SUDAN UNIVERSITY OF SCIENCE
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Treatment of Woven Fabrics to Enhance their Anti-Dust Property

معالجة الأقمشة المنسوجة لتحسين خاصية مقاومة الغبار

A Thesis Submitted in Fulfilment of the Requirements for the Degree of Doctor of Philosophy in Textile Engineering

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Dedication

I dedicate this humble effort

To

The Soul of my mother,

My father, sisters, brothers,

My husband and son,

My teachers,

My colleagues,

My students and

Everybody who contributed to this study.

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المستخلص

تتحدد كفاءة الأداء للأقمشة بمدى ملائمتها للوظيفة التى انتجت من اجلها. يتم تقييم ذلك من خلال مجموعة من المعايير التى تناسب كل نوع من انواع الأقمشة.تعتبر اختبارات الأقمشة من اهم الوسائل التى تستخدم فى عملية تقييم الأقمشة فى جميع مراحلها اثناء او بعد الإنتاج و ذلك باستخدام الأجهزة المعملية التى تناسب كل خاصية من خواص الأقمشة.مساحة كبيرة من جمهورية السودان تقع في المناخ شبه الصحراوى و يجرى بها نهر النيل وقد اثرت هذه الطبيعة الجغرافية فى بعض العوامل المناخية منها الرياح المحملة بالرمال و الاتربة التى تهب على فترات خلال العام.اجريت هذه الدراسة لإنتاج اقمشة مقاومة للغبار باستخدام ثلاثة انواع مختلفة من الخامات 100% قطن، 100% بولستر و مخلوط من 50%قطن و 50% بولستر و تم نسجها بتراكيب نسيجية مختلفة سادة ، مبرد 2/2 و اطلس 4 غير منتظم ممتد من اللحمة .تمت معالجة هذه الخامات بمادة كيميائيةوهي بوليمرات مستحلب من بيرفلورو -هيبتيل أكريليت- متعددالميثيلول الأكريلاميد.تم اختبار قياس قياس كفاءة الأقمشة وقدرتها على طرد الأتربة باستخدام جهاز نفاذية الغبار بالمركز القومى للبحوث بالقاهرة بجمهورية مصر العربية.تم تطبيق الإختبارات القياسية لتحديد مدى التغيير فى الخواص الميكانيكية و الفيزيائية للأقمشة قبل المعالجة و بعد المعالجة بالمادة الكيميائية و قياس نفاذية الهواء و وزن القماش بعد التعرض للغبار قبل و بعد المعالجة.وقد تم التوصل من خلال البحث الى انه تتحدد كفاءة اداء الاقمشة و قدرتها على الإحتفاظ بالاتربة على سطحها و خلال مسامها و على بعض الخواص الاخرى.و قد تبين من البحث ان نسبة الزيادة فى الوزن بعد التعرض للغبار كانت فى العينة 100% قطن و نفاذية الهواء قلت بنسبة بسيطة فى 100% بولستر.الوزن فى التصميم السادة كان اعلى قيمة بعد التعرض للغبار بعد المعالجة و نجد اعلى قيمة لنفاذية الهواء فى التصميم الاطلس بعد التعرض للغبار قبل و بعد المعالجة. بعد المعالجة الكيميائية للأقمشة بالمادة ضد إلتصاق الأتربة تم تحسين الأقمشة بعد المعالجة بنسبة 97%.

Abstract

The quality of fabrics is determined by their relevance to the functions they are produced for. It is evaluated according to a set of criteria's which appropriate for each type of fabrics. A fabric testing is one of the most important methods for fabrics evaluation during or after production by using laboratory devices which are relevant to fabric properties. A large area of the Republic of Sudan lies in the semi-desert climate through which the River Nile flows, and this geographical nature creates some climatic factors such as dusty winds that blow periodically through the year. This study is conducted to produce anti-dust fabrics by using three different types of materials: cotton (100%), polyester (100%) and a blend of cotton and polyester (50% for each). However, these materials are woven into various fabric designs: plain, twill 2/2 and sateen 4irregularextended from the weft. These materials are treated with a chemical substance namely emulsion copolymer of perflouro –heptyl acrylate-co-methylol acrylamide.The fabrics testing for the quality of fabrics and their capacity to resist dust was tested by the dust permeability instrument of National Centre for Research in Cairo, Egypt. Standard tests were used to determine the rate of change in mechanical and physical properties of the fabrics before and after treatment with the chemical substances to assess their air permeability and weight following their exposure to dust before and after treatment. The study concludes that the quality of fabrics depends on their liability to retain dust on their surface or pores and on other qualities as well.

Evidently, the study proofs the weight of the 100% cotton sample increased after exposition to dust and the air permeability decreased slightly in the 100% polyester sample. The highest increase in weight after exposure to dust was in the plain sample and the greatest air permeability after exposure to dust before and after treatment was in the Sateen Sample. After chemical treatment of the fabrics with anti-dust substance their quality improved by 97%.

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Nomenclature

Greek Letters

η	Anti-dust efficiency
μm	Micro meter

Abbreviation

AP	Air Permeability
ASTM	American Standardsfor Testing and Materials
BS	British Standards
C	Concentration of Dust
DMT	Dimethyl Terephtalate
EG	Ethylene Glycol
ISO	International Standardization Organization
IUPAC	International Union of Pure and Applied Chemistry
M	Mass Flow Rate of Air Permeability
M_t	Total Mass Flow Rate
PET	Polyethylene Terephthalate
TPA	Terephtalic Acid
V	Volumetric Flow Rate of Air Permeability
Pl/C	Plain design in cotton material
Tw/C	Twill design in cotton material
Sa/C	Sateen design in cotton material
Pl/P	Plain design in polyester material
Tw/P	Twill design in polyester material
Sa/P	Sateen design in polyester material
Pl/P/C	Plain design in polyester &cotton material
Tw/P/C	Twill design in polyester &cotton material
Sa/P/C	Sateen design in polyester &cotton material

Chapter (1)

Introduction

Chapter (1)

1 Introduction

1.1 Sudan

Sudan is located in northeastern Africa. It is bordered by Egypt to the north, the Red Sea to the northeast, Eritrea and Ethiopia to the east, South Sudan to the south, the Central African Republic to the southwest, Chad to the west and Libya to the northwest. Sudan is the third largest country in Africa. It had been the largest until the independence of South Sudan in 2011.

Although Sudan lies within the tropics, the climate ranges from arid in the north to tropical wet-and-dry in the far southwest. Temperatures do not vary greatly with the season at any location; the most significant climatic variables are the rainfall and the length of the dry season. Variations in the length of the dry season depend on which of two air flows predominates dry northeasterly winds from the Arabian Peninsula or moist southwesterly winds from the Congo River basin.(Fadlalla 2004).

From January to March, the country is under the influence of the dry north easterlies. There is practically no rainfall countrywide except for a small area in northwestern Sudan in where the winds have passed over the Mediterranean bringing occasional light rains. By early April, the moist southwesterlies would reach southern Sudan, bringing heavy rains and thunderstorms. By July the moist air reaches Khartoum, and in August it extends to its usual northern limits around Abu Hamad, although in some years the humid air may even reach the Egyptian border. The flow becomes weaker as it spreads north. In September the dry northeasterlies begin to strengthen and to push south and by the end of December they cover the entire country. Yambio, close to the border with Zaire, has a nine-month rainy season (April-December) and receives an average of 1,142 millimeters of rain each year; Khartoum has a three month rainy season (July September) with an annual average rainfall of 161 millimeters; Atbarah receives showers in August that produce an annual average of only 74 millimeters.(Metz 1991).

In some years, the arrival of the southwesterlies and their rain in central Sudan might delayed, or they may not come at all. If that happens, drought and famine follow. The decades of the 1970s and 1980s saw the southwester lies frequently fail, with disastrous results for the Sudanese people and economy.

The haboob, a violent dust storm, can occur in central Sudan when the moist southwesterly flow first arrives (May through July). The moist, unstable air forms thunderstorms in the afternoons. The initial down flow of air produces a huge yellow wall of sand and clay that can temporarily reduce visibility to zero.(Waleij et all 2004)

Sudan has a tropical climate. Summer temperatures often exceed 43degrees Celsius (about 110 degrees Fahrenheit) in the desert zones. Dust storms frequently occur in desert zone. High temperatures also occur in the south throughout the central plains region, but the humidity is generally low. In Khartoum the average annual temperature is about 26C° (about 80° Fahrenheit), and the annual rainfall is about 254 mm (about 10 inch).

No doubt, the scientific achievement of humanity in the two previous centuries enabled the mankind to live in different climatic regions, however, these variations in climates require a variation in clothing .People produce different types of clothes using a diversity of fabrics. These fabrics at the same time are subjected to dust, which is different in type according to the physical and chemical components of the dust particles and this in turn could affect the fabrics.(Naerstad 2007).

Sudan is highly vulnerable to climate change and climate variability. The interaction of multiple stresses—endemic poverty, ecosystem degradation, complex disasters, conflicts, limited access to capital, markets, infrastructure and technology, have all weakened people's ability to adapt to changes in climate.(Zakieeldeen 2009).

Other climate-related phenomena—such as dust storms, thunderstorms, and heat waves—also pose a serious threat to local livelihoods, although they occur less frequently. Climate change is expected to intensify these hazards.

1.2 Definition of Dust:

According to the International Standardization Organization (ISO 4225 - ISO, 1994),"Dust: small solid particles, conventionally taken as those particles below 75 µm in diameter, which settle out under their own weight but which may remain suspended for some time". According to the "Glossary of Atmospheric Chemistry Terms" (IUPAC, 1990),"Dust: Small, dry, solid particles projected into the air by natural forces, such as wind, volcanic eruption, and by mechanical or man-made processes such as crushing, grinding, milling, drilling, demolition, shovelling, conveying, screening, bagging, and sweeping. Dust particles are usually in the size range from about 1 to 100 µm in diameter, and they settle slowly under the influence of gravity".(Standars Geneva, 1999).

However, in referring to particle size of airborne dust, the term "particle diameter" alone is an over simplification, since the geometric size of a particle does not fully explain how it behaves in its airborne state. Therefore, the most appropriate measure of particle size, for most occupational hygiene situations, is particle aerodynamic diameter, defined as" the diameter of a hypothetical sphere of density 1 g/cm^3 having the same terminal settling velocity in calm air as the particle in question, regardless of its geometric size, shape and true density."The aerodynamic diameter expressed in this way is appropriate because it relates closely to the ability of the particle to penetrate and deposit at different sites of the respiratory tract, as well as to particle transport in aerosol sampling and filtration devices. There are other definitions of particle size, relating, for example, to the behaviour of particles as they move by diffusion or under the influence of electrical forces. But these are generally of secondary importance as far as airborne dust in the workplace is concerned.

In aerosol science, it is generally accepted that particles with aerodynamic diameter >50mm do not usually remain airborne very long: they have a terminal velocity >7cm/sec. However, depending on the conditions, particles even >100 m m may become (but hardly remain) airborne. Furthermore, dust particles are frequently found with dimensions considerably <1 m m and, for these, settling due to gravity is negligible for all practical purposes. The terminal velocity of a 1mm particle is about 0.03 mm/sec, so movement with the air is more important than sedimentation through it. Therefore, summarizing in the present context, it is considered that dusts are solid particles, ranging in size from below 1µm up to at least 100 µm, which may be or become airborne, depending on their origin, physical characteristics and ambient conditions.

The word (dust) is used generically to describe fine particles that are generally less than 75 microns (µm) in diameter and that can be transported in the atmosphere. Dust in the urban environment commonly includes sources from industry, vehicles, coal and wood smoke, and particles from the soil. Typically, the dust associated with aggregate operations consists of particles from exposed soil and rock. The presence of dust sometimes raises concerns that are not directly proportional to its impact on human health and the environment. Dust concentrations, deposition rates, and potential impacts tend to decrease rapidly away from aggregate operations. Federal, state, and local regulations put strict limits on the amount of airborne material that may be released from an aggregate site, especially dust that could be inhaled.(industrial-dust-air-pollution 2009).

Dust consists of solid particles projected into the air by natural forces such as wind, volcanic eruption, or earthquakes, or by human activities. Fumes are solid airborne particles usually 100 times smaller than dust particles, commonly formed by condensation of vapors of normally solid materials. Fumes that are permitted to age tend to agglomerate into larger clusters.(Wiley &Inc 2006)

Dust was defined as particulate matter which is or can be suspended into the atmosphere as a result of mechanical, explosive, or windblown suspension of geologic, organic, synthetic, or dissolved solids, and does not include non-geologic particulate matter emitted directly by internal and external combustion processes.(Western Governors' Association 2006)

Dust is finely divided solids that become airborne through a fracture process from a larger solid object. Common household dust is mainly composed of decayed skin particles, while industrial dust is commonly generated by sawing, grinding, or polishing of wood, metal, plastic, or masonry type materials.(Computer Dust Solutions, LLC 2009).

Dust particles can be as small as a few microns (micrometers) or as large as hundreds of microns in size. The larger and denser particles tend to settle, while the smaller and lighter ones can remain airborne indefinitely.

Dust particles can contain moisture (water or oils), organic material (carbon), various minerals, or various chemicals.(abdel-Shafy &Mansour 2016)

Airborne dust can arise from a wide variety of anthropogenic sources, including the following:

1. wind-blown dust from exposed surfaces such as bare land and construction sites

2. wind-blown dust from stockpiles of dusty materials such as sawdust, coal, fertilizer, sand and other minerals
3. Dust caused by vehicle movements on sealed or unsealed roads
4. Agriculture and forestry activities
5. Mines and quarries
6. Road works and road construction
7. Housing developments
8. Municipal landfills and other waste handling facilities
9. Dry abrasive blasting

Numerous industrial operations, including grain drying and storage, timber mills, stonemasons, mineral processing, cement handling and batching, and fertilizer storage and processing.(Ministry of the Environment 2001)

Large quantities of dust can also be generated from natural sources, such as dry river beds, pollen from plants and volcanic eruptions..(Ministry of the Environment 2016)

In the first instance, the fabric is designed to capture the maximum number of particles present. The particle size and size distribution will be of great importance.

As the particle size of the dust decreases, the available surface area increases, giving a greater capacity for rapid reaction. Therefore, the explosibility of dusts increases as the particle size decreases, and the smaller the particle size the less energy required to ignite the dust cloud. Fine dust can also be thrown into suspension more readily, can remain suspended longer than coarse dust, and will mix more uniformly with air.(Fayed and Otten 2013).

This study helps those who involved in textile industry to know the effect of dust on the different types of fabrics and enables them to produce antidust fabrics.

1.3 Objectives:

To achieve the objectives of this study we have to study and investigate the followings:-

- The effect of the dust on the fabrics.
- Fabrics resistance to dust.
- The different types of dust.
- Resistibility variation of different types of fabrics to dust.
- Fabrics that have the highest resistibility to dust.
- Effects of fibers, design and blends on the absorption of fabrics to dust.

1.3.1 Over all objectives:

The main objective to produce anti dust fabrics of this study is to help people know the effect of dust on the fabrics and to produce antidust fabrics.

1.3.2 Specific objectives:

Make a solid contribution to the textile industry in Sudan.

Study different types of dust particles and their magnitude and durations. Also to carry laboratory tests for different types of fabrics.

As well to study the relationship between the fabric designs and the tensile strength, elongation and air permeability. Morever to study the effect of designs accounts of yarn used on weight, thickness and water absorption.

All of these tests would be performed before and after treatment by chemical materials.

The methodology used in this research includes isolating all variables and carrying out laboratory investigations to determine the effects of dust on the studied fabrics.

Chapter (2)

Literature Review

Chapter (2)

2 Literature Review

A dust-proof fabric having an excellent dust-collecting efficiency and dust preventing property including a plurality of filament yarns having a thickness of 20 to 400 denier and consisting of plurality of individual filaments having a denier of 3.5 or less. The fabric has a number of a pores formed therein and exhibits an air permeability of 0.3 to 10 $cm^3/cm^2/sec$. In the fabric, the proportion of the integrated volume of pores having a size of 43 pm or more to the entire integrated volume of all the pores in the fabric is 40% or less.(Tadashi&Tsumoto 1986).

Articles of clothing for use in a clean room environment are provided. A cut-out with an attached fastener such as a zipper is formed in the donning-and-removing opening of the main body of the clothing and a gore made of an anti-dust fabric is attached to the inside of the cut-out.(Chikamori et all 1998).

A cleated dust control mat having a plurality of rows of elliptical cleats located at an angle to the border of the mat with the cleats in each row being parallel to the other cleats in the row and being substantially perpendicular to the cleats in the next adjacent rows of cleats. A second set of small circular cleats is located between the elliptical cleats in each row equally spaced from adjacent elliptical cleats in each row.(Murray&Kerr 1993).

Several types of fabrics were laboratory-tested for their effectiveness in worker protection to pesticide-laden dust encountered in the agricultural environment. Of the applied <100 mesh dust, penetrations through knitted jersey and woven fabrics were greater than 87% and less than 5.8%, respectively. Treatment of woven fabrics with fluorocarbon polymers curtailed penetration by greater than 60%. Nonwoven fabrics allowed less than 0.5% dust penetration. Parathion mixed with 100-mesh sieved dust resulted in increasing “ppm”; levels with decreasing particle size; extent of parathion conversion to paraoxon was independent of particle size for the sandy loam dust used. (Kawar et all 2008).

2.1 Purpose of Clothing:

Clothing is used to cover the body, to make you feel more attractive and to communicate with others. People wear clothes for many different reasons. Some of these reasons are physical. You wear clothes for comfort and protection. Others are for psychological and social reasons. Clothes give you self-confidence and express your personality. Clothes also help you identify with other people. (Purposes and Importance of clothing 2015).

All people have basic human needs. Meeting these needs provides satisfaction and enjoyment in life. Clothing helps to meet some of these needs. Knowing something about the role of clothing helps you to understand yourself and others better. Clothing is a complex but fascinating part of everyone’s life. Therefore clothes are worn for many reasons as follows:

2.1.1 Protection:

Our skin is uncovered and exposed. We can be easily affected by the elements, rain, snow, wind, cold, and heat. We can be harmed or injured on the job or while practising in sports. In some cases, we need to protect ourself with our clothes. It absorbs perspiration, prevents sudden chills, and acts as a buffer between your body and accidental burns, scratches, and rough surfaces. The right garments can insulate your body against extremely hot or extremely cold temperatures.

People who live in severely cold climates, such as the Eskimos, keep warm by wearing pants and parkas with fur linings. The fur traps the warm air around their bodies and creates a life-saving insulating layer of warmth. Desert nomads keep the harmful hot sun from dehydrating their bodies by covering their bodies with long flowing robes and headdresses. Their clothing actually keeps them cooler.

2.1.2 Safety:

Clothing also serves to protect your skin from harm or injury. Some sports and occupations require protective clothing for safety reasons. Football players wear helmets and protective padding to help prevent injury during rough play. Some peoples work requires them to be in such dangerous or hazardous conditions. Clothing can offer protection. Some items are even labelled with the term “safety” to identify them from regular day-to-day clothes and accessories.

Fire-fighters wear asbestos clothing in hazardous situations. Police officers wear bulletproof vests. Road workers wear florescent orange vests so that drivers can see them easily and prevent accidents.

2.1.3 Sanitation:

Special clothing and accessories are often worn for sanitation reasons. People who work in factories that produce food and medical products wear sanitary clothing, face masks and hair covering. This precaution prevents contamination of the products by germs. In operating rooms, doctors and nurses wear special disposable sanitary uniforms, gloves and face masks.

2.1.4 Modesty:

Modesty refers to the proper way for clothing to cover the body. Different groups of people may have different standards of modesty. For example clothes that a woman might wear to a fancy party would probably be unacceptable at work.

2.1.5 Identification:

Clothing can also identify people as members of a group. Certain types of clothing, colors, and accessories have become representative of certain groups, activities, and occupations. Or by simply dressing alike, people can show that they belong to the same group. e.g. Air Crews, Air hostess, Doctors, Pilots, etc.

2.1.6 Uniforms**:**

A uniform is one of the easiest ways to identify group members. Uniforms can provide instant recognition or create a special image for the group.

Members of the police force, fire department, and military wear uniforms so that they can be recognized quickly and easily for public safety. Athletic teams wear different colors to identify their team and to tell them apart from their opponents.

People who work in service occupations, such as restaurant workers, airline personnel, and hotel staff also wear special uniform. These uniforms help to identify the worker to their customers, as well as create an image for the company.

2.1.7 Styles and Colors**:**

Some occupations require a unique style of dress. Judges wear the traditional black robe. Ministers, priests, and other clergy members may wear special clothing for conducting religious services. The style of the clothing often dates back many centuries to show visually that what they are doing is linked to the past. Many people wear special styles and colors of clothing for special occasions in their lives. Graduates may wear ling robes and mortarboard hats with tassels.

2.1.8 Insignias**:**

Insignias are badges or emblems that show membership in a group. Patches or emblems can be worn on jackets or blazer pockets. A school letter with a sports pin can be worn on a jacket or sweater to indicate participation in athletics.

2.1.9 Status**:**

Kings and queens wear crowns to set them apart from the rest of their subjects. Their crowns indicate their status, or position or rank within a group. Clothes and other accessories are used by people to show their level of importance. They may also be used to give the wearer a sense of feeling important. Status symbols are clothes or other items that offer a sense of status for the ordinary person. Usually these items are more expensive or the latest in design. For some people, status symbols can be fur coats, expensive jewelry, or designer clothes.

2.1.10 Decoration**:**

People decorate themselves to enhance their appearance. They wear clothes, jewelry, and cosmetics in hopes of improving their looks and attracting favorable attention. Adornment, or decoration, also helps people to express their uniqueness and creativity. Clothing and accessories can be used to improve appearance in different ways. Clothing can also be decorated to make it special and unique.

2.2 Textile

The word textile is derived from the Latin term “texture” for woven fabrics. Thus by textiles we understand those objects which have been prepared by weaving. Textile has an important bearing on our daily lives and everyone needs to know about textiles as we use them in some way or the other. To understand about textiles the study of textiles will help to a great extent when we buy textile materials this knowledge will prevent us from making mistakes and we will be able to purchase good quality materials.(Cta assignment)

There is a growing demand for textiles and clothing by people of all walks of life.

Yarns are produced by twisting or spinning of the textile fibres and in turn fabric is a structure produced by interlacing or interloping of the yarns.

There are certain terms which are used very often in the study of textiles that are to be understood first. Most of the fabrics we use for various purposes are woven, that means they are constructed, by interlacing sets of yarns that run along lengthwise and crosswise directions. Each yarn is made up of several fibres therefore it is essential to know or to define the terms like fibre, yarns and fabrics.

2.2.1 Definition of Fibers:

A "fibre "is defined as any product capable of being spun or otherwise made into fabric. It is smallest visible unit of textile product.

Fiber can be defined as a "pliable" hair like strand that is very small in diameter in relation to its length". Fibres are the fundamental units or the building blocks used in the making of textile yarns and fabrics.

2.2.2 Definition of Yarns:

Fabrics made out of different fibres are available in the market. The common fibres that are used for fabrics are obtained from different sources. There are few fibres which are naturally available. Still some fibres are synthesized by using chemicals and are known as synthetic fibres eg. Nylon, polyester and acrylic fibres.

Some fibres are manufactured by using raw material from nature and they are termed as man made fibres. Eg: Rayon, Polynosic, azlon etc.

2.3 Classification of Textile Fibres

Let us see how fibres are classified according to the source from which textile fibres are obtained. Fibres are broadly classified into two groups.

2.3.1 Natural

2.3.1.1 Vegetable Fibers or Cellulosic Fibres

The fibers that are derived from plants are called vegetable fibres. The basic material of all plant life is cellulose. Cellulose is made up of elements like carbon, hydrogen and oxygen. These cellulose fibres have certain common properties like low resilience, high density, and good conductor of heat. They are highly absorbent and are resistant to high temperature. Cotton flax, jute, ramie are some of the examples of vegetable fibres.

2.3.1.2 Animal Fibres

The fibres which are obtained from animals are called animal fibres. Wool and silk are common examples of animal fibres. They are made up of protein molecules. The basic elements in the protein molecules are carbon, hydrogen, oxygen and nitrogen. Animal fibres have high resiliency but weak when wet because they are bad conductors of heat.

2.3.1.3 Mineral Fibres

They are the inorganic materials shaped in to fibres and are mainly used in the fire proof fabrics. Asbestos is the example of mineral fibre. Mineral fibres are fire proof, resistant to acids and are used for industrial purposes.

2.3.2 Man Made Fibres

These refer to those fibres that are not naturally present in nature and are made artificially by man. Man made fibres have high strength, and low moisture absorption characteristics. Examples of man made fibres are viscose rayon, acetate rayon, nylon, polyester etc. Depending on raw material chosen for making of the fibres they are classified as cellulosic fibres, protein fibres and synthetic fibres.

2.4 Cotton Crop:

Cotton is obtained from the seeds, the staple fibre measuring (10-65mm) in length and white to beige in color in its natural state. It is composed basically of a substance called cellulose. As cotton occupies 50% of the consumption of fibres by weight in the world it is called the king of all fibres. Cotton is the fabric for every home and is the most widely produced fabrics today.(Dantyagi 2006)

All varieties of cotton (botanical name ″Gossypium″) grew originally in the desert zones of both the old and the new world. The cotton fibre was used probably at the end of the Stone Age in both hemispheres to manufacture strings and maybe also fishing nets.(Tripthi&Ranjini2011).

The word ″cotton″ comes from the Arabic ″Katun″ which means plant of the conquered lands, with reference to the invasion of India by Alexander the Great in 327 BC.(Posselt).

Several cotton fabrics still today bear the names of Asiatic and European towns, as well as of sea harbours situated along the cotton sea routes to Europe. Thus the term ″satin″ originates from the Arab name of the Chinese town Tseutung (Canton, today). The very popular ″denim″ originates from the French town Nîmes. The name ″poplin″ originates from the papal city of Avignon and the name ″lisle″ from the French town Lille. The cotton plant, as it originates from the desert, needs much sunlight and a warm climate; consequently it cannot be grown in Western Europe except in Greece and Spain.

Cotton is now our chief vegetable fiber, the yearly crop being over six billion pounds, of which the United States raises three-fourths. Texas is the largest producer, followed by Georgia, Alabama and Mississippi. The remainder of the world supply comes chiefly from India, Egypt, Russia, and Brazil. The Hindoos were the first ancient people to make extensive use of the cotton fiber. Not until the invention of the cotton gin by Eli Whitney in 1794 when the cotton began to reach its present importance. Only four or five pounds of the fiber could be separated by hand from the seed by a week's labor. The modern saw gins turn out over five thousand pounds daily.(Waston 1907).

Cotton accounts for half of the world’s consumption of fibres and is likely to remain so owing to many of its innate properties and for economical reasons that will not be discussed here. Cotton is made of long chains of natural cellulose containing carbon, hydrogen and oxygen otherwise known as polysaccharides. The length of the chains determines the ultimate strength of the fibre. An average of 10000 cellulosic repeat or monomeric units makes up the cellulose chains which are about 2mm in length. The linear molecules combine into microfibrils and are held together by strong intermolecular forces to form the cotton fibre. The unique physical and aesthetic properties of the fibre, combined with its natural generation and biodegradability, are reasons for its universal appeal and popularity. Chemical treatments such as Proban and Pyrovatex are two examples of the type of durable finishes that can be applied to make cotton fire retardant. High moisture absorbency, high wet modulus and good handle are some of the important properties of cotton fibre.(eds Horrocks & Anand 2000).

2.4.1 Physical Properties

2.4.1.1 Structure:

The cotton fibre is essentially cellulose consisting of carbon, hydrogen and oxygen. Bleached cotton is almost pure cellulose; the raw cotton contains about 5% of impurities.

2.4.1.2 Strength:

Cotton fibre is relatively strong due to the intricate structure and 70% crystalline.

2.4.1.3 Elasticity:

Cotton is relatively inelastic because of its crystalline polymer system and for this reason cotton textile wrinkles and creases readily.

2.4.1.4 Hygroscopic Moisture:

Cotton does not hold moisture well as wool or silk but absorbs it and so feels damp much more quickly. It also rapidly spreads throughout the material.

2.4.1.5 Electrical Property:

The hygroscopic nature ordinarily prevents cotton textile materials from developing static electricity.

2.4.1.6 Absorbency:

As cotton has cellulose it is a good absorbent fibre.

2.4.2 Thermal Properties:

Cotton fibres have the ability to conduct heat, minimizing any destructive heat accumulation thus they can withstand hot ironing temperature.

2.4.2.1 Drapability:

Cotton does not have good body to drape well in shape. The type of construction of the fabric may improve this property.

2.4.2.2 Resilience:

Cotton wrinkles easily some wrinkle resistant finishes may reduce this property.

2.4.2.3 Cleanliness and Washability:

Cotton absorbs dust due to its rough nature. It can be washed easily in the hot water and strong soaps without damaging the fibre.

2.4.2.4 Luster:

The natural cotton has no pronounced lustre. This can be improved by the mercerization finish of the cotton (sodium hydroxide treatment).

2.4.2.5 Shrinkage:

The fibre itself does not shrink but cotton fibre which has been stretched in the finishing process tends to relax back creating shrinkage.

2.4.2.6 Heat Conductivity:

Cotton is the better conductor of heat than wool or silk but not as good as rayon.

2.4.3 Chemical Properties

2.4.3.1 Action of Acids and Alkalies

Strong acids will destroy the fibres immediately. Dilute inorganic acids will weaken the fibre and if left dry will rot it. Therefore after treatment with acidic solutions cotton articles should be thoroughly rinsed in water. They are affected very little by organic acids. They are also quite resistant to alkalis even to strong caustic alkalies at high temperature and pressure.

In 8% NaOH cotton fibre swells and become thicker. The resultant fibre is smoother, lustrous and stronger.

2.4.3.2 Effect of Bleaching:

These have no effects unless used in an uncontrolled conditions and heat.

2.4.3.3 Effect of Sunlight and Weather:

Ultraviolet rays of sunlight affect the strength of fibre and change the colour to yellow when exposed to prolonged periods. Pollution also effect fibre. Concentrated and diluted mineral acids like sulphuric acids will discolour fibre.

2.4.3.4 Affinity to Dyes:

Cotton takes in dyes better than linen but not as readily as silk and wool. If a mordant is used cotton is easy enough to dye mordant colours, director substantive dyes should be applied to the cotton.

2.4.3.5 Effect of Perspiration:

Both acidic and alkaline perspiration discolours the fibre.

2.4.4 Biological Properties

2.4.4.1 Resistance to Micro Organisms:

The mildew and bacteria damage cotton.

2.4.4.2 Resistance to Insects:

Moths and beetles will not affect or damage the cotton. But the sliver fish eats the cotton cellulose.

2.4.5 Consumer Demand for Cotton

2.4.5.1 Versatality:

Cotton can serve for food (cotton seed products), for clothing and for shelter. Cotton fibre can be spun alone or it can be blended with other textile fibres such as linen, wool, silk, viscose rayon, polyester and nylon. It serves the purpose of clothing, apparel, home furnishing and industrial fabrics. Cotton is famous for giving comfort, durability, fashion and ease for care.

2.4.5.2 Durability:

Due to natural twist, cotton spins so well that it can be twisted very tightly. Hence tightly twisted yarns produce durable fabrics.

2.4.5.3 Comfort:

Cotton conducts heat away from the body and allows the cooler temperature outside to reach the body, so it is a cool material for summer or tropical wear. Knitted cotton is used as comfortable wear.

2.4.5.4 Fashion Rightness:

Fashion designers of various countries have considered cotton glamorous enough to include in their collections.

2.4.5.5 Ease of care:

The factors of light, laundering, ironing and perspiration are common consideration in color fastness to cotton.

2.4.5.6 Economy or Price:

Cotton materials are flexible to fit into all types of economic groups. By products of cotton are used for many purposes.

2.4.6 Major end Uses

2.4.6.1 Cotton is used for Home Furnishing:

Towels are most common as it is high in absorbency, wide range of colors, washability and durability. Sheets and pillow cases are mostly a blend of cotton with polyester or made of pure cotton. Drapes, curtains and upholstery fabrics are made of cotton and its blends.

Since cotton can be autoclaved at high temperatures, absorbency, washability and low static build up are important factors for use of cotton in hospitals.

Industrial uses include book bindings, luggage’s, hand bags, shoes, slippers, tobacco cloth, woven wiping cloths and wall covering fabrics.

2.4.6.2 Wide Range of Wearing Apparels:

Blouses, shirts, dresses, children wear, active wear, separates swimwear, suits, jackets, skirts, pants, sweaters, hosiery, bedspreads, comforters, throws, sheets, towels, table cloths, tablemats and napkins are the main apparel products.

2.5 Polyester:

Synthetic fibres are also produced from an organic substance, namely crude oil. Crude oil originates from the transformation of huge quantities of marine organisms.(Industrie Vereeniging Chemiefaser e.V.)

Polyester is a synthetic fiber invented in 1941. The first polyester fiber is known as ‘Dacron’ in America and ‘Terylene’ in Britain. Later various types of polyesters are produced. Terylene fiber is made by synthesizing terephthalic acid and ethylene glycol.(Hess 1954).

The ground work for development of polyester fiber is done by W.H. Carothers. Polyester fiber is the long chain polymer produced from elements derived from coal, air, water and petroleum.(Kan 2015). Polyester is a thermoplastic fiber and has good strength. It melts in flame and forms a grey hard non-crushable bead. It is an easy care fabric and can be easily washed.

Polyester fiber looks smooth. The length, width, shape and luster of the polyester fibers are controlled during manufacture to suit a specific end use. It is mostly blended with other fibers to improve its absorbency and to lower static electricity.

Polyester fibres result from the poly-condensation process. When spinning, the melt spinning process is employed .A manufactured polyester fiber is composed of at least 85% by weight of an ester of a substituted aromatic carboxylic acid, including but not restricted to substituted terephthalate units.(Federal Trade Comission2002).

Polyester is the most common synthetic fibre and is marked by a high growth rate. At present polyester production (filament yarn + staple) accounts for 60% of the total production of synthetic fibres.

Polyester was produced on ethylene glycol (EG) and dimethyl terephtalate (DMT) basis; later also a second method based on terephtalic acid (TPA) was used. Also the discovery of polyester marked a new milestone in the industrial revolution, because this fibre has deeply changed the textile industry, imposing itself for its great versatility. Either pure or in blend with cotton and wool, it gave rise to new types of clothing and furnishing fabrics with interesting easy-care properties.(Edwards, Diller &Goheen 2006).

A further advantage was provided by the development of inherently flame-resistant polyester types, which allowed its wide application in products where fire resistance is a must. These special fibres, which resist or slow down flame propagation, retain an agreeable textile handle.

Polyester has excellent properties of dimensional stability, high tenacity, good resistance to light and weathering. Beside having increasing success in woollen, worsted and cotton type apparel fabrics, polyester fabrics find wide application in household textiles and in nonwovens.

(Technical high-schools 2000).

Since 1950 on wards, the huge growth in world production of polyester, initially for apparel and household textile applications, provided the incentive and economies of scale needed to develop and engineer this fibre as a lower cost alternative to both viscose and polyamide in an increasing range of technical applications.

Nowhere is this true that Japan and the developing industrial economies of Asia, including China, that their production capacities for both polyester staple and filament yarns are extremely high and there is an urgent search for new applications. Some high volume applications for technical textiles which would typically use polyolefins in Western Europe and North America such as geotextiles, carpet backing and cover stock are more likely to use polyester in Asia largely because of the greater availability and better economics of fibre supplies in those regions.

Polyethylene terephthalate (PET) polymer is produced from ethylene glycol and either dimethyl terephthalate (DMT) or terephthalic acid (TPA). Polyester filament yarn and staple are manufactured either by direct melt spinning of molten PET from the polymerization equipment or by spinning reheated polymer chips. Polyester fiber spinning is done almost exclusively with extruders, which feed the molten polymer under pressure through the spinnerets. Filament solidification is induced by blowing the filaments with cold air at the top of the spin cell. The filaments are then led down the spin cell through a fiber finishing application, from which they are gathered into tow, hauled off, and coiled into spinning cans. The post-spinning processes usually take up more time and space and may be located far from the spinning machines. Depending on the desired product, post-spinning operations vary but may include lubrication, drawing, crimping, heat setting, and stapling.(trans. Lindley 1997).

At a slightly less obvious level, there are differences in the polyamide supply situation. Western Europe and North America are more strongly oriented towards nylon 66. While Asia and Eastern Europe produce predominantly nylon 6.

2.5.1 Method of Manufacture

Generally each company produces its own variety of polyester through modifications under specific trademarks. The Principle raw material is ethylene diamine. The terepthalic acid is obtained from petroleum.

2.5.2 Physical Properties

2.5.2.1 Shape and Appearance:

These fibers are generally round and uniform. The fiber is partially transparent and white to slightly off -white in colour.

2.5.2.2 Strength:

The PET polyesters are in general, stronger. Polyester is found in industrial uses and the highly durable fabrics.

2.5.2.3 Elasticity:

Polyester fibers do not have high degree of elasticity. In general polyester fiber is characterized as having a high degree of stretch resistance, which means that polyester fabrics are not likely to stretch out of shape too easily.

2.5.2.4 Resilience:

Polyester fibers have high degree of resilience. Not only does a polyester fabric resist wrinkling when dry, it also resists wrinkling when wet.

2.5.2.5 Drapability:

Fabrics of polyester filament have satisfactory draping quality. Polyester spun yarn is flexible and softer, thereby draping quality is improved.

2.5.2.6 Heat Conductivity:

Fabrics of polyester filament are good conductors of heat. Polyester staple filament does not provide greater insulation in the yarns and fabrics. One of the reasons for apparel greater warmth of polyester is its low absorbency.

2.5.2.7 Absorbency:

Polyester is one of the least absorbent fibers. This low absorbency has important advantages, because they will dry very fast, suitable for water repellent purposes, such as rain wear and they do not stain easily.

2.5.2.8 Dimensional Stability:

If the polyester is properly heat set, it will not shrink, nor stretch when subjected to boiling water, cleaning solvents or ironing temperatures that are lower than heat setting temperatures.

2.5.2.9 Shrinkage:

Polyester fabrics shrink as much as 20 %during wet-finishing operations and they are generally heat set in later treatments. They have excellent dimensional stability.

2.5.2.10 Cleanliness and Washability:

Since polyester fibers are generally smooth, has low absorbency, many stains lie on surface, and are easily washed, by hand or machine but oil stains are very hard to remove.

2.5.3 Chemical Properties

2.5.3.1 Reaction to Alkalies:

At room temperature, polyesters has good resistance to weak alkalies and fair resistance to strong alkali. Its resistance reduces with increase in temperature and alkalies concentration.

2.5.3.2 Reaction to Acids :

Depending upon type, polyester has good resistance to mineral and organic acids. Highly concentrated solutions at high temperatures cause degradation.

2.5.3.3 Effects of Bleaches:

Fabrics of polyester may be safely bleached, because polyesters have good resistance to deterioration to household bleaches. If the polyester have optical brightener, bleaching is not necessary.

2.5.3.4 Effect of Heat:

Ironing should be done at low temperatures. It gets sticky at 4400 F.

2.5.3.5 Effect of Light:

Polyester has good resistance to degradation by sunlight. Over prolonged use, gradual deterioration of fiber occurs.

2.5.3.6 Affinity for Dyes:

Polyesters are dyed with appropriate disperse, developed dyes at high temperatures producing a good range of shades and color fastness.

2.5.3.7 Resistance to Perspiration:

Polyesters has no loss of strength due continues contacts with either acid or alkaline perspiration.

2.5.3.8 Polyester Blends:

Polyester/ cotton blend, polyester /wool blend, polyester /rayon, blend and polyester/ silk blend are some common blends.

2.5.4 Uses of Polyester

The most important uses of the polyester are in “woven fabrics”. The blended fabrics are attractive, durable, comfortable and easy care. The first use of staple polyester was in tropical suiting for men’s summer suits. The suits were light in weight and machine washable.

Polyester and polyester blends are also used in home-furnishings, sheets, blankets bed spreads, curtains that match bed spreads, mattress ticking and table clothes. They are also used in upholstery fabrics. Polyester carpets have a softer hand than nylon carpets. Spun yarn is used in knitted fabrics.

It has many industrial uses as in pile fabrics, tents, ropes, cording, fishing line, cover stock for disposable diapers, garden hoses, sails, seat belts, filter fabrics and fertilizer bags. In the medical field it is used for artificial arteries, veins and hearts.

Consumers are mostly aware of the fiber content with fibres and their blends.

2.6 Weaving

Woven fabrics generally consist of two sets of yarns that are interlaced and lie at right angles to each other. The threads that run along the length of the fabric are known as warp ends whilst the threads that run from selvedge to selvedge, from one side to the other side of the fabric, are weft picks. Frequently they are simply referred to as ends and picks. In triaxial and in three-dimensional fabrics yarns are arranged differently.(eds. Horrocks &. Anand 2000)

Fabrics are produced mostly from yarns. Few fabrics are directly produced from fibers. In Indian market 70% of the fabrics are produced by weaving. Among the other fabrics there is a nonwoven fabric and lace making that worth mentioning along with needle punched and tufted fabrics. Felts are fabrics made directly from fibers without making yarns where their uses are mostly emerging now a day.

The fabric construction process determines the appearance, the texture, the performance during use, care and cost. The process often determines the name of the fabric, felt lace, double knitt and jersey. The cost of fabrics in relation to the construction process depends upon the number of steps involved and the speed of process. The fewer the steps the faster the process and the cheaper is the fabric.

For a fabric to have strength and compactness combined with a fair degree of elasticity, the warp and filling threads must be interlaced. This interlacing is called weaving and it is done on a loom.

An interlacing where the filling threads are passed alternatively over and under the warp threads is called a plain weave. It is the simplest of all weaves.

If the fillings threads are passed one over and 2 under or more warp threads will result in twill fabrics. The surface of such fabric has pattern of parallel diagonal ridges.

The number of weave structures that can be produced is practically unlimited. In this section basic structures, from which all other weave structures are developed, are discussed. They briefly referred to be lenos, because of their importance in selvedge constructions and triaxial fabrics, because they show simple structural changes which can affect the physical properties of fabrics.

2.6.1 Weaves:

Weaves are named according to the system or design followed in interlacing warp and weft yarns. The basic weaves used in fabric construction are, Plain weave, Twill weave and Satin weave. These are the basic weaves and form the basis of all other types of weaves.(Acetate 2001)

2.6.1.1 Plain weave**:**

Plain weave is the simplest of all the weaves. About seventy percent of the woven fabrics available in the market today are woven in plain weave or its variations.

Most two-dimensional woven technical fabrics are constructed from simple weaves and of these at least 90% of them use plain weave. (ed.Dubrovski 2010)

2.6.1.2 Construction of A plain Weave:

The plain weave is the most common, nearly all light weight goods are plain woven. In plain weaving, each thread of both warp and filling passes alternately over and under the threads at right angles.

Plain weave is the simplest interlacing pattern which can be produced. It is formed by alternatively lifting and lowering one warp thread across one weft thread.

The diagrams are idealized because yarns are seldom perfectly regular and the pressure between the ends and picks tends to distort the shape of the yarn cross sections unless the fabrics are woven from monofilament yarns or strips of film. The yarns also do not lie straight in the fabric because the warp and weft have to bend round each other when they are interlaced. Plain weave fabrics have no right or wrong sides. Plain weave provides a wide scope for introducing variations in the fabrics by use of yarns of different colours, different textured yarns and also by use of thick and thin yarns. Fabrics can be produced in large variety, with different degrees of yarn twist and with different degrees of tensions in the loom. Fabrics made by tightly twisted warp and loosely twisted weft make it easy for a napping finish to be given to it.

Plain weave is made interesting by printing and embossing. Plain weaving also allows the use of many different finishing processes to produce varieties and different styles of fabrics.

Plain weave is used in the construction of the fabrics from almost all the textile yarns. It is the most serviceable of all fabrics. This plain weave is easy to wash, dry clean and wear well and also is comparatively inexpensive.

2.6.2 Twills Weave:

After the plain weave the twill is the most common, being much used for dress goods, sittings, etc. In this weave the intersections of the threads produce characteristic lines diagonally across the fabric; most often at an angle of 45°.The twill may be hardly visible or very pronounced. The simplest twills are the so-called "doeskin" and "prunella." In the doeskin the filling threads pass over one and under two of the warp threads and in the prunella twill over two and under one. The most common twill is the cassimere twill in which both the warp and filling run over two and under two of the threads at right angles.

Twill made by running both warp and filling under one and over three threads is called a swans down twill and the reverse is known as the crow weave. In these the diagonal twilled effect is much more marked. Various twills are often combined with each other and with plain weave, making a great variety of texture. Numerous uneven twills are made, two over and three under, etc.

Twill is a weave that repeats on three or more ends and picks and produces diagonal lines on the face of a fabric. Such lines generally run from selvedge to selvedge.

The direction of the diagonal lines on the surface of the cloth is generally described as a fabric along the warp direction. When the diagonal lines are running upwards to the right they are ‘Z twill’ or ‘twill right’ and when they run in the opposite direction they are ‘S twill’ or ‘twill left’. Their angle and definition can be varied by changing the thread spacing and/or the linear density of the warp and weft yarns. For any construction twills will have longer floats, fewer intersections and a more open construction than a plain weave fabric with the same cloth particulars.

Twill weave produces strong material because of the tightly yarns which are used to bring out the diagonal effect and the compactness of its construction. Twill weave fabrics are mostly expensive because of their elaborate construction, but they are strong, stand hard and long wear. This weave is generally used in wool and cotton fabrics where durability is a prime necessity. Twill weave fabrics do not show dirt or dust as much as the fabric woven in plain weaves do and are therefore more suitable for dresses, men's shirts and suits and children garments.

2.6.3 Satins and Sateens Weave:

In Britain a satin is a warp-faced weave in which the interlacing points are arranged to produce a smooth fabric surface free from twill lines. Satins normally have a much greater number of ends than picks per centimeter. To avoid confusion a satin is frequently described as a 'warp satin'. A sateen, frequently referred to as a 'weft sateen', is a weft-faced weave similar to a satin with binding places arranged to produce a smooth fabric free of twill lines. Sateens are generally woven with a much higher number of picks than ends. Satins tend to be more popular than sateens because it is cheaper to weave a cloth with a lower number of picks than ends. Warp satins may be woven upside down, that is as a sateen but with a satin construction, to reduce the tension on the harness mechanism that has to lift the warp ends.(Wilson 2001)

In the sateen weave, nearly all of either the warp or the filling threads are on the surface, the object being to produce a smooth surface fabric like sateen. With this weave it is possible to use a cotton warp and silk filling, having most of the silk appear on the surface of the fabric.

To avoid twill lines, satins and sateens have to be constructed in a systematic manner. To construct a regular satin or sateen weave without a twill effect a number of rules have to be observed. The distribution of interlacing must be as random as possible and there has only to be one interlacing of each warp and weft thread per repeat, which is per weave number. The intersections must be arranged in an orderly manner, uniformly separated from each other and never adjacent.

Chapter (3)

Materials and Methods

Chapter (3)

3 Materials and Methods

The three types of investigations reported in this research are:

1. Using three certain different textile materials in three basic weaves.
2. Treatment of textile materials by chemical material.
3. Determining weight, thickness, tensile strength, elongation, air permeability, force of the blast and degree of absorption of water, before and after treatment of all fabrics produced.
4. Determining the relationship between fabric dust collection efficiency and fabric weight and air permeability before and after treatment.

3.1 Fabric Specifications and Materials:

3.1.1 Fabric Material:

Three different materials were employed in this research which are:

1. Cotton 100% (25Tex_2)
2. Polyester 100%% (25Tex_2)
3. Cotton50%+polyester 50% (25Tex_2)

3.1.2 Fabric specifications:

1. Plain weave1\1.
2. Twill weave 2\2.
3. Satin weave 4.

Three weft yarn counts were used (25Tex_2), while the warp yarn count was remained as well the same in all weave structures (15/2Tex_1).

All fabrics have the same number of ends. In weft direction, each fabric has its own capacity of picks according to the weft count used and weave structure.

Table 3.1Specifications of samples

Fabric material	100%Cotton		
Weave	Plain	Twill2/2	Satin 4
Warp count(Tex_1)	15/2	15/2	15/2
Ends\cm	36	36	36
Weft count(Tex_2)	25	25	25
Picks\cm	21	21	21
Fabric material	**100%Polyester**		
Weave	Plain	Twill2/2	Satin 4
Warp count(Tex_1)	15/2	15/2	15/2
Ends\cm	36	36	36
Weft count(Tex_2)	25	25	25
Picks\cm	21	21	21
Fabric material	**50%Cotton &50% polyester**		
Weave	Plain	Twill2/2	Sateen 4
Warp count(Tex_1)	15/2	15/2	15/2
Ends\cm	36	36	36
Weft count(Tex_2)	25	25	25
Picks\cm	21	21	21

3.2 Methodology:

3.2.1 Washing the sample:

Samples are washed in an automatic washing machine brand Arston Italian. Adding 2 grams/ liter of non ionic detection and 2 grams of sodium carbonate at 60 ° C for 40 minutes and then repeating rinsing (four times) and then drying at 90 ° C and then treating the samples chemically.

Figure 3.1Washing machine

3.2.2 Chemical Treatment:

Emulsion copolymer of perflouro –heptyl acrylate-co-methylol acrylamide .

$$\left(\begin{matrix} CH_2 - CH \\ CO - OCH_2(CF_2)_6F \end{matrix} \quad \overline{\qquad\qquad} \quad \begin{matrix} CH_2 - CH \\ CO - NHCH_2OH \end{matrix}\right)_n$$

Perfluoroheptyl methacrylate (PFHMA) and glycidyl methacrylate (GMA) (emulsion) individually as well as in binary mixtures was investigated under different conditions. Results obtained indicated that:-

(a) The chemical prepare by 600 ml of emulsion was added with distilled water of 600 ml, in addition to an anti-wrinkle material of 100 ml (dihydroxy diethylene urea) with the addition of catalyst material of 3 g (NH_4Cl).

(b) The fabrics pieces were submerged in the chemical and then it was squeezed by padder device to dispose of the chemical.

(c) The fabrics pieces were drying in theromfixation device at 140°C at duration time 1 minute.

Figure 3.2Padder Machine

Figure 3.3Thermofixation Machine

3.2.3 Test Conditions:

All testes were carried out at the standard conditions for testing textiles, where temperature and relative humidity were maintained at 20°c±2°c and 65±2%, respectively.

Test specimens were left for 24 hours before testing in the laboratory atmosphere.

3.2.4 Experimental Work:

The experimental work was carried out at the Textile laboratory,
National Research Centre, Cairo.

3.2.4.1 Determination of Fabric Weight per Unit Area:

Can be expressed as the weight of the cloth to one of the two methods, namely the weight per unit area or weight per unit length, and in all cases, you must specify the method of estimation and the unit weight and the unit of measurement used.

There are a range of factors that affect the process of assessing the weight and that must be taken into account such as the accuracy in determining the sample size and accuracy of the sample cut and in the process of weight. The percentage of moisture in the fabric is one of the direct impact on the accuracy of the results of estimating the cloth weight factors.

The method of obtaining this value was achieved by using SHIMADZU digital scale with a precision of up to 0.01g .Samples were cut from the fabric.

The samples were cut with circular samples cutter, which gives an area of 100cm^2 for each sample.

The scale digital reading gives directly the fabric weight per 1m^2 .The average weight was determined of five samples cut from different places of the fabric not including selvedges. This method was performed according to the standard ASTM 3776-85 (1990).

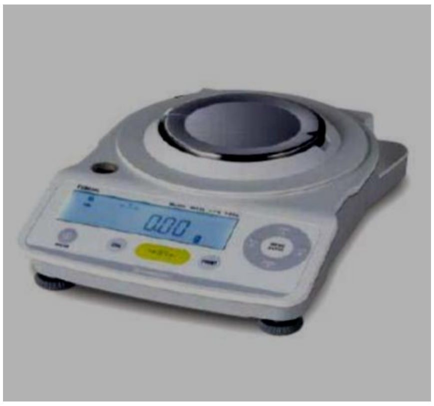


Figure 3.4Weight Instrument

3.2.4.2 Determination of Tensile Strength and Elongation:

To determine the tensile strength and elongation lengthwise and width wise of the fabric, a tensile testing machine was used according to BS NO.2576 (1986).

During cutting 7 samples some factors must be taken into account. The Sample cut from the original dress must be one meter long and at least 3 meters away from both sides of the dress. Any area of the damage or obvious flaws or wrinkle must be excluded. Selvedges which differ little in their properties as much as for the central region because of increased tension as well as the impact of temples must be avoided. Random samples must be taken so that not to include the same warp yarns or groups of the same weft yarns.

The strip test

The actual area of the test sample of 5 cm × 20 cm and leaving extra length on both sides of the sample to be installed between the jaws. Samples are processed in a manner, where the sample is cut parallel to the threads inside textile design. An increase of 1 cm in the sample is required, half a centimetre from each side, to attain the required sample width of 5 cm.

The sample must be parallel and uniform.

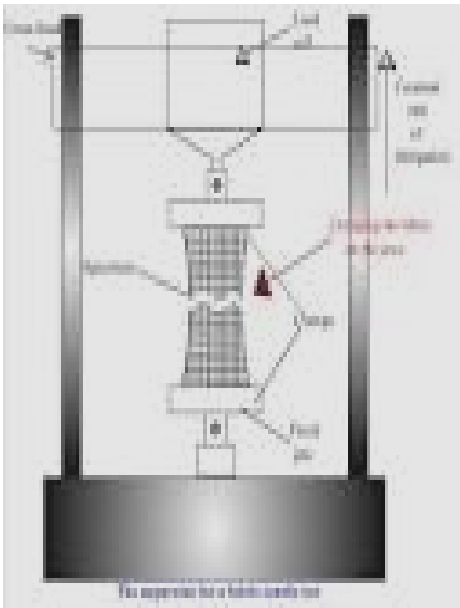


Figure 3.5Tensile Strength and Elongation Instrument

3.2.4.3 Determination of Fabric Thickness

TECLOCK digital thickness gauge for measuring the thickness of the fabric is used.

The instrument is shown in figure (2.7) and the test was carried out according to ASTM D.1777-64 (1975).

Thickness test for Textiles differs for thickness tests for other materials. The fabrics are considered compressible materials, so they need a special test to determine the thickness. The basis of the thickness tested textiles depends on accurate measurement of the distance between two parallel surfaces, separated by a slice of cloth. A known pressure between the two surfaces is applied. One biplane works as a compressor and the other surface as a base. There are many devices of measuring the thickness of the fabrics .The majority of these devices has the same previous theory. They may differ among themselves by the method of estimating thickness for various types of fabrics with different degrees of thickness.

3.3 Measure the thickness of the Hill:

It consists of two legs, one representing the upper surface, which moves under the influence of weight, which represents the pressure on the sample, and the other foot represents the base, and relate to the upper foot animated Scale Digital from which to read the thickness directly.

Before putting fabric, the legs of the machine must be cleaned completely from any dust or plankton. The cloth is placed on the bottom surface disk without causing any strains, taking into account to avoid wrinkled places and selvedge. 10 samples should be tested from 10 different places in one test, and then the average reading is calculated. Taken into account when using this device the index should be at zero adjustments before lifting the foot and putting the sample. Also take into account that the foot is moving toward the cloth slowly and the reading is taken 10 seconds after the stability of the foot on the surface of the cloth.

Figure 3.6Thickness Instrument

3.3.1.1 Determination of Fabric Air Permeability:

The definition of air permeability of fabric is the air measured by the volume of air in cubic centimeters that passes per second through a square centimetre of fabric at the air pressure of 1 cm of water equivalent.

The sample is installed in the path of the suction stream of air through the pump device, it is controlled by the amount of air pressure flowing through the valve in order to reach a desired pressure and using the indicated amount of air pressure passing. The test sample is placed into a box where exposed to air stream which passes through the circular diameter of 2.54cm. The readings of the device is recorded through a number of glass tubes containing moored on buoys cork Light and which are affected by the air stream, that passes through the samples. The reading is determined by the float level.

The apparatus used for air permeability testing is FRAZIER permeability tester shown in figure 2.8 by using BS NO.5636 (1990).

Figure 3.7Air permeability Instrument

3.3.1.2 Determination of Water Repellency of Fabric:

Water repellency is the fabric's ability to repell water. Hairy towels have a high capacity to absorb water. Flak jackets, tents, blankets and Textile sacks must be water-repellent or water-proof. Some types of processing such as wax or rubber processing with an insulating layer of plastic to improve the quality of fabrics to prevent or reduce the permeation of water droplets into the body.

3.4 Determination of resistance of fabrics to water (Waterproof):

ASTM offers a test to estimate the resistance of the outer surface of the cloth to water. This test relies on the use of specific amount of water to fall on the tested sample which is to be installed at an angle of 45° to the direction of the fall of the water. This test used a spray tester, which consists of a face spray that contains record holes for the passage of the water and a glass cup to collect the water .The sample is installed at 45° to horizontal so that the water is sucked into the center of the sample completely. The distance between the face of the machine gun and the center of the sample is 15cm altogether. This test uses distilled water at a temperature of 26.5 degrees Celsius. The amount of 250 ml of water is put into the cup to pass through the spray holes in a time of (25 – 30) seconds. The area of the sample is 18x18cm in size, and is fastened to the device so that the direction of water flows along the direction of warp yarns. In the case of fabrics with ribbed structures, the sample is placed at an angle to the flow of water. Figure (2.9) shows the device used. After the completion of the test it is necessary to get rid of the accumulated water on the surface of the sample by clicking the sample gently against a hard surface.

Table 3.2classification of the fabrics resistance to water

Class	Specification
100	Does not have any trace of wetting or attached to the surface of the water sample.
90	Few drops random scattered on the sample surface.
80	Drops of water with a wetting when spraying points.
70	Wetting of the surface of the molecule to the surface of the sample.
50	Complete wetting of the surface of the sample.
Zero	Full wetting of the surface and the face of the sample.

Figure 3.8Water Repellency Instrument

3.4.1.1 Determination of Fabric Dust Permeability:

The dust permeability of fabrics is determined by a simple apparatus, which was newly designed by Dr Mohamad Saad in Textile Department, National Research Center, Cairo.

The main purpose behind the design and development of the concerned apparatus is to ensure the efficiency and durability of filter fabrics to avoid risking failure when a proposed filter is introduced.

Using such apparatus may lead to minimizing the cost and to take correct decisions in selecting filter fabrics.

All fabrics tested were successfully used as bag filters in number of filtration applications, where woven and non-woven fabrics are used.

3.5 The Apparatus:

The apparatus consists of the following parts:

1. Particle Separator Unit:

This unit is based on inertial impact system adapted to be used in different dust concentrations and suction flow rate up to 500 I/min.

The unit also has the facility to use arange of pressure drops between 2 and 18 bars.

A pressure gauge is connected to the separator to measure the degree of vacuum in the chamber; where it is indicated on a scale.

The separating unit is provided with a master filter made of glass fibres. It is entrapped in the front face of the air sampler to prevent micro dust particles that may escape through the tested filter fabric sample.

2. Dust Feeder and Dust Chamber:

Dust is fed through a conical tube at controlled rates into a glass chamber, the dimension of which is 75x50x50 cm^3.

It has the facility to agitate dust via compressed air, so as to obtain uniform scattering inside it and also to prevent sticking of dust against chamber walls.

3. Fabric Sample Holder:

The fabric sample holder is designed so that a wide range of fabrics of different thickness could be accommodated and tested conveniently; they range between the extremely thin and the very thick fabrics. The area of fabric under test has a circular diameter of 11.3 cm. It is cut with a standard sample cutter to give a total area equal to 100 cm^2 to facilitate clamping into the fabric holder. The tested fabric area, however, is only 39 cm^2.

4. Jet –Pulse Unit:

An electric control unit is used to apply different rates of jet-pulses. The changeable duration of pulses is similar to field conditions. The applicable pulse range is between 0.5 and 60 pulses/min.

5. Heat Sensor:

Hot gases and heated dust are used to test filter fabrics used in some industrial sites, particularly cement plants.

A heat sensor is provided in order to obtain different temperatures of the dust particles and gases inside the vacuum chamber, temperatures up to 90 °C could be reached.

6. Pressure Gauge:

The air sample unit is provided with a pressure gauge to adjust the flow rate of gas through the tested fabric.

3.5.1 Testing steps:

1. The fabric sample to be tested was placed in contact with a vacuum chamber fed with concentration of dust having certain quality and characteristics.

2. Weight of 10 gm. Talc powder as dust was used for the test.

3. The particle separator evacuated air from the dust chamber through an outlet port for emitting air. During the evacuation of dusty air through the tested sample, the cleaning action was automatically performed.

1.Mass efficiency was obtained by weighing the amount of fly dust on the surface of the master filter, and on the surface of the sample filter.

And thus anti dust efficiency (η %) was given as:

$$\eta = \frac{(mass\ of\ dust\ fed)-(mass\ of\ dust\ deposite\ \ fabric\ )}{mass\ of\ dust\ fed} \qquad (3.1)$$

The filtering- cleaning cycle were run for each filter sample, the efficiency was measured after time intervals of 15 minutes.

The anti dust efficiency was calculated for all samples concerning one changeable factor.

For all fabric samples in cleaning cycle the pulse range used is 3 pulses/min. All other factors remained constant such as, powder weight, quality, temperature, pressure drop and air cycle speed.

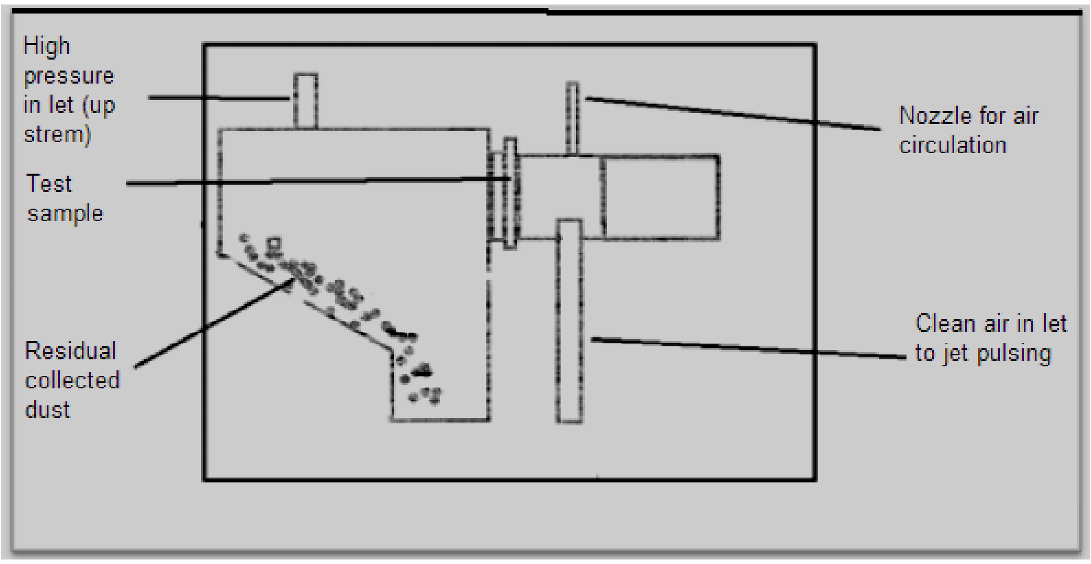


Figure 3.9Dust Permeability Instrument

3.6 Material balance on resistance adhesive dust on fabrics:

Rate mass in (g/sec) = accumulation + mass out

$$A = (D + C) + B \qquad (3.2)$$

Arrangement:

$$C = A - (D + C) \qquad (3.3)$$

Where:

A=amount of dust used (mass in)$\frac{g}{sec}$

B=amount of dust pass through the porous of fabric (mass out)$\frac{g}{sec}$

C = dust stuck to the fabric$\frac{g}{sec}$

D = residual dust (repelled dust)$\frac{g}{sec}$

Efficiency of expelling dust = $\frac{D}{A} \times 100$

Efficiency of absorption (sticking) of dust = $\frac{C}{A} \times 100$

Area of dust fabric = 39cm^2

From Tables (4.4), (4.5) and (4.6) to be calculation flow rate of dust

Volumetric flow rate of air permeability

$$(V)\,\frac{cm^3}{sec} = \frac{(AP)airpermeability\ \left(\frac{\frac{cm^3}{sec}}{cm^2}\right)}{\text{Area of dust fabric}} \qquad (3.4)$$

$$\text{Mass flow rate of air permeability}(M)\left(\frac{g}{sec}\right) = \frac{\text{Volumetric flow rate}}{\text{concenteration of dust (C)}} \qquad (3.5)$$

$$\text{Total mass flow rate} = \frac{10\text{g}}{300\,\text{sec}} = \frac{0.0333\,\text{g}}{\text{sec}}$$

$$\text{Air permeability ratio} = \frac{Mass\ flow\ rate\ of\ air\ permeability}{\text{Total mass flow rate}} \times 100 \qquad (3.6)$$

Table 3.3Calculation Air Permeability Ratio before Treatment

Design	$AP\left(\frac{cm^3}{\frac{sec}{cm^2}}\right)$	$V\frac{cm^3}{sec}$	C $\left(\frac{g}{cm^3}\right)$	$(M)\left(\frac{g}{sec}\right)$	$M_t\left(\frac{g}{sec}\right)$	AP ratio%
	100%Cotton					
Plain	4.8	0.12308	0.00004	4.92308E-06	0.033333	0.01477
Twill	21.3	0.54615	0.00004	2.18462E-05	0.033333	0.06554
Sateen	22.2	0.56923	0.00004	2.27692E-05	0.033333	0.06831
Design	**100%Polyester**					
Plain	2.8	0.07179	0.00004	2.87179E-06	0.033333	0.00862
Twill	23.5	0.60256	0.00004	2.41026E-05	0.033333	0.07231
Sateen	30.5	0.78205	0.00004	3.12821E-05	0.033333	0.09385
Design	**50%Cotton&50% Polyester**					
Plain	5.1	0.13077	0.00004	5.23077E-06	0.033333	0.015692
Twill	19.7	0.50513	0.00004	2.02051E-05	0.033333	0.060615
Sateen	20.7	0.53077	0.00004	2.12308E-05	0.033333	0.063692

Table 3.4 Calculation Air Permeability Ratio after Treatment

Design	$AP\left(\frac{cm^3}{\frac{sec}{cm^2}}\right)$	$V\frac{cm^3}{sec}$	C $\left(\frac{g}{cm^3}\right)$	$(M)\left(\frac{g}{sec}\right)$	$M_t\left(\frac{g}{sec}\right)$	AP ratio%
	100%Cotton					
Plain	4	0.10256	0.00004	4.10256E-06	0.033333	0.01231
Twill	17.9	0.45897	0.00004	1.8359E-05	0.033333	0.05508
Sateen	19.3	0.49487	0.00004	1.97949E-05	0.033333	0.05938
Design	**100%Polyester**					
Plain	1.8	0.04615	0.00004	1.84615E-06	0.033333	0.00554
Twill	16	0.41026	0.00004	1.64103E-05	0.033333	0.04923
Sateen	22	0.56410	0.00004	2.25641E-05	0.033333	0.06769
Design	**50%Cotton&50% Polyester**					
Plain	3.5	0.08974	0.00004	3.58974E-06	0.033333	0.01077
Twill	14	0.35897	0.00004	1.4359E-05	0.033333	0.04308
Sateen	22.5	0.57692	0.00004	2.30769E-05	0.033333	0.06923

Calculation

From tables (3.5), (3.6) given A, B, C and AP

To calculate

$$\mathrm{B} = \mathrm{AM} \times \mathrm{AP}$$

$$\mathrm{D} = \frac{\mathrm{D\%} \times \mathrm{AM}}{100}$$

$$\mathrm{C} = \mathrm{A} - (\mathrm{B} + \mathrm{D})$$

$$\eta\mathrm{D} = \frac{\mathrm{D}}{\text{Total mass flow rate}} \times 100$$

$$\eta\mathrm{B} = \frac{\mathrm{B}}{\text{Total mass flow rate}} \times 100$$

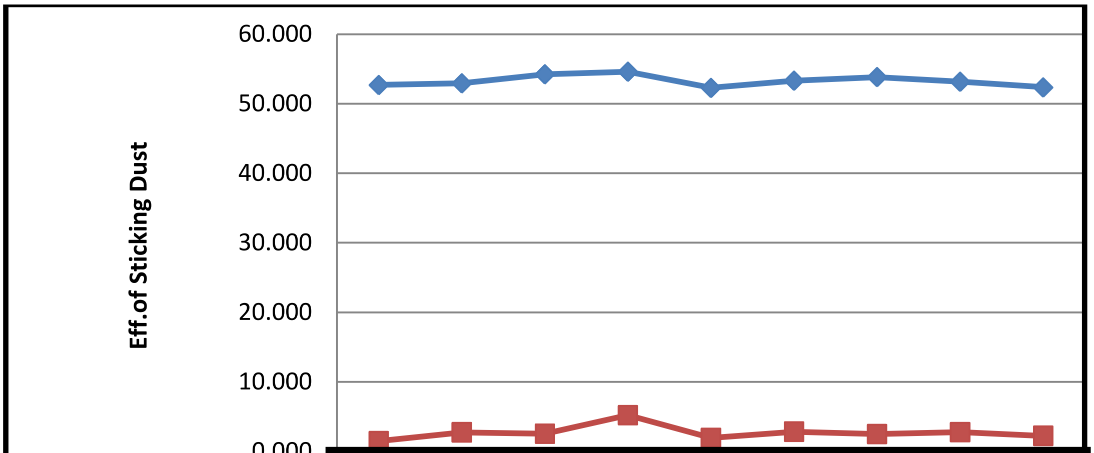
$$\eta\mathrm{C} = \frac{\mathrm{C}}{\text{Total mass flow rate}} \times 100$$

Table 3.5 Efficiency of Expelling, Sticking Dust and Dust Pass through the Porous before Treatment

Mass in(g)	Time(sec)	A M(g/s)	D%	D (g/sec)	AP%	B (g/sec)	D+B (g/sec)	C (g/sec)	η_C	η_D	η_B
10	300	0.033333	47.3000	0.0158	0.0148	0.000005	0.0158	0.0176	52.6852	47.3000	0.0148
10	300	0.033333	47.0000	0.0157	0.0655	0.000022	0.0157	0.0176	52.9345	47.0000	0.0655
10	300	0.033333	45.7000	0.0152	0.0683	0.000023	0.0153	0.0181	54.2317	45.7000	0.0683
10	300	0.033333	45.3000	0.0151	0.0086	0.000033	0.0151	0.0182	54.6000	45.3000	0.1000
10	300	0.033333	46.9000	0.0156	0.0723	0.000277	0.0159	0.0174	52.2700	46.9000	0.8300
10	300	0.033333	45.8000	0.0153	0.0939	0.000297	0.0156	0.0178	53.3100	45.8000	0.8900
10	300	0.033333	46.0000	0.0153	0.0157	0.000057	0.0154	0.0179	53.8300	46.0000	0.1700
10	300	0.033333	46.1600	0.0154	0.0606	0.000227	0.0156	0.0177	53.1600	46.1600	0.6800
10	300	0.033333	46.9600	0.0157	0.0637	0.000233	0.0159	0.0174	52.3400	46.9600	0.7000

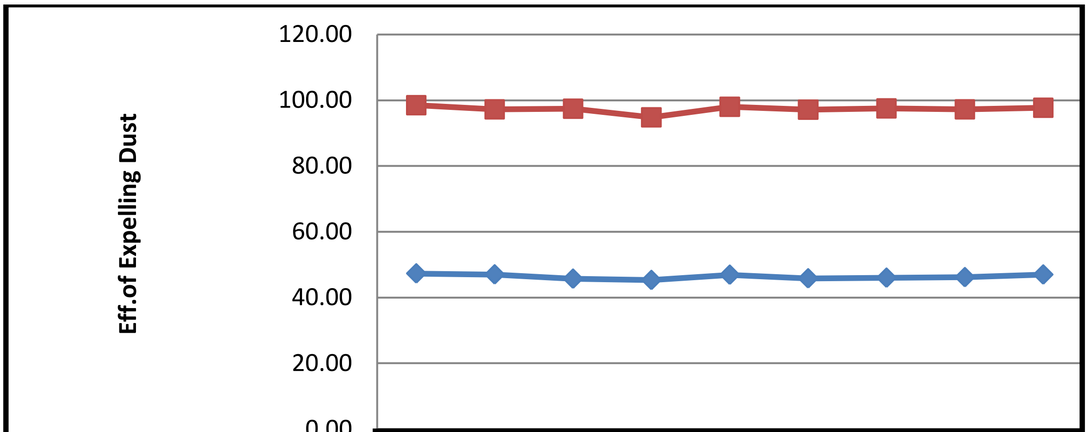
Table 3.6 Efficiency of Expelling, Sticking Dust and Dust Pass through the Porous after Treatment

Mass in(g)	Time(sec)	A M(g/s)	D%	D (g/sec)	AP%	B (g/sec)	D+B (g/sec)	C (g/sec)	η_C	η_D	η_B
10	300	0.03333	98.5000	0.03283	0.01231	0.000004	0.03284	0.00050	1.48769	98.5000	0.01231
10	300	0.03333	97.2000	0.03240	0.05508	0.000018	0.03242	0.00091	2.74492	97.2000	0.05508
10	300	0.03333	97.4000	0.03247	0.05938	0.000020	0.03249	0.00085	2.54062	97.4000	0.05938
10	300	0.03333	94.8000	0.03160	0.00554	0.000002	0.03160	0.00173	5.19446	94.8000	0.00554
10	300	0.03333	98.0000	0.03267	0.04923	0.000016	0.03268	0.00065	1.95077	98.0000	0.04923
10	300	0.03333	97.1000	0.03237	0.06769	0.000023	0.03239	0.00094	2.83231	97.1000	0.06769
10	300	0.03333	97.5000	0.03250	0.01077	0.000004	0.03250	0.00083	2.48923	97.5000	0.01077
10	300	0.03333	97.2000	0.03240	0.04308	0.000014	0.03241	0.00092	2.75692	97.2000	0.04308
10	300	0.03333	97.7000	0.03257	0.06923	0.000023	0.03259	0.00074	2.23077	97.7000	0.06923



	Pl/C	Tw/C	Sa/C	Pl/P	Tw/P	Sa/P	Pl/P/C	Tw/P/C	Sa/P/C
%Berore Treatment	52.68	52.93	54.23	54.60	52.27	53.31	53.83	53.16	52.34
%After Treatment	1.488	2.745	2.541	5.194	1.951	2.832	2.489	2.757	2.231

Figure 3.10 Efficiency of Sticking Dust before and After Treatment



	Pl/C	Tw/C	Sa/C	Pl/P	Tw/P	Sa/P	Pl/P/C	Tw/P/C	Sa/P/C
%Berore Treatment	47.3	47.0	45.7	45.3	46.9	45.8	46.0	46.1	46.9
%After Treatment	98.5	97.2	97.4	94.8	98.0	97.1	97.5	97.2	97.7

Figure 3.11 Efficiency of Expelling Dust before and AfterTreatment

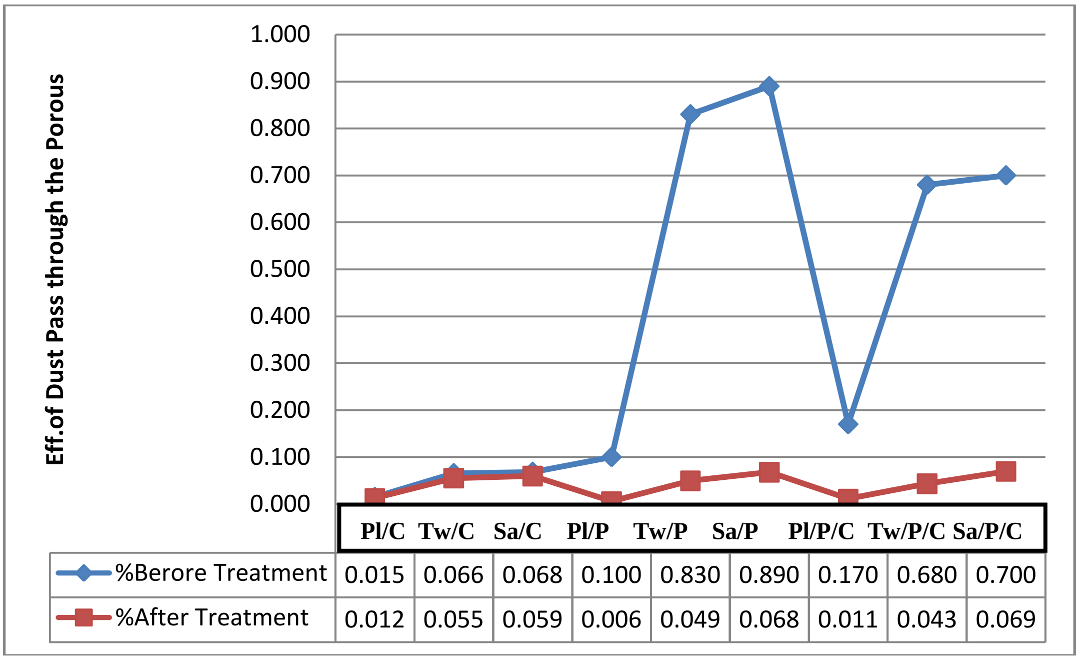


Figure 3.12 Efficiency of Dust Pass through the Porous before and After Treatment

Chapter (4)

Results and Discussions

Chapter(4)

4 Results and Discussions

This chapter presents full details of range of experimental results obtained for the fabrics tests, according to the main objective of the thesis.

The effects and relationships considered in this work due to anti dust treatments are:

1- The effect of fabric structure before and after treatment.

2- Comparison among three main textile materials (100%cotton, 100%polyester and a blend of 50%cotton&50%polyester) in all tests.

3- The correlation between thickness and air permeability before and after treatment.

4.1 Plain fabric before and after treatment:

Table 4.1Plain fabric before and after treatment

No. sample	material	before	After
		Tensile strength (warp way) kg/5cm	
C	100 %Cotton	95	90
P	100%Polyester	93	83
P/C	50%cotton&50% polyester	97	87
		Tensile strength (weft way) kg/5cm	
C	100 %Cotton	37	40
P	100%Polyester	90	115
P/C	50%cotton&50% polyester	59	60
		Elongation(warp way)%	
C	100 %Cotton	38	30
P	100%Polyester	38	30
P/C	50%cotton&50% polyester	40	32

Continued Table 4.1 Plain before and after treatment

		Elongation(weft way)%	
C	100 %Cotton	15	10
P	100%Polyester	22	25
P/C	50%cotton&50% polyester	21	15
		Weight of m^2 (g)	
C	100 %Cotton	175	181
P	100%Polyester	186	195
P/C	50%cotton&50% polyester	200	207
		Thickness (mm)	
C	100 %Cotton	0.47	0.46
P	100%Polyester	0.45	0.43
P/C	50%cotton&50% polyester	0.47	0.46
		% of expelled water	
C	100 %Cotton	90	100
P	100%Polyester	90	100
P/C	50%cotton&50% polyester	90	100
		Air permeability ($cm^3/s/cm^2$)	
C	100 %Cotton	8.73	7.68
P	100%Polyester	4.34	3.14
P/C	50%cotton&50% polyester	7.09	5.37

4.1.1 Tensile Strength (Warp Direction)

As can be seen from table 4.1, the tensile strength in the warp direction for the blended fabric (50%cotton +50%polyester) before treatment got the highest value when compared between the100%cotton&100%polyester fabrics as shown on table 4.1and drawn in figure4.1.There is a general decrease in the tensile strength after treatment for all samples in the warp direction. It can also be seen that the blend of 50%cotton&50% polyester showed the maximum value of tensile strength after treatment as well.

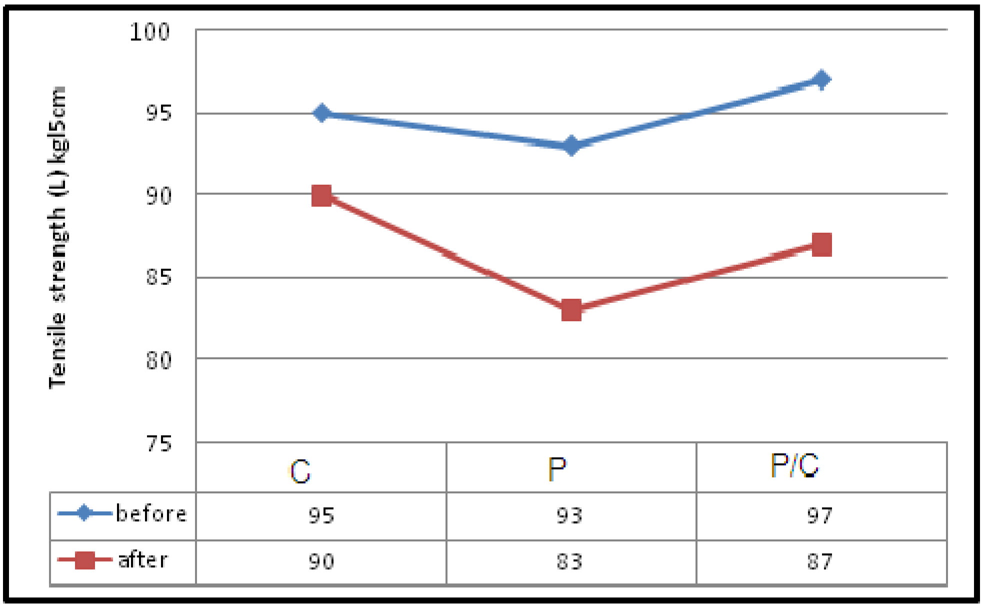


Figure 4.1Tensile Strength (Warp Direction)

4.1.2 Tensile Strength (Weft Direction)

The results of the tensile strength in the weft direction are shown in figure 4.2. The 100% polyester fabric showed the highest value of tensile strength before and after treatment. Thermo fixation is used in the treatment where the polyester is a good conductor of heat.

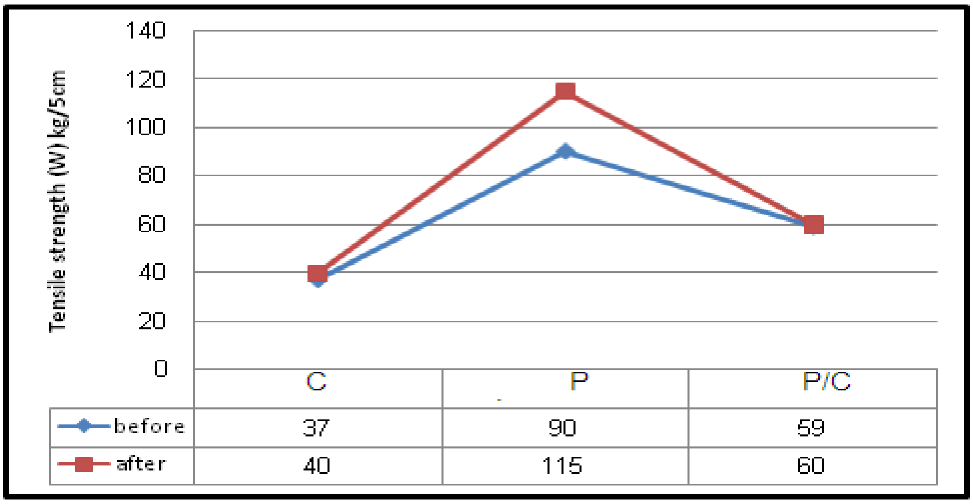


Figure 4.2Tensile Strength (Weft Direction)

4.1.3 Elongation Warp Directions

Elongation at warp wise before treatment is better than that after treatment as shown in figure 4.3. It is obvious that the treatment has affected the stretchability of the yarn.

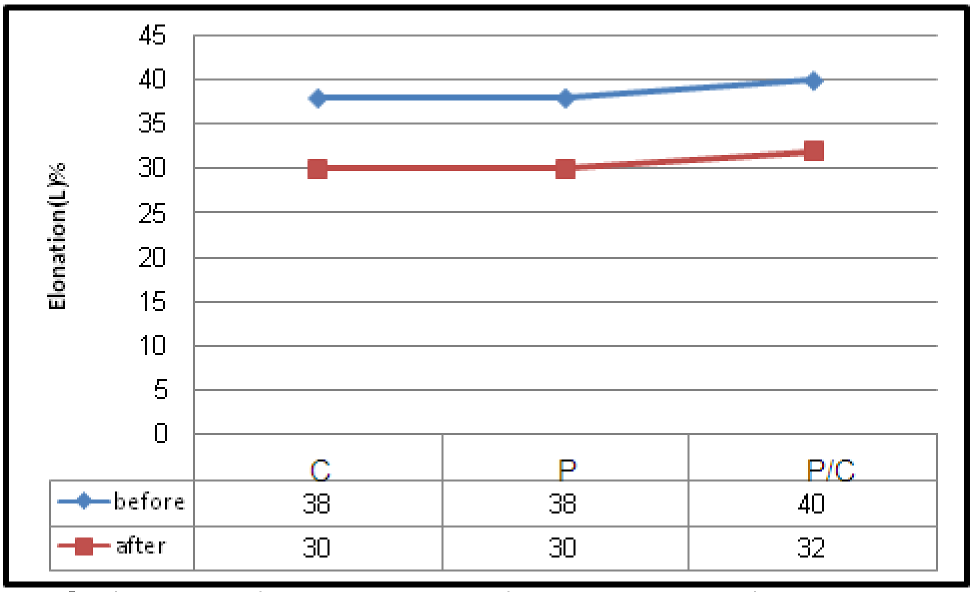


Figure 4.3Elongation Warp Directions

4.1.4 Elongation (Weft Directions)

The elongation in the weft direction showed a decrease after treatment. But the 100%polyester fabric showed an increase in elongation value. This odd value is due to heat setting process. This is shown in figure4.4.

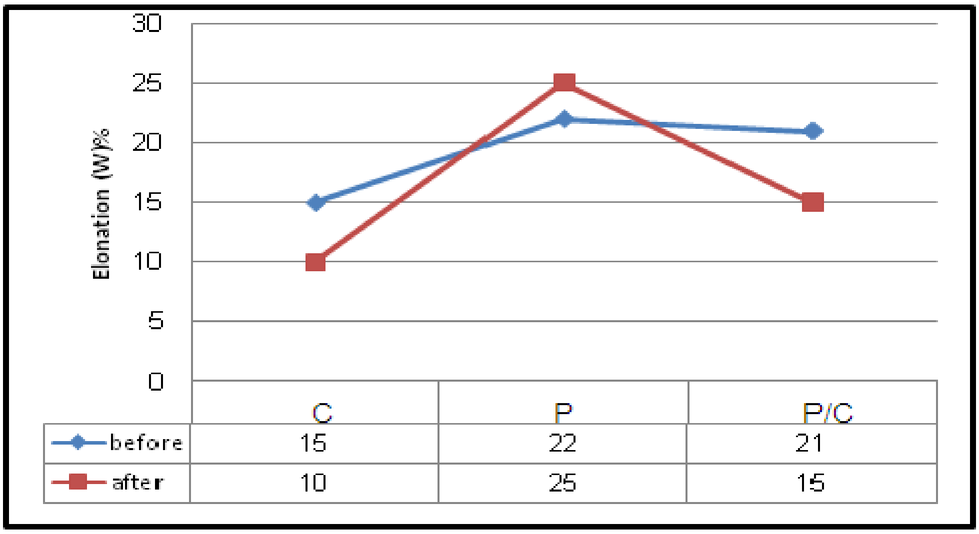


Figure 4.4Elongation (Weft Directions)

4.1.5 Weight of m^2

The weight is increased in all samples after treatment, because of the material added during the process, as shown in Figure 4.5. Also it can be seen that the blend fabric of 50%cotton&50%polyester got the greater value of weight before and after treatment.

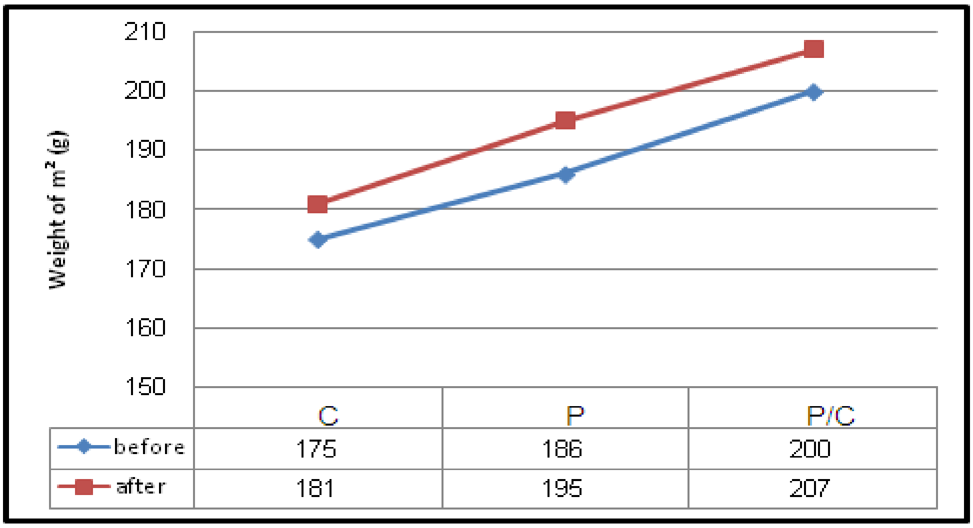


Figure 4.5Weight of m^2

4.1.6 Thickness of Fabric

Thickness before treatment is greater than that after treatment; this is because during the process all samples are squeezed. This is shown in figure 4.6. The lowest value of thickness is showed by the 100% polyester fabric.

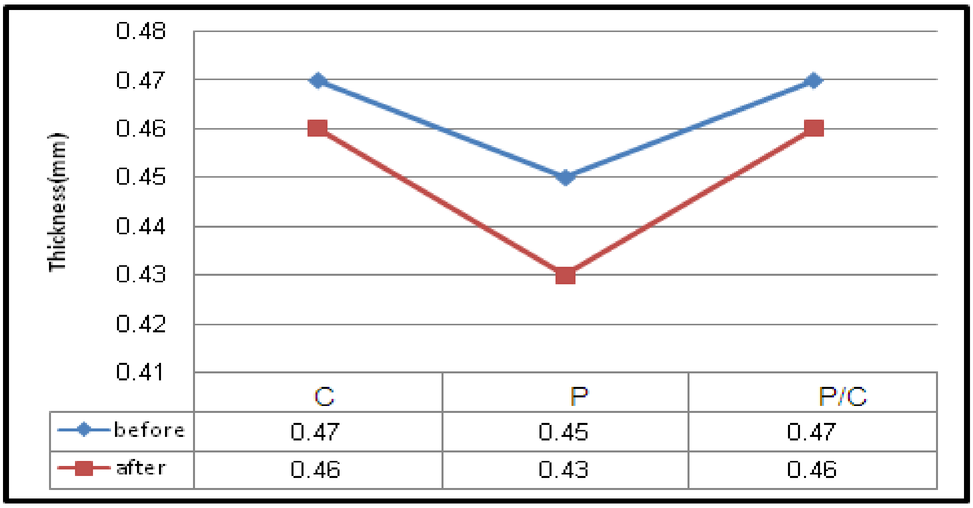


Figure 4.6Thickness of Fabric

4.1.7 Percentage of Expelled Water

Before treatment few drops are randomly scattered on the sample surface. But after treatment no trace of wetting occurred on the surface of the sample, as shown in figure 4.7.

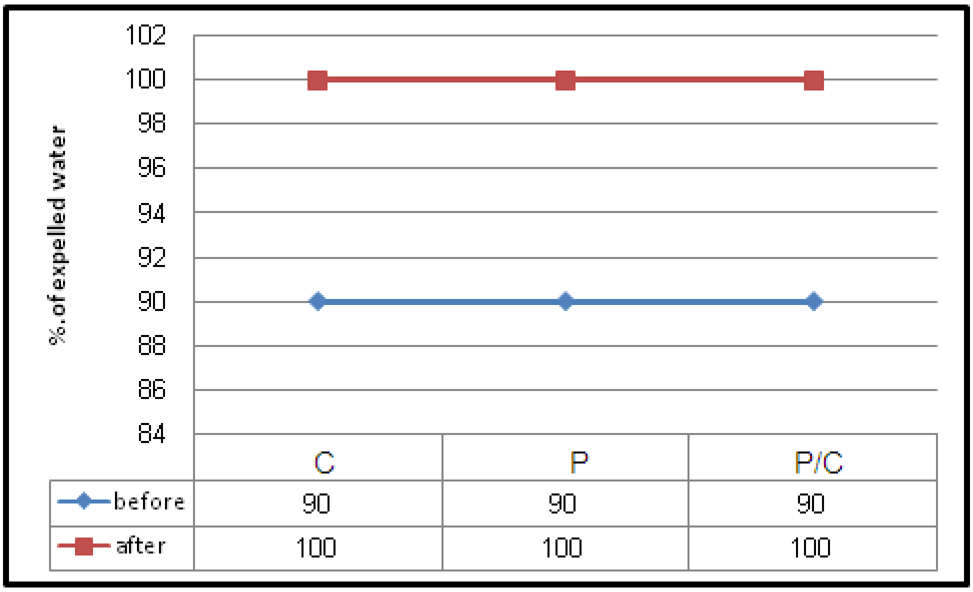


Figure 4.7Percentage of Expelled Water

4.1.8 Air Permeability

The air permeability values have decreased after treatment because the fabrics have become less porus. It can be seen that the 100% polyester fabric after treatment got the lowest value as shown in figure 4.8.

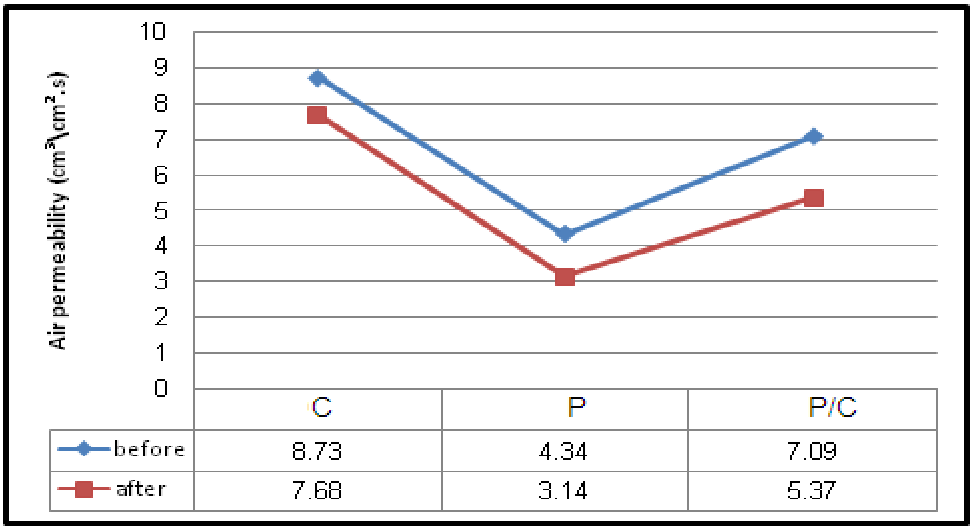


Figure 4.8Air Permeability

4.2 Twill before and after treatment:

Table 4.2Twill fabric before and after treatment

No. sample	Material	Before	after
		Tensile strength (warp way) kg/5cm	
C	100 %Cotton	110	95
P	100%Polyester	100	97
P/C	50%cotton&50% polyester	105	95
		Tensile strength (weft way) kg/5cm	
C	100 %Cotton	25	30
P	100%Polyester	95	105
P/C	50%cotton&50% polyester	57	64
		Elongation(warp way)%	
C	100 %Cotton	28	23
P	100%Polyester	28	25
P/C	50%cotton&50% polyester	33	24
		Elongation(weft way)%	
C	100 %Cotton	17	15
P	100%Polyester	24	22
P/C	50%cotton&50% polyester	21	15
		Weight of m^2(g)	
C	100 %Cotton	174	178
P	100%Polyester	177	183
P/C	50%cotton&50% polyester	176	201
		Thickness (mm)	
C	100 %Cotton	0.61	0.58
P	100%Polyester	0.60	0.56
P/C	50%cotton&50% polyester	0.64	0.60
		% of expelled water	
C	100 %Cotton	90	100
P	100%Polyester	80	100
P/C	50%cotton&50% polyester	90	100
		Air permeability ($cm^3/s/cm^2$)	
C	100 %Cotton	32.30	24.00
P	100%Polyester	35.00	21.68
P/C	50%cotton&50% polyester	28.50	19.70

4.2.1 Tensile Strength (Warp Direction)

From table 4.2 it can be seen that the 100%cotton fabric before treatment got the highest value as shown also in figure 4.9. All samples showed a decrease in tensile strength in warp direction after treatment. The resultes are drawn in figure 4.9.

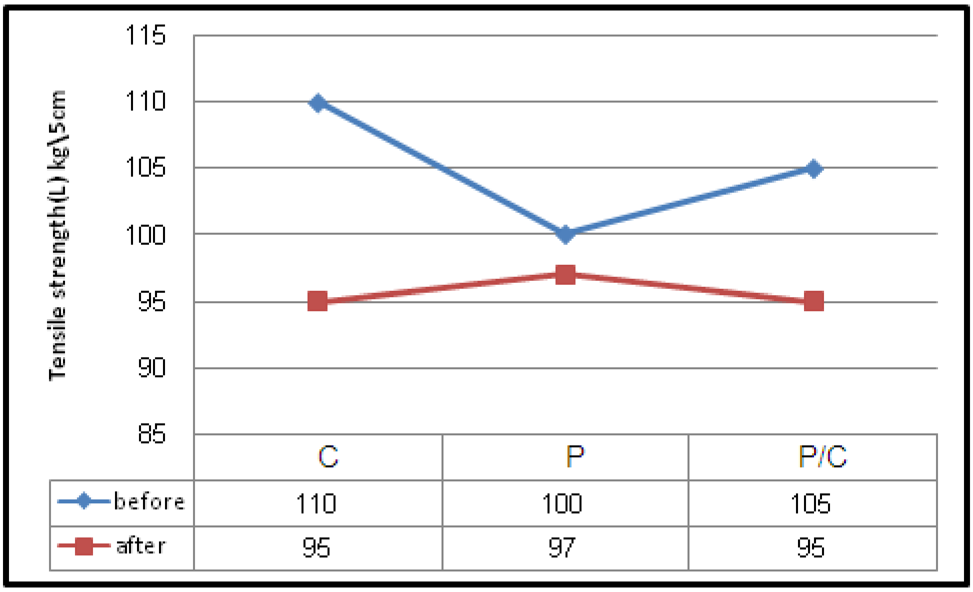


Figure4.9Tensile Strength (Warp Direction)

4.2.2 Tensile Strength (Weft Direction)

Figure 4.10 showed the tensile strength in weft direction before and after treatment. All values are increased after treatment. The 100% polyester fabric got the greater value after treatment. This is because thermo fixation is used in the process of treatment.

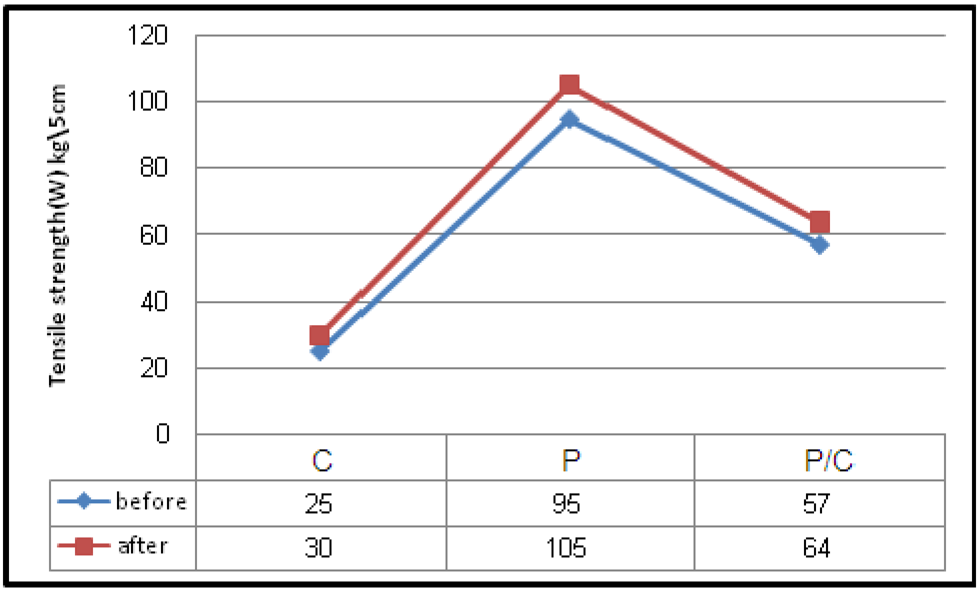


Figure 4.10Tensile Strength (Weft Direction)

4.2.3 Elongation (Warp Direction)

The results of the elongation in the warp direction are shown in figure 4.11.There is a general decrease in the elongation of all samples after treatment. Thus it could be said that treatment has affected negatively the stretch ability of the yarn.

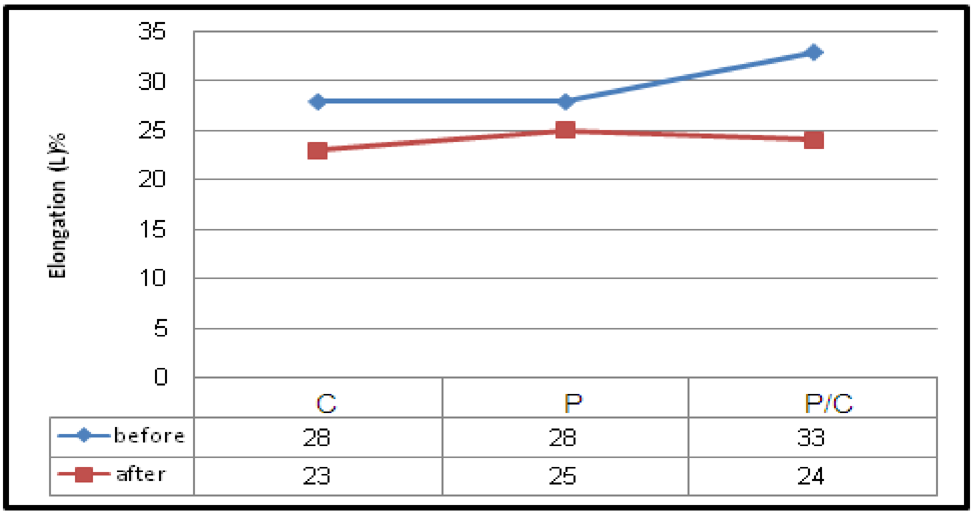


Figure 4.11Elongation (Warp Direction)

4.2.4 Elongation (Weft Direction)

The elongation in weft direction is shown in figure 4.12.The 100%polyester fabric showed the highest values in both before and after treatment. There is a general decrease in elongation after treatment for all samples.

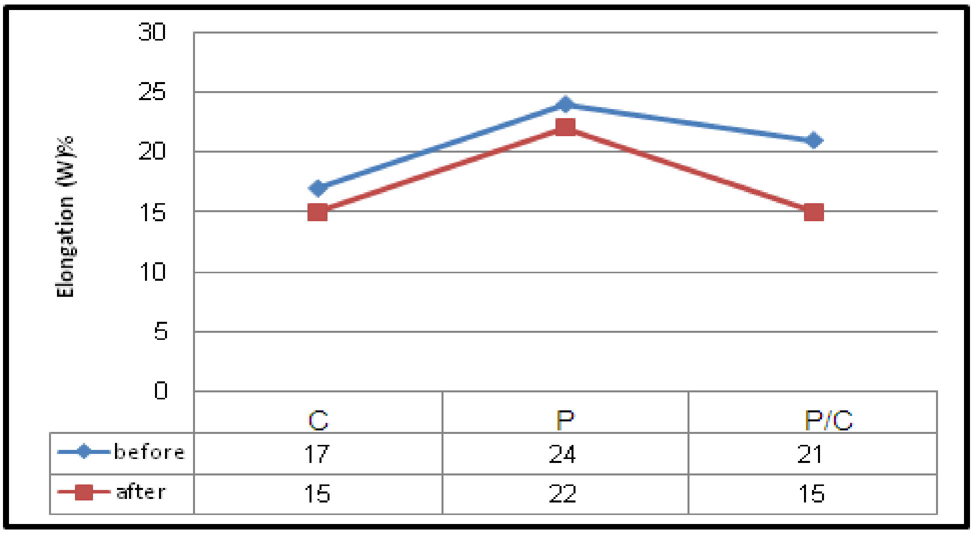


Figure 4.12Elongation (Weft Direction)

4.2.5 Weight of m^2

The weight of samples before and after treatment are shown in figure 4.13. There is a general increase in weight of all samples after treatment. It can be seen that the blend of 50%cotton&50%polyester fabric showed the highest value after treatment. This is might be due to the improvement of the absorption property of the blended fabric after treatment.

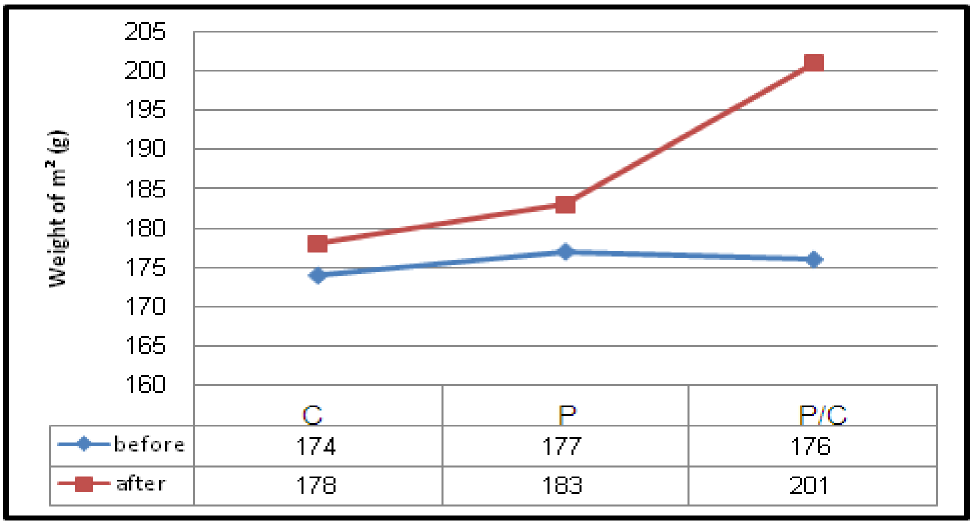


Figure 4.13Weight of m^2

4.2.6 Thickness

The thickness of fabrics before and after treatment is shown figure 4.14. There is a general decrease of thickness of all samples after treatment. The 100% polyester fabric showed the lowest value. This might be due to the squeezing process during treatment.

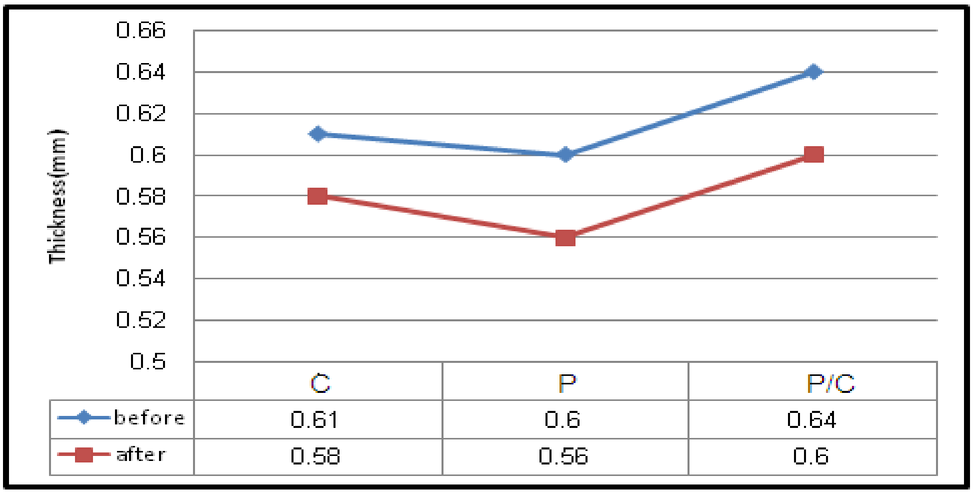


Figure 4.14Thickness

4.2.7 Percentage of Expelled Water

Results of the percentage of expelled water are shown in figure 4.15.Before treatment few drops of water are randomly scattered on the surface of all fabrics. Before treatment the fabrics expelled approximately more than 80% of water. But after treatment all fabrics expelled 100% of water.

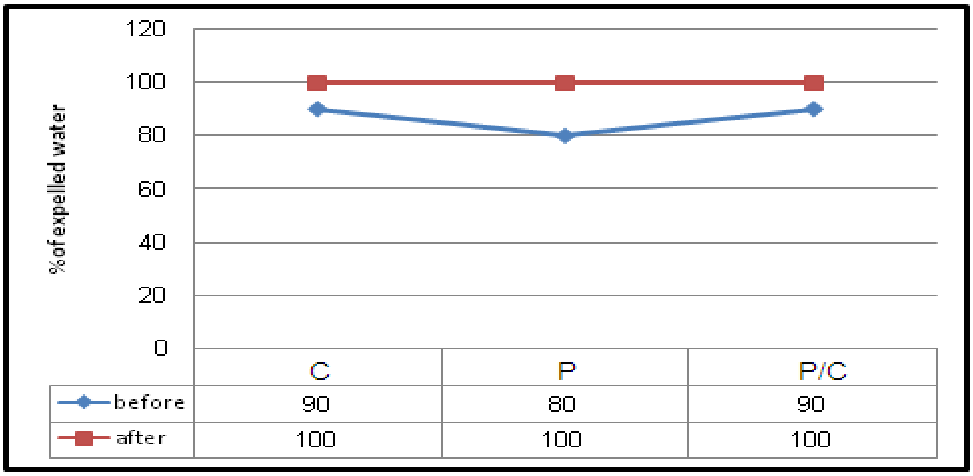


Figure 4.15Percentage of Expelled Water

4.2.8 Air Permeability

The air permeability values before and after treatment are shown in figure 4.16. There is a general decrease in the air permeability values for all samples. It could be said that all fabrics become less porus after treatment.

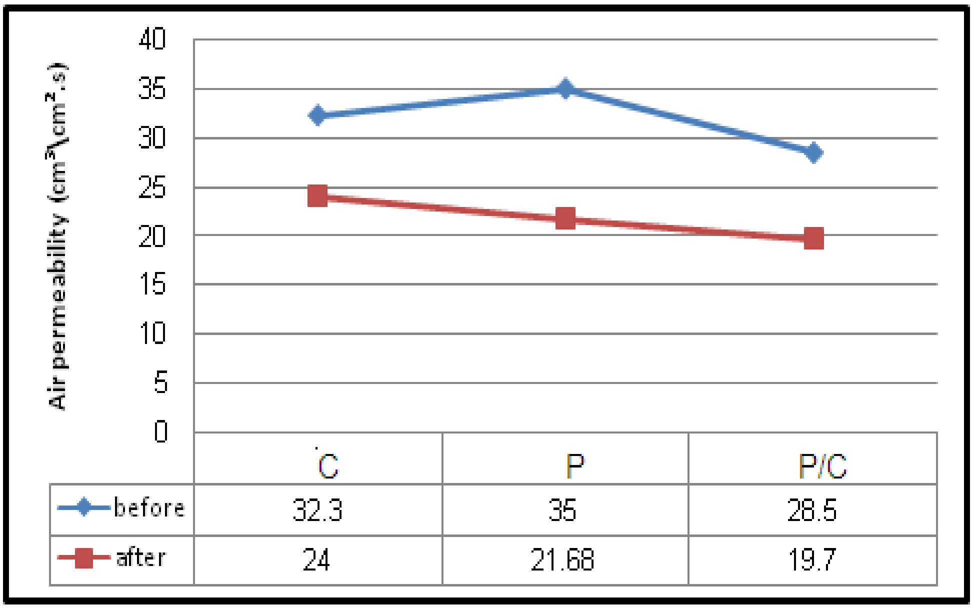


Figure 4.16Air Permeability

4.3 Experiments of sateen fabric before and after treatment

This part of study discusses the effect of sateen design on some properties of fabric, namely tensile strength, elongation, weight, thickness, percent of expelled water and air permeability, before and after treatment.

Table 4.3Sateen before and after treatment

Sample	Material	Before	After
		Tensile strength (warp way) kg/5cm	
C	100 %Cotton	110	100
P	100%Polyester	105	82
P/C	50%cotton&50% polyester	105	98
		Tensile strength (weft way) kg/5cm	
C	100 %Cotton	40	35
P	100%Polyester	87	85
P/C	50%cotton&50% polyester	62	60
		Elongation(warp way)%	
C	100 %Cotton	30	18
P	100%Polyester	28	20
P/C	50%cotton&50% polyester	35	25
		Elongation(weft way)%	
C	100 %Cotton	20	12
P	100%Polyester	19	20
P/C	50%cotton&50% polyester	22	15
		Weight of m^2 (g)	
C	100 %Cotton	174	178
P	100%Polyester	173	176
P/C	50%cotton&50% polyester	196	205
		Thickness (mm)	
C	100 %Cotton	0.60	0.55
P	100%Polyester	0.57	0.54
P/C	50%cotton&50% polyester	0.63	0.60
		% of expelled water	
C	100 %Cotton	90	100
P	100%Polyester	90	100
P/C	50%cotton&50% polyester	80	100
		Air permeability ($cm^3/s/cm^2$)	
C	100 %Cotton	34.81	24.81
P	100%Polyester	37.60	26.45
P/C	50%cotton&50% polyester	29.55	29.55

4.3.1 Tensile Strength (Warp Direction)

The results of experiments carried on sateen weave are shown on table 4.3. The results of the tensile strength on the sateen fabric in the warp direction are shown in figure 4.17. There is a general decrease in the tensile strength of all fabrics after treatment. The 100% polyester fabric showed the lowest value.

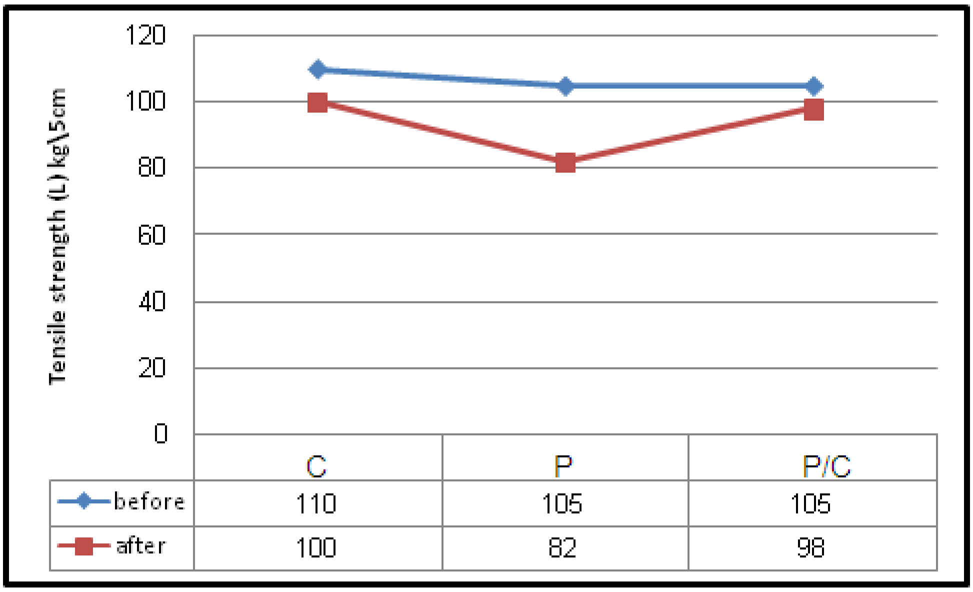


Figure 4.17Tensile Strength (Warp Direction)

4.3.2 Tensile Strength (Weft Direction)

Figure 4.18 showed the tensile strength in weft direction. All values decreased after treatment. The 100% polyester fabric got the highest values of tensile strength in weft direction for both before and after treatments.

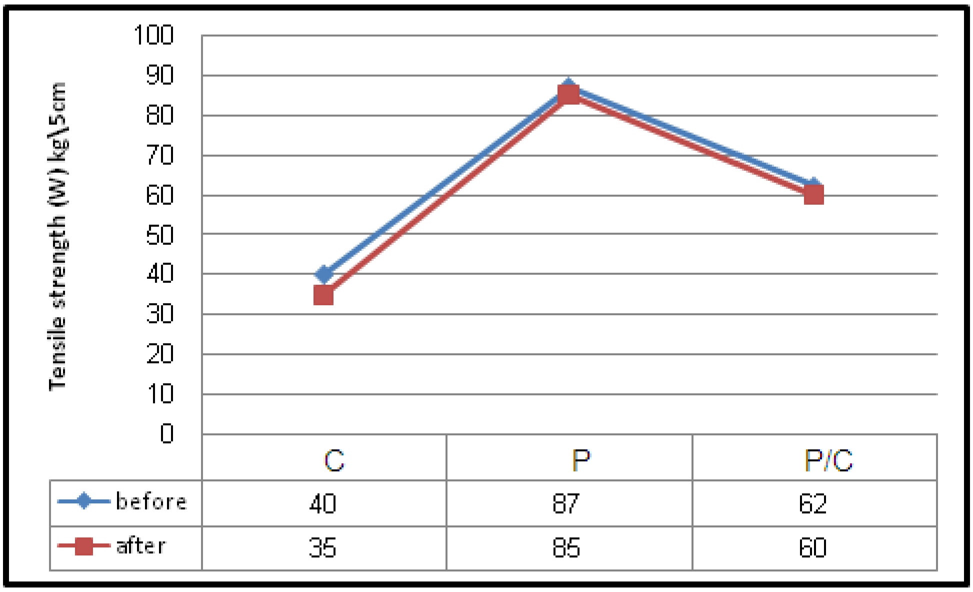


Figure 4.18Tensile Strength (Weft Direction)

4.3.3 Elongation (Warp Direction)

The results of elongation in the warp direction for sateen design are shown in figure 4.19. There is a general decrease in elongation for all fabrics after treatment. It is obvious that the treatment had affected negatively the stretchability of the fabrics.

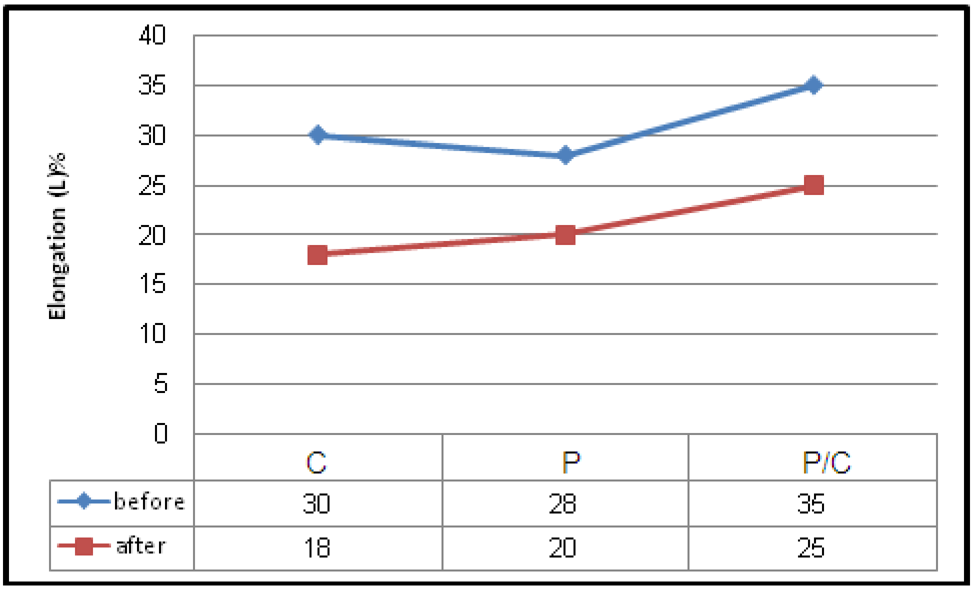


Figure 4.19Elongation (Warp Direction)

4.3.4 Elongation (Weft Direction)

The elongation results in the weft direction of all fabrics before and after treatments are shown in figure 4.20. It is obvious there is a general decrease in elongation after treatment except the odd value of the 100%polyester fabric. This odd value might be due to the heat setting accompanied the treatment process.

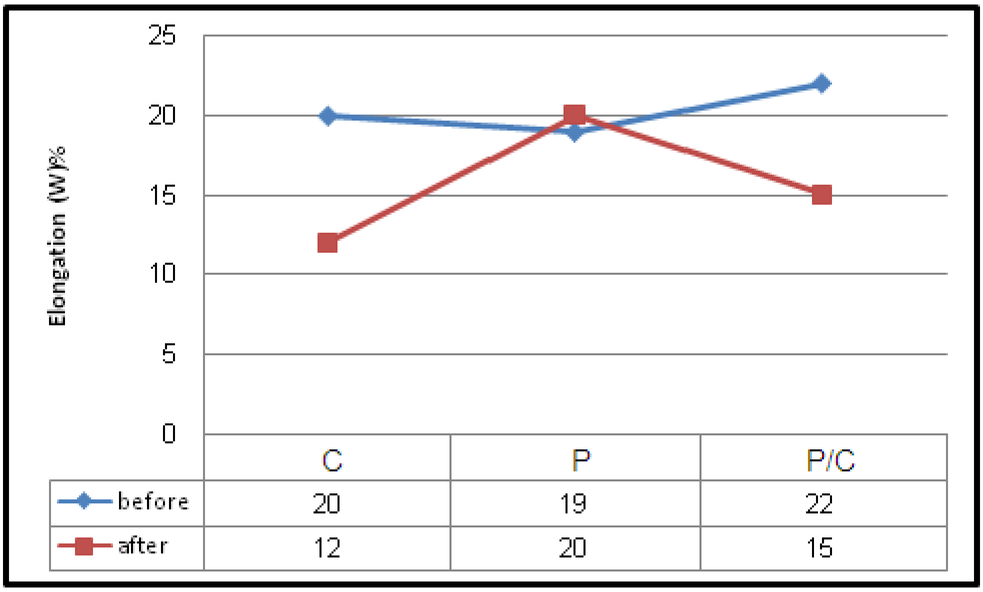


Figure 4.20Elongation (Weft Direction)

4.3.5 Weight of m^2

Results of the weight of square meter of fabric are shown in figure 4.21.There is a general increase in the weight for all fabrics after treatment. This increase in weight due to the material added to fabrics during the treatment process. There is a large increase in weight showed by the blended fabric. This might be due to the improvement of the absorption property of the blended fabric after the treatment process.

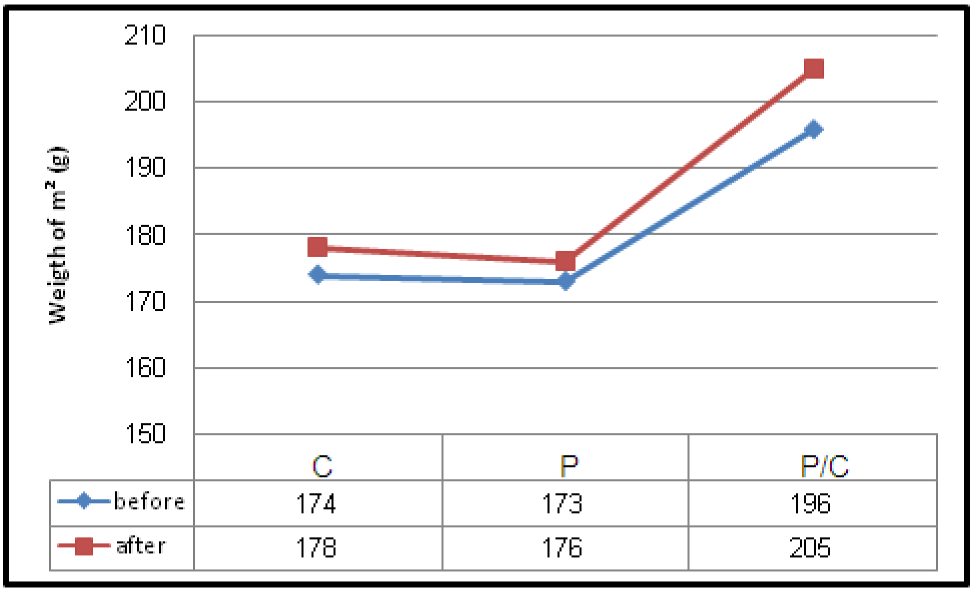


Figure 4.21Weight of m^2

4.3.6 Thickness

The results of the thickness of fabrics before and after treatment are shown in figure 4.22. There is a general decrease in the thickness of all fabrics after treatment. This might be due to the squeezing process during the treatment.

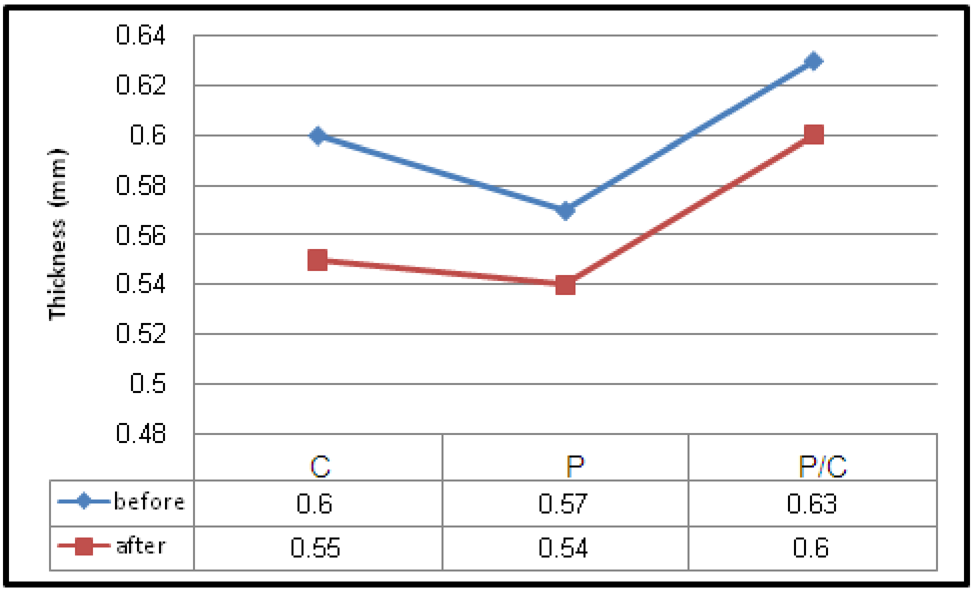


Figure 4.22Thickness

4.3.7 Percentage of Expelled Water

The percentage of expelled water before and after treatment are shown in figure 4.23.Before treatment few drops of water are randomly scattered on the surface of fabrics. Before treatment all fabrics expelled more than 80% of water. But after treatment all fabrics expelled 100% of water added. The lowest value of expelled water before treatment is showed by the blended fabric.

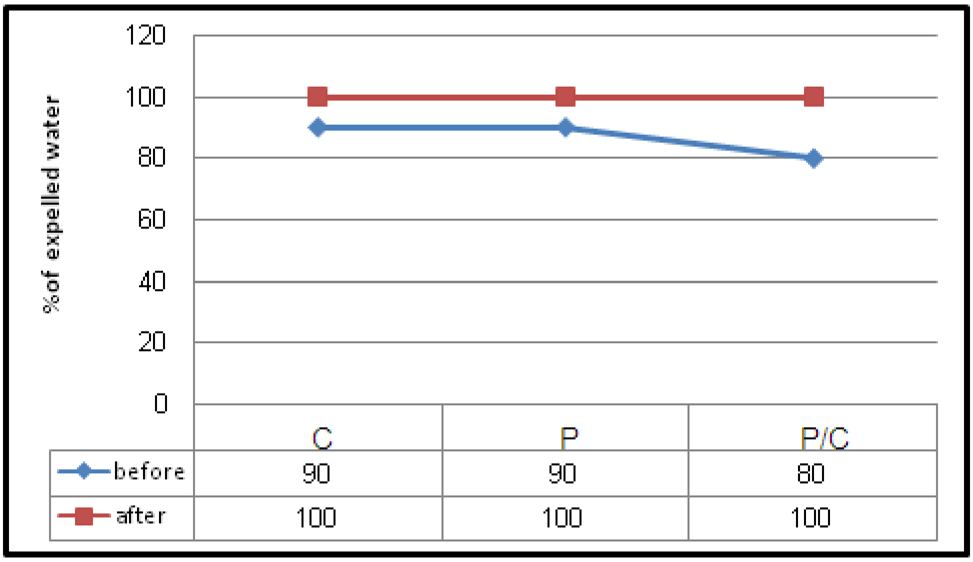


Figure 4.23Percentage of Expelled Water

4.3.8 Air Permeability

The results of air permeability values before and after treatment are showed in figure 4.24. The figure 4.24 showed a general decrease of air permeability of all fabrics after treatment. It could be said that all fabrics become less porus after treatment.

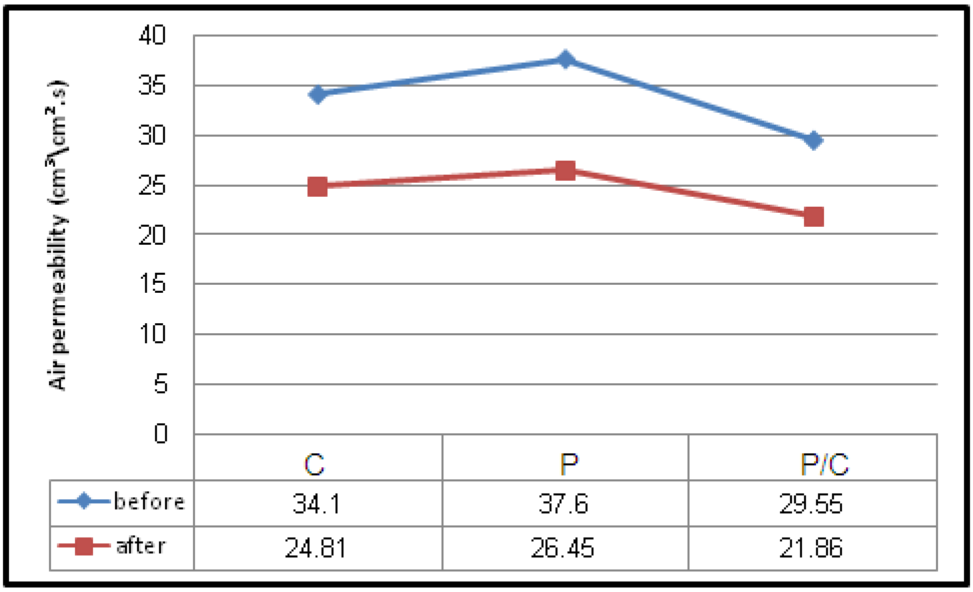


Figure 4.24Air Permeability

4.4 Effect of design (Plain, Twill and Sateen) before and after treatment.

4.4.1 Tensile strength in warp direction:

The effects of design of fabrics on the property of tensile strength in warp direction before and after treatment are studied in this work and the results are shown in figure 4.25. The sateen fabrics showed the highest values of tensile strength for all materials used.

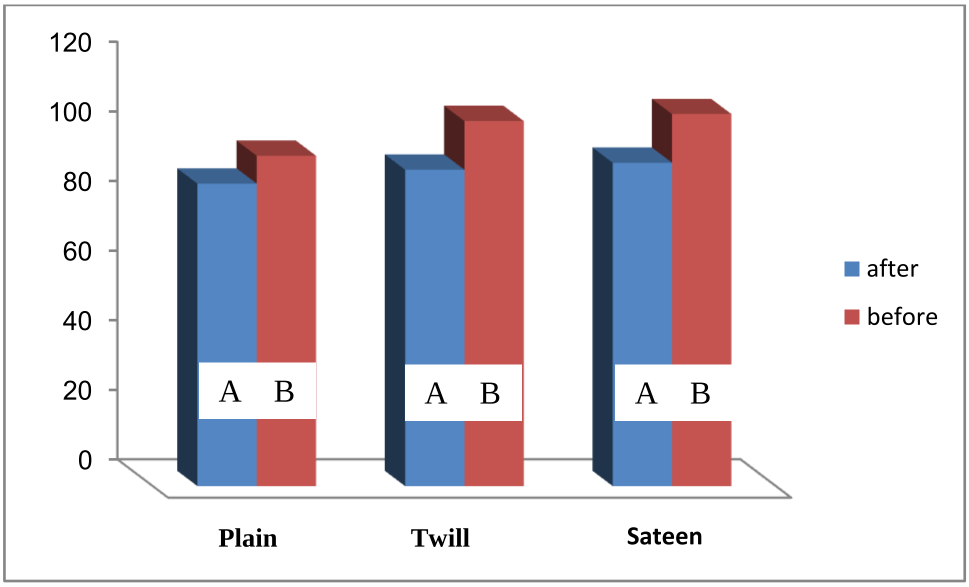


Figure 4.25Tensile Strength (Warp Direction)

4.4.2 Tensile strength in weft direction:

Results of tensile strength in weft direction before and after treatment are shown in figure 4.26. Plain design fabrics got the highest value after treatment .Because the plain design got more interlacings than the other two designs.

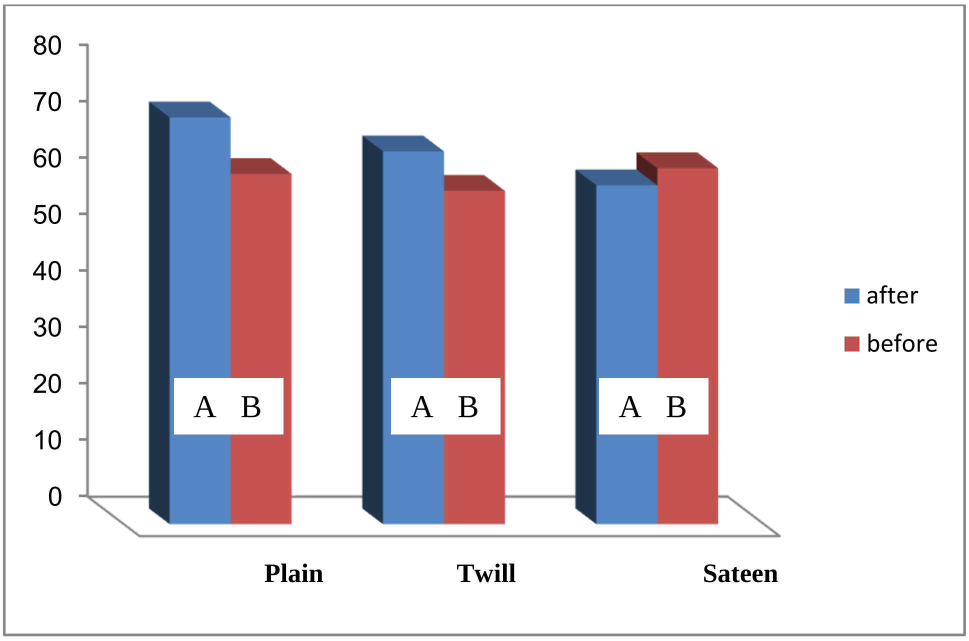


Figure 4.26Tensile Strength (Weft Direction)

4.4.3 Elongation in warp direction:

The elongation results at warp direction before and after treatment are shown on tables 4.1, 4.2, 4,3 and drawn in figure 4.27.Plain design fabrics got the maximum values for all other designs.

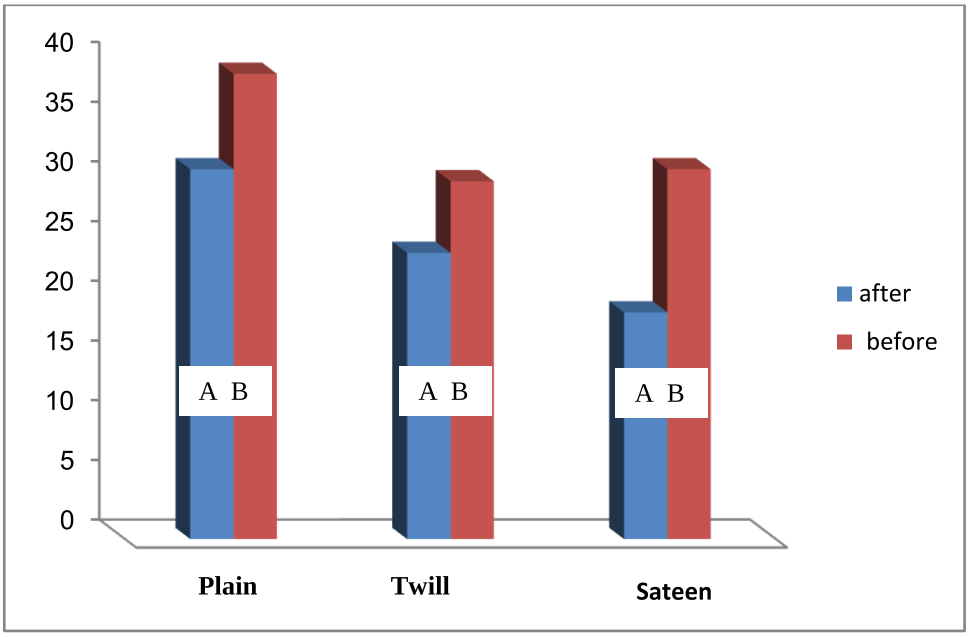


Figure 4.27Elongation (Warp Direction)

4.4.4 Elongation in weft direction:

The result of the effects of design of fabrics on elongation in weft direction before and after treatment are shown on tables 4.1, 4.2, 4,3 and drawn in figure 4.28.Twill fabrics showed the highest value of elongation for all samples used after treatment.

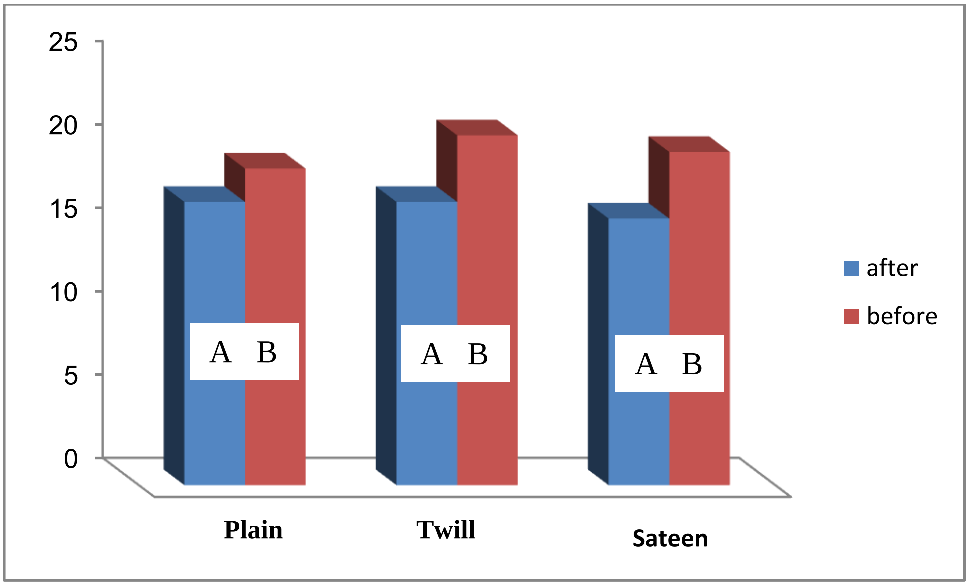


Figure 4.28Elongation (Weft Direction)

4.4.5 Weight of m^2:

The results of the weights of samples before and after treatment are showed on tables 4.1, 4.2, 4,3 and drawn in figure 4.29. The weight of all samples of fabrics increased after treatment. The plain fabric got the highest values of weight before and after treatment. The plain weaves are generally compactly constructed.

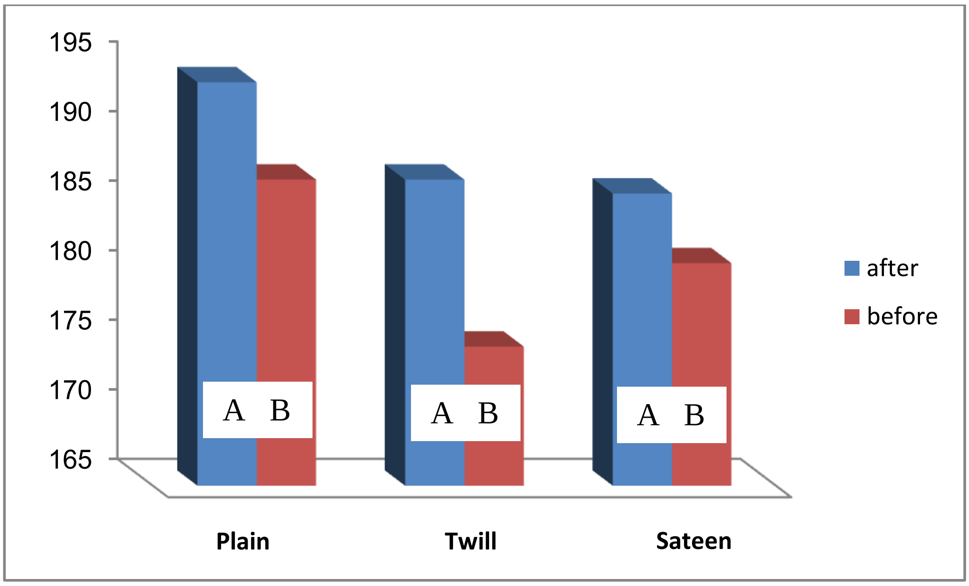


Figure 4.29Weight of m^2

4.4.6 Thickness:

Results of the effects of design of fabrics on the thickness before and after treatment are shown on tables 4.1, 4.2, 4,3 and drawn in figure 4.30. The thickness of all samples decreased after the treatment. The plain design fabric got the lowest values. This is might be due to the squeezing process accompanied the treatment.

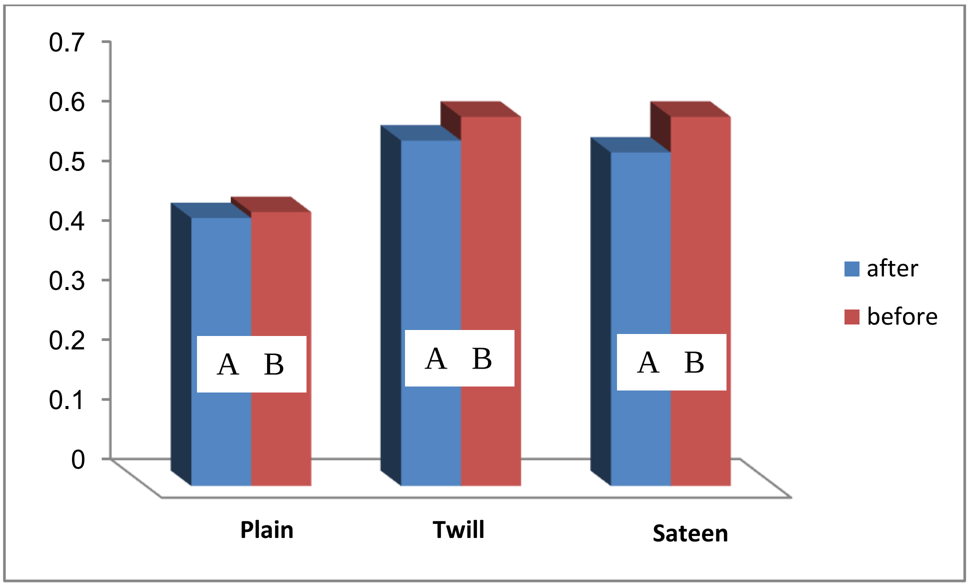


Figure 4.30Thickness

4.4.7 Percentage of Expelled Water

Percentage of expelled water before and after treatment is shown on tables 4.1, 4.2, 4,3 and drawn in figure 4.31. Before treatment the fabrics expelled about 80% of water. But after treatment all fabrics expelled 100% of the water.

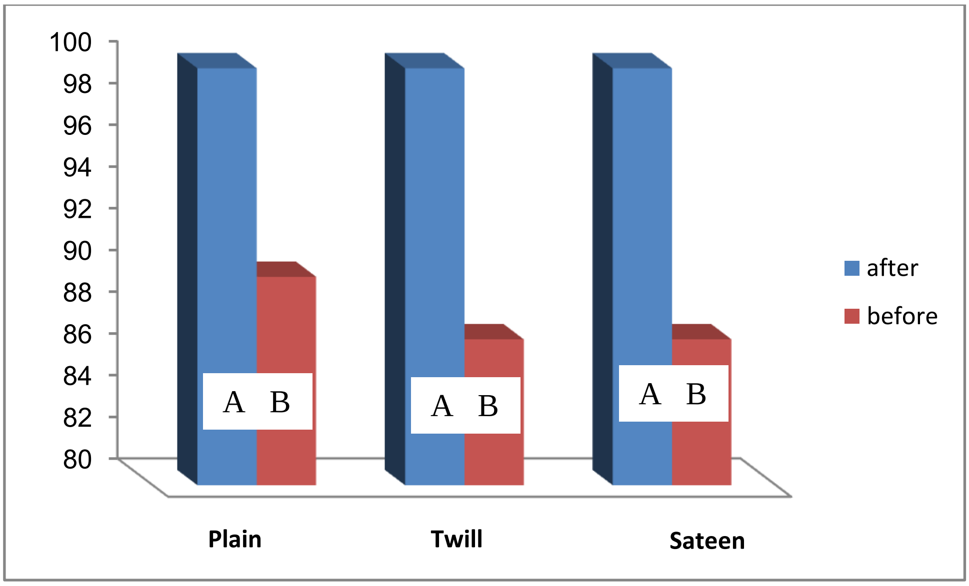


Figure 4.31Percentage of Expelled Water

4.4.8 Air Permeability

The results of the effects of design of fabrics on the property of air permeability of fabrics before and after treatment are seen in figure

4.32.Plain design got the lowest values before and after treatment. This value might be due to the compactness of fabric. Sateen design fabrics got the highest values before and after treatment. This result might be due to the low compactness of the sateen weaves.

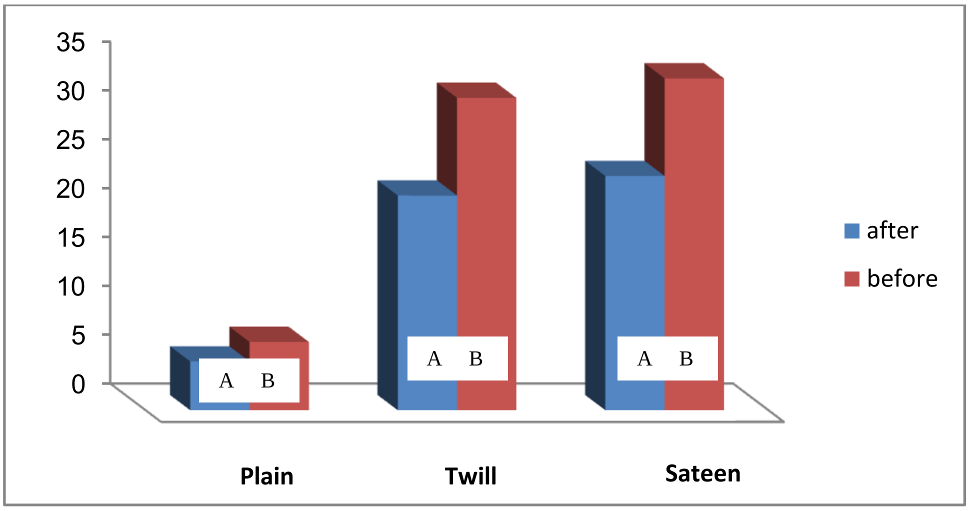


Figure 4.32Air Permeability

4.5 Plain fabrics when exposed to dust before and after treatment

Table 4.4effects of treatment on weight and air permeability of plain fabrics when exposed to dust

sample	Material	Weight of m² (g)					
		Before treatment			After treatment		
		Before	After	% increase	Before	After	% increase
C	100 %Cotton	175	191	8.4	181	196	7.7
P	100%Polyester	186	271	31.4	195	280	30.4
P/C	50%cotton&50% polyester	200	210	4.8	207	217	3.7
sample	**Material**	**Air permeability ($cm^3/s/cm^2$)**					
		Before treatment			**After treatment**		
		Before	After	% increase	Before	After	%Increase
C	100 %Cotton	8.73	4.8	45	7.68	4.0	47.9
P	100%Polyester	4.34	2.8	35.5	3.14	1.8	42.7
P/C	50%cotton&50% polyester	7.09	5.1	28	5.37	3.5	34.8

4.5.1 Weight of m^2:

It can be seen from table 4.4 that the untreated samples increased in weight before and after being exposed to dust. As well the treated samples increased in weight before and after being exposed to dust. The weight of the untreated samples before and after being exposed to dust increased by 14%. The weight of treated samples before and after being exposed to dust increased as well by 13%. The results are drowning in figure 4.33.

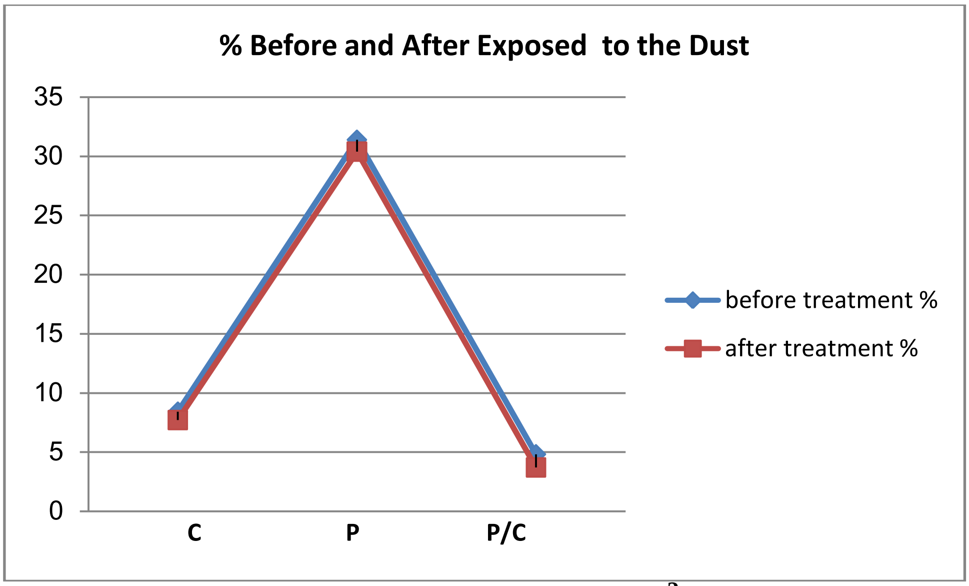


Figure 4.33Weight of m^2

4.5.2 Air Permeability

As can be seen also from table 4.4 that the air permeability of the untreated samples decreased before and after being exposed to dust. As well the air permeability of the treated samples decreased before and after being exposed to dust. The air permeability of untreated samples before and after being exposed to dust decreased by 36%. For treated fabrics the air permeability decreased by 41% before and after being exposed to dust. The results are shown in figure 4.34. 100 % cotton fabrics got the highest values before and after exposure to dust. This is might be due to the material added during the process of treatment has decreased the porosity of the fabric.

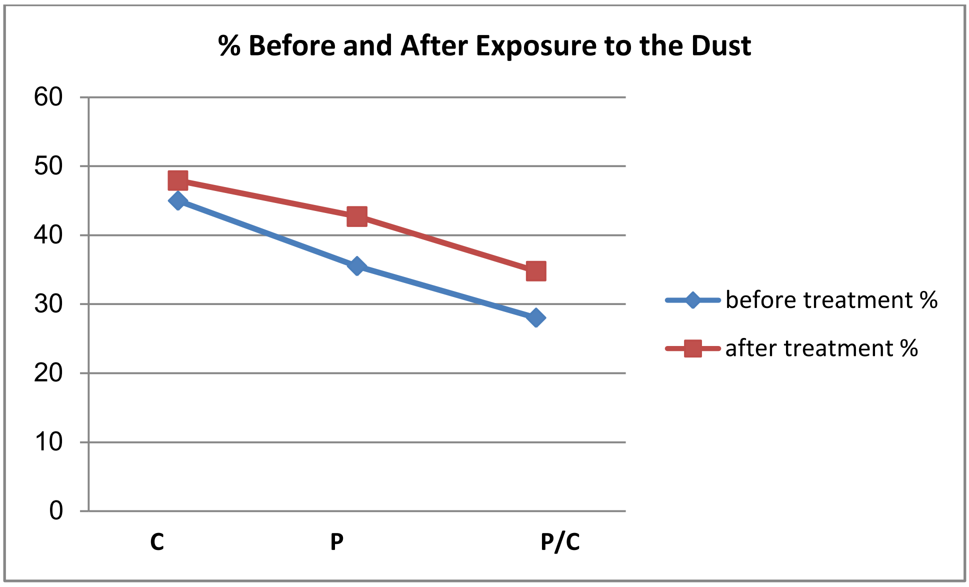


Figure 4.34Air Permeability

4.6 Twill fabrics when exposed to dust before and after treatment

Table 4.5effects of treatment on weight and air permeability of twill fabrics when exposed to dust

Sample	Material	Weight of m^2 (g)					
		Before treatment			After treatment		
		Before	After	%increase	Before	After	%Increase
C	100 %Cotton	174	190	8.4	178	192	7.3
P	100%Polyester	177	185	4.3	183	190	3.7
P/C	50%cotton&50% polyester	176	183	3.8	201	208	3.4

Sample	Material	Air permeability ($cm^3/s/cm^2$)					
		Before treatment			After treatment		
		Before	After	%increase	Before	After	% Increase
C	100 %Cotton	32.30	21.3	34.1	24.00	17.1	28.8
P	100%Polyester	35.00	23.5	32.9	21.7	16.0	26.3
P/C	50%cotton&50% polyester	28.50	19.7	30.9	19.70	14.0	28.9

4.6.1 Weight of m^2:

Table 4.5 shows the results of the weight of the untreated samples before and after being exposed to dust. The weight of all samples increased by 5%. The same table had shown the weight of treated samples before and after being exposed to dust. The weight of all samples increased as well by 5%.Because the treatment itself added some weight to the samples, therefore the amount of dust sticked to the treated fabrics is less than that sticked to the un treated fabrics. The results of table 4.5 are drawn in figure 4.35.

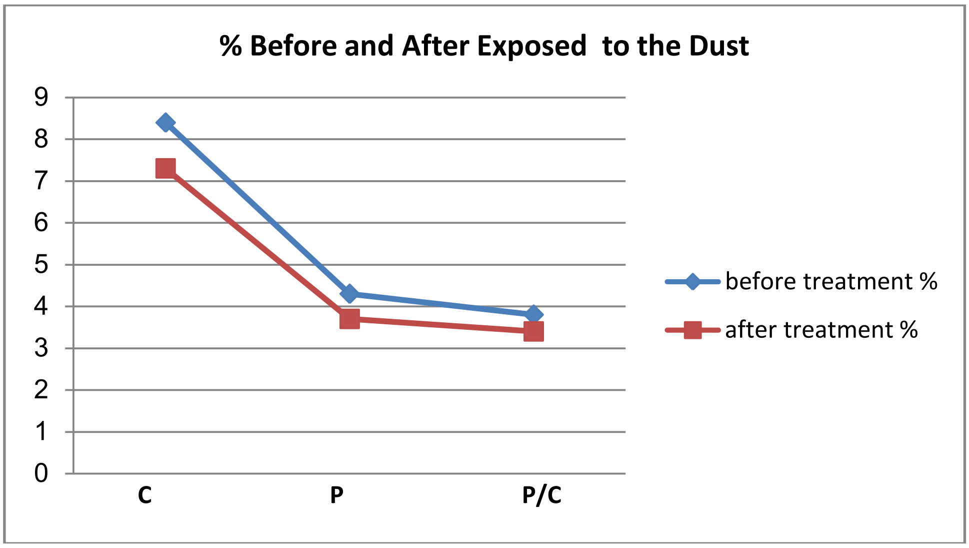


Figure 4.35Weight of m^2

4.6.2 Air Permeability

Table 4.5 also shows the results of air permeability of the untreated samples before and after being exposed to dust. The air permeability decreased by 32% after being exposed to dust. As well table 4.5 shows the results of air permeability of the treated fabrics before and after being exposed to dust. For the treated fabrics the air permeability decreased by 27% after being exposed to dust. The porus become less when the material added to the samples during treatment. The results are drawn in figure 4.36.It can be seen that the air permeability of the blended fabric decreased by 2%.

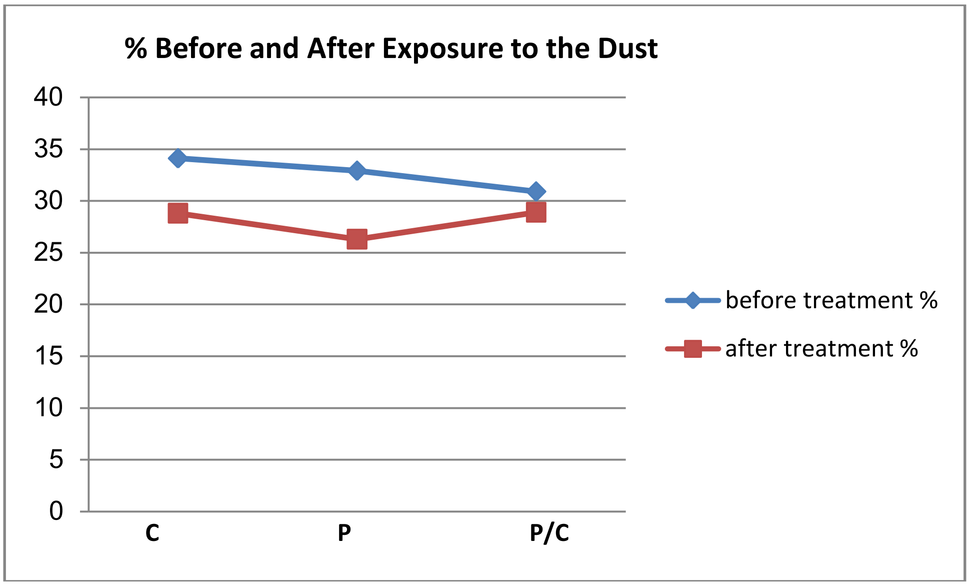


Figure 4.36Air Permeability

4.7 Sateen fabrics when exposed to dust before and after treatment

Table 4.6effects of treatment on weight and air permeability of sateen fabrics when exposed to dust

sample	material	Weight of m^2 (g)					
		Before treatment			After treatment		
		Before	After	%increase	Before	After	% increase
C	100 %Cotton	174	181	3.9	178	189	5.8
P	100%Polyester	173	181	4.4	176	185	4.9
P/C	50%cotton&50% polyester	196	205	4.4	205	215	4.7
sample	**material**	**Air permeability ($cm^3/s/cm^2$)**					
		Before treatment			**After treatment**		
		Before	After	%increase	Before	After	% increase
C	100 %Cotton	34.81	22.2	36.2	24.81	19.3	22.2
P	100%Polyester	37.60	30.5	18.9	26.45	22.0	16.8
P/C	50%cotton&50% polyester	29.55	20.7	29.9	29.55	22.5	23.9

4.7.1 Weight of m^2:

Table 4.6 shows the results of the weight of the untreated samples before and after being exposed to dust. The weight of all samples increased by 4%. The same table had shown the weight of treated samples before and after being exposed to dust. The weight of all samples increased as well by 5%.Because the treatment itself added some weight to the samples, therefore the amount of dust sticked to the treated fabrics is less than that sticked to the un treated fabrics. The results of table 4.6 are drawn in figure 4.37.

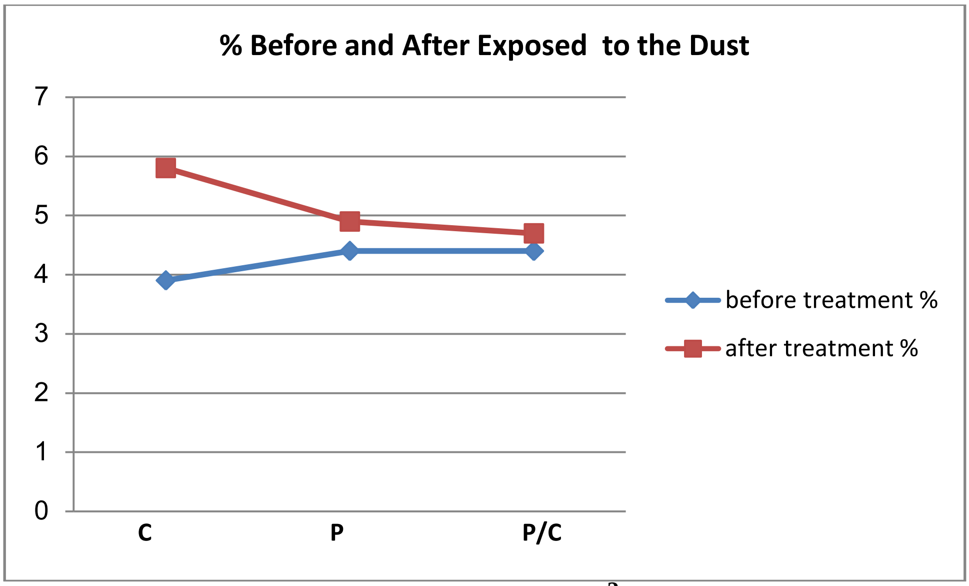


Figure 4.37Weight of m^2

4.7.2 Air Permeability

Table 4.6also shows the results of air permeability of the untreated samples before and after being exposed to dust.The air permeability decreased by 28% after being exposed to dust. As well table 4.6 shows the results of air permeability of the treated fabrics before and after being exposed to dust. For the treated fabrics the air permeability decreased by 20% after being exposed to dust. The porus become less when the material added to the samples during the treatment. The results are drawn in figure 4.38.

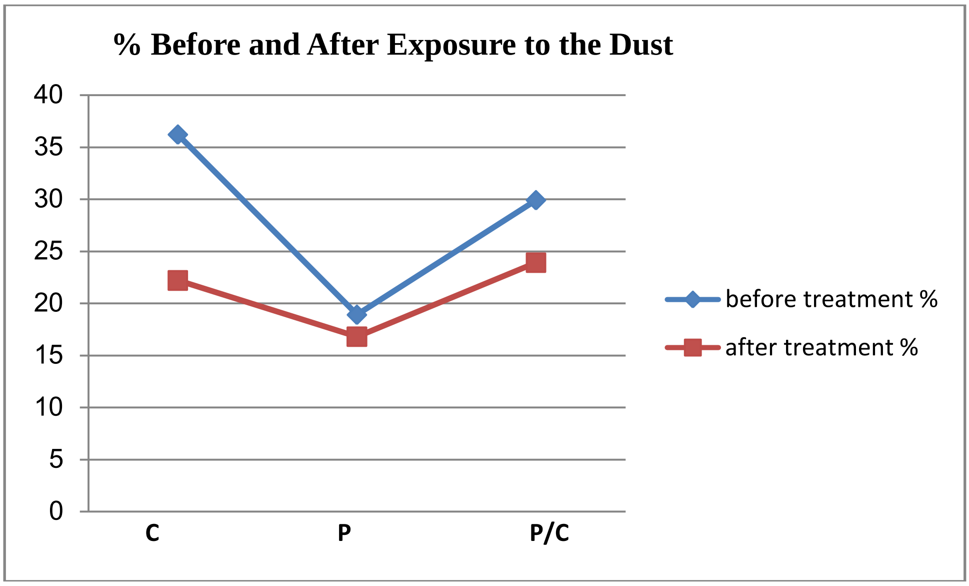


Figure 4.38Air Permeability

4.8 Effect of design (Plain, Twill and Sateen) fabrics when exposed to dust before and after treatment

4.8.1 Weight of m^2:-

The effects of design of fabrics on the weight are shown in figure Plain design fabric got the highest value after being treated and exposed todust. The process of treatment had added some weight to the fabrics.

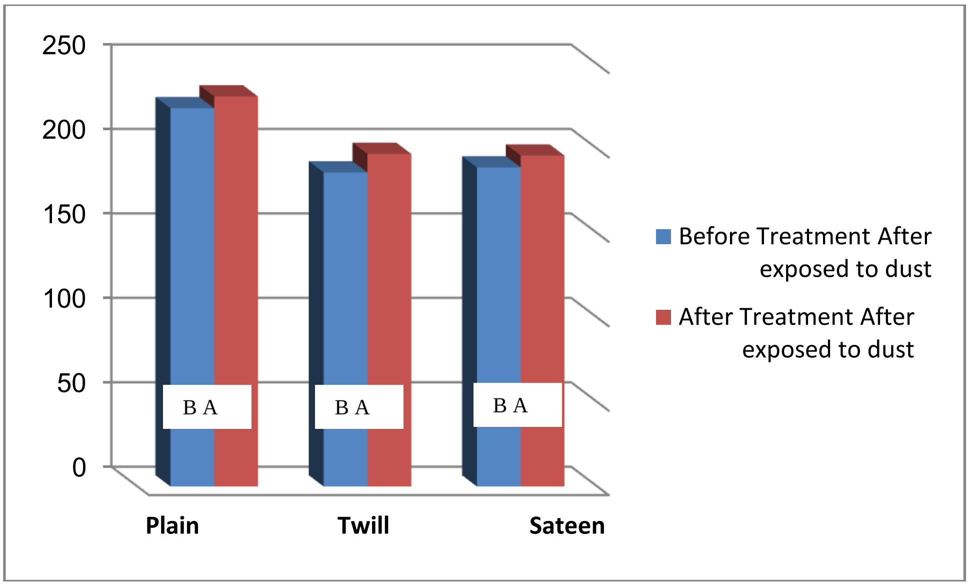


Figure 4.39Weight of m^2

4.8.2 Air Permeability

The results of the effects of design of fabrics on the property of air permeability before and after treatment when exposed to dust. Sateen design fabric got the maximum value when treated and exposed to dust. Because of its loose constructed design. The dust particles has deposited between the pores of the fabric. Plain weave got the lowest value due to its high compactness as shown in figure 4.40.

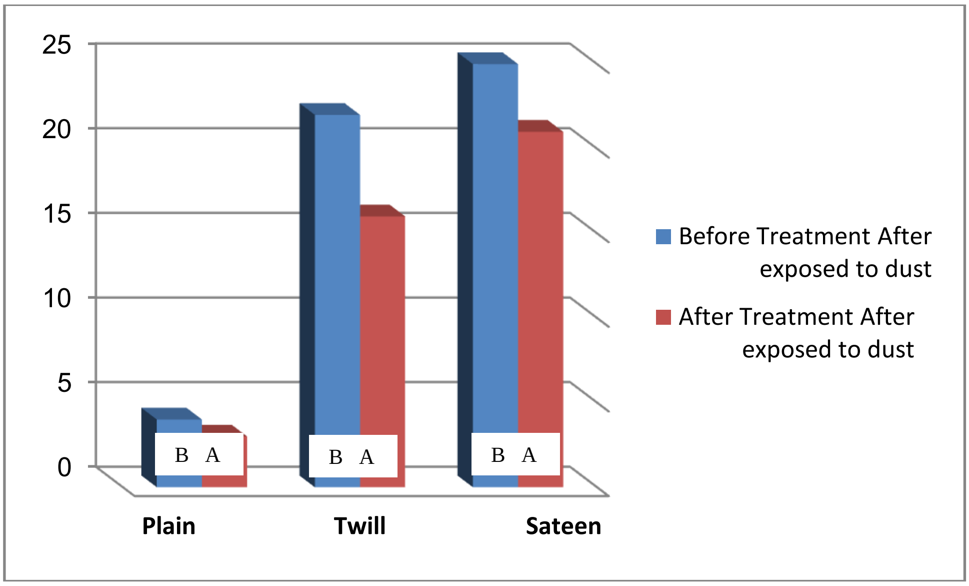


Figure 4.40Air Permeability

4.9 The Model of Tensile Strength

The tensile strength is considered to be as a function of elongation,:

$$Y = a + bX \qquad (4.1)$$

Where:
Y= Tensile strength.
X= Elongation
a and b = Constants

4.9.1 Model of Tensile Strength for plain design to Warp Way Before treatment

From the data given in table (4.7), the final tensile strength and elongation for warp way before treatment are calculated.

$$Y = 37 + 1.5X \qquad (4.2)$$

4.9.1.1 Validation of the proposed Model

The developed models were tested against actual values using data sets for testing. The accuracy and ability of each mentioned model for predicting tensile strength was checked with actual values and Table (4.7) and Figure(4.41)show this comparison.

Table 4.7 Validation of the proposed Model of Tensile Strength for plain design to Warp Way Before treatment

Tensile strength	Elongation	Predict values	E_i%
95	38	94	1.052632
93	38	94	-1.07527
97	40	97	0

Where $E_i$is the relative deviation of an estimated value from an experimental value.

$$E_i = \frac{[(x_{exp} - x_{est})]}{x_{exp}} \times 100 \qquad i = 1,2 \ldots \ldots . . n_d \text{B. } 2 \qquad \textbf{(4.3)}$$

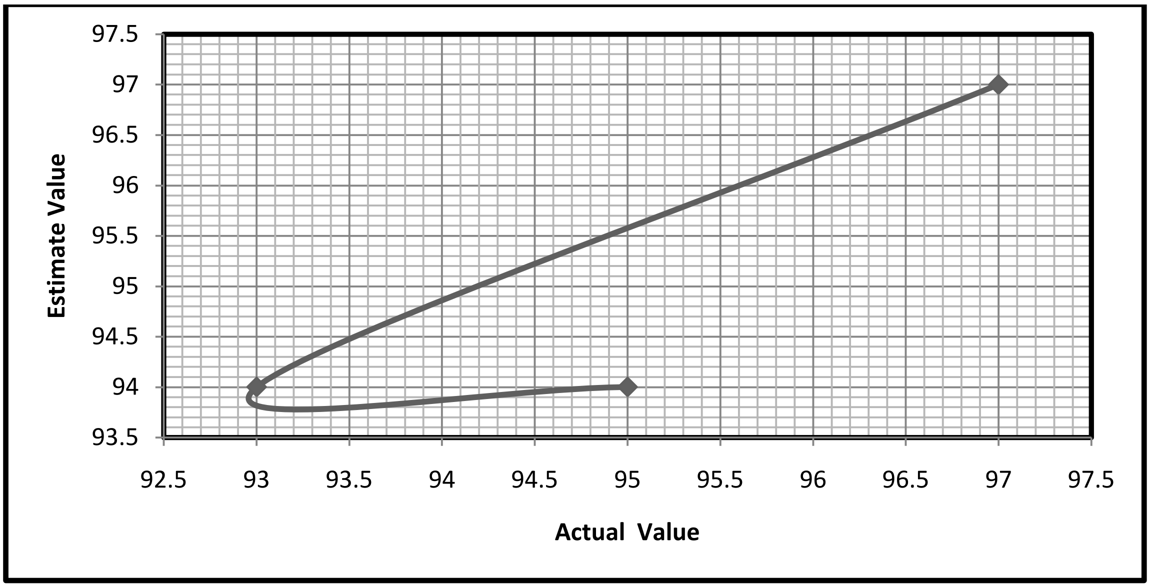


Figure 4.41Cross plot of Experimental Values versus Predicted Values from Proposed Model before treatment.

4.9.2 Model of Tensile Strength for Plain design to Weft Way

Before treatment

From the data given in table 4.8, the final tensile strength and elongation for weft way before treatment are calculated.

$$Y = 58.046 + 6.209X \qquad (4.4)$$

4.9.2.1 Validation of the proposed Model

The developed models were tested against actual values using data sets for testing. The accuracy and ability of each mentioned model for predicting tensile strength was checked with actual values and Table (4.8) and Figure (4.42) show this comparison.

Table 4.8Validation of the Proposed Model of Tensile Strength for Plain design to Weft Way Before treatment

Tensile strength	Elongation	Predict values	E_i%
37	15	35.09353	5.15262
90	22	78.55864	12.71262
59	21	72.34934	-22.62600

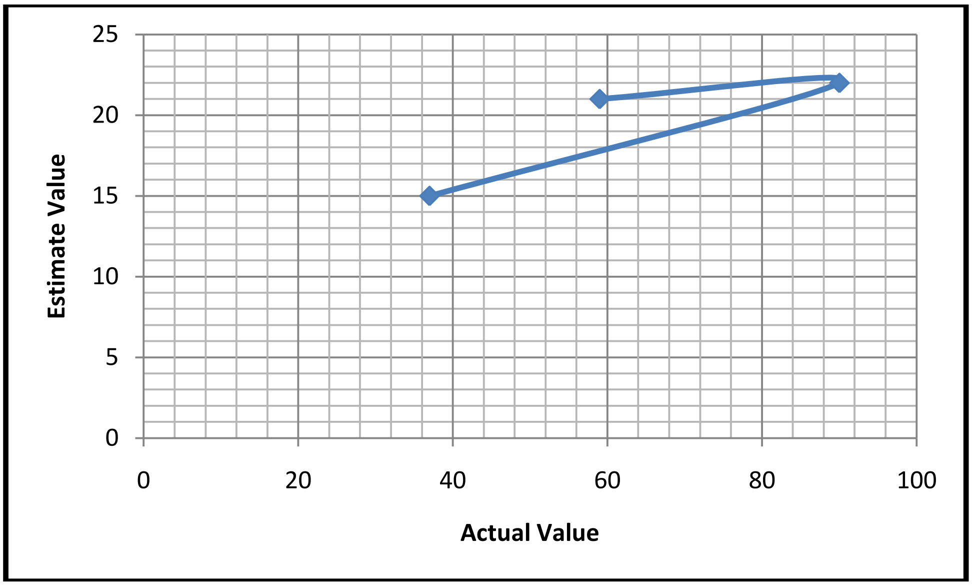


Figure 4.42Cross plot of Experimental Values versus Predicted Values from Proposed Model before treatment.

4.9.3 Model of Tensile Strength for twill design to warp way Before treatment

From the data given in Table (4.9), the final tensile strength and elongation for warp way before treatment are calculated.

$$Y = 105 \qquad (4.5)$$

4.9.3.1 Validation of the proposed Model

The developed models were tested against actual values using data sets for testing. The accuracy and ability of each mentioned model for predicting tensile strength was checked with actual values and Table (4.9) and Figure (4.43) show this comparison.

Table 4.9Validation of the proposed Model Tensile Strength for twill design Before treatment

Tensile strength	Elongation	Predict values	E_i%
110	28	105	4.545
100	28	105	-5.000
105	33	105	0.000

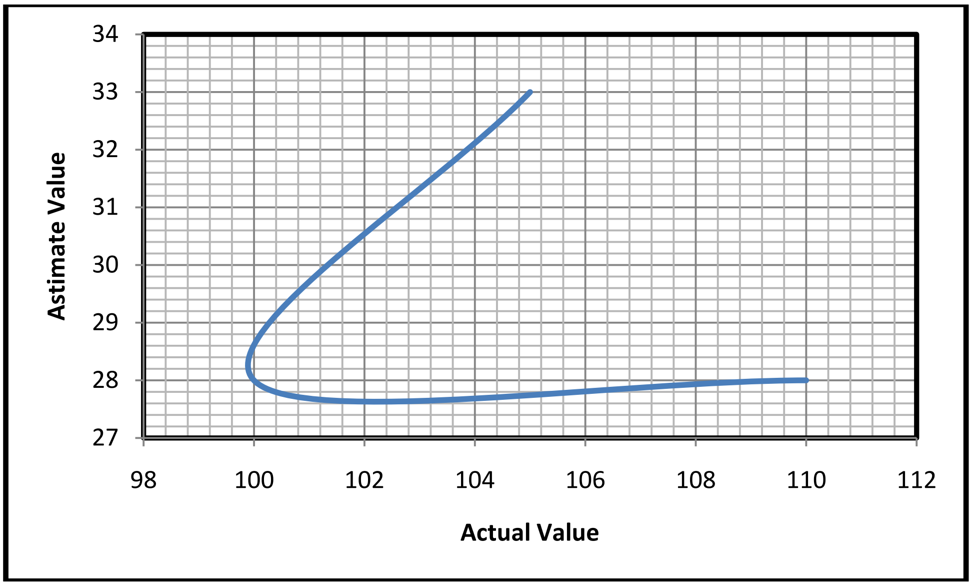


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Figure 4.43 Cross plot of Experimental Values versus Predicted Values from Proposed Model before treatment

4.9.4 Model of Tensile Strength for twill design to Weft way

Before treatment

From the data given in table (4.10), the final tensile strength and elongation for weft way before treatment are calculated.

$$Y = -145.432 + 9.892X \qquad (4.6)$$

4.9.4.1 Validation of the proposed Model

The developed models were tested against actual values using data sets for testing. The accuracy and ability of each mentioned model for predicting tensile strength was checked with actual values and Table (4.10) and Figure (4.44)show this comparison.

Table 4.10Validation of the proposed Model of Tensile Strength for twill design to Weft way Before treatment

Tensile strength	Elongation	Predict values	E_i%
25	17	22.7303	9.0788
95	24	91.9736	3.185684
57	21	62.2979	-9.29456

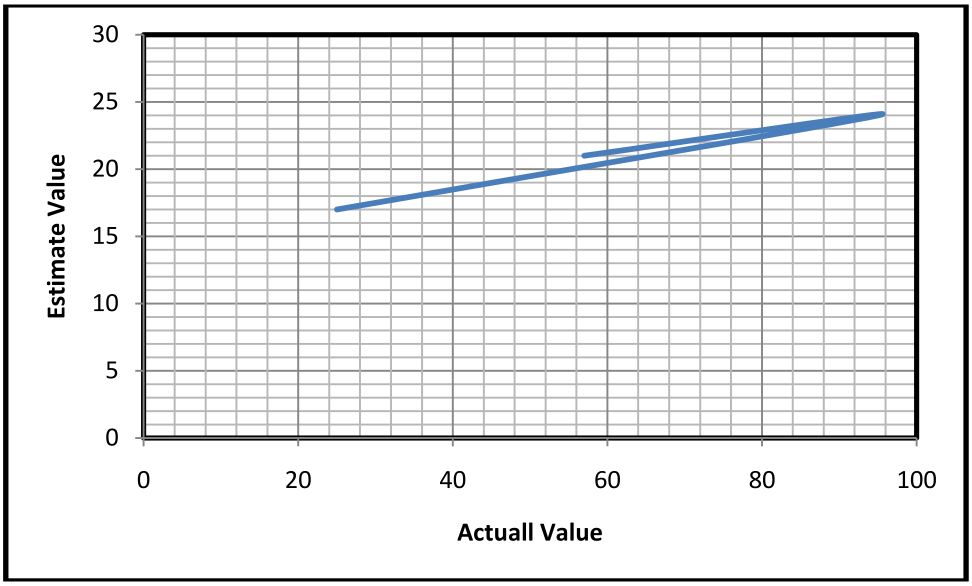

Figure 4.44Cross plot of Experimental Values versus Predicted Values from Proposed Model before treatment.

4.9.5 Model of Tensile Strength for sateen design to warp way

Before treatment

From the data given in table (4.11), the final tensile strength and elongation for warp way before treatment are calculated.

$$Y = 112.6282 - 0.19231X \qquad (4.7)$$

4.9.5.1 Validation of the proposed Model

The developed models were tested against actual values using data sets for testing. The accuracy and ability of each mentioned model for predicting tensile strength was checked with actual values and Table (4.11) and Figure (4.45) show this comparison.

Table 4.11Validation of the proposed Model of Tensile Strength for sateen design to warp way Before treatment

Tensile strength	Elongation	Predict values	E_i%
110	30	106.8589	2.855545
105	28	107.2435	-2.13669
105	35	105.8974	-0.85462

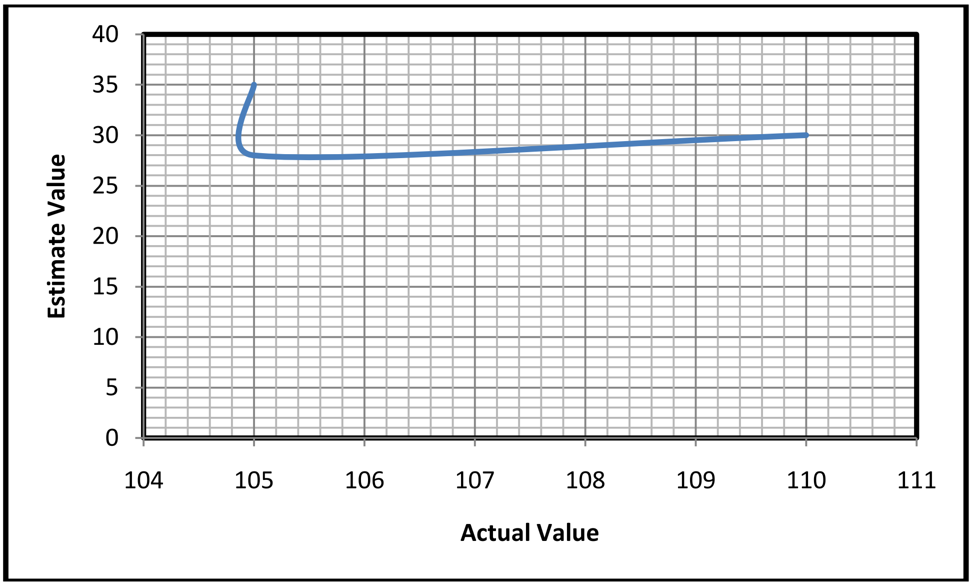

Figure 4.45Cross plot of Experimental Values versus Predicted Values from Proposed Model before treatment.

4.9.6 Model of Tensile Strength for sateen design to weft way

Before treatment

From the data given in table (4.12), the final tensile strength and elongation for weft way before treatment are calculated.

$$Y = 176.2857 - 5.57143X \qquad (4.8)$$

4.9.6.1 Validation of the proposed Model

The developed models were tested against actual values using data sets for testing. The accuracy and ability of each mentioned model for predicting tensile strength was checked with actual values and Table (4.12) and Figure (4.46)show this comparison.

Table 4.12 Validation of the proposed Model of Tensile Strength for sateen design to weft way Before treatment

Tensile strength	Elongation	Predict values	E_i%
40	20	64.8571	-62.1428
87	19	70.42853	19.04767
62	22	53.71424	13.36413

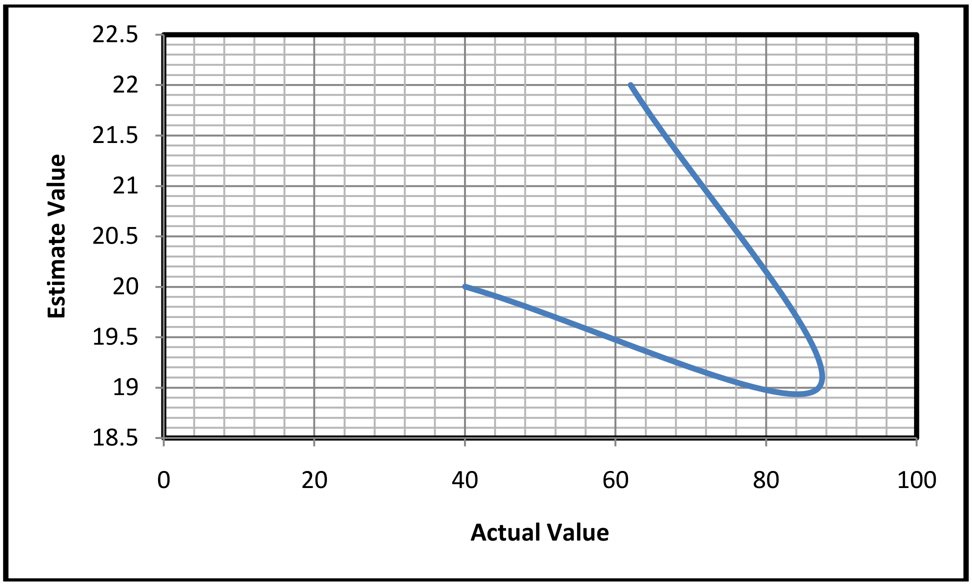

Figure 4.46Cross plot of Experimental Values versus Predicted Values from Proposed Model before treatment

4.9.7 Model of Tensile Strength for plain design to Warp Way After treatment

From the data given in table (4.13), the final tensile strength and elongation for warp way after treatment are calculated.

$$\boldsymbol{Y = 79 + 0.25X} \qquad \textbf{(4.9)}$$

4.9.7.1 Validation of the proposed Model

The developed models were tested against actual values using data sets for testing. The accuracy and ability of each mentioned model for predicting tensile strength was checked with actual values and Table (4.13) and Figure (4.47) show this comparison.

Table 4.13Validation of the proposed Model of Tensile Strength for plain design to Warp Way After treatment

Tensile strength	Elongation	Predict values	E_i%
90	30	86.5	3.888889
83	30	86.5	-4.21687
87	32	87	0

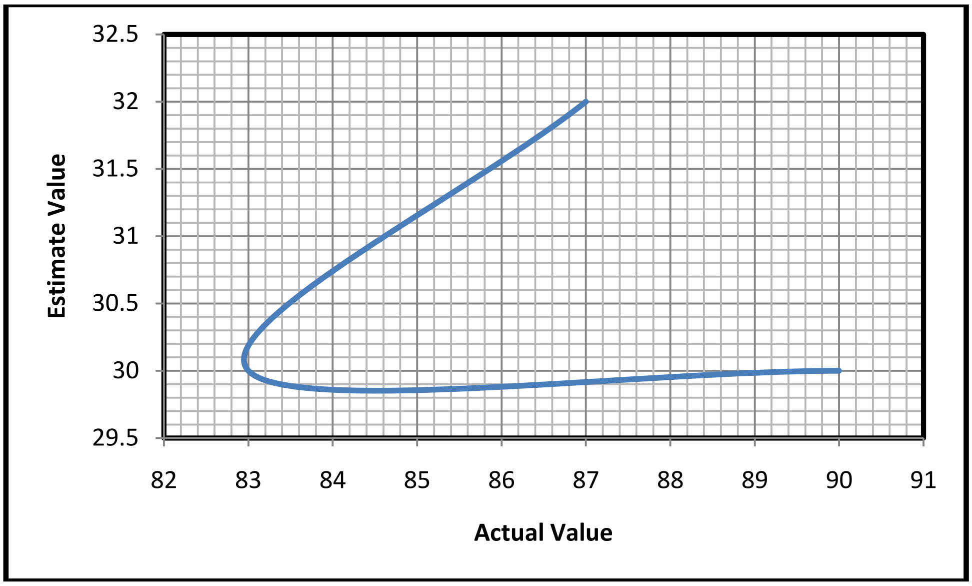

Figure 4.47Cross plot of Experimental Values versus Predicted Values from Proposed Model after treatment.

4.9.8 Model of Tensile Strength for plain design to weft Way After treatment

From the data given in table (4.14), the final tensile strength and elongation for weft way after treatment are calculated.

$$Y = -12.8571 + 5.071429X \qquad (4.10)$$

4.9.8.1 Validation of the proposed Model

The developed models were tested against actual values using data sets for testing. The accuracy and ability of each mentioned model for predicting tensile strength was checked with actual values and Table (4.14) and Figure (4.48) show this comparison.

Table 4.14Validation of the proposed Model of Tensile Strength for plain design to weft Way After treatment

Tensile strength	Elongation	Predict values	E_i%
40	10	37.85719	5.357025
115	25	113.9286	0.93163
60	15	63.21434	-5.35723

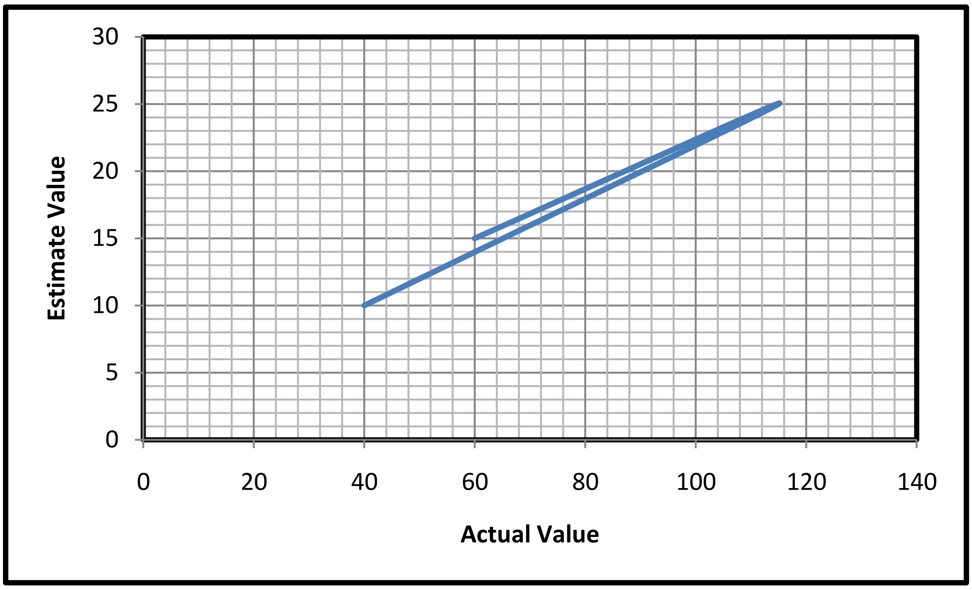

Figure 4.48Cross plot of Experimental Values versus Predicted Values from Proposed Model after treatment.

4.9.9 Model of Tensile Strength for twill design to warp Way After treatment

From the data given in table (4.15), the final tensile strength and elongation for warp way after treatment are calculated.

$$\boldsymbol{Y = 71.66667 + X} \qquad \textbf{(4.11)}$$

4.9.9.1 Validation of the proposed Model

The developed models were tested against actual values using data sets for testing. The accuracy and ability of each mentioned model for predicting tensile strength was checked with actual values and Table (4.15) and Figure (4.49) show this comparison.

Table 4.15Validation of the proposed Model of Tensile Strength for twill design to warp Way After treatment

Tensile strength	Elongation	Predict values	E_i%
95	23	94.66667	0.350874
97	25	96.66667	0.343639
95	24	95.66667	-0.70176

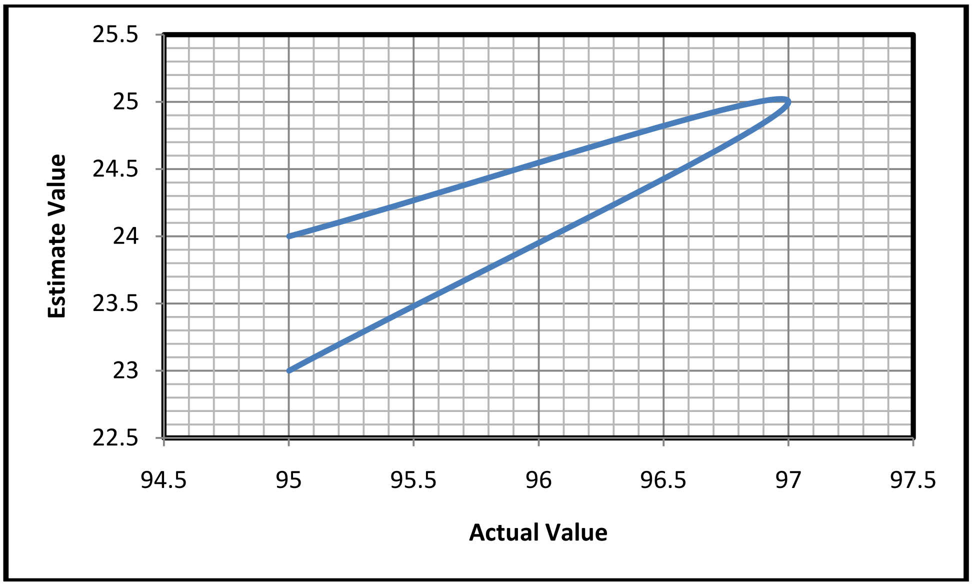

Figure 4.49Cross plot of Experimental Values versus Predicted Values from Proposed Model after treatment.

4.9.10Model of Tensile Strength for twill design to weft Way

After treatment

From the data given in table (4.16), the final tensile strength and elongation for weft way after treatment are calculated.

$$Y = -77.2857 + 8.2857X \qquad (4.12)$$

4.9.10.1 Validation of the proposed Model

The developed models were tested against actual values using data sets for testing. The accuracy and ability of each mentioned model for predicting tensile strength was checked with actual values and Table (4.16) and Figure (4.50)show this comparison.

Table 4.16Validation of the proposed Model of Tensile Strength for twill design to weft WayAfter treatment

Tensile strength	Elongation	Predict values	E_i%
30	15	46.9998	-56.666
105	22	104.9997	0.000286
64	15	46.9998	26.56281

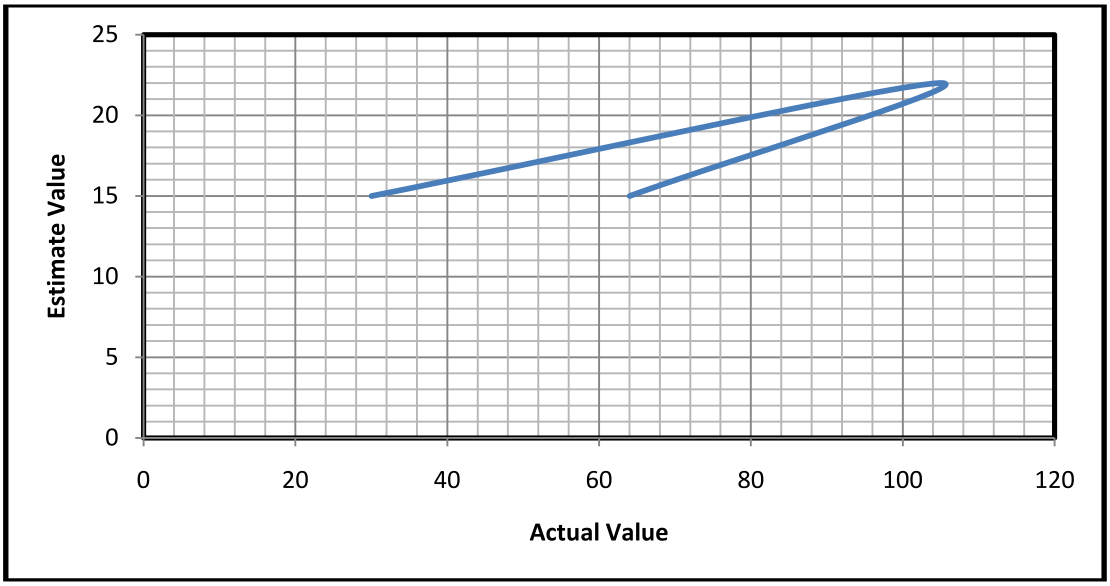

Figure 4.50Cross plot of Experimental Values versus Predicted Values from Proposed Model after treatment.

4.9.11Model of Tensile Strength for sateen design to warp Way After treatment

From the data given in table (4.17), the final tensile strength and elongation for warp way after treatment are calculated.

$$\boldsymbol{Y = 85.25641 + 0.384615X} \qquad \textbf{(4.13)}$$

4.9.11.1 Validation of the proposed Model

The developed models were tested against actual values using data sets for testing. The accuracy and ability of each mentioned model for predicting tensile strength was checked with actual values and Table (4.17) and Figure (4.51) show this comparison.

Table 4.17Validation of the proposed Model of Tensile Strength for sateen design to warp Way After treatment

Tensile strength	Elongation	Predict values	E_i%
100	18	92.17948	7.82052
82	20	92.94871	-13.3521
98	25	94.87179	3.192056

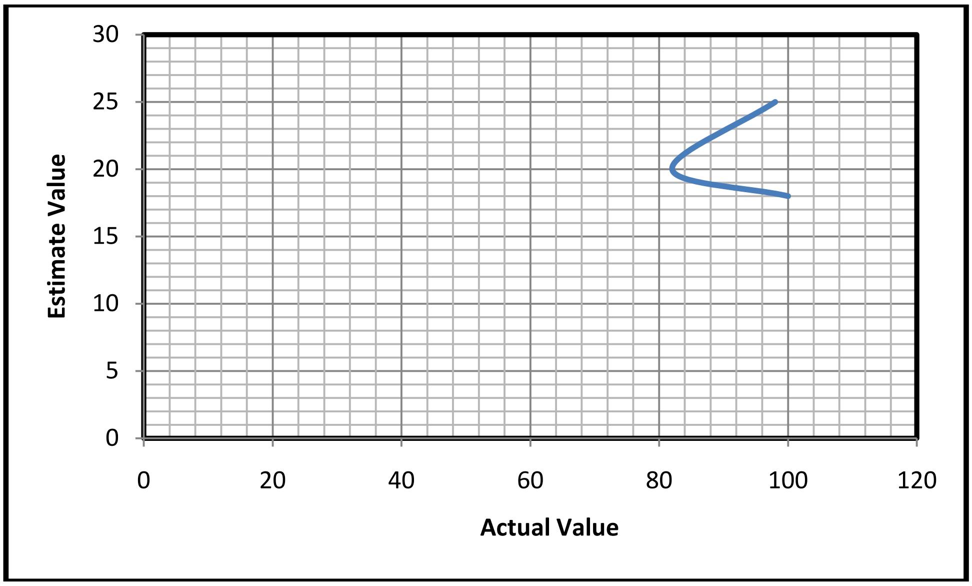

Figure 4.51Cross plot of Experimental Values versus Predicted Values from Proposed Model after treatment.

4.9.12Model of Tensile Strength for sateen design to weft Way After treatment

From the data given in table (4.18), the final tensile strength and elongation for weft way after treatment are calculated.

$$Y = -35.9184 + 6.122449X \qquad (4.14)$$

4.9.12.1 Validation of the proposed Model

The developed models were tested against actual values using data sets for testing. The accuracy and ability of each mentioned model for predicting tensile strength was checked with actual values and Table (4.18) and Figure (4.52) Show this comparison.

Table 4.18Validation of the proposed Model of Tensile Strength for sateen design to weft Way After treatment

Tensile strength	Elongation	Predict values	E_i%
35	12	37.55099	-7.28854
85	20	86.53058	-1.80068
60	15	55.91834	6.802775

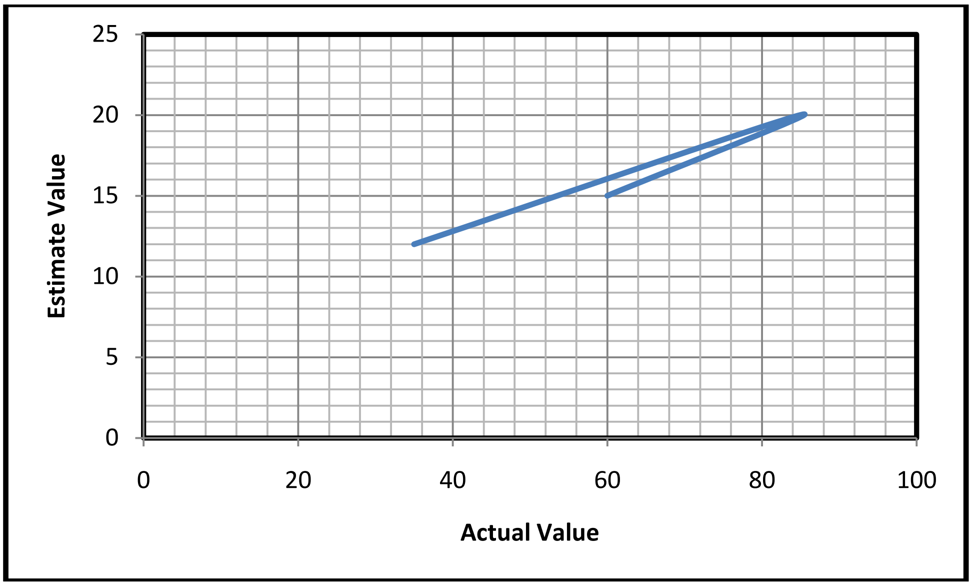

Figure 4.52 Cross plot of Experimental Values versus Predicted Values from Proposed Model after treatment.

Table 4.19The results of tests of nine samples fabric before and after treatment with chemicals to resist adhesion dust the surface of the fabric

Samples / Test Conditions		100% Cotton						100% Polyester					
		Plain		Twill		Sateen		Plain		Twill		Sateen	
Pulses /min		3		3		3		3		3		3	
Powder Weight (gm)		10		10		10		10		10		10	
Room Volume (m^3)		0.1875		0.1875		0.1875		0.1875		0.1875		0.1875	
Powder Concentration (g/m^3)		40		40		40		40		40		40	
Pressure (bar)		5		5		5		5		5		5	
Pressure Drop (mbar)		18		18		18		18		18		18	
Test Time (S)		300		300		300		300		300		300	
Pulse Time (S)		1		1		1		1		1		1	
		Bef.	Aft.	Bef.	Aft.	Bef.	Aft.	Bef.	Aft.	Bef.	Aft.	Bef.	Aft.
Residual powder %		47.3	98.5	47.0	97.2	45.7	97.4	45.3	94.8	46.9	98.0	45.8	97.1
Sample weight (gm/m^2)	Before Test	175	181	174	178	174	178	186	195	177	183	173	176
	After Test	191	196	190	192	181	189	271	280	185	190	181	185
	Change %	8.4	7.7	8.4	7.3	3.9	5.8	31.4	30.4	4.3	3.7	4.4	4.9
Sample air permeability (cm/cm2.sce) @ 12.5 mm WG	Before Test	8.7	7.7	32.3	24	34.8	24.8	4.3	3.14	35	21.7	37.6	26.5
	After Test	4.8	4.0	21.3	17	22.2	19.3	2.8	1.8	23.5	14.1	30.5	22.0
	Change %	44.8	48.1	34.1	28.9	36.2	22.2	34.9	42.7	32.9	26.3	18.9	17.0

Continued Table 4.19The results of tests of nine samples fabric before and after treatment with chemicals to resist adhesion dust the surface of the fabric

Samples / Test Conditions		50% Cotton&50% Polyester					
		Plain		Twill		Sateen	
Pulses /min		3		3		3	
Powder Weight (gm)		10		10		10	
Room Volume (m3)		0.1875		0.1875		0.1875	
Powder Concentration (g/m3)		40		40		40	
Pressure (bar)		5		5		5	
Pressure Drop (mbar)		18		18		18	
Test Time (S)		300		300		300	
Pulse Time (S)		1		1		1	
		Bef.	Aft.	Bef.	Aft.	Bef.	Aft.
Residual powder %		46.0	97.5	46.16	97.2	46.96	97.7
Sample weight (gm/m^2)	Before Test	200	207	176	201	196	205
	After Test	210	217	183	208	205	215
	Change %	4.8	4.6	3.1	3.4	4.4	4.7
Sample air permeability (cm/cm2.sce) @ 12.5 mm WG	Before Test	7.1	5.4	28.5	19.7	29.6	29.6
	After Test	5.1	3.5	19.7	14	20.7	22.5
	Change %	28.2	35.2	31	28.9	30.1	24

Chapter (5)

Conclusions and Future Work

Chapter (5)

5 Conclusions and Future Work

5.1 Conclusions

The wind load with sand and dust blows periodically during the year in Sudan. The dust affects the dresses of the Sudanese people and thus affects negatively the economics of the families.

This study finds solution to the dresses to enhance their abilities to expel the dust when they are exposed to the main objective of this study is to produce an anti dust fabrics suitable for manufacturing Sudanese dresses (GALABYA) to stand the dusty weather.

Three materials of fabrics are used in the study namely; 100%cotton, 100% polyester and a blend of 50%cotton and 50% polyester. These materials are woven into three fabric designs namely; plain, twill and sateen. Tests are carried out to investigate the changes of the physical and mechanical properties of the fabrics before and after the chemical treatment. As well the changes before and after being exposed to dust are investigated in this study.

The study shows that the 100%polyester fabric got the highest values of tensile strength after the treatment. The weight of all samples used increased after the treatment as well.

It was found that the thickness of all the samples has decreased after the chemical treatment.

It was noticed that all fabrics become less porus after the chemical treatment, therefore the air permeability has decreased.

The plain fabric in the weft direction got the highest value in tensile strength, while the twill fabric got the highest elongation in the weft direction after the treatment.

Sateen weave got the highest value of air permeability before and after treatment, while the plain weave got the lowest value of air permeability before and after treatment.

It was found that the 100% cotton plain fabric got the maximum expelling 98.5% efficiency while the 100% polyester twill fabric 98% comes next and the blend of 50%cotton and 50% polyester sateen fabric comes third 97.7%.

In the study the woven fabrics are chemically treated to become anti dust fabrics.

After the chemical treatment of the fabrics against dust. It was found that the efficiency of expelling dust has improved by 97%.

5.2 Future work:

For future work, nonwoven and knitted fabrics should be investigated for the property of expelling dust. Other materials and designs should be tested for this property by the other researchers in the future.

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Appendix A

A. Appendix (A)

A.1 Work Sheet to Develop model for predicting tensile strength before treatment

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.866025
R Square	0.75
Adjusted R Square	0.5
Standard Error	1.414214
Observations	3

ANOVA

	Df	*SS*	*MS*	*F*	*Significance F*
Regression	1	6	6	3	0.333333
Residual	1	2	2		
Total	2	8			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	37	33.49627	1.104601	0.468385	-388.61	462.6104	-388.61	462.6104
X Variable 1	1.5	0.866025	1.732051	0.333333	-9.5039	12.5039	-9.5039	12.5039

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*
1	94	1
2	94	-1
3	97	0

A.2Work Sheet to Develop model for predicting tensile strength before treatment

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.882863
R Square	0.779447
Adjusted R Square	0.558894
Standard Error	17.68457
Observations	3

ANOVA

	Df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1105.256	1105.256	3.534057	0.311226
Residual	1	312.7442	312.7442		
Total	2	1418			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-58.0465	64.66873	-0.8976	0.534321	-879.741	763.6476	-879.741	763.6476
X Variable 1	6.209302	3.302981	1.879909	0.311226	-35.759	48.17765	-35.759	48.17765

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*
1	35.09302	1.906977
2	78.55814	11.44186
3	72.34884	-13.3488

A.3 Work Sheet to Develop model for predicting tensile strength before treatment

SUMMARY OUTPUT

Regression Statistics	
Multiple R	65535
R Square	-1.4E-16
Adjusted R Square	-1
Standard Error	7.071068
Observations	3

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	-7.1E-15	-7.1E-15	-1.4E-16	#NUM!
Residual	1	50	50		
Total	2	50			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	105	51.5461	2.037012	0.290524	-549.955	759.9552	-549.955	759.9552
X Variable 1	0	1.732051	0	1	-22.0078	22.00779	-22.0078	22.00779

RESIDUAL OUTPUT

Observation	Predicted Y	Residuals
1	105	5
2	105	-5
3	105	0

A.4 Work Sheet to Develop model for predicting tensile strength before treatment

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.991335
R Square	0.982745
Adjusted R Square	0.96549
Standard Error	6.509868
Observations	3

ANOVA

	df	SS	MS	F	Significance F
Regression	1	2413.622	2413.622	56.95408	0.083868

Residual	1	42.37838	42.37838
Total	2	2456	

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-145.432	27.34815	-5.31782	0.118333	-492.924	202.0587	-492.924	202.0587
X Variable 1	9.891892	1.310741	7.546793	0.083868	-6.76265	26.54644	-6.76265	26.54644

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*
1	22.72973	2.27027
2	91.97297	3.027027
3	62.2973	-5.2973

A.5Work Sheet to Develop model for predicting tensile strength before treatment

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.240192
R Square	0.057692
Adjusted R Square	-0.88462
Standard Error	3.96297
Observations	3

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.961538	0.961538	0.061224	0.845579
Residual	1	15.70513	15.70513		
Total	2	16.66667			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	112.6282	24.20167	4.653737	0.134749	-194.883	420.1396	-194.883	420.1396
X Variable 1	-0.19231	0.777202	-0.24744	0.845579	-10.0676	9.682984	-10.0676	9.682984

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*
1	106.859	3.141026
2	107.2436	-2.24359
3	105.8974	-0.89744

A.6Work Sheet to Develop model for predicting tensile strength before treatment

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.361903
R Square	0.130974
Adjusted R Square	-0.73805
Standard Error	31.0023
Observations	3

ANOVA

	df	SS	MS	F	Significance F
Regression	1	144.8571	144.8571	0.150713	0.764254
Residual	1	961.1429	961.1429		
Total	2	1106			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	176.2857	292.3578	0.602979	0.654565	-3538.47	3891.043	-3538.47	3891.043
X Variable 1	-5.57143	14.35128	-0.38822	0.764254	-187.922	176.7788	-187.922	176.7788

RESIDUAL OUTPUT

Observation	Predicted Y	Residuals
1	64.85714	-24.8571
2	70.42857	16.57143
3	53.71429	8.285714

A.7Work Sheet to Develop model for predicting tensile strength after treatment

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.082199
R Square	0.006757
Adjusted R Square	-0.98649

Standard Error	4.949747
Observations	3

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.166667	0.166667	0.006803	0.947611
Residual	1	24.5	24.5		
Total	2	24.66667			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	79	92.99731	0.849487	0.551695	-1102.64	1260.643	-1102.64	1260.63
X Variable 1	0.25	3.031089	0.082479	0.947611	-38.2636	38.76364	-38.2636	38.7634

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*
1	86.5	3.5
2	86.5	-3.5
3	87	0

A.8 Work Sheet to Develop model for predicting tensile strength after treatment

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.997333
R Square	0.994672
Adjusted R Square	0.989345
Standard Error	4.008919
Observations	3

ANOVA

	df	SS	MS	F	Significance F
Regression	1	3000.595	3000.595	186.7037	0.046508
Residual	1	16.07143	16.07143		
Total	2	3016.667			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-12.8571	6.604729	-1.94666	0.302107	-96.7782	71.0639	-96.7782	71.0639
X Variable 1	5.071429	0.371154	13.66396	0.046508	0.355473	9.787384	0.355473	9.787384

RESIDUAL OUTPUT

Observation	Predicted Y	Residuals
1	37.85714	2.142857

2	113.9286	1.071429
3	63.21429	-3.21429

A.9 Work Sheet to Develop model for predicting tensile strength after treatment

SUMMARYOUTPUT

Regression Statistics	
Multiple R	0.866025
R Square	0.75
Adjusted R Square	0.5
Standard Error	0.816497
Observations	3

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	2	2	3	0.333333
Residual	1	0.666667	0.666667		
Total	2	2.666667			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	71.66667	13.86442	5.169106	0.121656	-104.498	247.8309	-104.498	247.8309
X Variable 1	1	0.57735	1.732051	0.333333	-6.33593	8.335931	-6.33593	8.335931

RESIDUAL OUTPUT

Observation	Predicted Y	Residuals
1	94.66667	0.333333
2	96.66667	0.333333
3	95.66667	-0.66667

A.10 Work Sheet to Develop model for predicting tensile strength after treatment

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.891675
R Square	0.795084
Adjusted R Square	0.590168
Standard Error	24.04163
Observations	3

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	2242.667	2242.667	3.880046	0.299062
Residual	1	578	578		
Total	2	2820.667			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-77.2857	74.22058	-1.0413	0.487122	-1020.35	865.7761	-1020.35	865.7761
X Variable 1	8.285714	4.206409	1.969783	0.299062	-45.1618	61.73321	-45.1618	61.73321

RESIDUAL OUTPUT

Observation	Predicted Y	Residuals
1	47	-17
2	105	-1.4E-14
3	47	17

A.11Work Sheet to Develop model for predicting tensile strength after treatment

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.140562
R Square	0.019758
Adjusted R Square	-0.96048
Standard Error	13.81378
Observations	3

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	3.846154	3.846154	0.020156	0.910218
Residual	1	190.8205	190.8205		
Total	2	194.6667			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	85.25641	57.44751	1.484075	0.377477	-644.683	815.1962	-644.683	815.1962

X Variable 1	0.384615	2.709105	0.141971	0.910218	-34.0378	34.80706	-34.0378	34.80706

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*
1	92.17949	7.820513
2	92.94872	-10.9487
3	94.87179	3.128205

A.12Work Sheet to Develop model for predicting tensile strength after treatment

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.989743
R Square	0.979592
Adjusted R Square	0.959184
Standard Error	5.050763
Observations	3

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1224.49	1224.49	48	0.091258
Residual	1	25.5102	25.5102		
Total	2	1250			

	Coefficients	*Standard*	*t Stat*	*P-value*	*Lower 95%*	*Upper*	*Lower*	*Upper*

		Error				95%	95.0%	95.0%
Intercept	-35.9184	14.14839	-2.53869	0.238885	-215.691	143.854	-215.691	143.854
X Variable 1	6.122449	0.883699	6.928203	0.091258	-5.10602	17.35091	-5.10602	17.35091

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*
1	37.55102	-2.55102
2	86.53061	-1.53061
3	55.91837	4.081633