck on the front bed, creating a loop in the back bed. The next thread is looped in both beds.

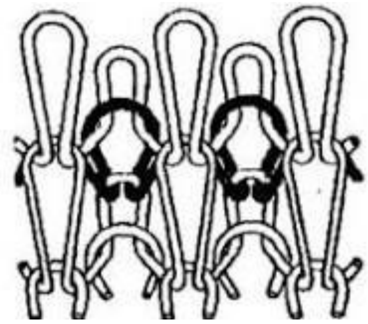

Figure 3.25 Half cardigan fabric construction [26]

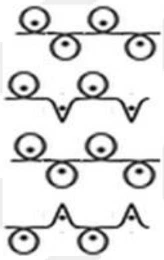

Figure 3.26 Half Cardigan fabric needle diagram

It has an unbalanced structure because of its two faces. The loops on the face of the fabric consisting of only loops are quite large and circular because they draw yarn from the straps on the other side. On the other side, the loops are relatively small due to the yarn draw. Due to the tuck stitches in the fabric structure, the rib is thicker, heavier and larger than the weaves. Usually they are used in winter sweater, cardigan, scarf and hat production [27].

Figure 3.27 Half Cardigan fabric front and back side

3.1.1.6 Cardigan

RR structure is seen on both sides of the plain stitches. They are produced by double needle bed knitting machines. They are hot in volume and used in winter outerwear. As seen in the figure, the back of the bed in the bed on the front bed, with the black thread thread on the back, the bed on the front bed, while the next course is the thread forming the next course, while the opposite is the thread.

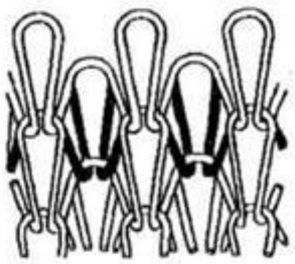

Figure 3.28 Cardigan fabric construction [26]

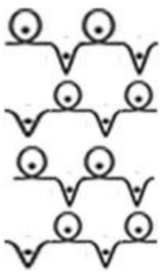

Figure 3.29 Cardigan fabric needle diagram

Since it has two sides, it is balanced. Since the number of tuck stitch in the structure is higher than that of half cardigan, they are thicker, wider and wider fabrics.

Figure 3.30 Cardigan fabric front and back side

3.1.1.7 Single Lacoste

Single lacoste fabrics are a kind of knitted fabric knitted in single bed knitting machines. It consists of a combination of stitch and tuck. In acourse stitch and tuck is seen respectively than in the next course stitches and tucks are interchanged. It means tuck is over the stitch and stitch is over the tuck. Due to the use of a large number of strap loops in the fabric structure, the fabric tends to stretch in the transverse direction, its flexibility in the longitudinal direction is small. Tuck stitches are more prominent in the reverse of the fabric, usually the back side is used. Air permeability is higher than single jersey fabrics. It is often used in summer t-shirt production.

Figure 3.31 Single lacoste fabric needle diagram

Figure 3.32 Single lacoste fabric front and back side

3.1.1.8 Double Locoste

Double Lacoste fabrics are a kind of knitted fabric knitted in RL knitting structure, single bed knitting machines. It consists of a combination of stitch and tuck. In a course a stitch and tuck is seen respectively than in the next course again one stitch and one tuck loop is seen then in the third course tuck and stitch loops are interchanged. It means tuck loops are over the stitch loops and stitch loops are over the tuck loops.In the third course, the strap on the straps, the strap is knitted on the loops and repeats it a second time. Because of the large number of loop loops in the fabric structure, the fabric tends to stretch in the transverse direction and is more transverse than the single lacost. They have little flexibility in longitudinal direction. Tuck stitches are more prominent on the reverse side of the fabric and are usually used on the back side. air permeability is higher than single jersey fabrics. It is often used in summer t-shirt production.

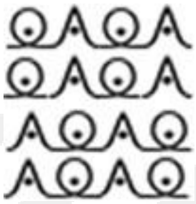

Figure 3.33 Double lacoste fabric needle diagram

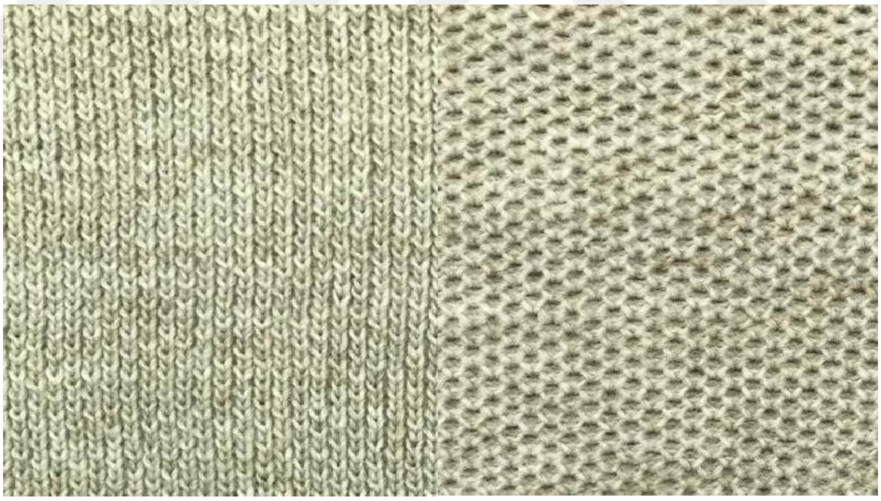

Figure 3.34 Double lacoste fabric front and back side

3.1.1.9 Lace

Lace fabrics are porous structures obtained by transferring loops to the right or left. Reposition of the stitches is done by repeating the stitches, otherwise, as at least two of the stitches transferred are transferred onto each other, the width of the fabric is narrowed. Lace fabrics have high permeability due to their porous structure. In summer clothes, net is used in the production of clothes. They are used in combination with other designs for design purposes.

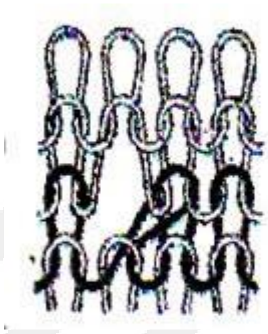

Figure 3.35 Lace fabric construction [26]

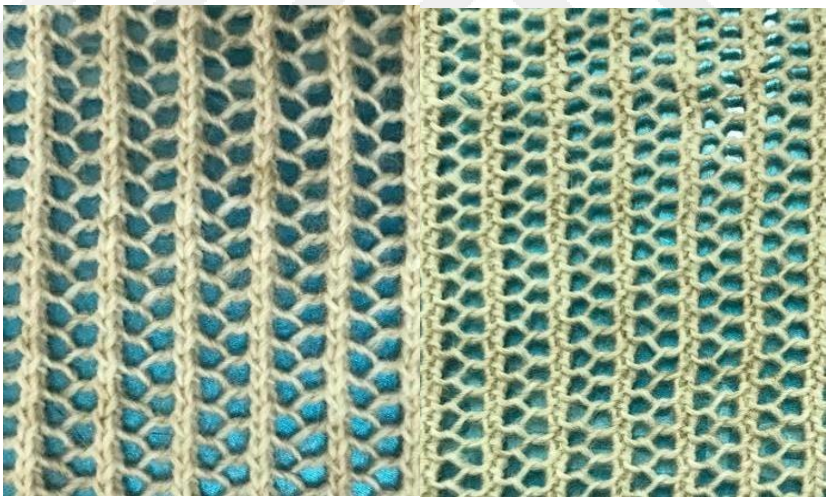

Figure 3.36 Lace fabric front and back side

3.1.1.10 Moss Stitch

In moss stitch knittings, one face one reverse loop is knitted along two courses and the straight loops are inverted on the reverse loops in the 3rd course, and the straight loops are knit and repeats. The fabric is regular and balanced. In the production of baby blanket, it is used in female top clothing patterning.

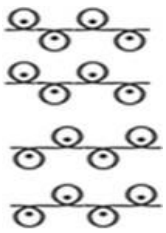

Figure 3.37 Moss Stitch fabric needle diagram

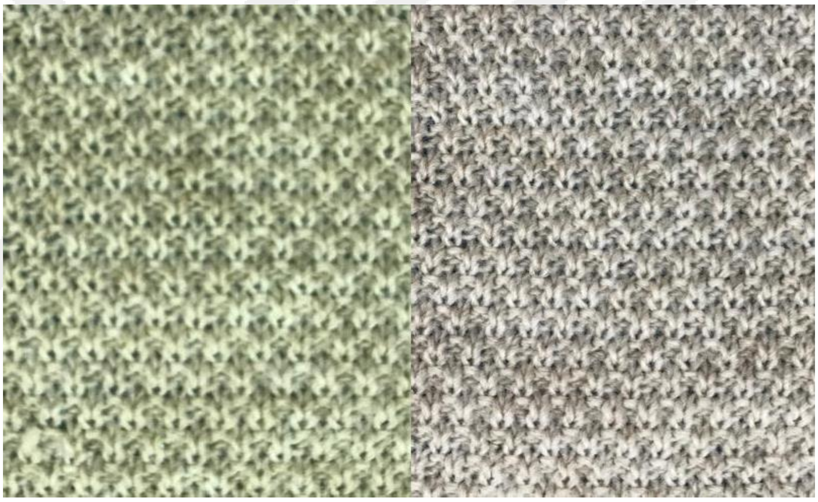

Figure 3.38 Moss Stitch fabric front and back side

3.2 METHOD

3.2.1 Structural Properties of Samples

The fabrics produced are based on common pattern sets of different thicknesses and different raw materials. The comparisons were made in terms of raw material and number but not in terms of raw material, but in terms of pattern changes. The change in patterns also changes the structural properties of fabrics. Structural changes are the parameters that directly affect the performance test results of knitted fabrics. Test are applied in accordance with International Standards. Before testing all the samples were conditioned for 24 hours in laboratry condition for relaxation.

- The ***unit weight*** of the samples were measured according to standard TS EN 12127: 1999 Textile - Fabrics - Determination of mass per unit area using small samples standard. 5 samples of 100 cm^2 from each fabric type were cut in diagonal direction from the fabric and were weighed by 100 by weighing in the sensitive balance. By taking the average of 5 values, fabric weight was calculated as g / m^2.

- The ***thickness*** of the samples was measured according to the EN TS EN "standard. From each fabric type, 5 samples were cut in diagonal direction from the fabric and thickness was determined by thickness gauge. The thickness of the fabric was calculated by taking the average of 5 values in mm.

- The wale and caurse number in 1 cm with the help of loupes were measured from 5 different locations and the averages of stitches and sticks were determined. Stitch density is a term frequently used in knitting and represents the total number of needles loop in a given area. Stitch density is the product of courses and wales per unit length and is measured in units of loops per square centimeter.

- Loop length is one of the most important factors controlling the properties of knitted fabrics. Theoretically the loop length which is adjusted on the knitting machine is equal to the loop length spent to form a loop of the knitted fabric. Practically, while relaxation and finishing operations applied to the knitted fabric change this length; studies showed that this change is negligible. For this reason, in this study the terms loop length, stitch length and SCSL terms are used interchangeably. Loop length or stitch length in a weft knitted structure is measured by unraveling a particular course, which is straightened by applying a suitable tension without stretching the yarn. The length of the yarn is then measured, which is then divided by the number of loops presents in that particular course to obtain the loop length. The loop length, measured in mm is the length of the yarn in the knitted loop. Generally longer the loop length, the more open and lighter the fabric. [21]

- Loop shape factor determines the dimensions of the fabric, this factor depends upon the yarn used and it is expressed as the ratio of course density to wale density (cpc/wpc)

- Porosity can be defined as the ratio of the total amount of void space in a material to the bulk volume occupied by the material. Fabric porosity depends on the fabric and yarn construction methods. Porosity is one of the main physical parameters that have a great influence on comfort properties. Porosity of knitted fabric can be calculated by the following formula:

$$Porosity = \left(1 - \frac{GSM}{t * \rho}\right) * 100 \qquad \textbf{Equation 1}$$

t:Fabric Thickness in cm

ρ : Density of fiber in g/cm^3

GSM: Fabric area in g/cm^2 [22]

3.2.1.1 Air Permeability Test

The air permeability of the samples was tested according to TSE 391 EN ISO 9237 standard with SDL Atlas test device in Gaziantep University Textile Engineering laboratory (Figure 3.25.). The tests were carried out by taking measurements from 10 different locations of the fabric with a pressure gauge of 20 cm² and a pressure difference of 100 kPa.

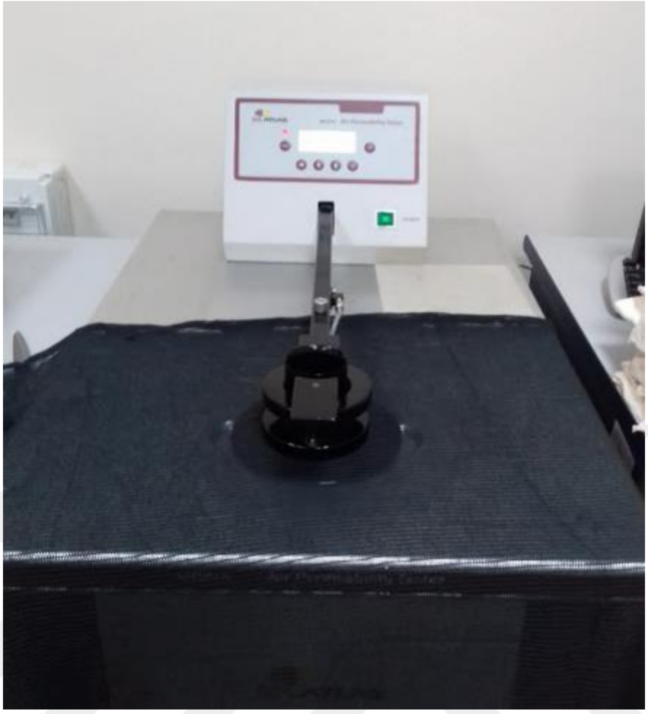

Figure 3.39 Air permeability tester

3.2.1.2 Bursting strength testing

Bursting strength testing is the application of a vertical force to a fabric until it ruptures. By the effect of air which is applied multi directions the fabric become inflated until bursting as shown in Figure 3.40.

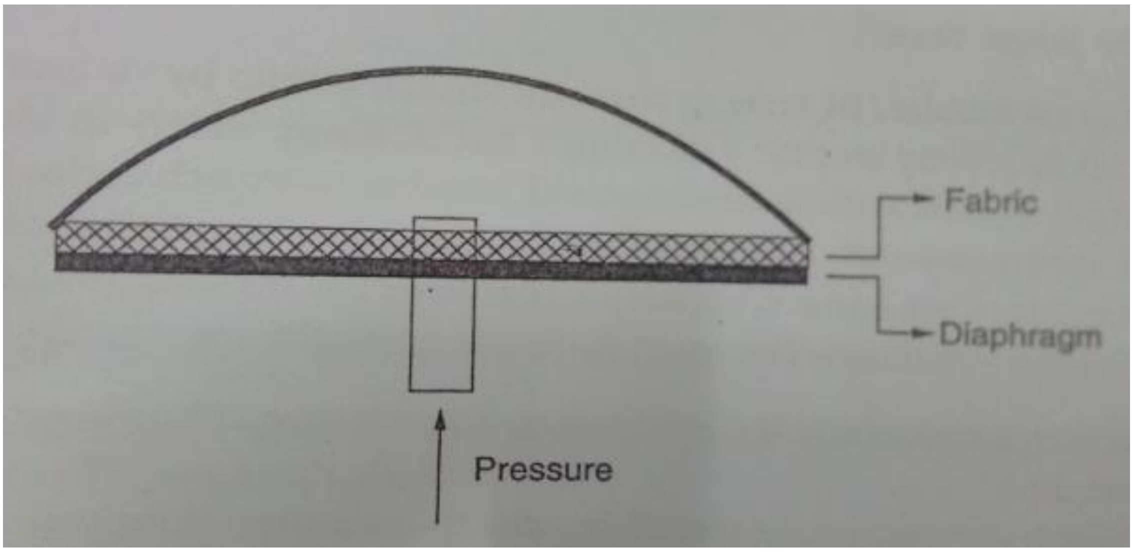

Figure 3.40 Bursting strength test principle [23]

In order to test the stability of the sample fabrics, the fabric was tested with the TRUBURST 2 test device according to BS EN ISO 13938-2 (Figure 3.41.). The tests were carried out by adjusting the burst velocity at 5 different locations of the sample fabrics and fixing the time. The strength test results of the diaphragm correction fabrics were averaged and comparisons were made.

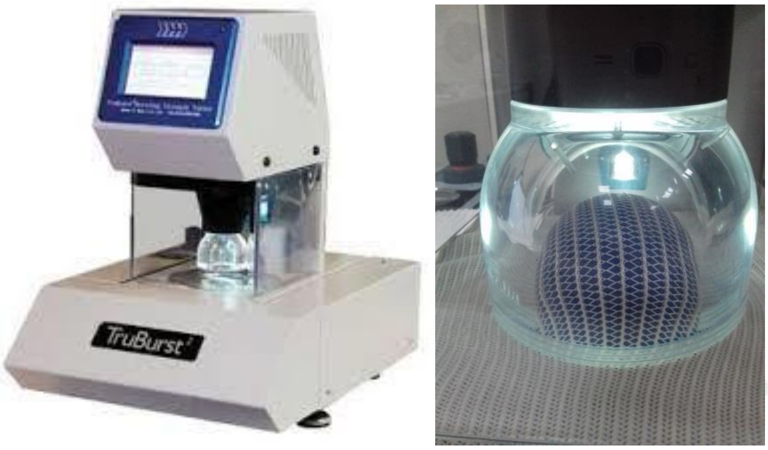

Figure 3.41 Bursting strength image of tester and fabric burst moment

3.2.1.3 Abrasion Resistance Test

Abrasion is defined as the wearing away of any part of the fabric by rubbing against another surface. Fabrics are subjected to abrasion during their lifetimes and this may result in wear, deterioration, damage and a loss of performance. However, the abrasion resistance is only one of several factors contrubuting to wear performance or durability. Abrasion can occur in many ways and can include fabric to fabric rubbing when sitting, fabric to ground abrasion during crawling, and sand being rubbed into upholstery fabric and it is difficult to correlate correlate conditions of abrasion of a textile in wear or use with laboratory tests. This may explain the reason why there are many different types of abrasion testing machines, abradants, testing conditions, testing procedures, methods of evaluation of abrasion resistance and interpretation of results. [23]

In order to test the abrasion resistance of the sample fabrics, Martindale device as shown in Figure 3.42 was used according to TS EN ISO 12947 standard. The analysis was performed by determining the rupture at the loops of fabrics. During the thesis, this test was carried out through the procurement of services from the Kahramanmaras USKIM laboratory.

Figure 3.42 Abrasion resistance tester [28]

3.2.1.4 Pilling Resistance Test

Pilling is a knitted fabric failure. During use, the fiber ends come up to the surface and wanders by the friction. This type of pilling is seen in fabrics produced with short fiber technology. If the fabric consists of synthetic fibers, the pilling starts and continues for a long time without breaking. The more fibers in the cross-section of the fibers of the fine fibers, the greater the pilling, while the less the pilling of the fibers of the long fibers [21]. Pilling resistance all the samples are tested according to TS EN ISO 12945-2 Determination of surface tufting and pilling susceptibility in textile - fabrics - Part 2: Martindale wear and pilling strength test device as shown in Figure 3.43. The pilling of the fabrics after 125, 500, 1000, 2000, 5000 and 7000 revolutions was graded between 1 and 5 compared to the EMPA standard photographs. During the thesis, this test was carried out through the procurement of services from the Kahramanmaras USKIM laboratory.

Figure 3.43 Pilling resistance tester [28]

3.2.2 Examination of Aesthetic Properties of Samples

3.2.2.1 Drapeability Test

A Cusick tester (Figure 3.44.) was used to measure the drapability of sample fabrics. This test was performed using 2 different samples. The test is based on the determination of the shadow of the fabric, which is formed by its own weight, with the help of a mirror, the shadow on the paper and then the shaded parts on the paper and the mathematical expression of the cast. The test result is obtained by taking the average of the two samples according to BS 5058:1973 Method For The Assessment Of Drape Of Fabrics (British Standard).

Figure 3.44 a) Drapeability tester; b) Shadow of fabric tested

3.2.2.2 Bending Rigidity Test

The bending strength is the resistance of the textile sample, which is cut in certain rectangular shapes, against the bending under its own weight. Bending strength and bending strength of fabrics are determined by bending strength test. (TS 1409, BS 3356). The determination of the bending strength of the sample fabrics was done by Wira flexural strength tester (Figure 3.45) in Gaziantep University Textile Engineering laboratory. Actually, this test is applied to woven fabrics, but the results of the study emphasized that, this method can be used for flat knitted fabrics.

Figure 3.45 Bending rigidity tester

There is a strong relation between bending rigidity and bending length. Bending length (C) and bending rigidity (G) is calculated by the following formula. In this equation W is the unit weight of the sample, bending rigidity of wale (Gw) and bending rigidity of course (Gc); bending length of wale (Cw) and bending length of course (Cc) and general bending rigidity (Gg).

$G = 0,1 * W * C^3 \qquad G_g = \sqrt{G_w} * \sqrt{G_c}$ [29] Equation 2

3.2.2.3 Wrinkle Recovery Test

Wrinkle recovery tests of sample fabrics according to AATCC 128-1999 test method Figure 3.46. The AATCC was tested with the AATCC test apparatus and the wrinkle recovery of the fabrics was evaluated according to the AATCC 'Wrinkle Recovery Sample Images' given in Figure 3.46.b. This test simulates the fabric wrinkling by waiting for a specified period of time under a certain weight, and the ability of this wrinkle to open automatically after weight is removed. The fabrics are numbered from 1 to 5 according to their similarity to the standard photographs (1-Most wrinkled and 5-least wrinkled).

Figure 3.46 Wrinkle recovery tester and sample pictures and comparasion of fabrics

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Structural Properties of Sample Fabrics

The structural properties of sample fabrics are measured according to international standards and the results are given in Table 1.

Table.1 Structural properties of sample fabrics

Raw Material/Pattern		**Course/cm**	**Wale /cm**	**Thickness (mm)**	**Unit weight (g/m^2)**	**Stitch Density** (wpc*cpc)	**Loop Shape Factor** (cpc/wpc)	**Porosity**	**Stitch yarn length**
POLYAMID	**Single Jersey**	13	9	1.27	280	117	1.44	76.88	0.51
	Ribana	13	10	1.49	329	130	1.3	80.68	0.49
	Interlock	12	13	1.41	351	156	0.92	78.15	0.48
	Purl	7	12	1.50	247	84	0.58	85.67	0.52
	Half Cardigan	7	8	1.69	285	56	0.87	85.52	0.52
	Cardigan	8	7	2	296	56	1.14	87.02	0.49
	Single Lacoste	10	6	1.12	280	60	1.67	78.11	0.43
	Double Lacoste	10	7	1.37	277	70	1.42	82.19	0.46
	Lace	10	8	1.25	221	80	1.25	84.54	0.51

	Moss Stitch	11	7	0.98	226	77	1.57	79.58	0.59
ACRYLIC	**Single Jersey**	9	7	1.2	214	63	1.29	85.00	0.62
	Ribana	8	10	2.41	363	80	0.8	87.35	0.65
	Interlock	8	11	2.04	373	88	0.73	84.59	0.57
	Purl	11	6	1.96	255	66	1.83	89.02	0.61
	Half Cardigan	5	6	2.58	297	30	0.83	90.38	0.77
	Cardigan	6	5	2.59	317	30	1.2	89.74	0.66
	Single Lacoste	7	11	1.73	259	77	0.64	87.41	0.52
	Double Lacoste	6	9	2.01	303	54	0.67	87.36	0.53
	Lace	7	6	1.73	159	42	1.17	92.12	0.63
	Moss Stitch	7	7	1.82	200	49	1	90.78	0.73
COTTON	**Single Jersey**	14	9	0.85	185	126	1.56	86.00	0.44
	Ribana	11	17	1.78	250	187	0.65	90.90	0.57
	Interlock	9	14	1.44	243	126	0.64	89.09	0.48
	Purl	12	7	1.23	159	84	1.71	91.60	0.5
	Half Cardigan	12	7	2.38	213	84	1.71	93.85	0.57
	Cardigan	9	7	2.14	181	63	1.29	93.16	0.57
	Single Lacoste	11	10	1.09	154	110	1.1	90.98	0.48
	Double	8	11	1.16	169	88	0.73	90.65	0.5

	Lacoste								
	Lace	10	6	1.05	100	60	1.67	93.88	0.51
	Moss Stitch	8	9	1.37	149	72	0.89	93.30	0.63

When Table 1 is examined, the thickness of the fabrics with cardigan pattern is the highest. Ribana and Interlock pattern fabrics have the highest value. The reason for this is that the stitch structures of these fabrics are firmly settled.

4.2 Performance Tests Applied to Fabrics

4.2.1 Bursting Strength

Graphics were used to determine the effect of the pattern parameter on the strength of the sample fabrics produced with different raw materials. Figure 4.1 shows the bursting strength values of the sample fabrics knitted from polyamide fiber.

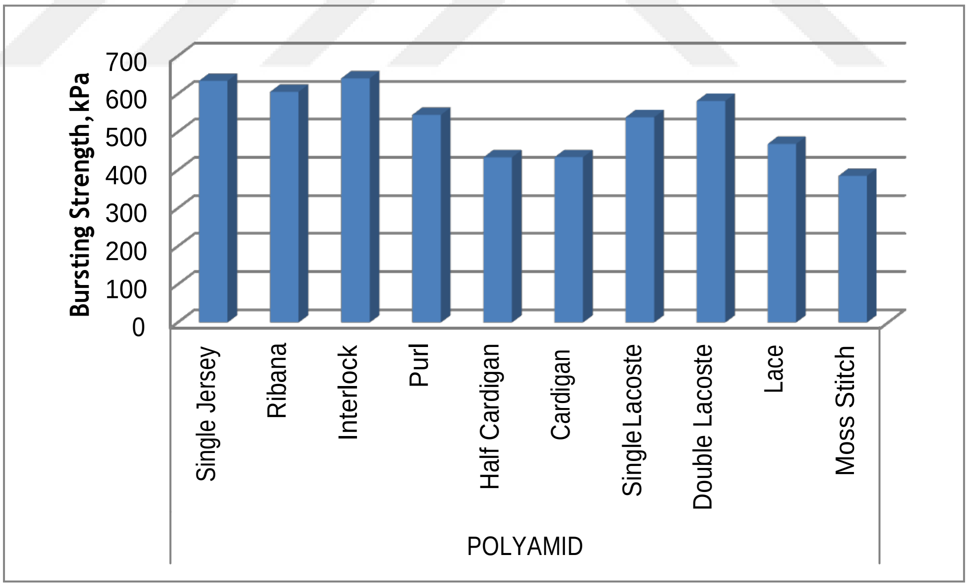

Figure 4.1 Bursting strength test results of polyamide fabrics

The strength values of the knitted fabrics made of polyamide according to Figure 4.1 vary between 380 kPa and 641 kPa. It is seen that interlock fabric has the highest strength value. Table 4.1 shows that the highest unit weight and the density of the loop was seen to belong to the interlock pattern fabric. Therefore, it is expected that the resistance will be high as the corresponding fiber density is higher in the unit area. The lowest value is 433 kPa and half cardigan belongs to the fabric. When Table 4.1, is analyzed, it is seen that the lowest density of wale and course in cm belongs to the half cardigan and cardigan fabrics. The tuck stitches in the structures of these fabrics have gathered the loops together and caused the fabric's bursting strength to decrease. The tucks in the structure of the lace fabric allowed the fabric to have a more porous structure, but these pores were filled due to the bulky structure of the high-bulk polyamide yarn. This, in turn, made the strength of such fabrics higher than that of cardigan fabrics.

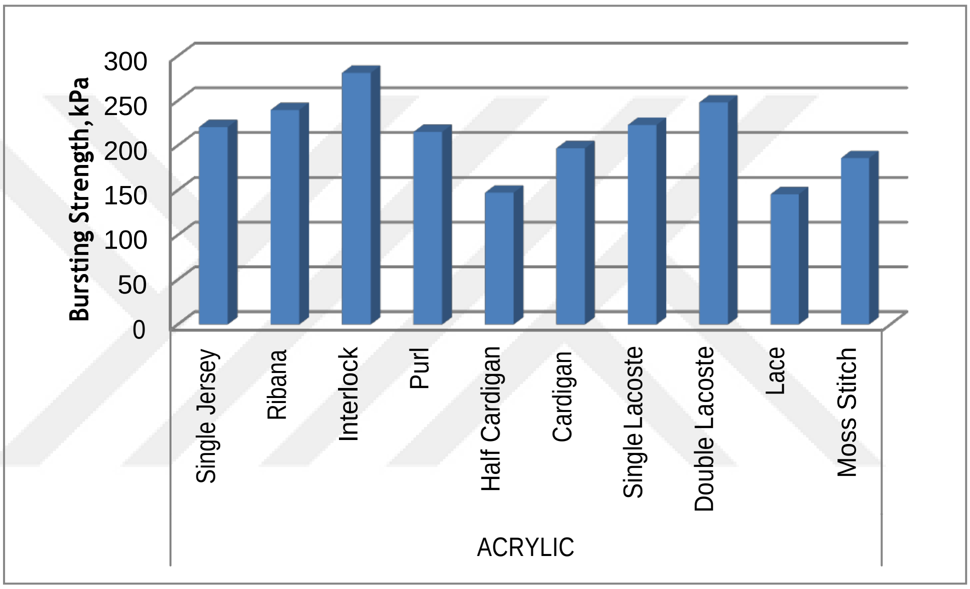

Figure 4.2 Bursting strength test results of acrylic fabrics

The strength values of the knitted fabrics produced according to Figure 4.2 vary between 145 kPa and 281 kPa. It is seen that the interlock fabric has the highest strength value. Interlock fabrics have very flexible structure since they are double-layered and dense looped fabric. More fibers are found in the unit area of the fabric, the higher the bursting resistance of the fabric is due to the separation of the fibers that make up the yarn at the time of the burst. The fabric with the lowest burst strength value is 145 kPa. The numerous tuck loops in the lace fabric structure cause the elastic limits to be reached earlier at these points, resulting in low strength.

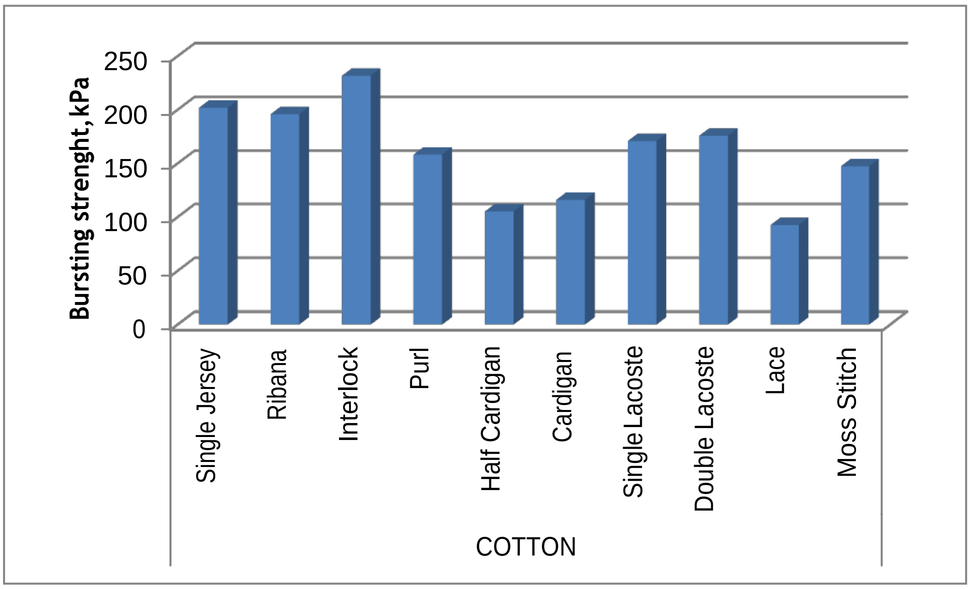

Figure 4.3 Bursting strength test results of cotton fabrics

The tensile strength values of fabrics made of cotton fibers are similar to those of acrylic fibers. The highest value belongs to the interlock fabric with 231 kPa. The lowest value belongs to lace fabric with 92 kPa. It is expected that the strength values of staple fibers will be similar.

4.2.2 Air Permeability

Air permeability in fabrics is defined as the amount of air per unit time with a certain pressure difference from the fabric surface in the unit area. The air permeability value of the fabrics is gaining importance according to the usage area of the fabric. The knitted fabrics have a more porous structure than the woven fabrics and the air permeability of the knitted fabrics is generally higher than the woven fabrics of the same weight and the same raw material. Especially for the use of clothing as knitted fabrics to keep warm, wind protection, breathing, etc. The air permeability test that determines its properties is quite important.

Air permeability is an important factor in the choice of knitted fabrics. The air permeability is the rate of air flow perpendicularly between the two surfaces of the fabric. TSE (1996) defines air permeability as the velocity of air passing through a determined test piece in the test direction, pressure field and time. The velocity of the air flow perpendicular to the fabric from a given area is measured at a given time interval from the pressure difference within the test area of the fabric. The concept of air permeability is often used as a technical knowledge in explaining the character of the fabric in the textile industry, particularly the functional performance of the product [1]. Air permeability significantly affects the comfort of the fabric, because air-permeable fabrics can often pass water in the vapor and liquid phase, and the movement of air and water vapor in a garment can be the most important factor in the comfortable wearing of that garment [2].

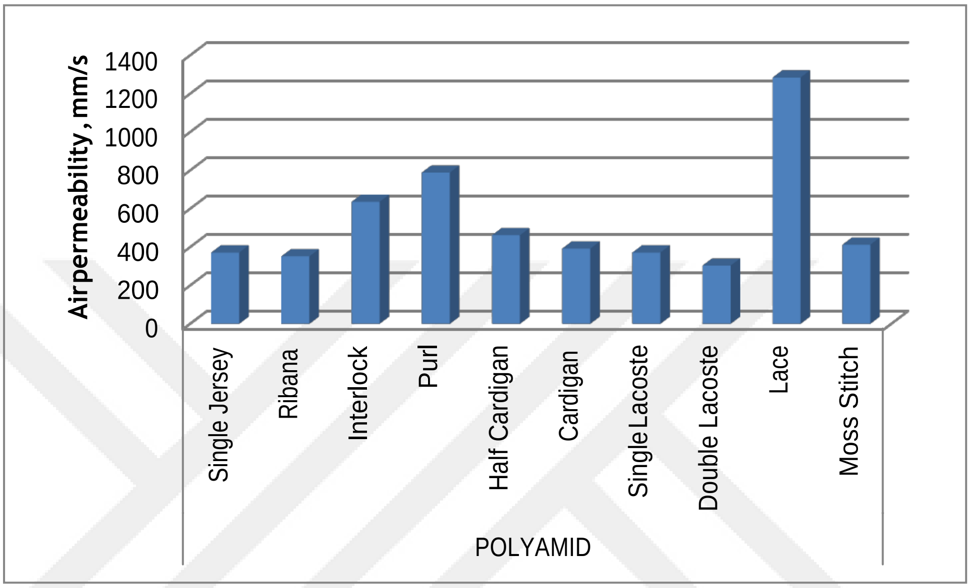

Figure 4.4 Air permeability test results of polyamide fabrics

When the air permeability values of the polyamide fabric are considered, the air permeability of the lace fabric having the porous structure due to the tuck loops has the most value. In the purl patterned fabric, the opposite stitches on the face loops and the face loops on the reverse loops have decreased and the porosity in the fabric has decreased. These pores have a positive effect on air permeability. Fabrics with low air permeability value are fabric fabrics. The high-bulk structure of the polyamide yarns by overlapping the tuck loops has caused the shrinkage of the formed pores and reduced air permeability.

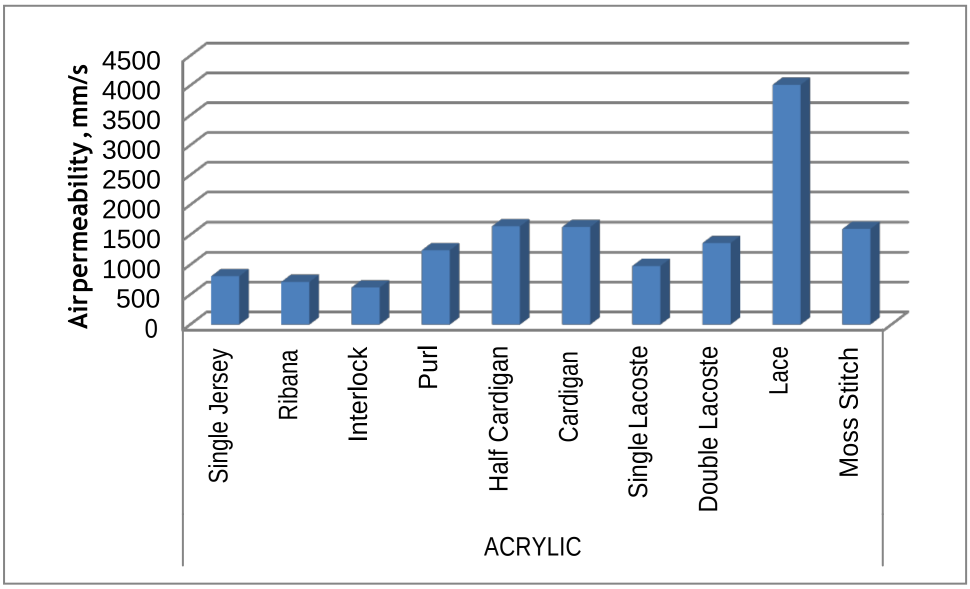

Figure 4.5 Air permeability test results of acrylic fabrics

When the air permeability values of acrylic fabrics are examined, lace pattern with a large number of tuck has the highest air permeability value. Interlock fabric with the most frequent loop structure to the lowest air permeability value. When we look at the other fabrics, Cardigan fabrics are high due to this value because of their diameters of stitch density compared to other fabrics.

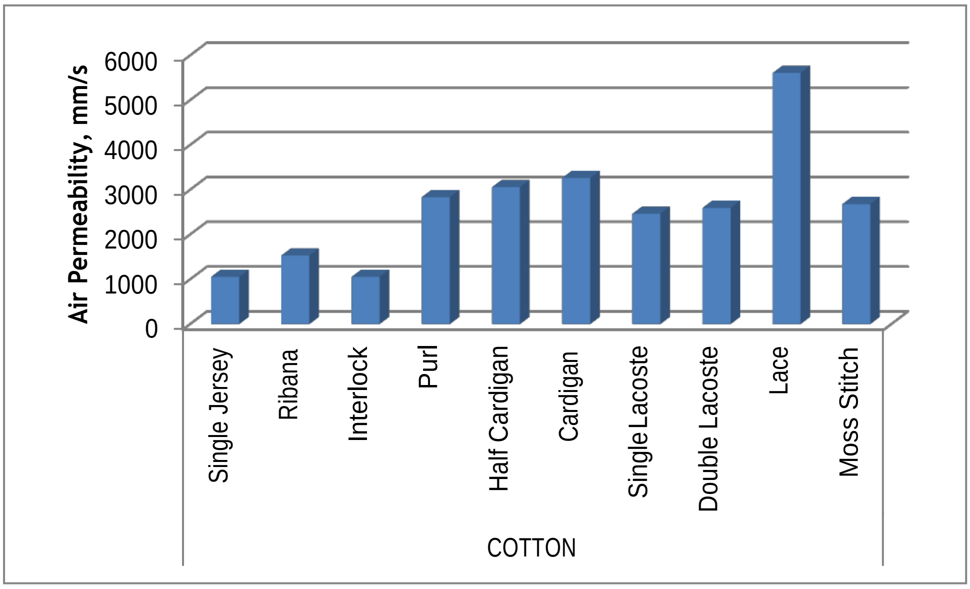

Figure 4.6 Air permeability test results of cotton fabrics

Referring to Figures.4.4, 4.5 and 4.6 above, it is seen that the fabric having the highest air permeability value is lace. Lace fabric is the expected result since it has the highest porosity compared to other fabrics.

4.2.3 Abrasion Resistance

Abrasion is defined as the abrasion of any other part of the fabric by re-rubbing another surface. The fabrics are subject to wear during their lifetime, which can lead to wear, deterioration, damage and loss of performance. However, abrasion resistance, performance or durability are several factors that continue to wear. Wear may occur in many respects and may involve fabric to fabric friction, friction of the fabric to the floor during friction and rubbing of the fabric to the fabric, and it is difficult to associate the conditions of use of a textile in wear or abrasion with laboratory tests. This may explain the reason for the interpretation of many different types of abrasion testing machines, breakers, test conditions, test procedures, assessment methods of abrasion resistance and results.

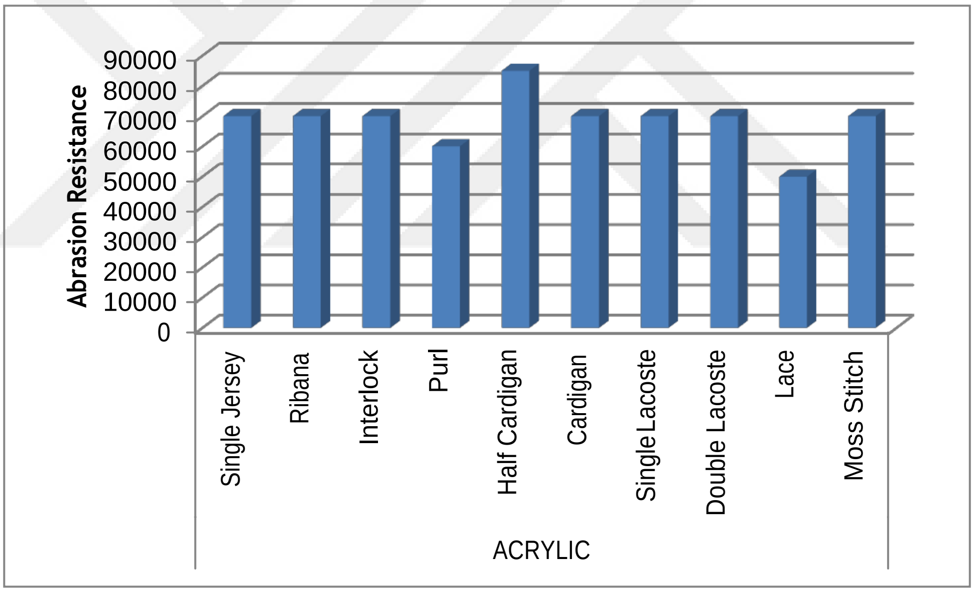

Figure 4.7 Abrasion resistance test results of acrylic fabrics

Due to tuck loops in the half cardigan, the overlapping loops made the fabric resistant to abrasion. The fabric with the lowest abrasion resistance is lace because it has tuck loops and porous structure.

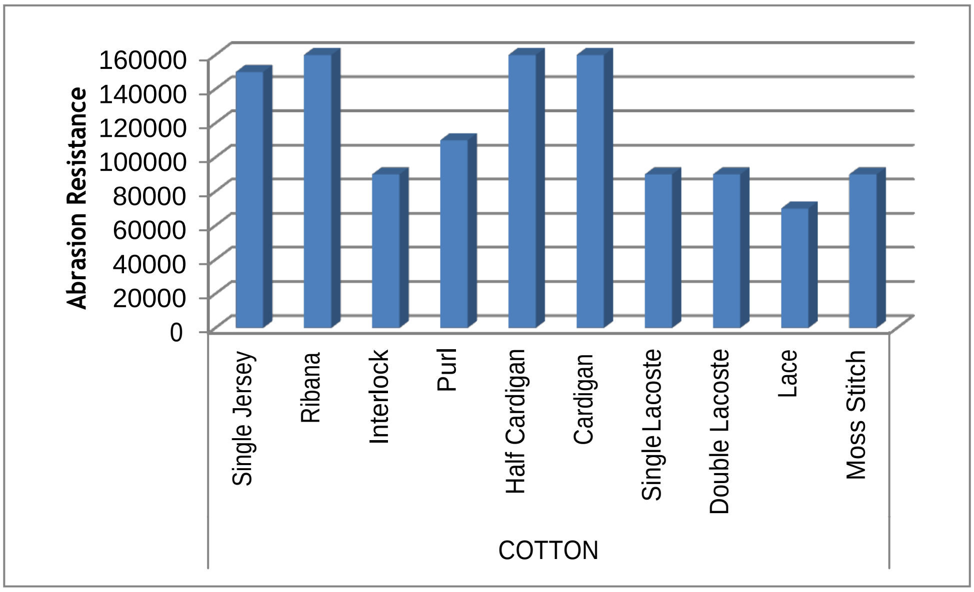

Figure 4.8 Abrasion resistance test results of cotton fabrics

The highest abrasion resistance of fabrics are knitted by cotton fibers are ribana, cardigan and half cardigan. When we look at the structure of these fabrics, we see that the stitch structures are tight. Fabrics with a tight loop structure are more difficult to wear. The lowest value with abrasion resistance is lace. Since the tuck loop is dense, it has a porous structure and long tuck yarns have reduced the abrasion resistance of the fabric.

The abrasion resistance of the polyamide yarn has not been observed even at very high speeds. The abrasion resistance of polyamide raw material could not therefore be established.

4.2.4 Pilling Resistance

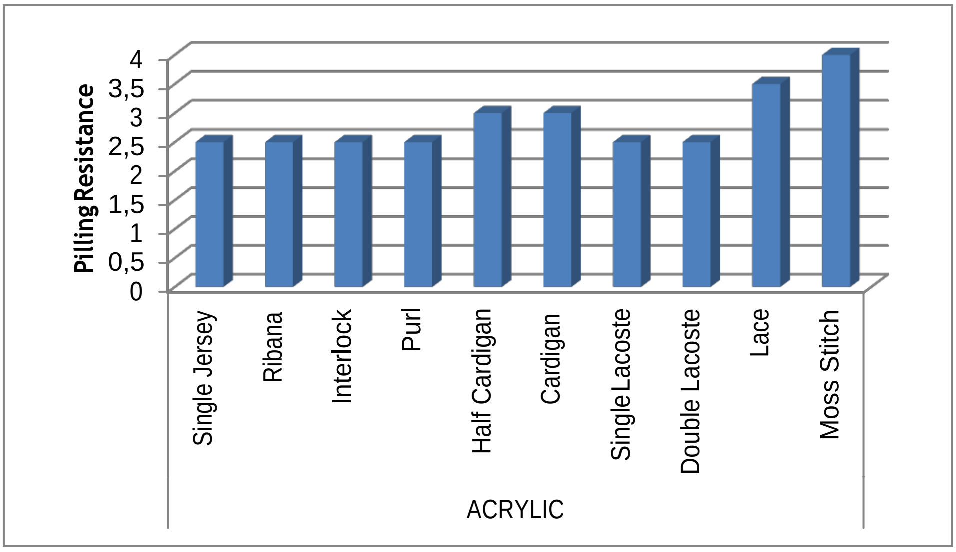

Figure 4.9 Pilling resistance test results of acrylic fabrics

When we look at pilling resistance of acrylic fabrics, the highest value belongs to moss stitch fabric. The reason for this is that the face loops on the reverse loops in 2 times, the formation of the fiber head difference on the surface is easier when the surface ends are formed by the friction of the surface protrusions on the face loops. Lace patterned fabric which has a value close to the moss stitch fabric also has the structure of the fabric tuck on the surface by making long tucks and the fibers on the surface of the yarn have a tendency to form balls. The pilling values of single, ribana, interlock, purl, cardigan, half cardigan, double lacost and single lacost fabrics are close to each other. The reason for this is that the pilling is related to the fibers that make up the fabric rather than the pattern.

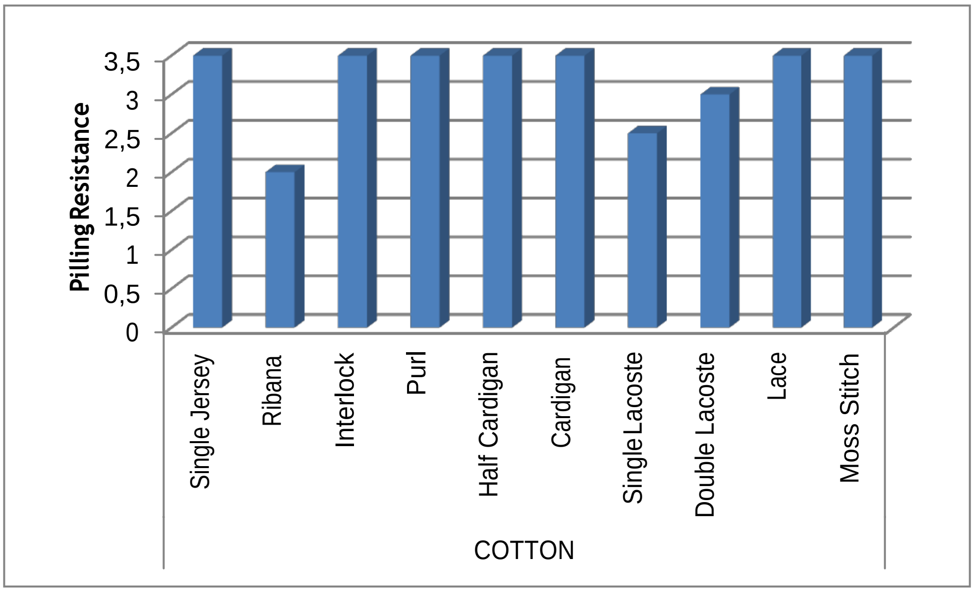

Figure 4.10 Pilling resistance test results of cotton fabrics

When we look at the pilling values of fabrics made of cotton fibers, we see that the fabric has the lowest value. The reason for this is that the width of the ribana fabric is half and has a bulky structure. The pilling resistance of the polyamide yarn has not been observed even at very high speeds. The pilling graphic from the polyamide raw material was therefore not formed.

4.3 Aesthetic Tests Applied to Fabrics

4.3.1 Wrinkle Recovery

The wrinkle recovery is the ability of fabrics to return from wrinkling under the influence of their own weight and gravity after a certain load. In the evaluation made between 1 and 5, the lowest decrease in the wrinkle value is considered as 5.

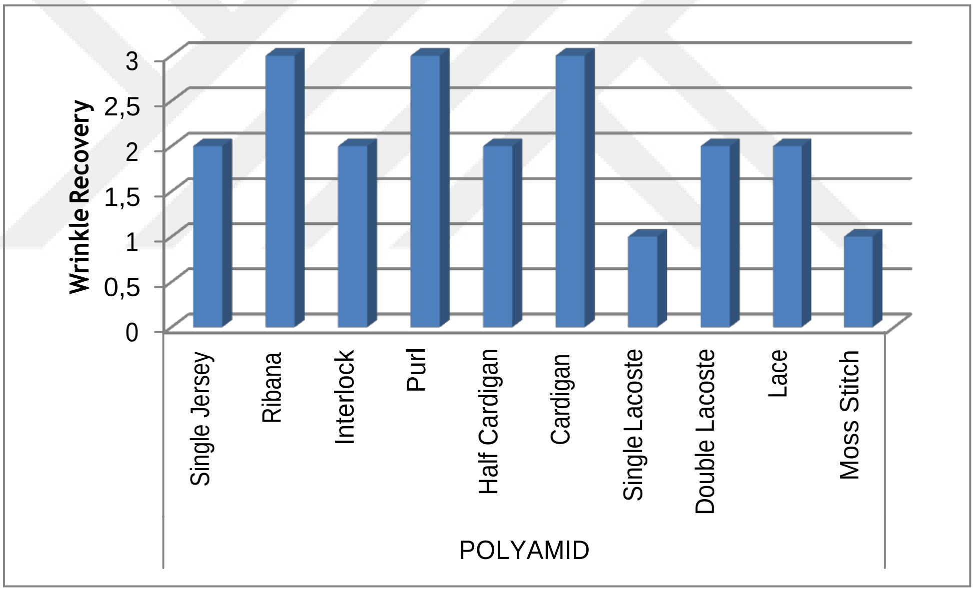

Figure 4.11 Wrikle recovery test results of polyamid fabrics

When we look at polyamide yarns, we see that they have softer structures than other raw materials. This soft structure of the yarn affects the wrinkle values of the fabric. When we look at the wrinkle recovery table in polyamide fabrics, we see that the patterns with the most tendency to wrinkle are single lacoste and moss stitch. This is the result of higher number of tuck loops.

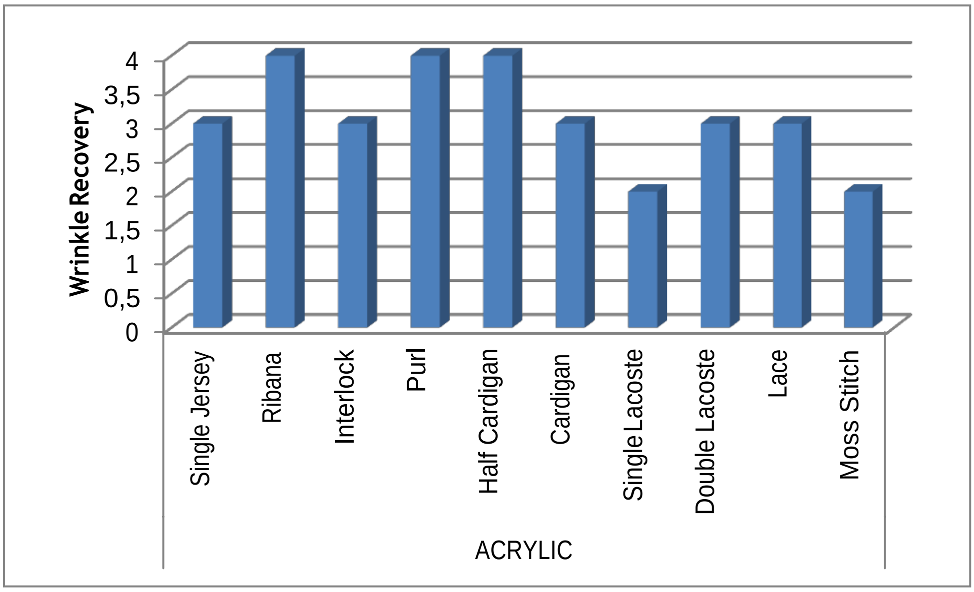

Figure 4.12 Wrinkle recovery test results of acrylic fabrics

Acrylic knitted fabrics for the most wrinkles of the fabric also belongs to lacoste and moss stitch. The result is thought to be the density of the tuck loops. We can see that the fabrics with the lowest wrinkle values are ribana, purl and half cardigan fabrics. Since the loop structures of these fabrics are the same on both sides of the fabric and the balanced structure of these fabrics have a positive effect on the wrinkle recovery.

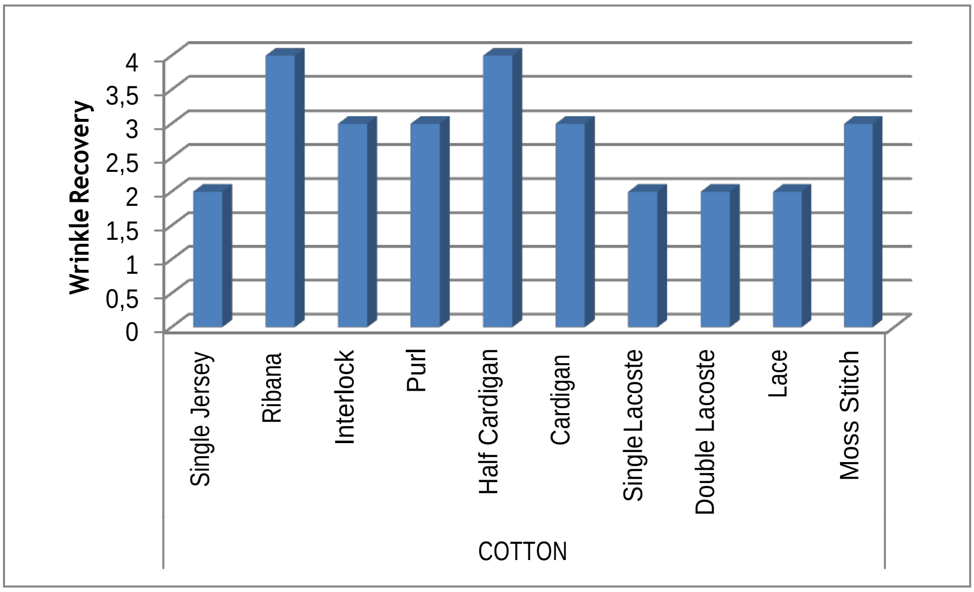

Figure 4.13 Wrinkle recovery test results of cotton fabrics

In cotton knitted fabrics, it is observed that the lacoste fabrics, which are dense and tuck loops, are the voluminous fabrics. Likewise, the ribana structure and half cardigan loop structures have a balanced structure, which has high wrinkle recovery.

4.3.2 Drapeability

Drapeability is one of the important characteristics affecting the appearance of the fabric and it can be defined as the deformation behavior of the fabric under its own weight. It emerges as an important parameter for predicting the appearance of the fabric during use. In recent years, when the perception of comfort came to the focus, draping and bending properties of fabrics started to gain importance.

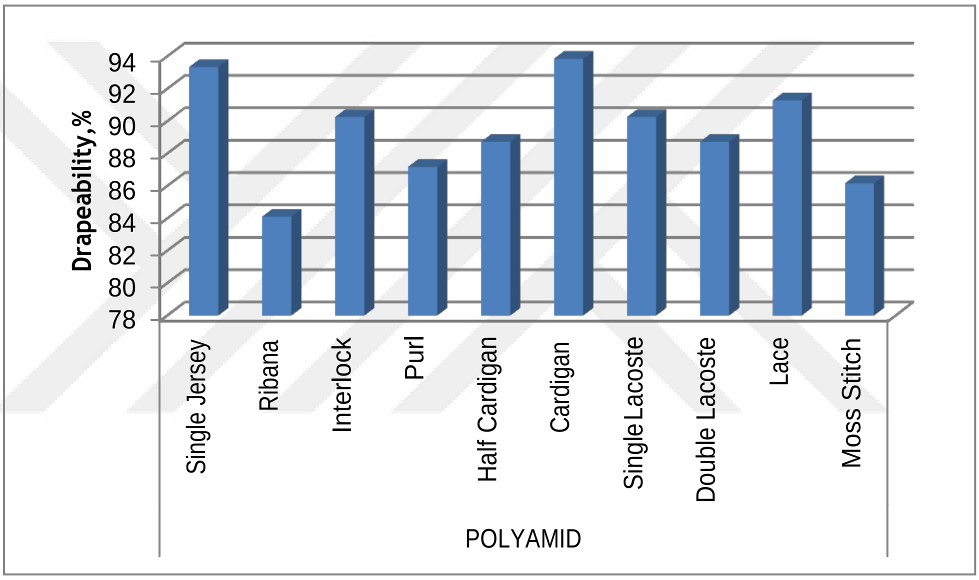

Figure 4.14 Drapeability test results of polyamid fabrics

In terms of draping, single jersey, cardigan fabrics was the highest value, while the ribana fabric gave the lowest value. However, each of the two fabric is produced with double needle beds. However, for all cardigan fabrics, the tuck loops in each bed caused the fabric to grow and increased the drape. Ribana and purl fabrics have the lowest drape. This is because the loop structures are tight.

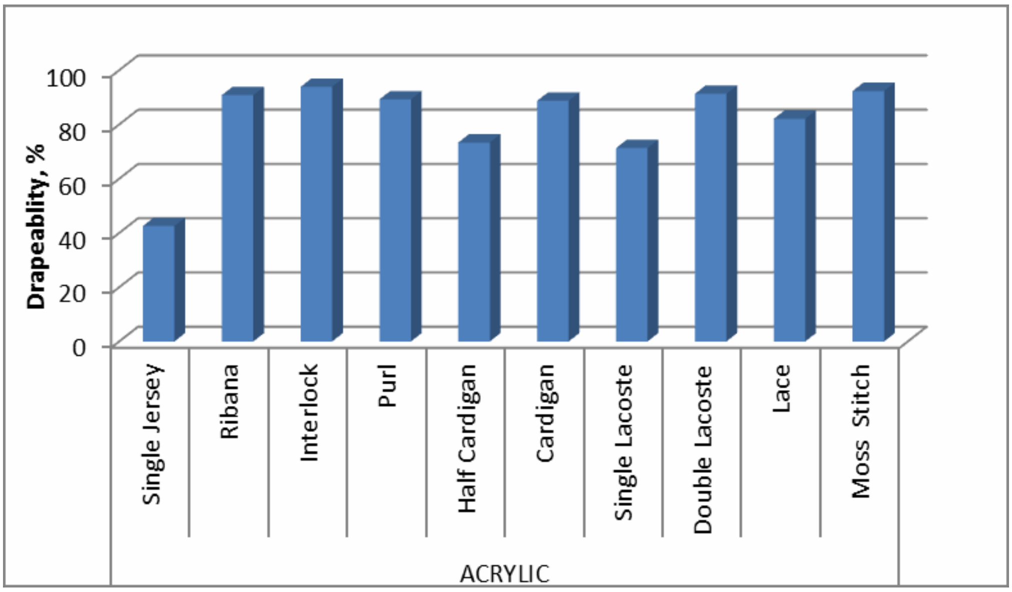

Figure 4.15 Drapeability test results of acrylic fabrics

Acrylic yarns have course structure than other raw materials. When the values of the drape values and fabric thickness are compared, it is seen that the thickness of the ribana, interlock, cardigan and moss stitch fabrics with high drape values is higher than that of the other fabrics. These values are considered to have a negative effect on fabric drapability. It has single jersey to the lowest value. The reason for this is that the fabric is stabilized in the longitudinal direction due to the fact that the fabric edges are in the desire to curl.

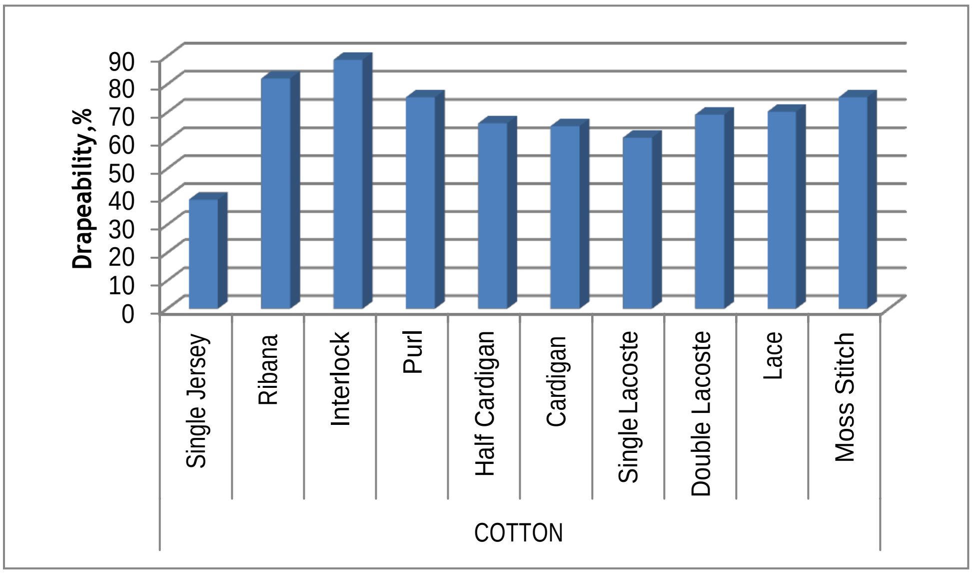

Figure 4.16 Drapeability test results of cotton fabrics

When the drapability of cotton fabrics is examined, it is seen that ribana and interlock fabrics have the highest value. This is due to the fact that these fabrics have the highest value of the stitch density. The fabric with the lowest value is single jersey. The reason is that the fabric is stabilized in the longitudinal direction because the fabric edges are in the desire to curl.

In general, the polyamide fabric is more draped. It can be thought that the flexibility is related to drapeability.

4.3.3 Bending Rigidity

Bending is defined as a horizontal deviation of a rectangular fabric, whose horizontal end is fixed horizontally. In recent years, when the perception of comfort came to the fore, draping and bending properties of fabrics started to gain importance. Actually, this test is applied to woven fabrics, but the results of the study emphasized that, this method can be used for flat knitted fabrics.

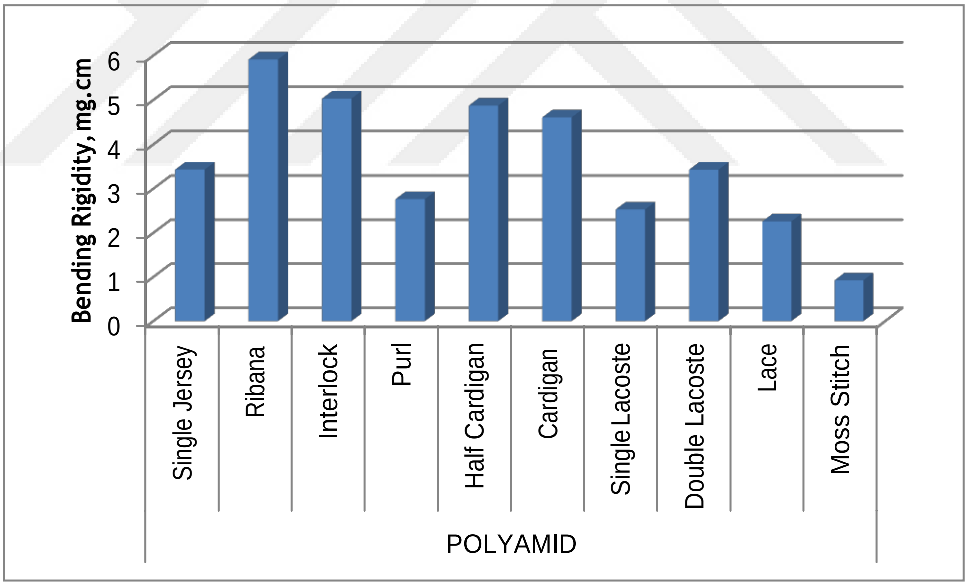

Figure 4.17 Bending rigidity test results of polyamid fabrics

When we look at the bending rigidity graph of polyamide fabric, we see that the bending rigidity of ribana fabrics are at the highest value. When we look at the structure of the ribana fabrics in the fabric structure RL structure, and therefore the width of the fabric in the jersey fabrics compared to a single half of the fall in the bending strength has caused. On the other hand, when we look at the fabric weight, we see that the fabric with the highest unit weight is the ribana. When we look at the application of bending strength test, we reach the result of bending rigidity of the fabric at the moment when it starts to bend with its own weight. When we look at the fabric with the lowest bending strength we see that it is moss stitch. When we look at the structure of moss stitch fabrics, we see that the reverse and face loops are arranged in a regular way. This balanced and regular structure of the fabric, fabric width and width of the fabric at the time of knitting is the best to protect the fabric, the thickness of the fabric is the lowest we can say. The bending rigidity of the fabric is also observed to increase with decreasing fabric thickness. When looking at the bending rigidity of the lace fabrics, the pores formed by the floats in the structure of the fabric due to the voluminous structure of the yarn decreased due to the high bulk structure of the yarn. This has affected the bending rigidity result.

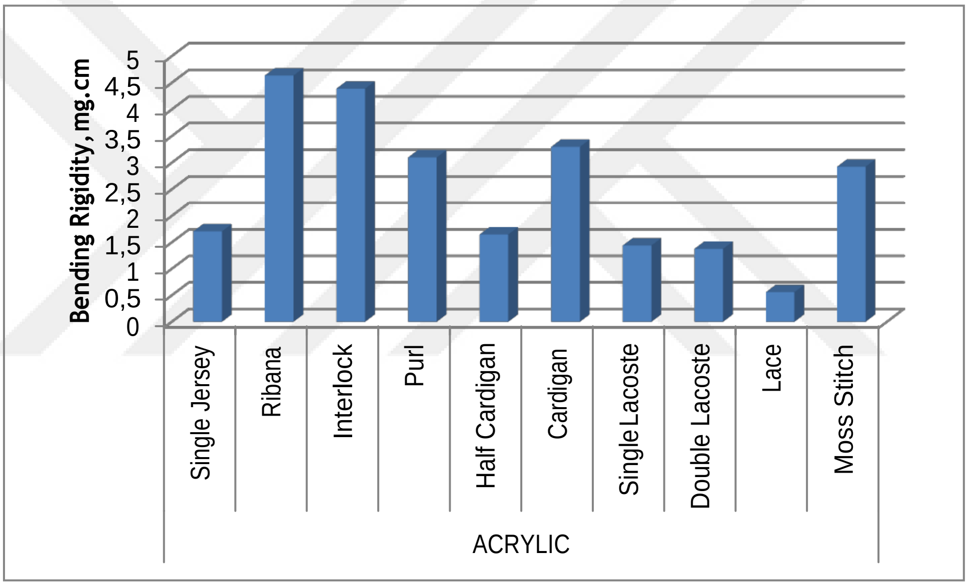

Figure 4.18 Bending rigidity test results of acrylic fabrics

Bending rigidity of ribana and interlock fabrics are closer and higher than the others. These are the heavier fabrics. Then it is concluded that these are the softer fabrics than the others. But all the results are higher then the other raw materials.

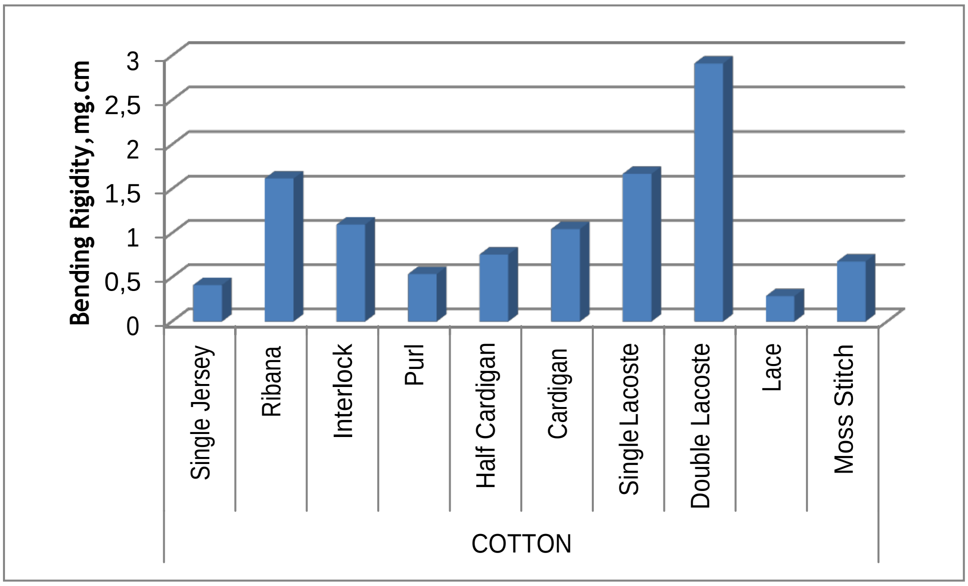

Figure 4.19 Bending rigidity test results of cotton fabrics

4.4 STATISTICAL ANALYSIS

The statistical analysis of the test results were performed by using Design Expert package program. The design expert program and the patterns and raw materials were evaluated together and the significance of pattern and raw material changes on each test result was analyzed with the help of ANOVA test. As the confidence interval was considered as 95% when analyzing the results, p> 0.05 values in ANOVA test results showed that the variables had no significant effect on the result whereas p <0.5 values were the opposite. Afterwards, the effects of the structural properties (thickness, weight, loop density, loop thread length, loop shape factor and porosity) on performance tests were explained by drawing correlation graphs. In addition, the statistical effect of the raw material on each test result, independent of the pattern, is also explained by the help of graphs. On the other hand, it was determined that ANOVA test was used with the help of MiniTab program only if the pattern had a significant difference for different raw materials.

4.4.1 ANOVA Variance Analysis Test

The analysis of variance is used to test hypotheses about whether the difference between the averages of two or more groups is significant. The significance of the difference between the averages of the two groups can also be examined using the t test. If the averages of more than two groups are compared, F Test, ANOVA, Analysis Of Variance is applied. In this study, it is more appropriate to analyze whether the effects of raw materials and patterns on the structural and performance of the fabric are significant because of the three different raw materials and 10 different patterns. Therefore, ANOVA test was performed with 2 separate packages. With the help of the Design Expert package program, the patterns and raw materials were evaluated together and the effects of the raw materials on the mentioned properties were tested with variance analysis. The difference between the test results was considered statistically significant when the p value was less than 0.005 after testing at 95% confidence interval and this result was given as significant. This result shows that this parameter has a significant and significant effect on the test. Otherwise, the effect of the variable is decided to be insignificant. These analyzes are made for all tests but only statistically significant are presented in Table 4.2.

Table 4.2 ANOVA Analysis Table of Effect of Raw Material and Pattern Variables on Performance Characteristics

Responses	Source	Sum of Squares	df	Mean Square	F-value	p-value	
Thickness	Model	6.20	11	0.5638	14.37	< 0.0001	significant
	A-Pattern	3.96	9	0.4403	11.23	< 0.0001	
	B-Raw material	2.24	2	1.12	28.55	< 0.0001	
Weight	Model	1.303E+05	11	11842.66	22.89	< 0.0001	Significant
	A-Pattern	68309.50	9	7589.94	14.67	< 0.0001	
	B-Raw material	61959.80	2	30979.90	59.88	< 0.0001	
Air Permeability	Model	4.037E+07	11	3.670E+06	10.41	< 0.0001	Significant
	A-Pattern	1.873E+07	9	2.081E+06	5.90	0.0007	
	B-Raw material	2.164E+07	2	1.082E+07	30.69	< 0.0001	
Drapeability	Model	2063.88	2	1031.94	7.03	0.0035	Significant

	A-Pattern						
	B-Raw material	2063.88	2	1031.94	7.03	0.0035	
Bending Rigidity	Model	30.85	2	15.43	9.61	0.0007	Significant
	A-Pattern						
	B-Raw material	30.85	2	15.43	9.61	0.0007	
Pilling	Model	26.62	2	13.31	70.11	< 0.0001	Significant
	B-Raw material	26.62	2	13.31	70.11	< 0.0001	
Abrasion Resistance	Model	3.361E+10	2	1.681E+10	36.26	< 0.0001	Significant
	B-Raw material	3.361E+10	2	1.681E+10	36.26	< 0.0001	

When the table is examined, it is seen that the effects of the raw material on the thickness, weight, air permeability, drapability, bending strength, pilling and abrasion resistance of the knitted fabrics in question are statistically significant. On the other hand, the difference between the stitch thread length, loop density, loop shape factor and strength of the fabrics was not significant. The thickness, weight, air permeability, drapability and bending rigidity of the fabrics resulting from pattern change were also found to be statistically significant. In this case, it can be said that making a pattern change has no significant effect on the wear and pilling of fabrics.

4.4.2 Correlation Analysis of Responses and Structural Parameters

4.4.2.1 Air permeability versus structural parameters

Thickness : This graph shows the relationship between the thickness of all samples and their air permeability. While we choose clothes in our daily life, fine textiles are generally preferred more than course in cold weather. The graph is drawn for this perception.

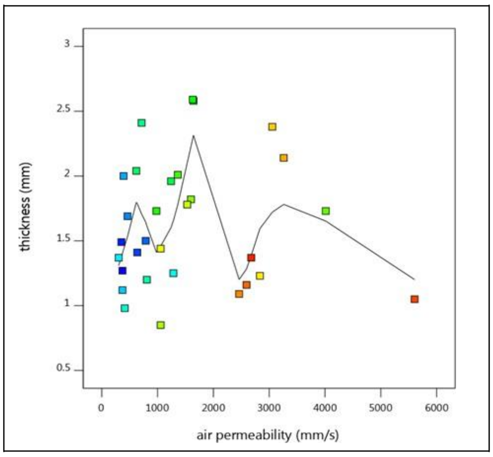

Figure 4.20 Relationship between thickness and air permeability

According to the graphic, there is a negative relationship between the thickness of the sample fabrics and air permeability at 10%. In this case, contrary to the general consumer perception, the air permeability decreases as the thickness of the fabrics increases, it will be academicly wrong.

Weight: This chart shows the relationship between the weights of all samples and their air permeability. Heavy textile materials were predicted to have less air and were plotted.

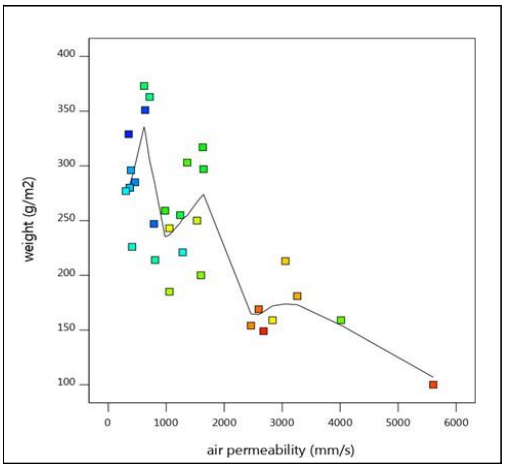

Figure 4.21 Relationship between weight –air permeability

According to the graphic, there is a negative correlation between the weights of the sample fabrics and air permeability at the level of significance level of 0.001 and 73%. In this case, as the weights of fabrics increase, their air permeability decreases and this is a very strong correlation. In other words, it can be said that weight on air permeability is an important parameter.

Porosity: This graph shows the relationship between porosity and air permeability of all samples. As the porosity of the fabric increases, the air permeability increases, but the calculated porosity is different from the perforation. With the help of graphics, it is tried to determine whether this increase is strong or weak.

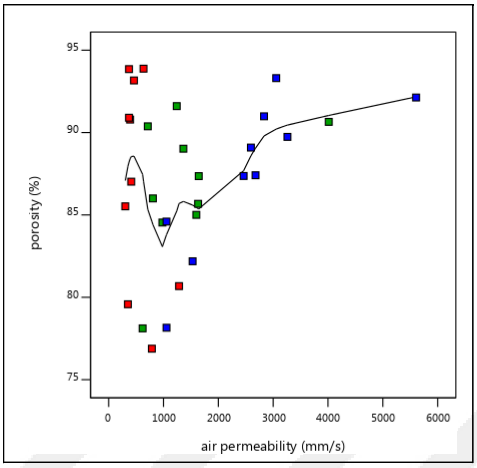

Figure 4.22 Relationship between porosity –air permeability

According to the graphic, there 30% has a positive relationship between the weights of the sample fabrics and the air permeability at the level of significance level of 0.001. In this case, the air permeability of the fabrics increases as the porosity of the fabrics increases and this value is not statistically significant, but it can be said that the porosity is an effective parameter on the air permeability, although it is not alone.

Loop density: This graph shows the relationship between loop density and air permeability of all samples. The density of the stitch indicates the density of the number of wales and courses in the unit area, that is, the tightness of the fabric.

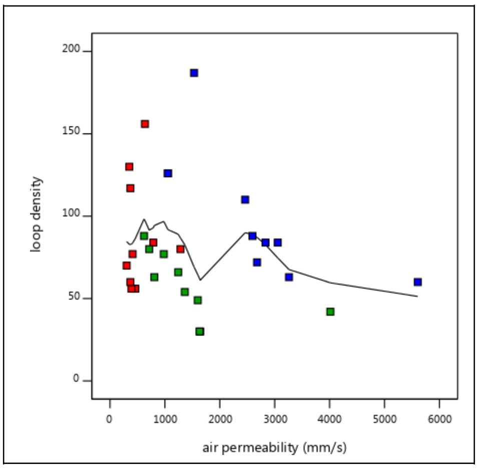

Figure 4.23 Relationship between loop density–air permeability

According to the graphic, there is a negative relationship between the loop density and air permeability of the sample fabrics at a level of 0.001% 22%. In this case, the air permeability of fabrics decreases as the stitch density of fabrics increases.

Yarn loop length: This graph shows the relationship between the loop length and the air permeability of all samples.

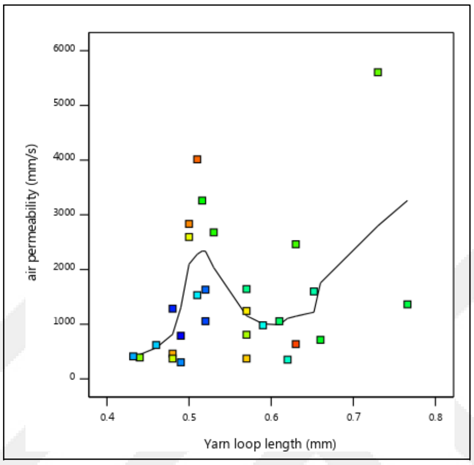

Figure 4.24 Relationship between air permeability-yarn loop lenght

According to the graphic, there is a positive relationship between 27% and 0.001 significance level between the loop yarn length and air permeability of the sample fabrics. In this case, the air permeability of the fabrics increases as the yarn loop length increases.

As a result, When the correlation between structural properties and air permeability is evaluated statistically, the most important parameter on air permeability is seen as unit weight. In this case, it was concluded that each factor (yarn raw material, yarn number, pattern) which causes the unit weight increase leads to decreased air permeability.

4.1.2 Bursting strength versus structural parameters

Thickness: This graph shows the relationship between the thickness and burst strength of all samples. Thicker fabrics are more resistant to the bursting, this graph has been drawn.

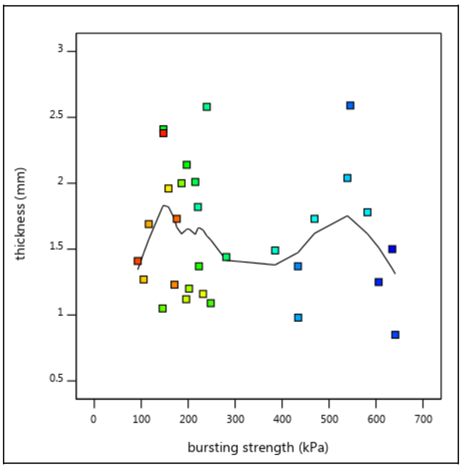

Figure4.25 Relationship between thickness-bursting strength

According to the graphic, there is a negative relationship between the thickness of the sample fabrics and the burst strength at the level of significance level of 0.001 and 10%. In this case, there was no significant relationship between the thickness and the strength of the fabrics.

Weight: This chart shows the relationship between the unit weight and bursting strength of all samples.

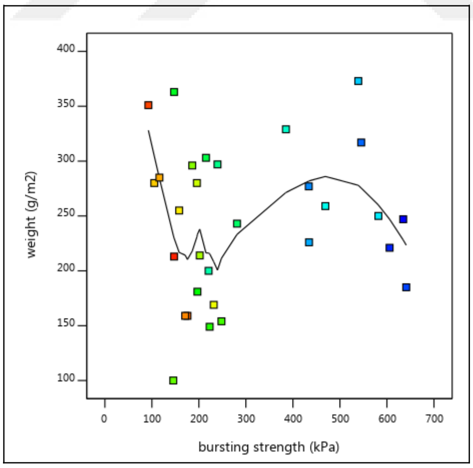

Figure 4.26 Relationship between weight-bursting stength

According to the graphic, there 10% has a positive relationship between the weight of the sample fabrics and the bursting strength at the level of significance level of 0.001. In this case, no significant relationship was found between the weights and the strength of the fabrics.

Porosity: This graph shows the relationship between porosity and burst strength of all samples.

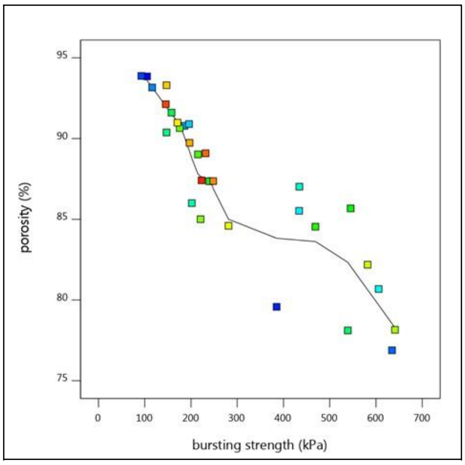

Figure 4.27 Relationship between porosity-bursting stength

According to the graphic, there is 89% level negative correlation between the porosity and the burst strength of the sample fabrics at the level of significance level of 0.001. In this case, a significant and strong relationship was determined between the porosity and the strength of the fabrics.

Loop Density: This graph shows the relationship between stitch density and burst strength of all samples. It is thought that the number of loops in the unit area affects the bursting strength.

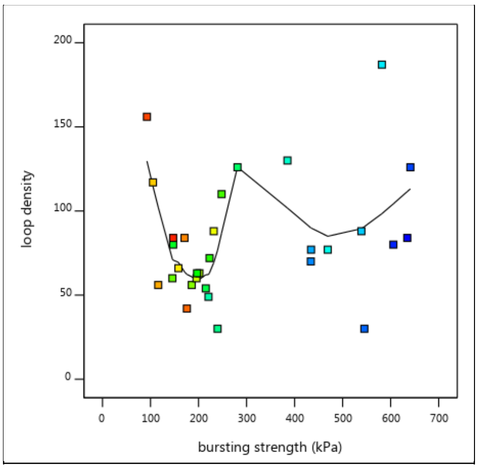

Figure 4.28 Relationship between loop density-bursting stength

According to the graphic, there is a positive relationship between 23% and 0.001 significance level between the stitch density and burst strength of the sample fabrics.

In this case, a significant but weak relationship was determined between the stitch density and the strength of the fabrics.

Yarn loop length: This graph shows the relationship between the loop length and the air permeability of all samples.

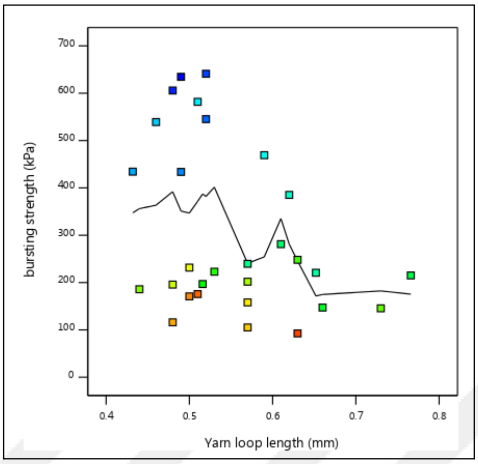

Figure 4.29 Relationship between bursting stength-loop length

According to the graphic, there is a negative relationship between the yarn loop length and burst strength of the sample fabrics at the level of significance level of 37% and 0.001. In this case, the stitch strength of the fabrics increases as the loop length increases.

As a result, When the correlation between structural properties and burst strength is statistically evaluated, the most important parameter on burst strength is seen as porosity. In this case, it has been concluded that each factor that causes the porosity to increase (yarn number, pattern) leads to a decrease in burst strength.

4.4.3 Abrasion resistance versus structural parameters

Thickness: This graph shows the relationship between thickness and abrasion resistance of all samples.

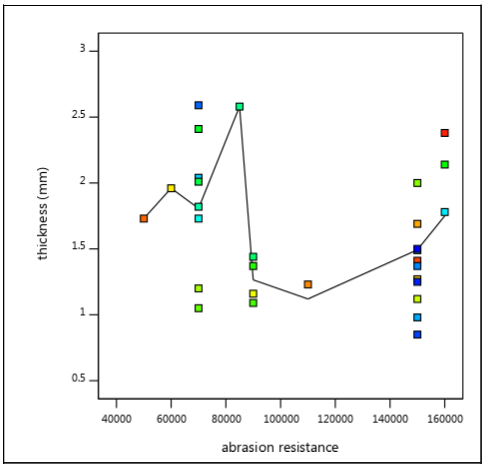

Figure 4.30 Relationship between thickness-abrasion resistance

According to the graphic, there is a negative correlation between the thickness of the sample fabrics and the abrasion resistance at the level of significance level of 24% and 0.001. In this case, it can be said that there is a weak but significant relationship between the thickness and abrasion resistance of fabrics.

Weight: This chart shows the relationship between unit weight and abrasion resistance of all samples.

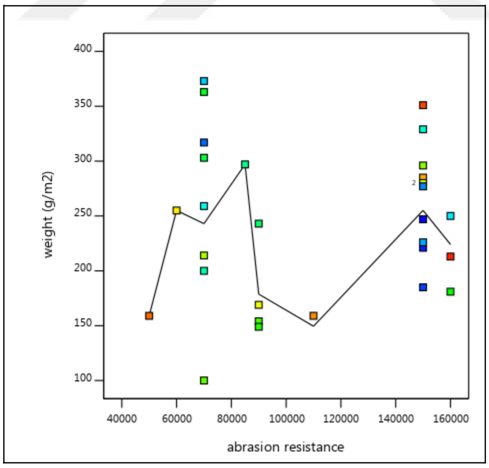

Figure 4.31 Relationship between weight-abrasion resistance

According to the graphic, there is 10% positive relationship between the weight of the sample fabrics and the abrasion resistance at the level of significance level of 0.001. In this case, it can be said that there is a weak but significant relationship between the unit weight and the abrasion resistance of the fabrics. Porosity: This graph shows the relationship between porosity and abrasion resistance of all samples.

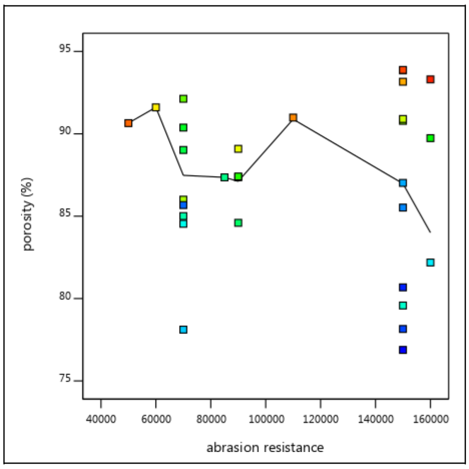

Figure 4.32 Relationship between porosity-abrasion resistance

According to the graphic, there is 5% negative correlation between the porosity of the sample fabrics and the abrasion resistance at the level of significance level of 0.001. In this case, it can be said that there is a weak but significant relationship between the unit weight and the abrasion resistance of the fabrics.

Loop Density: This graph shows the relationship between the stitch density and abrasion resistance of all samples.

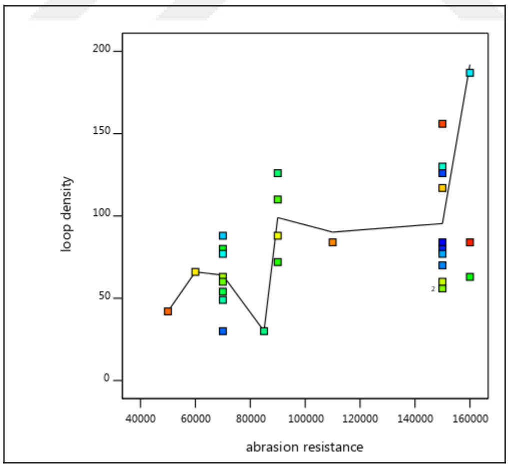

Figure 4.33 Relationship between loop density-abrasion resistance

According to the graphic, there is 44% positive relationship between stitch density and abrasion resistance of the sample fabrics at the level of significance level of 0.001. In this case, it can be said that there is a significant relationship between the stitch density and abrasion resistance of the fabrics.

Yarn loop length: This graph shows the relationship between the loop length and the air permeability of all samples.

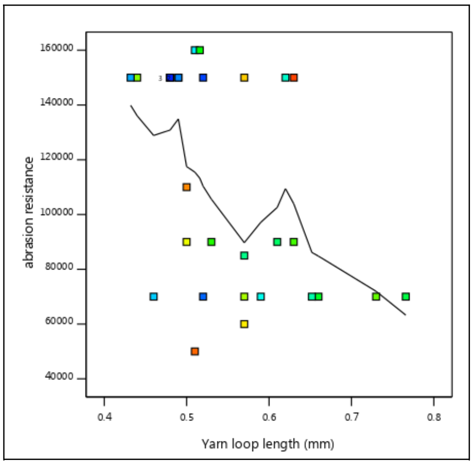

Figure 4.34 Relationship between abrasion resistance-yarn loop length

According to the graphic, there is a negative relationship between 47% and 0.001% significance level between the yarn length and abrasion resistance of the sample fabrics. In this case, the abrasion resistance of fabrics increases as the loop length increases.

As a result, When the correlation between structural properties and abrasion resistance is evaluated statistically, the most important parameter on abrasion resistance is seen as loop density. In this case, it has been concluded that each factor (yarn number, pattern) which causes the increase of the stitch density leads to an increase in the abrasion resistance.

4.4.4 Wrinkle recovery versus structural parameters

Thickness**:** This graph shows the relationship between thickness and wrinkle recycling of all samples.

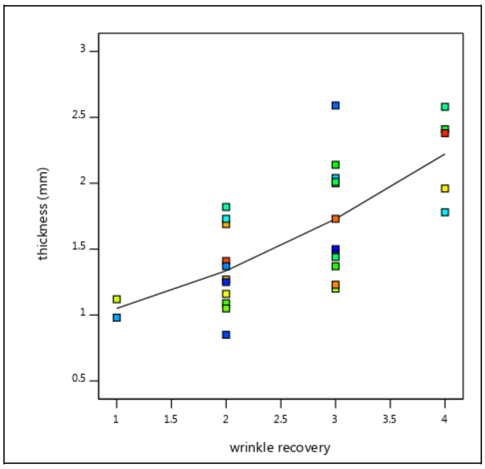

Figure 4.35 Relationship between thickness-wrinkle recovery

According to the graphic, there is a positive relationship between the thickness and wrinkle recovery of the sample fabrics at the level of significance level of 0.001 and 71%. In this case, it can be said that there is a strong and significant relationship between thickness and wrinkle recovery of fabrics. As the thickness increases, wrinkle recovery increases.

Weight: This chart shows the relationship between unit weight and wrinkle recycling of all samples.

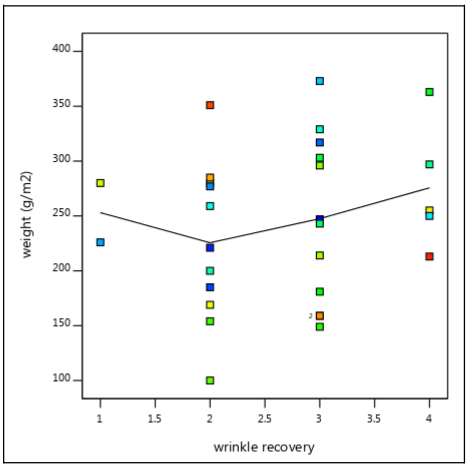

Figure 4.36 Relationship between weight-wrinkle recovery

According to the graphic, there is 19% positive relationship between the weight of the sample fabrics and wrinkle recycling at the level of significance level of 0.001%. In this case, it can be said that there is a weak but significant relationship between the unit weights of the fabrics and the wrinkle recovery. That is, as the weight increases, the resistance to wrinkling increases.

Yarn loop length: This graph shows the relationship between the loop length and the air permeability of all samples.

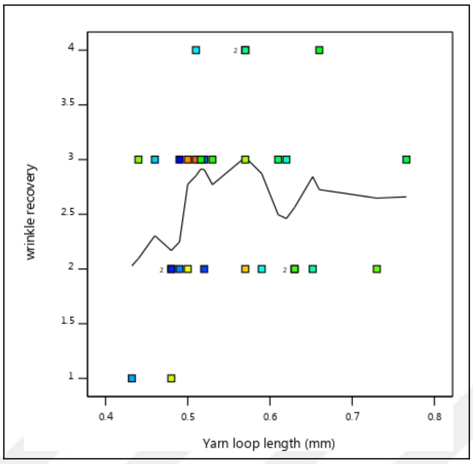

Figure 4.37 Relationship between wrinkle recovery-yarn loop length

According to the graphic, there is a negative relationship between 47% and 0.001% significance level between the yarn length and abrasion resistance of the sample fabrics. In this case, the wrinkle recovery of fabrics increases as the loop length increases.

As a result, When the correlation between the structural properties and the wrinkle recycling is statistically evaluated, the most important parameter on the wrinkle recycling is the thickness. In this case, it was concluded that each factor (yarn number, pattern) which caused the increase in thickness caused an increase in wrinkle recovery.

4.4.5 Bending rigidity versus structural parameters

Thickness: This graph shows the relationship between thickness and bending strength of all samples.

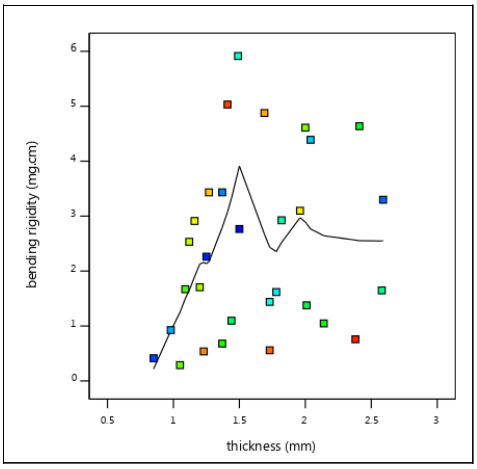

Figure 4.38 Relationship between bending rigidity-thickness

According to the graphic, there is 23% positive relationship between thickness and abrasion resistance of the sample fabrics at the level of significance level of 0.001%. In this case, it can be said that there is a significant but weak relationship between the thickness and bending rigidity of the fabrics.

Weight: This chart shows the relationship between the unit weight and the bending rigidity of all samples.

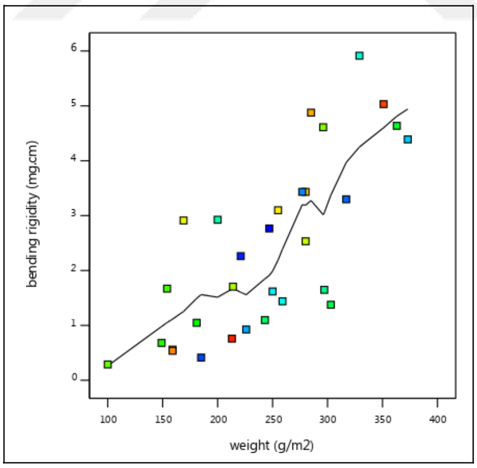

Figure 4.39 Relationship between bending rigidity-weight

According to the graphic, there is a positive relationship between 74% and 0.001% significance between the weight and bending strength of the sample fabrics. In this case, it can be said that there is a strong and significant relationship between the unit weights and bending rigidity of the fabrics. In other words, as the weight increases, the resistance to bending increases.

Loop density: This graphic shows the relationship between the stitch density and bending strength of all samples.

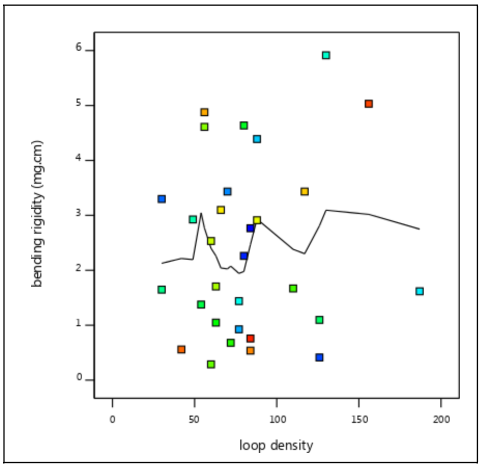

Figure 4.40 Relationship between bending rigidity-loop density

According to the graphic, there is 12% negative relationship between loop density and bending rigidity of the sample fabrics at the level of significance level of 0.001. In this case, it can be said that there is a weak relationship between the loop density and bending rigidity of fabrics.

As a result, When the correlation between structural properties and bending strength is statistically evaluated, the most important parameter on bending strength is unit weight. In this case, it has been concluded that each factor (yarn number, pattern) which causes the unit weight to increase increases bending strength.

4.4.6 Pilling tendency versus structural parameters

Thickness: This graph shows the relationship between thickness and pilling strength of all samples.

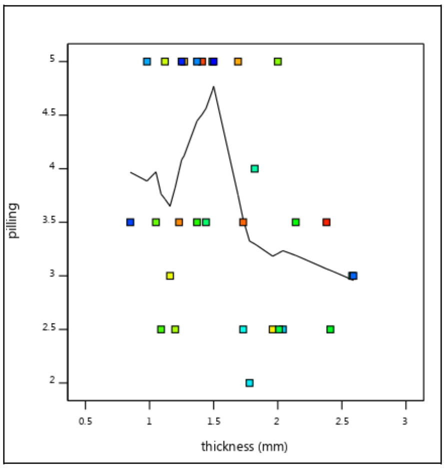

Figure 4.41. Relationship between pilling-thickness

According to the graphic, there is 34% negative correlation between thickness and abrasion resistance of the sample fabrics at 0.001% level. In this case, it can be said that there is a significant but weak relationship between the thickness of the fabrics and the pilling resistance.

Weight: This chart shows the relationship between the unit weight and the bending rigidity of all samples.

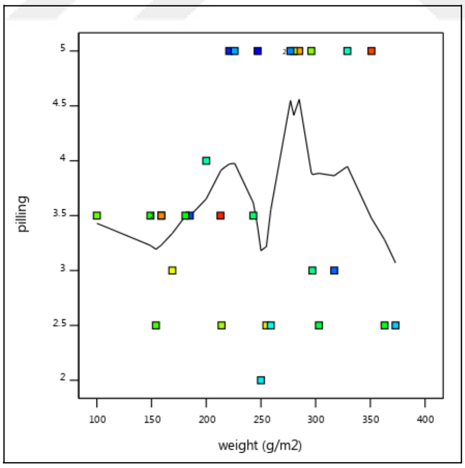

Figure 4.42 Relationship between pilling-weight

According to the graphic, there is 12% positive relationship between the weights of the sample fabrics and the pilling rigidity at the level of significance level 0.001. In this case, it can be said that there is a weak relationship between the unit weights and the pilling resistance of the fabrics.

Yarn loop length: This graph shows the relationship between the loop length and the air permeability of all samples.

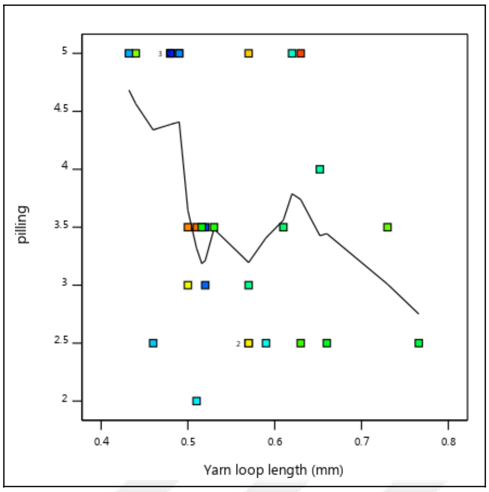

Figure 4.43 Relationship between pilling-yarn loop length

According to the graphic, there is a negative relationship between the loop yarn length and abrasion resistance of the sample fabrics at the level of 0.001% and 34%. In this case, the loop yarn length of the fabrics increases and their pilling resistance decreases.

As a result, when the correlation between structural properties and pilling strength is evaluated statistically, the most important parameter on pilling strength is unit weight. However, it is not possible to mention a meaningful and strong relationship between structural properties and pilling strength according to the samples tested.

4.4.7 Drapeability versus structural parameters

Thickness: This graph shows the relationship between the thickness and the drapeability of all samples.

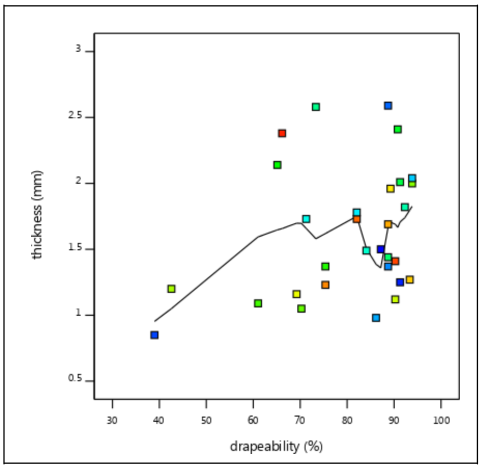

Figure 4.44 Relationship between thickness-drapeability

According to the graphic, there is 29% positive relationship between the thickness and the drape of the sample fabrics at the level of significance level of 0.001. In this case, it can be said that there is a significant but weak relationship between the thickness and drape of the fabrics.

Weight: This chart shows the relationship between the unit weight of each sample and its draping.

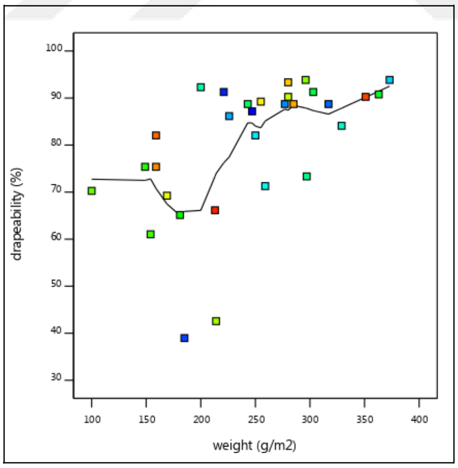

Figure 4.45 Relationship between drapeability-weight

According to the graphic, there is 29% positive relationship between the weights and drapeability of the sample fabrics at the level of significance level of 0.001. In this case, it can be said that there is a strong and meaningful relationship between the unit weights and drapeability of the fabrics. So when the weight increases, the drought increases.

Porosity: This graph shows the relationship between porosity and drapeability of all samples.

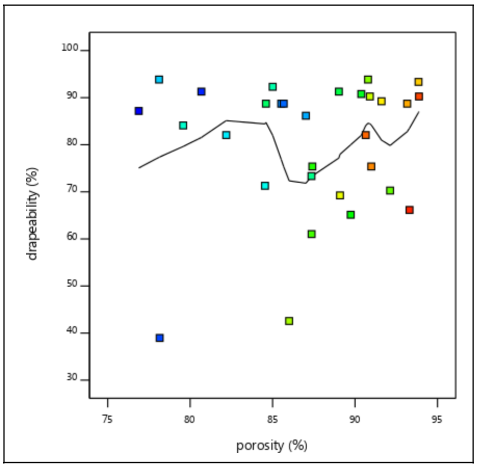

Figure 4.46 Relationship between drapeability-porosity

According to the graphic, there is a positive relationship between 11% and 0.001% significance between porosity of sample fabrics. In this case, it can be said that there is a weak relationship between the porosity and drapeability of the fabrics.

As a result, When the correlation between structural features and drapeability is evaluated statistically, the most important parameter on drapeability is unit weight. In this case, it was concluded that each factor that causes the unit weight to increase (yarn number, pattern) leads to increased drapeability.

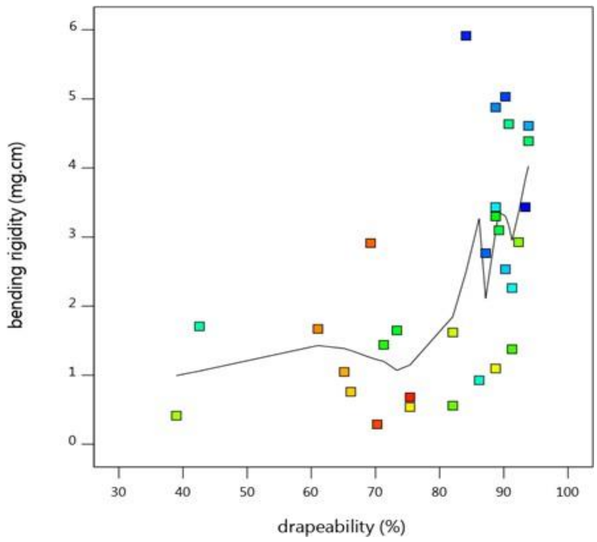

Figure 4.47 Relationship between bending rigidity- drapeability

According to the graphic, there is a positive and strong relationship between the bending strength of the fabrics and their drapeability. In other words, the fabric with high drape thickness also has high bending rigidity.

4.5 Raw material effect on the structural and performance properties of the samples

Raw material versus thickness

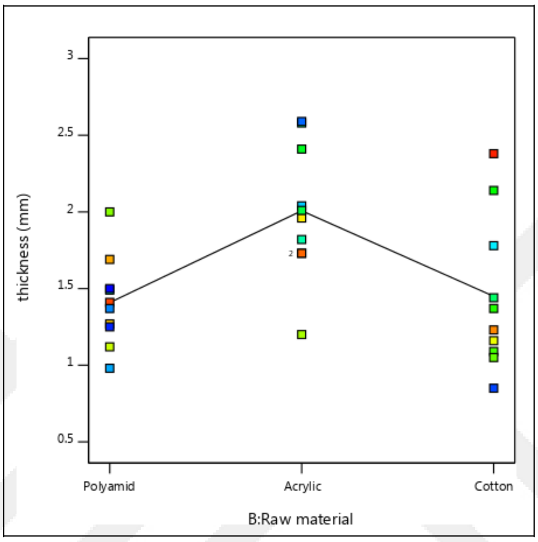

Figure 4.48 Effect of raw material on the thickness of samples statistically

When the graph is examined, it is seen that the thickest fabrics are acrylic fabrics. This is an expected result because the thickest yarn is acrylic.

Raw material versus weight

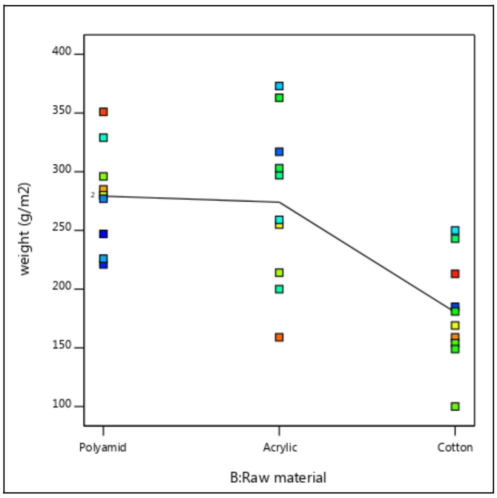

Figure 4.49 Effect of raw material on the weight of samples statistically

When the graphs are examined, it is seen that the weight of polyamide and acrylic fabrics is close to average and the cotton is low. It is concluded that the unit weight decreases due to the yarn number.

Raw material versus porosity

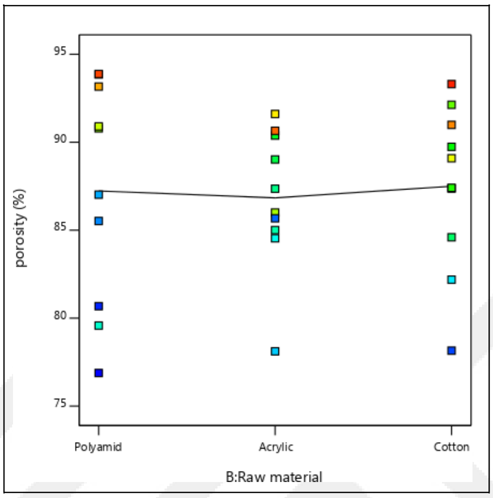

Figure 4.50 Effect of raw material on the porosity of samples statistically

When the graph is examined, it is seen that the thickest fabrics are acrylic fabrics. This is an expected result because the thickest yarn is acrylic.

Raw material versus loop density

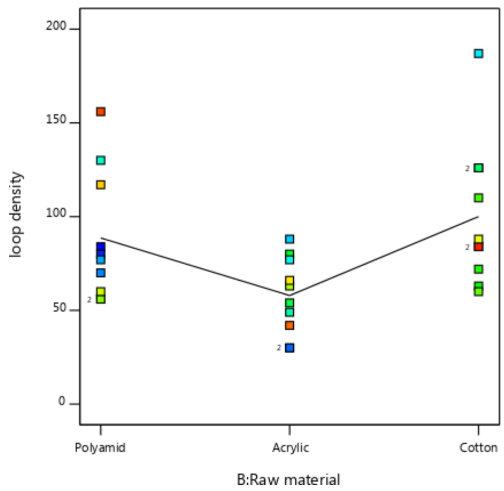

Figure 4.51 Effect of raw material on the loop density of samples statistically

When the graph is examined, it is seen that the density of acrylic fabric is less in terms of loop density. This is due to the fact that the number of wales and courses in the unit area is low due to the thickness of the acrylic yarn.

Raw material versus loop shape factor

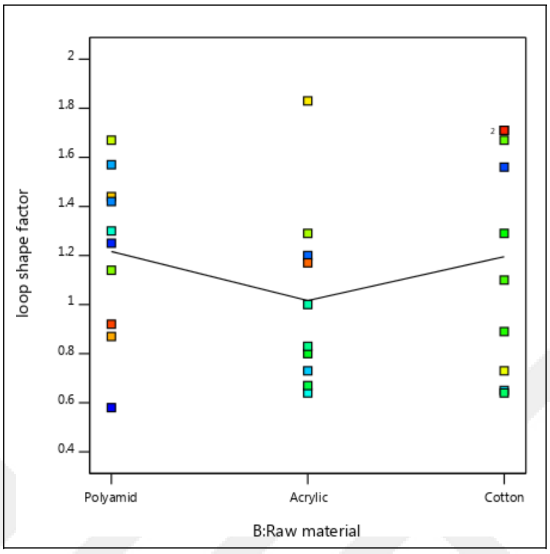

Figure 4.52 Effect of raw material on the loop shape factor of samples statistically

When the graph is examined, it is seen that the loop shape factor of the acrylic fabrics is as low as the stitch density. The reason for this is that the number of course be lower in the unit area of acrylic fabrics.

Raw material versus air permeability

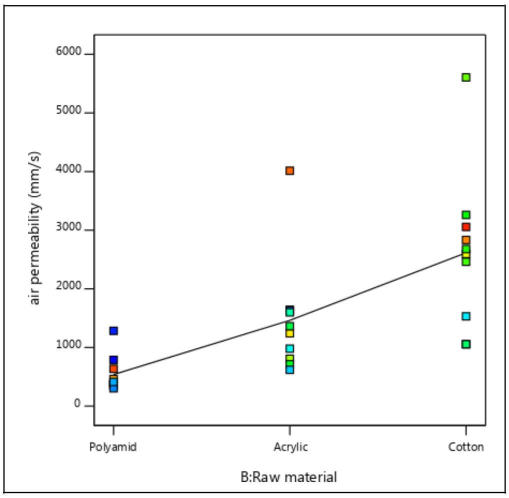

Figure 4.53 Effect of raw material on the air permeability of samples statistically

When the graphic is examined, it is seen that the lowest air permeability of cotton fabrics has the lowest air permeability of polyamide fabrics. The most important parameter on air permeability was determined as the unit weight according to the correlation analysis. The results are consistent with the change in unit weight.

Raw material versus bursting strength

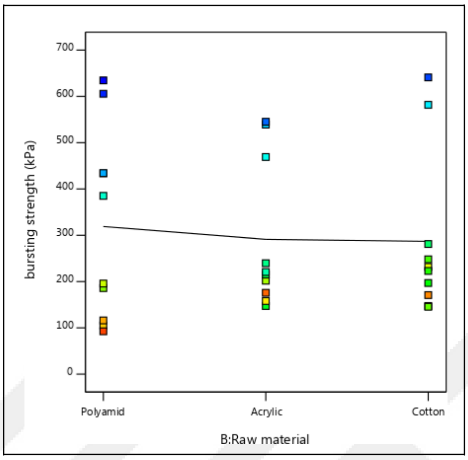

Figure 4.54 Effect of raw material on the bursting strength of samples statistically

When the Figure 54 is observed that statistically bursting strength behaviour of samples are independent from the raw material.

Raw material versus drapeability

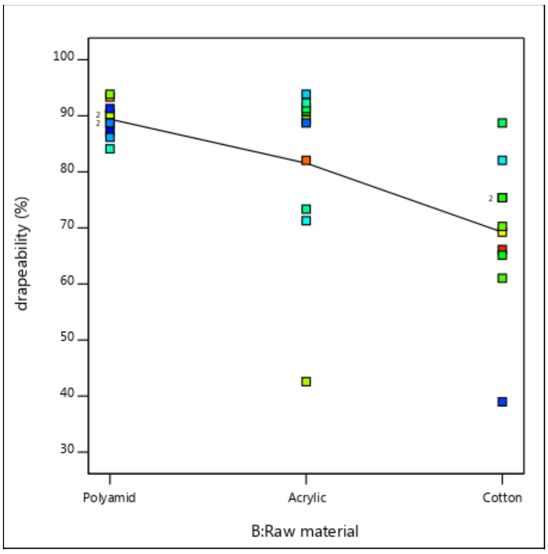

Figure 4.55 Effect of raw material on the drapeability of samples statistically

As seen from the Figure 55 drapeability property of the samples depend on the raw material. Drapeability of cotton is the lowest.

Raw material versus bending rigidity

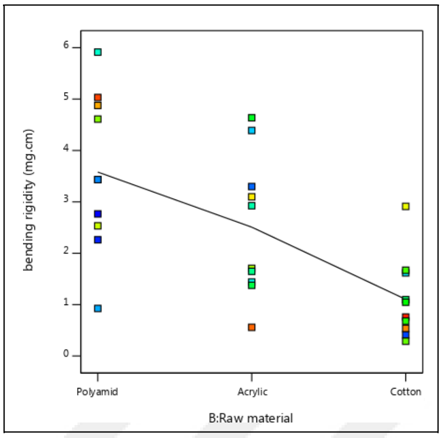

Figure 4.56 Effect of raw material on the bending rigidty of samples statistically

The graphic is examined and the highest bending rigidity belongs to polyamide fabrics. The lowest bending strength belongs to cotton fabrics. In terms of statistics, the most important parameter on bending rigidity is weight rather than raw material.

Raw material versus wrinkle recovery

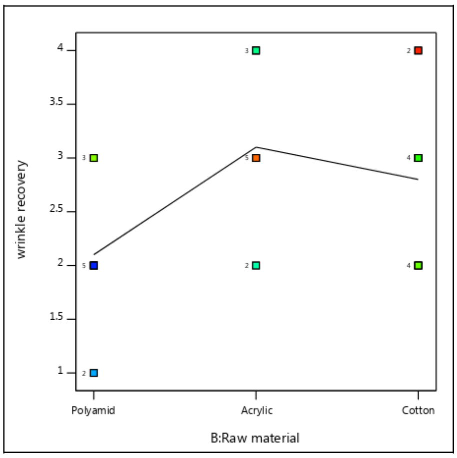

Figure 4.57 Effect of raw material on the wrinkle recovery of samples statistically

When the graphic is examined, wrinkle recovery is one of the worst fabrics made of polyamid. This shows that polyamid-containing fabrics turn harder after wrinkling.

The most resistant to wrinkling is acrylic. The reason for this is the voluminous and heavy structure of acrylic.

Raw material versus pilling density

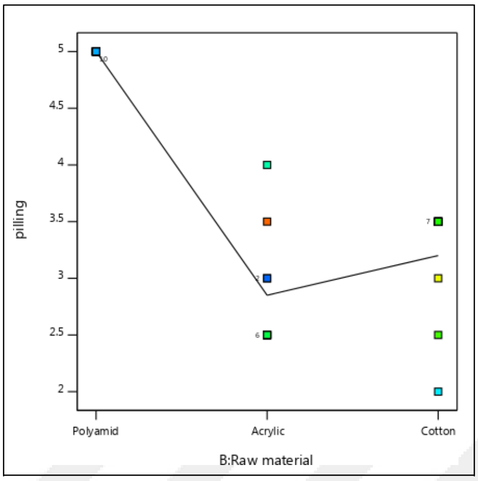

Figure 4.58 Effect of raw material on the pilling of samples statistically

When the graphic is examined, it is seen that the fabrics produced from polyamide are highly resistant to pilling. Although the pilling resistance of cotton and acrylic fabrics come close to each other, the lowest value belongs to acrylic fabrics. As the fiber length increased and hairiness decreased, the results were such that pilling decreased.

Raw material versus abrasion resistance

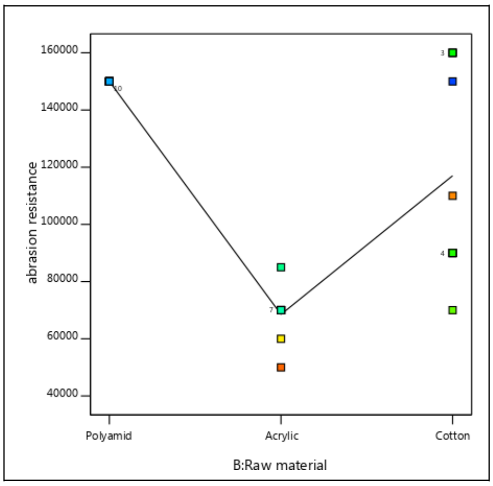

Figure 4.59 Effect of raw material on the abrasion resistance of samples statistically

When the graphic is examined, it is seen that polyamide fabrics have the highest abrasion resistance. Acrylic fabrics, which exhibit the lowest resistance to abrasion, have low resistance despite being thick.

CHAPTER 5

CONCLUSION

In this study 30 samples were produced from 10 different patterns and 3 different raw materials under the same conditions and the results were tried to be expressed by means of graphs and statistical analysis. To summarize the results;

- Pattern variation changed unit thickness, unit weight and stitch density. Then porosity has changed. Reproducibility of results with raw material modification was tested. Increasing the floats and number of tuck loops change the structural properties.
- Every parameter that changes structural properties affects performance and aesthetics characteristic of the samples. As the porosity increased, the air permeability increased and the strength decreased. The flexibility and strength of the polyamide fiber increased the abrasion resistance of these fabrics but reduced pilling.
- Within the fabrics with the lowest wrinkle recovery are the fabrics lacoste and moss stitch in which the tuck loops produced are distributed evenly.
- To determine the strength of knitted fabrics bursting strength test is applied. According to the results of bursting strength for polyamide fabrics; the highest strength belongs to the interlock and the jersey fabric. In general, however, the fiber is very flexible and the strength values are very high. As the tuck loops lengthen the yarn more than necessary, it is thought to be a decrease in strength as the tuck increases. When the strength results of acrylic fabrics are examined, it shows that strength is about half of polyamide fabrics. It is also seen that the density of the suspension loops leads to a decrease in strength. The lowest strength values belong to cotton fabrics. When the correlation between structural properties and burst strength is

statistically evaluated, the most important parameter on burst strength is seen as porosity. In this case, it has been concluded that each factor that causes the porosity to increase (yarn number, pattern) leads to a decrease in burst strength.

- According to the results of air permeability, in polyamide fabrics, as expected, the most permeable fabric belongs to the lace fabric which has the most perforated pattern. The permeability of acrylic fabrics is about 2 times higher. This is the reason why polyamide yarns are hairless and have low porosity. The permeability of cotton fabrics is similar to that of acrylic fabrics. It was found that the fabrics of purl and cardigan were more permeable than lacost fabrics. In the full cardigan fabrics obtained from double bed machines, the tuck loops are opposed with the knitting loops, whereas in the half cardigan fabrics, the tuck and the knit loops are relocated by changing in each order and the gaps are less. This reduced the permeability. When the correlation between structural properties and air permeability is evaluated statistically, the most important parameter on air permeability is seen as unit weight. In this case, it was concluded that each factor (yarn raw material, yarn number, pattern) which causes the unit weight increase leads to decreased air permeability.
- According to the results of the abrasion resistance for the polyamide fabrics, there was no abrasion on the 150000 cycle. On the other hand, cotton fabrics have a loop break between 60000 and 150000 cycles. The effect of pattern on acrylic fabrics is not seen very clearly. For cotton raw material single jersey, ribana and cardigan fabrics are the most durable pattern. The abrasion resistance of lacoste and lace fabrics is similar to that of purl and interlock. When the correlation between structural properties and abrasion resistance is evaluated statistically, the most important parameter on abrasion resistance is seen as loop density. In this case, it has been concluded that each factor (yarn number, pattern) which causes the increase of the stitch density leads to an increase in the abrasion resistance.
- According to the results of pilling resistance, polyamide fabrics have not been pilling even at very high cycles. In acrylic knitted fabrics, pilling is average. The most durable fabric pattern was found to be moss stitch. When the correlation between structural properties and pilling resistance is evaluated

statistically, the most important parameter on pilling resistance is unit weight. However, it is not possible to mention a meaningful and strong relationship between structural properties and pilling resistance according to the samples tested.

- With respect to wrinkle recovery of sample knitted fabrics the best type raw material is polyamid. When we look at polyamide yarns, we see that they have softer structures than other raw materials. This soft structure of the yarn affects the wrinkle values of the fabric. When we look at the wrinkle recovery table in polyamide fabrics, we see that the patterns with the most tendency to wrinkle are single lacoste and moss stitch. We can see that the fabrics with the lowest wrinkle values are ribana, purl and half cardigan fabrics produced by acrylic fiber. Since the loop structures of these fabrics are the same on both sides of the fabric and the balanced structure of these fabrics have a positive effect on the wrinkle recovery. When the correlation between the structural properties and the wrinkle recovery is statistically evaluated, the most important parameter on the wrinkle recovery is the thickness. In this case, it was concluded that each factor (yarn number, pattern) which caused the increase in thickness caused an increase in wrinkle recovery.

- In terms of drapeability, single jersey, cardigan fabrics was the highest value in polyamid. The fabric with the lowest value is single jersey (cotton). The reason is that the fabric is stabilized in the longitudinal direction because the fabric edges are in the desire to curl. In general, the polyamide fabric is more draped. It can be thought that the flexibility is related to drapeability. When the correlation between structural properties and drapeability is evaluated statistically, the most important parameter on drapeability is unit weight. In this case, it was concluded that each factor that causes the unit weight to increase (yarn number, pattern) leads to increased drapeability.

- When the correlation between structural properties and bending rigidity is statistically evaluated, the most important parameter on bending rigidity is unit weight. In this case, it has been concluded that each factor (yarn number, pattern) which causes the unit weight to increase increases bending rigidity.

The results show that the changing pattern parameter is mathematically and statistically effective on the performance and aesthetic properties of fabrics. It is known that before buying a textile material customers have many expectations from the product. To increase the useful life of the product the strength and durability are the most important parameters. These parameters can be expressed as bursting strength, abrasion and pilling resistance tests. According to the test results to obtain strong and durable fabrics polyamid raw material and interlock pattern can be preferred. For deciding any fabric is convenient for winter or summer season air permeability is decisive parameter during the fabric selection. The most permeable fabric type is lace and raw material is cotton. So this sample is convenient for summer use. And cardigan patterned acrylic fabrics' permeability is quite low therefore these samples are convenient for winter use. Nobody wants to use easily wrinkles textile materials and within the samples fabrics produced by polyamid and ribana and cardigan type fabrics' wrinkle recovery are good. Drapeability and bending rigidity are related terms and they are related with the softness of the fabrics. Statistically each term depends on the thickness of the fabrics. Than according to thickness when the raw material is selected as acrylic and the pattern are ribana, interlock and cardigan the sample will be drapeable and soft.

Further Studies

In this study three raw material and one yarn count were used. For further studies effect of different raw materials, different yarn counts and number of ply on the performance of the samples can be studied.

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