STUDY THE PHYSICAL PROPERTIES OF THERMAL BONDED NONWOVEN FABRICS PRODUCED FROM ALKALINE TREATED AND UNTREATEED POLYESTER STAPLE FIBER

A PROJECT REPORT

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BONAFIDE CERTIFICATE

Certified that this project report "**STUDY THE PHYSICAL PROPERTIES OF THERMAL BONDED NONWOVEN FABRICS PRODUCED FROM ALKALINE TREATED AND UNTREATEED POLYESTER STAPLE FIBER**" is the bonafide work of "**S.GEETHANJALI, M.SHANJEEV, G.VIJESHKUMAR & V.INDRAJITH**" who Carried out the project work under my supervision.
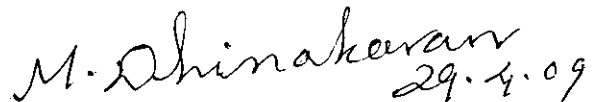
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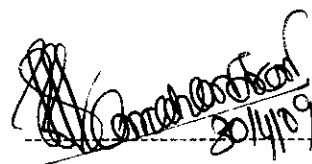
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II

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ABSTRACT

In today world of fashion, textile material occupies primary importance and thinking from standpoint of human needs textile materials are preferably called as second skin to human. In such case textile material should be comfortable and compatible for day to day activities of mankind. Textile fibers used for fabrication are broadly classified under natural and synthetic base. Synthetic fibers such as Polyester are known for their Easy care and Functional properties. The polyester staple fibers of the present innovation may be hollow fibers or non- hollow fibers.

Polyester fibers have excellent mechanical properties and resistance to chemicals, and therefore they are widely employed for non woven fabrics. The non woven fabric formed from the polyester staple hollow fibers of the present invention alone exhibits a specific soft hand other than that of the non woven fabric comprising the conventional PET staple fibers. Here Polyester non-woven fabrics produced from Hollow, Non-Silconise staple fibers were treated with aqueous solution of different concentrations like 4%, 6% and 8% at 70°C for 30 min . The physical and performance test for different concentrations are conducted to study their comfort properties.

IV

TABLE OF CONTENTS

IAPTER NO.	TITLE	PAGE NO

LITERATURE REVIEW

\

1. INTRODUCTION

In 1996, 24.1 million metric tones of manmade were produced worldwide. 75% of the entire Polyester production is directed toward fiber manufacturing. Hoechst, DuPont & Eastman are the world's largest polyester producers in the world. The cost of polyester, with the combination of its superior strength and resilience is lower than that of rayon. Polyester fibers are hydrophobic, which is desirable for light weight facing fabrics used in the disposable industry. As new methods of processing and bonding of PET are developed, rayon is being replaced by polyester on the market. Polyester has become the most widely used polymer in the non woven industry since 1995.

Progress has been observed in PET synthesis technology and production and use of PES textile and industrial yarn and staple fiber, particularly for creating nonwovens by the melt and textile methods.

1.1. GENERAL POLYESTER FIBER CHARECTERISTICS;

1. Strong

2. Resistant to stretching & shrinking

3. Resistant to most chemicals, Easily washable

4. Quick drying, Wrinkle resistant, Mildew resistant

5. Crisp & resilient

6. Abrasion resistant

7. Retains heat-set pleats & crease

1.2 WORLDS PRODUCTION OF POLYESTER FIBERS
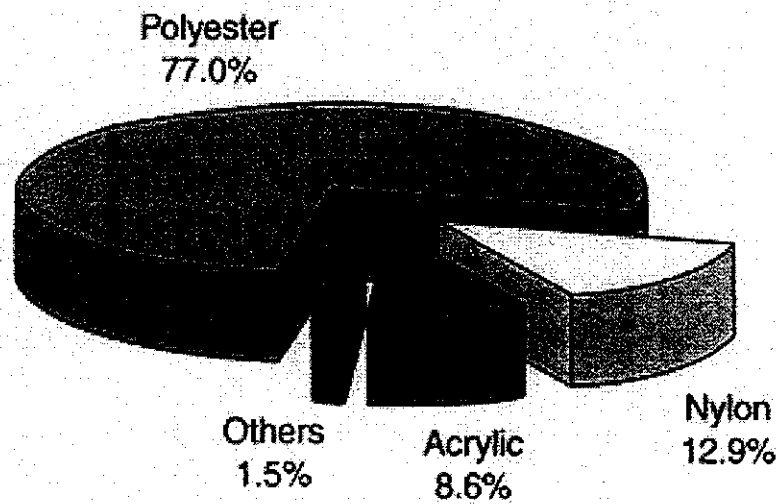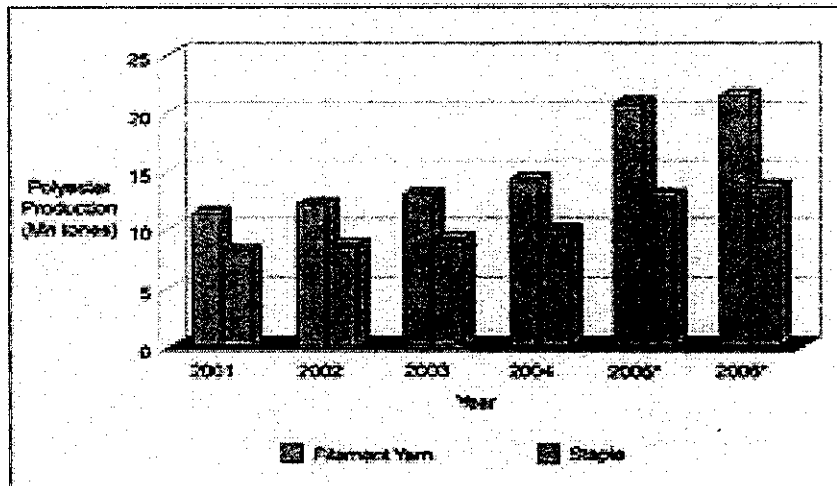
1.3 NON WOVENS

Nonwovens are a sheet, web, or bat of natural and/or man-made fibers or filaments, excluding paper, that have not been converted into yarns, and that are bonded to each other by any of several means. The mechanical properties of non woven fabrics depend on many parameters including, fiber properties, web structure, processing.

Nonwoven fabrics are broadly defined as sheet or web structures bonded together by entangling fiber or filaments (and by perforating films) **mechanically, thermally or chemically**. They are flat, porous sheets that are made directly from separate fibers or from molten plastic or plastic film. They are not made by weaving or knitting and do not require converting the fibers to yarn.

Nonwoven fabrics are engineered fabrics that may be a limited life, single-use fabric or a very durable fabric. Nonwoven fabrics provide specific functions such as absorbency, liquid repellency, resilience, stretch, softness, strength, flame retardence, wash ability, cushioning, filtering, bacterial barrier and sterility. These properties are often combined to create fabrics suited for specific jobs, while achieving a good balance between product use-life and cost. They can mimic the appearance, texture and strength of a woven fabric and can be as bulky as the thickest padding's. In combination with other materials they provide a spectrum of products with diverse properties, and are used alone or as components of apparel, home furnishings, health care, engineering, industrial and consumer goods.

1.3.1. Listed below are some of the more familiar products made with nonwovens:

- Disposable diapers, sanitary napkins & tampons

- Sterile wraps, caps, gowns, masks and draping used in the medical field

- Household and personal wipes

- Laundry aids (fabric dryer-sheets)

- Apparel interlining

- Carpeting and upholstery fabrics, padding and backing

- Agricultural coverings and seed strips

- Automotive headliners and upholstery

- Filters

- Tags and labels

- Civil engineering fabrics/Geo textile.

1.4. THERMO – BONDING

1.4.1. INTRODUCTION

The first thermally bonded nonwovens were produced in 1940s. Initial products used rayon as the carrier fiber and plasticized cellulose acetate (PCA) or vinyl chloride (PVC) as the binder fiber. The viability of the thermal bonding process is rooted in the price advantage obtained by lower energy costs. However, the thermal bonding process also addresses the demanding quality requirements of the market place. The development of new raw materials, better web formation technologies and higher production speeds have made thermal bonding a viable process for the manufacture of both durable and disposable nonwovens. The development of the past few years has shown that the share of thermally bonded webs is growing steadily.

1.5. BINDERS

Many materials that can be used as a binder for thermally bonded nonwovens.

- Binding fibers

- Binding powder

- Binding web

The following are the essential characteristics of the binder polymer:

- Efficient melt flow

- Good adhesion to the carrier fiber

- Lower melting point than the carrier fiber

- Desired stiffness or elasticity.

1.5.1. BINDING FIBERS

Single-component and bi-component fibers, as binder fibers, are most widely used in thermal bonding of nonwovens. Single-component fibers are the least sophisticated and most economical because the fibers are often already in existence and low in cost. The type bond that is formed is dependent on several factors including fiber chemistry, morphology, linear density, staple length, crimp, and processing conditions. The major disadvantage encountered when using 100 percent single-component fibers is the narrow temperature range that is necessary when thermal bonding. If the temperature is too low, there is inadequate bond strength. If the temperature is too high, the web will melt excessively and lose its identity as a web.

When bi-component fibers are used to produce thermal bonded nonwoven, the acceptable temperature range for bonding may be as great as 25°C. When thermal bonding, the high melting portion of the fiber maintains the integrity of the web, while the low melting point portion melts and will

bond with other fibers at the fiber crossover points. The product produced tends to have bulk and exceptional softness.

1.5.2. BINDING POWDER

Powdered polymers are sometimes used in thermal bonding of nonwovens. The most prevalent use is powdered polyethylene. The powder can be applied between layers of fibers when cross-laying, air laying, or as an after treatment. A short exposure in an oven is sufficient to melt and fuse the powder. It is often used when a light weight and open structure is required with a soft hand or when a reinforced, molded product is necessary.

1.5.3. BINDING WEB

A very open-structured, low-melting-point thermoplastic fabric is placed between the webs and, during thermal bonding between the calendar rolls, the fabric melts completely bonding the webs together. The nonwoven produced by this technique is soft and bulky. Thermoplastic coatings and hot melt print bonding have been used to a limited extent in controlled porosity filters, impermeable membranes and other items. However, the use of this method of bonding is not expected to achieve a high level of importance.

1.6. METHODS OF THERMAL BONDING

- Hot calendaring

- Belt calendaring

- Through-air thermal bonding

- Ultrasonic bonding

- Radiant-heat bonding, etc.

1.6.1. HOT CALENDERING

There are three main types of hot calendaring.

- Area bonding

- Point bonding

- Embossing.

1.6.2 AREA BONDING

This process involves the use of a calendar with a hot metal roll opposed by a wool felt, cotton or special composition roll. Two, three or four roll calendars can be used, depending on the weight of the web to be bonded and the degree of bonding desired. The three-roll calendar has the heated roll in the middle while the four-roll configuration has the heated rolls on the top and bottom, with the two composition roll in the middle. The amorphous or co-polymeric binder fibers used in this process provide bonding at all cross-over points between the carrier and binder fibers. The resultant product - commonly used in electrical insulation and coating substrates - is smooth, thin and stiff. The material is always two sided, but this effect is most apparent in material processed through two and three roll calendars. Four roll calendars minimize this effect.

The application of heat from the outside produces a material whose inner area is less bonded than its outer surface. This becomes more pronounced as the product weight increases beyond 35 g/m^2 and can become detrimental unless corrective measures are taken. These include increasing heat, slowing speed, or increasing the binder/carrier fiber ratio. The two-roll calendar is used for low-to-medium weight products with light-to- medium bonding. The three-roll calendar is used for special bonding and finish effects

on a single surface. The four roll calendar produces the widest weight range of materials because it provides more flexibility in the application of heat.

Area-bond hot calendaring is influenced by five factors:

- **Heat**

  Bonding occurs at the surface of the metal roll, which obtains its heat by conduction from heated oil circulated through its center or from restrictive heating. The composition rolls obtain their heat from contact with the heated metal roll. Before the start of a production run, the roll stacks are operated until the composition rolls achieve dynamic heat equilibrium.

- **Pressure**

  Bonding occurs through simultaneous application of heat and pressure. The heat causes the fiber binder to become thermoplastic. The pressure enhances mechanical bonding by forcing the binder polymer to flow in and around the carrier fibers.

- **Speed**

  The speed at which the nonwoven passes through the calendar, combined with heat and pressure conditions, determines the degree of bonding in the nonwoven. It also determines the throughput rate of the entire nonwoven line and is a critical factor in product cost. The faster the rate, the lower is the cost. This is the primary reason for the recent development of lower melting binders.

Roll combination.

The only practical roll combination for area bonding is a metal roll-felt roll. The metal roll applies the heat. The surface resilience of the felt roll enables uniform application of pressure to all the minute surface thickness variations throughout the product.

Cooling rolls

The product is warm and thermoplastic as it leaves the calendar nip. If the product were to be wound while it was still hot, the tension applied to eliminate wrinkles would stretch the web and introduce unrelieved stresses. This would lead to shrinkage whenever post-heat treatments were used. A set of two cooling rolls placed immediately after the calendaring stage eliminates these unwanted side effects.

1.6.3. POINT BONDING

Point-bond hot calendaring is the main method of thermally bonding in disposables as diaper, sanitary products, and medical products. This method involves the use of a two-roll nip consisting of a heated male patterned metal roll and a smooth or patterned metal roll (fig 1 a, b, c & d). This second roll may or may not be heated, depending on the application. In a typical production line, the web is fed by an apron leading to a calender nip and the fiber temperature is raised to the point at which tackiness and melting cause fiber segments caught between the tips of engraved points and the smooth roll to adhere together. The heating time is typically of the order of milliseconds [3]. The fabric properties are dependent on the process temperature and pressure and other parameters like the contact time, quench rate and calendar pattern. Experimental results show that for a given nip line pressure and calendaring speed, the breaking strength reaches a maximum at a critical bonding temperature (fig1e); on keeping the nip line pressure constant, the critical temperature was found to be a function of the calendaring speed. Fig. 1A,B, C and D Showing details of point bonding
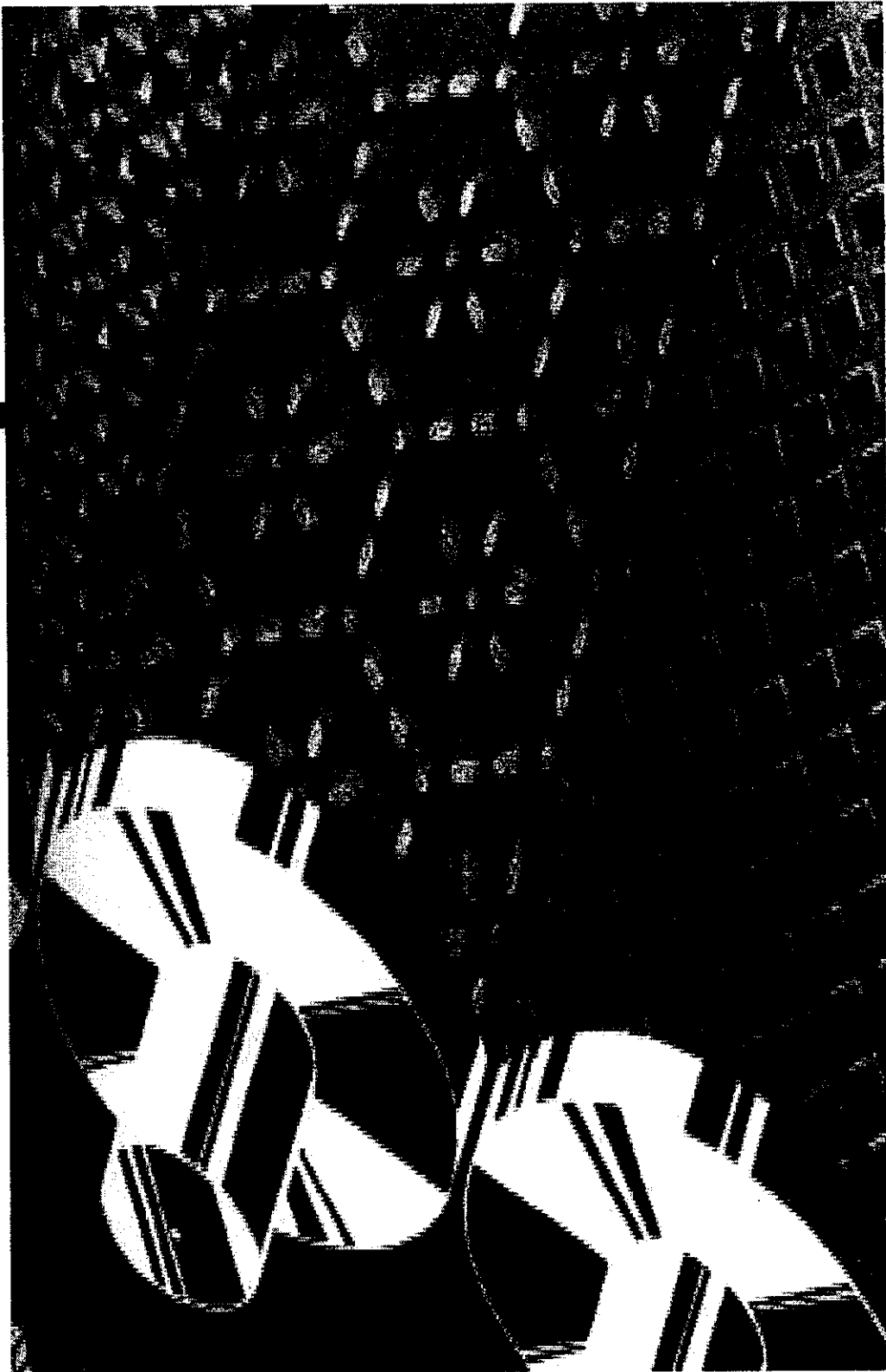
Fig. 1a: Engraved rolls for point bonding [7]

FIBERVISION 021 BONDING PATTERN

TOP VIEW
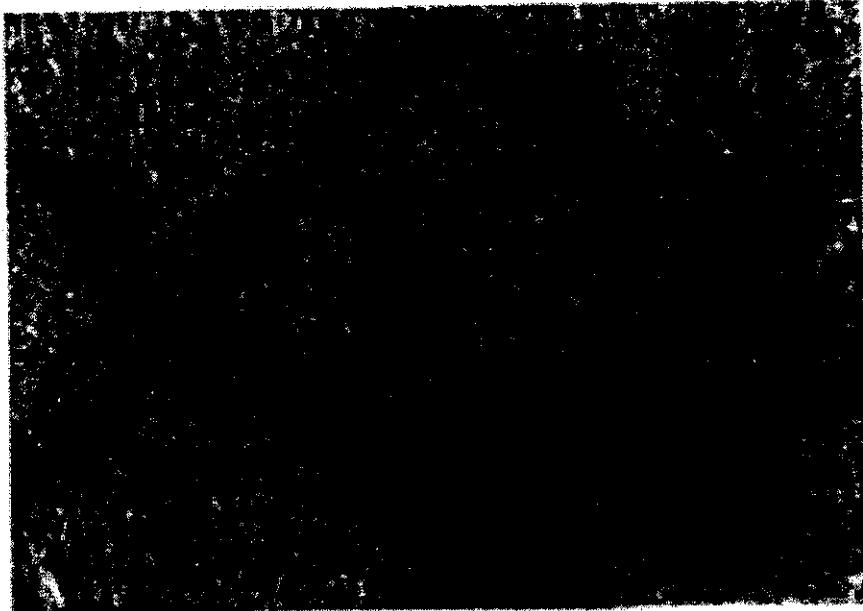
SIDE VIEW

Fig. 1b: Advances in bonding with a release pattern
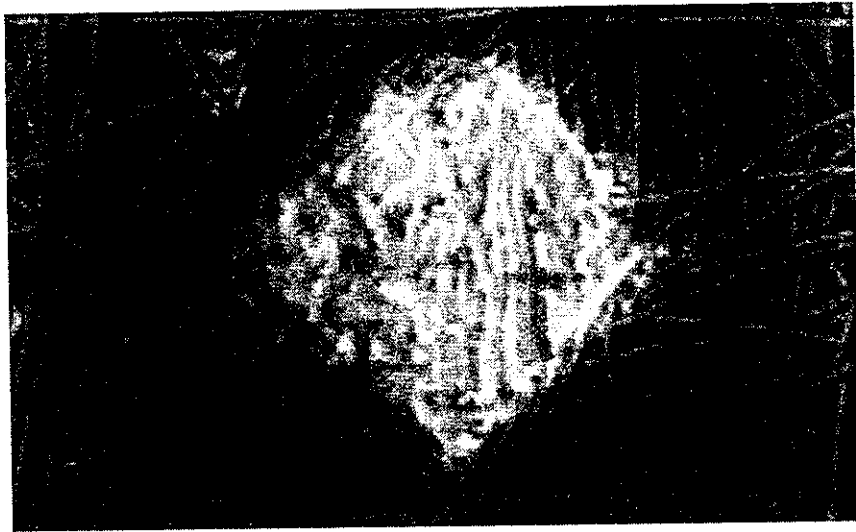
Fig. 1c: SEM of point bonding
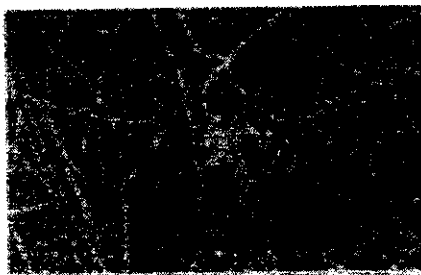
Failure by Debonding

Failure by Fiber breakage

Fig. 1d: SEM of point bonding failures

The maximum strength achieved is influenced by the nip line pressure. This influence depends on the melting behavior of the fiber. If the maximum occurs in the softening region, higher pressure yields higher strength. On the other hand, if maximum occurs in the early melting region, a low calendaring pressure is desirable. The degree of product bonding depends on the pattern of bond points on the roll surface. Bonded areas are compressed and densely compacted. Unbonded area is very open, breathable and porous. The products formed range from thin, closed, inelastic, strong, and stiff to open, bulky, weak, flexible and elastic depending on the number density, the size and the pattern of the bond points
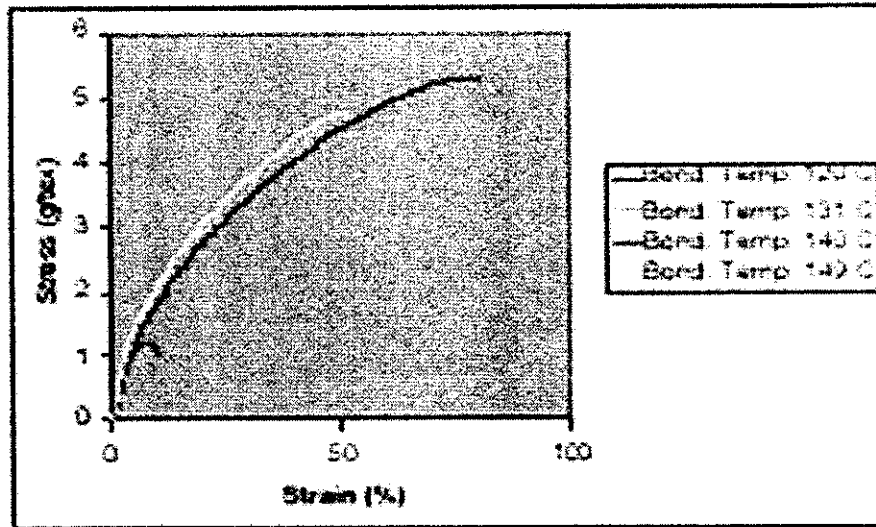
Fig. 1e: Stress-strain curves for various bonding temp (PET)

1.6.4. EMBOSSING

This method is a figured or sculptured area-bond hot calendaring. In this case, though, the area bonding is three-dimensional. A "bulky but thin" product can be made in any pleasing or functional construction, depending on the faces of the embossing rolls. The calendar roll combination has a male patterned heatable metal roll and a matching female patterned felt roll.

1.6.5. BELT CALENDERING

Belt calendaring is a modified form of hot roll calendaring. The two main differences are the time in the nip and the degree of pressure applied. In belt calendaring, time in the nip is 1-10 seconds. The pressure applied is about 1/10th of the pressure applied in the hot calendaring process. The belt bonder consists of a heated roll and a rubber blanket. The nonwoven fabric is heat bonded by running it between the roll and the blanket. Pressure is applied by varying:

- The tension on the blanket against the heated roll.

- The pressure on the exit guide rolls inside the rubber blanket.

Belt calendared products are much less dense and papery compared to hot roll calendaring. The belt bonder facilitates the use of binders with sharp melting and flow properties. Such binders can present difficulties in a hot roll calendaring process.

1.6.6. THROUGH-AIR BONDING

Through-air thermal bonding involves the application of hot air to the surface of the nonwoven fabric. The hot air flows through holes in a plenum positioned just above the nonwoven. However, the air is not pushed through the nonwoven, as in common hot air ovens. Negative pressure or suction, pulls the air through the open conveyor apron that supports the nonwoven as it passes thorough the oven. Pulling the air through the nonwoven fabric allows much more rapid and even transmission of heat and minimizes fabric distortion. (See Fig.2)
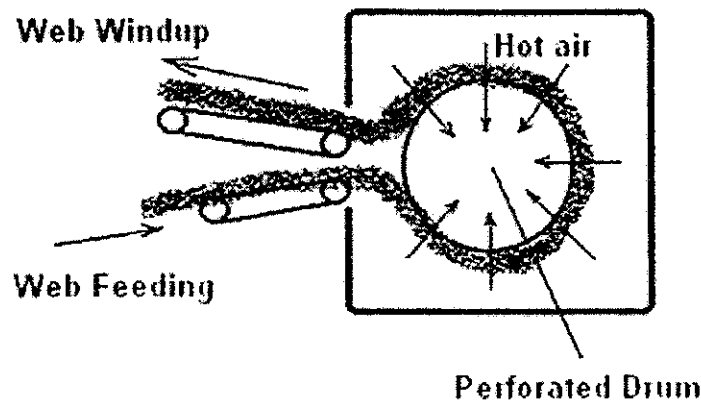
Fig. 2: Through-air bonding

Binders used in through-air thermal bonding include crystalline binder fibers, bi-component binder fibers, and powders. When using crystalline binder

fibers or powders, the binder melts entirely and forms molten droplets throughout the nonwovens cross-section. Bonding occurs at these points upon cooling. In the case of sheath/core binder fibers, the sheath is the binder and the core is the carrier fiber. Products manufactured using through-air ovens tend to be bulky, open, soft, strong, extensible, breathable and absorbent. Through-air bonding followed by immediate cold calendaring results in thicknesses between a hot roll calendared product and one that has been though-air bonded without compression. Even after cold calendaring, this product is softer, more flexible and more extensible than area-bond hot-calendared material.

1.6.7. ULTRASONIC BONDING

This process involves the application of rapidly alternating compressive forces to localized areas of fibers in the web. The stress created by these compressive forces is converted to thermal energy, which softens the fibers as they are pressed against each other. Upon removal from the source of ultrasonic vibration, the softened fibers cool, solidifying the bond points. This method is frequently used for spot or patterned bonding of mechanically bonded materials.

No binder is necessary when synthetic fibers are used since these are self-bonding. To bond natural fibers, some amount of synthetic fiber must be blended with the natural fiber. Fabrics produced by this technique are soft, breathable, absorbent, and strong. This bonding method is used to make patterned composites and laminates, such as quilts and outdoor jackets.

1.6.8. RADIANT HEAT BONDING

Radiant heat bonding takes place by exposing the web or mat to a source of radiant energy in the infrared range. The electromagnetic energy radiated from the source is absorbed by the web, increasing its temperature.

The application of radiant heat is controlled so that it melts the binder without affecting the carrier fiber. Bonding occurs when the binder resolidifies upon removal of the source of radiant heat. Lower energy and equipment costs make this a favored method for processing powder-bonded nonwovens. Versatility and lower shipping costs are also factors. Post-calendared rolls can be shipped in thin, compacted form and rebulked by reapplication of heat, without pressure or restraints, to the desired state at the time of use. Powder bonded products made in this manner are soft, open, and absorbent with low-to-medium strength. They also can be reactivated by heat for use in the manufacture of laminated composites.

1.7. ADVANTAGES AND ENERGY COMPARISION

Compared to other bonding processes, thermal bonding and the products thus obtained offer a number of advantages:

- Quality of product soft and textile-like.

- High economic efficiency as compared to chemical bonding with binder agents because no water evaporation is required, i.e., considerable energy saving results. In comparison with chemical bonding, thermal bonding only has a heat energy requirement of 1/4 to 1/6 (also in this respect ecologically beneficial).

- Less expensive machinery. The capital expenditure, maintenance and operating costs are often lower because no binder preparation station and no binder application units are required.

- It is possible to bond even thicker webs uniformly and thoroughly to the core that cannot be achieved by spraying. While a regular bonding effect across the web cross- section can be achieved for a web with a homogeneous distribution of the binding fibers, spraying only produces a bonding effect in the outer layers of the web.

- No binder agents are required and no curing process is needed. Hence, there is no exhaust air or wastewater problem. Objections against certain chemicals can be dropped. Thus, thermal bonding is non-polluting. (Note: New developments of the binder producers in the meantime have put on the market new dispersions, which also can be considered ecologically harmless).

- As pure polymer fibers or blends can be used for thermal bonding processes, recyclability is 100% in practice.

- Fiber properties can be influenced in an ideal manner (e.g. flame-retardence, nonwovens with high bulk and excellent resilience owing to fiber crimping, heat-insulating characteristics due to hollow fiber, etc.).

It has to be mentioned, however, that not all nonwovens can be processed by thermal bonding in such a way that the product obtains the requested properties. It can be assumed therefore that binder bonding can also secure its market share because the binder producers are trying to develop polymer dispersions which are biodegradable and, in connection with the fiber polymers using the same polymer basis, allow recycling of the respective nonwovens.

1.8. ALKALINE HYDROLYSIS

Alkali treatment is nothing but treating fabric with chemicals such as sodium hydroxide, potassium hydroxide, etc. The main thing behind the use of sodium hydroxide is that weight loss will be less compared to other alkalis. Hydrolysis of polyester with sodium hydroxide is a saponification reaction through elimination of - OH groups, as a result of which polyester loses its weight. From x-ray analysis of alkali treated polyester, it was established that caustic hydrolysis initially proceeds over the whole fiber surface and then continues through enlarged surface cavitations causing

higher weight loss, but no evidence was found of core cavitations in fiber stage to prove the weakening in the fiber interior. Sodium hydroxide can probably react only at the surface of polyester and it cannot penetrate the fiber surface.

2. LITERATURE REVIEW

2.1. POLYESTER

The work of W.H.Carothers, on linear fiber forming polymers put this initial foots on polyester by polycondensation method. The polyester was aliphatic polyesters, made from dibasic acid like adipic acid and glycols. The melting point of the polyester were below 100° C having molecular weights in the range of 2500-5000. it is only short step on word from him to J.R.Whinfield and J.T.Dickson, who prepared the first high molecular weight, high melting polyester in 1940. this polymer is is poly(Ethylene terephthalate) or poly(oxyethylene terephthaloyl) or simply PET. Polyester fiber is defined as a manufactured fiber in which the fibre forming substance is any long chain synthetic polymer composed of at least 85% weight of an ester of dihydric alcohol and terephthalic acid. So this may include pure polyester or polyester ? ? ether fiber. Generally polyester fibers are produced from spinnerets. Polyester polymer is produced commercially in a two step polymerization process, i.e., monomer formation by ester interchange of dimethyl terephthalate with glycol or estrification of terephthalic acid with glycol followed by polycondensation by removing excess glycol. Monomer formation [Step 1] by the catalyze ester interchange reaction between molten dimethyl terephthalate and glycol takes place at 200°C. The product mixture of monomer, very low molecular weight polymer, as a methanol by product, which distills at 150°C. Ester interchange catalysts are divalent salts of manganese, cobalt, magnesium, zinc, or calcium. An alternative monomer formation system involves terephthalicphthalate and a catalyzed direct esterification rather ester interchange. The monomer which is the same form of both methods except for some end groups usually is a polymerized in the presence of antinomy catalyst. Chain extension is promoted by removal of

excess glycol from the various viscous melt at about 200 Pa. heating is continued about 280°C until the desired degree of condensation is obtained.

Polyester fibers have excellent mechanical properties and resistance to chemicals, and therefore they are widely employed for non woven fabrics. The non woven fabric formed from the polyester staple hollow fibers of the present invention alone exhibits a specific soft hand other than that of the non woven fabric comprising the conventional polyester staple fibers.

2.1.1. STRUCTURE OF POLYESTER FIBER

The length of the repeated unit in polyester along the chain is 10.75° A, a value only slightly less the expected for a fully extended chain with one chemical unit to the geometric repeating unit, and successive ester groups in the trans configuration to each other (10.9°A). the chains are therefore nearly planar. The unit cell is triclinic the atomic position in the crystalline indicate that no special forces of attraction exist between the molecules. The spacing's between atoms of neighboring molecules is of order expected if Vander Waals forces operate. Drawn polyester fibers may be considered to be composed of crystalline and non crystalline regions. The theoretical density of pure crystalline material can be determined mathematically from the dimensions of the unit cell. Percentage crystallinity and molecular orientation relate to tensile strength and shrinkage; how ever the various methods of measurement are problematic. Polyester fibers have many favorable properties, such as high strength and resilience, resistance to many chemicals and resistance to abrasion, stretching, shrinking and wrinkling. It has certain demerits such as tendency to pill, static charges and high luster, as well as being unbreathable difficult to dye and resistant to oily stain removal, due to its hydrophobic nature and inactive surface. Improving the undesirable properties of polyester fibers is done under harsh conditions, since the fibers are more resistant to most chemicals. In order to modify the

surface of the polyester enzymes are used. The enzyme, polyesterase, is a serine esterase that acts by cleaving the polymer chain through hydrolysis of ester bonds of the polyester fibers.

2.2. PHYSICAL PROPERTIES

2.2.1MOISTURE REGAIN

The moisture regain of polyester is low, ranges between 0.2 to 0.8%. Although polyester is non absorbent they do not have wicking ability. In wicking, moisture can be carried on the surface of the fiber without absorption.

2.2.2. SPECFIC GRAVITY

The specific gravity 1.38 or 1.22 depending on the type's polyester fibers is moderate. Polyester fibers have a density greater than Polyamide fibers and lower than rayon. Fabrics made from polyester fibers are medium in weight.

2.2.3. HEAT EFFECT

The melting point of polyester is close to Polyamide, ranging from 250 to 300° C. Polyester fibers shrink from flame and melt, leaving a hard black residue. Heat setting of polyester fibers not only stabilizes size and shape but also enhances wrinkle resistance of fibers.

2.3. CHEMICAL PROPERTIES

2.3.1. EFFECT OF ALKALIES

Polyester fibers have good resistance to weak alkalis at high temperatures. It exhibits only moderate resistance to strong alkali's at room temperature and degraded at elevated temperature.

2.3.2. EFFECT OF ACIDS

Weak acids, even at the boiling point, have no effect on the polyester fibers are exposed for several days. Polyester fibers have good resistance to strong acid at room temperature. Prolonged exposure to boiling Hydrogen Chloride destroys the fibers and 96% Sulphuric acid and causes disintegration of the fibers.

2.3.3. EFFECT OF SOLVENTS

Polyester fibers are generally resistant to organic solvents. Chemical used in cleaning and stain removal do not damage it, but hot m-cresol destroys the fibers, and certain mixtures of phenol with trichloromethane dissolve polyester fibers. Oxidizing agents and bleachers do not damage polyester fibers.

2.4. MISCELLENEOUS PROPERTIES

Polyester fibers exhibits good resistant to sunlight, and it also resists abrasion very well. Soaps, synthetic detergent, and other laundry aids do not damage it. One of the most serious faults with polyester is its oleophilic quality. It absorbs oily materials easily and holds the oil tenaciously.

2.5. MECHANICAL PROPERTIES

A wide of polyester fiber properties is possible depending on the method of manufacture. Generally, as the degree of stretch is increased, which yields higher crystallinity and greater molecular orientation, so are the properties, e.g., tensile strength and initial young's modulus. At the same time, elongation normally decreases. An increase in molecular weight further increase tensile strength, modulus and extensibility. Shrinkage of the fibers also varies with the mode of treatment. If relaxation of stress and strain in the oriented fiber occurs, shrinkage decreases, but the initial modulus may be also reduced. Yarns maintained at the fixed length and constant tension during

heat setting are less affected with respect to changes in modulus, and reduced shrinkage values are obtained. Polyester shows non linear and time dependant elastic behavior. Creep occurs under the load with subsequent delay in recovery on removal of the load, but compared to that of other melt spun fibers, creep is small.

2.6. MODIFICATIONS OF POLYESTER WITH ALKALI

Polyester fibers have taken the major positions ? textiles all over the world although they have many drawbacks e.g., (a) low moisture regain (0.4%), (b) the fibers has a tendency to accumulate static electricity, (c) the cloth made up of polyester fibers pickup more soil during wear and it also difficult to clean during washing, (d) the PET garments from pills and thus, the appearance of a garment is spoiled, (e) the polyester fiber is flammable. Thus, it has been suggested that surface modification can have an effect on hand, thermal properties, permeability, and hydrophilicity.

Numerous research papers and patents are available and considerable amount of research works is in progress on the hydrolysis and aminolysis of polyester fibers to overcome their advantages.

Namboodri and Haith carried out a comparative study by treating the polyester fibers with alkali's and alkaloids (e.g. sodium hydroxide with water, sodium ethoxide in ethanol, sodium isopropoxide in isoproponal, and potassium tertiary butoxide in tertiary butanol) at 60°C and at different concentrations. It was found that the loss in weight of the polyester fiber was in the order sodium hydroxide < tertiary butoxide < secondary propoxide < methoxide and ethoxide. It was suggested that the observed order followed the nucleophilicity of the bases and the relatively lower reactivity of sodium propoxide and tertiarybutoxide was assumed to be due to streric retardation during the equilibrium reactions. The hydrolysis of PET fibers was assumed to betaking place on the surface of the fiber it was assumed that a random

attack of the base on the carboxyl groups of the surface polymer molecules took place with removal of the shorter chains from the surface, which was further hydrolyzed by the base present in the solution.

Kosohk wonetal, have reported that the treatment of a polyester fabric with aqueous sodium hydroxide solution caused a decrease of weight and breaking strength and improved handle with increase in sodium hydroxide concentration, treatment time and temperature. It has been reported that these effects were further enhanced in the presence of a carrier, such as palanil carrier A. the molecular weight of the fiber was also decreased, but crystallinity was not affected by the alkali treatment.

Hydrolysis improves the smoothness of the fabric and decrease the electrostatic charge for friction. Elisson Etal, absorved that untreated polyester fibers have smooth surface, while Sodium Hydroxide treatment causes pitting of the fiber surface. The pits increase in number and depth as the time of hydrolysis was lengthened.

Song and Kim found that the weight loss of PET fibers by alkali treatment decreased in the order of Potassium Hydroxide > sodium hydroxide > Sodium carbonate and increased with increase in alkali concentration and treated temperature and time. With increase in weight loss, drape and flex stiffness and tear strength decreased, and tear strength retention at weight loss at 17% was > 70%. At the same weight loss, handle was affected by the treatment conditions. Zhang and co-workers absorbed that the addition of dodecyldimethybenezeammonium bromide cationic surfactant reduces the concentration of Sodium Hydroxide and thus lowered the degree of degradation of polyester fibers.

The hydroxyl ions in the solution of Sodium Hydroxide attack the carboxyl group in the polymer which results in the formation of disodium terephthalate and ethylene glycol. Disodium terephthalate is double is soluble

in alkaline solution (pH above 8) up to 13 - 14%. Free terephthalic acid is on the surface of the fabric which is to be washed out with alkaline water before neutralizing the fabric.

2.7. COMFORT DESCRIPTION

2.7.1. INTRODUCTION

Comfort is one of the most important aspects of clothing. It has been defined by very ways:

1. Bekesius defines comfort as "The absence of unpleasantness or discomfort or a neutral state compared to the more active state of pleasure".

2. Rees describes comfort as "The temperature regulation of the body in order to define the system in which comfort must be maintained".

3. Rodwell state that "Comfort is influenced by the physiological reaction of the wearer".

4. Yaglou suggests that "A satisfactory definition will never be achieved because such a definition is not possible".

Over all comfort can be defined as a state of pleasant psychological, physiological and physical harmony between a human being and the environment. All these three aspects are equally important, since people feel uncomfortable if any one of them is absent. So to know about the comfort characteristics of any particular fabric or clothing it is required to determine the different properties of the fabric which have direct effects on the comfort.

Different aspects of clothing comfort

- Thermo physiological comfort: it concerns the heat and moisture transport properties of clothing, i.e. transmission of heat, temperature,

heat of wetting, air permeability, moisture absorption/regain, liquid water transmission, moisture vapor transmission.

- Skin sensational/tactile comfort: it concerns the mechanical contact of the fabric with skin, how a fabric or garment feels when it is worn next to the skin i.e. fabric handle/feel, softness, fullness, feeling of cold/ warmth, static charge generation, pliability, bending, flexing.

- Physiological comfort: it concerns the aesthetic properties of fabric, i.e. drape, luster, color/dye pick up, crease recovery, pilling, soiling and staining.

2.7.2. Thermal Comfort

Thermo-physiological comfort is objectively a state in which the individual is free from thermal strain as defined by excessive departure from normal values of body temperature and other physiological parameters, such as blood flow or heat generation rate. The human body tries to maintain a constant temperature of about 37C and a rise or fall of ~ 5C can be fatal. The heat produced from the metabolism of food and muscle activity should be equivalent to the heat lost to the environment and stored in the body.

The following equation demonstrates the balance between heat loss and heat generation.

$M = E + S,$

Where M = metabolic heat production

E = Heat loss by evaporation, convection, conduction & radiation

S = Body heat storage

An unclothed human can survive in a relatively small temperature range from the average comfort temperature of 29°C, within the

temperature range of ±5C. Temperature just below this can be compensated by eating more food or increasing exercise.

In a warmer environment (>29°C) an unclothed human must be cool itself by dissipating the generated and absorbed heat to the environment. Under this condition the body will dilute the blood capillaries which enable the evaporation of water diffusing from the body interior to increase perspiration, thereby increasing the cooling effect. This action is known as insensible perspiration. If the environment temperature increases the body will activate the sweat glands and liquid water is evaporated for increased cooling, known as sensible perspiration. Hypothermia and hyperthermia may results respectively due the deficiency or excessiveness of heat the body.

The textile material provides the thermo physiological comfort to the body. The thermal resistance of fabrics in cold condition is of vital importance, the insulative effect is also detrimental in hot environment. During physical activity fabrics allow moisture to be transported from the body in order to maintain thermo physiological comfort and reduce the degradation of thermal insulation caused by moisture build-up. This is an important factor in cold environment, because the presence of moisture layer reduces the heat insulation, as water is about 23 times higher heat conductive than air.

Important Fabric Properties for Maintaining Comfort

 a. Heat transmission

 b. Moisture transmission

 c. Air transmission

2.8 Heat transmission

When the body temperature differs from the environment temperature, then the transmission of heat happens. There are three methods of heat transfer through which the body loses heat to the environment to maintain the heat balance. How heat transfers by these three methods from body to the environment are shown from body to the environment is shown in the Fig.1 below.

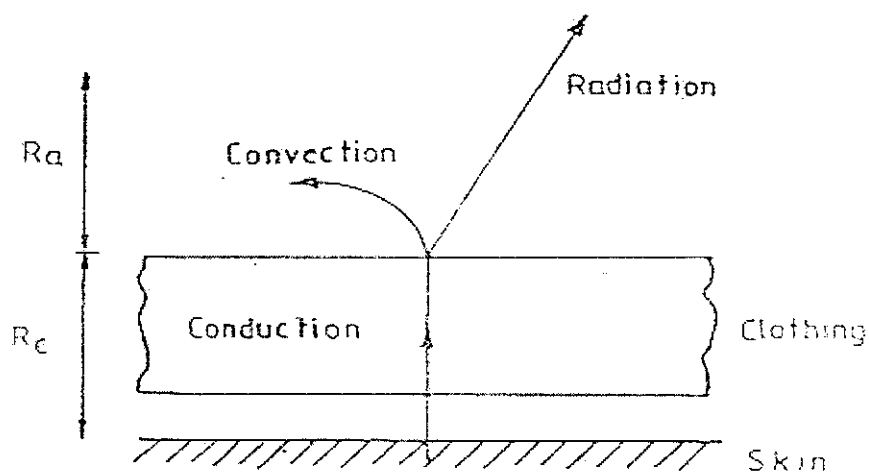**Fig. 1: Different Mechanism of heat transfer**

2.8.1. Conduction

In this process the transmission happens by direct contact (e.g. body in contact with any cold object). The rate of transfer of heat energy by conduction depend s on the temperature drop per unit thickness and the area of the material through which the heat flows.

The conductivity of the fabric can be defined by the following equation:

Where,

$dQ/dt = [nA(T2-T1)]l^{-1}$

$dQ/dT = -KA*dT/dl$

dQ/dT = Heat flow per time interval, i.e. flow of thermal energy per unit time;

A = Cross-sectional area of the object;

dT/dl = Temperature drop per unit thickness; and

K = Thermal conductivity.

Thermal resistance (resistance to heat flow) is inversely proportional to thermal conductivity and is defined by the equation:

Thermal resistance (R) = h/K,

Where

h = Thickness of the material.

2.8.2. Convection

In this process the heat transmission happens by the movement of fluid (liquid or gas) [e.g. air in contact with body takes away heat]. In case of the heat transfer through the sweat this process is followed.

2.8.3. Radiation

In this case the transmission of heat occurs by electromagnetic waves. Cloth acts to reduce radiation loss by reducing the temperature difference between the body and its immediate surroundings as the clothing effectively becomes the immediate surroundings.

Besides the three above processes evaporation is also an important process for transferring heat. In this method the transmission of heat happens by the evaporation of sweat through the cloths. Sweat takes the latent heat of evaporation from the body and cools it.

Cool + Dry – Comfortable

Hot + Humid – Problematic

2.9. Moisture transmission

The thermo physiological wearing comfort of a clothing system is determined mainly by the water vapor permeability of the textile materials in the system. A high degree of water vapor permeability of the clothing system supports the moisture transfer from the skin of the wearer through the textile layers into the environment and establishes a comfortable microclimate.

The moisture transported through the fabric in two forms:

> i) Water vapor form
>
> ii) Liquid water form

2.9.1. Mechanism of water vapor transmission

The water vapor can pass through the textile layer by following mechanisms:

i) Diffusion of the water vapor through the air spaces between the fibers.

ii) Absorption, transmission and desorption of the water vapor by the fibers.

iii) Adsorption and migration of the water vapor along the fiber surface.

iv) Diffusion of the water vapor through the fiber or yarn capillaries.

I. The water vapor transmission property of a fabric is essentially the property of inter yarn pores. The vapor diffuses through the air spaces between the fiber materials. An open fabric structure in a given material promotes the diffusion process. From the holographic visualization of vapor diffusion through textiles (Fig. 2) it is observed that the resistance to the water vapor diffusion comes in different layers. These different layers are i) Evaporating fluid layer, which remains full of water saturated vapor, ii) Confined air layer, between the skin and fabric, iii) Boundary air layer, and iv) Ambient air.
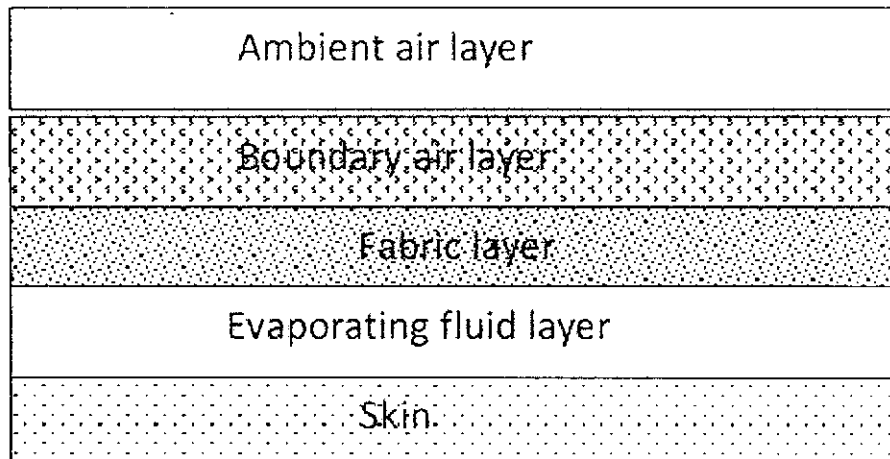
Fig.2 Different layers through which water vapor transport

Water vapor resistance mainly depends on the air permeability of the fabric (Yoon & Buckley, 1984) and represents its ability to transfer perspiration coming out of the skin. From the holographic visualization (Schneider & Roustan, 1990), it is observed that resistance provided by the fabric is lower than that of the external boundary layer, and often much lower than the inner confined air layer between skin and fabric.

The diffusion of vapor through the fibrous assembly is a mass transfer which occurs on a molecular basis in low speed flow. The vapor is transported from the higher concentration zone to the lower concentration zone. The equation of the diffusion process is governed by Fick's law. It states that the mass flux of the constituent vapor per unit area is proportional to the concentration gradient.

$$m = - DA * dc/dx$$

Where, m = mass flux (kgs-1)

A = area of transfer (m2)

D = proportionality constant/ diffusion constant (m2s-1)

C = mass concentration of the vapor (kgm-3)

dc = concentration difference between two layers

dx = equivalent air thickness between the layers

The diffusion which follows Fick's law is called Fickian diffusion. In this case the diffusion constant doesn't alter with changes to the water vapor concentration within the polymer or with changes in temperature. In case of air permeable fabrics and micro -porous polymers this type of diffusion takes place.

Whereas those diffusion doesn't follow this law is called non-Fickian diffusion. Hydrophilic polymers transfer water vapor according to Non-Fickian diffusion. The transmission rate of the hydrophilic polymers conforms to the following relationship:

$WVT = DS\,(\text{p1-p2})/l$

Where, (p1-p2) = partial pressure gradient between the two surfaces

l = thickness of the polymer

D = diffusion constant

S = solubility coefficient

Gretton and Brook found that in case of hybrid polymers also (consisting of both micro porous and hydrophilic components) the diffusion is mainly dependant on the concentration gradient.

2.9.2. Mechanism of liquid water transportation

In this process water is transported through the fabric, due to the capillary action of the fibrous structure. Transport of liquid perspiration in textiles can occur by fibers, along their surfaces or the capillaries between them. The nature of the fibers and the structure of the assemblies determine the speed and the amount of liquid transport. In fibrous structures liquids can wick into the inter-fiber spaces because of the capillary pressure. The law of hydrodynamic flow through the cylindrical capillaries, in the pressure of gravitational acceleration, leads to the following differential equation

DL/dt = (?rcos?/4?L) - (gpr2/8?)

Where L = the height of liquid rise

T = the time

r = the radius of capillary

? = viscosity

? = surface tension of the liquid

g = gravitational acceleration

? = the contact angle of the liquid-surface

The liquid wicks vertically through the fibers are limited by the gravitational force. Ultimately the equilibrium height wicked by the liquid is expressed as,

L = 2?cos?/rgp

The capillary force which is the cause for the wicking arises from the wetting of the fiber surface. If the liquid does not wet the fibers it will not wick the fibrous assembly. The balance between the forces involved in wetting the fiber surface, drives the wicking process. When contact angle is above 90°C, liquid in a capillary is depressed below the surface instead of rising above it.

A high contact angle for water with the surface means that water will run off it, a low contact angle means that water will wet the material. So the wet ability of the fabric, which is a surface characteristic, has a very important effect on the wicking process.
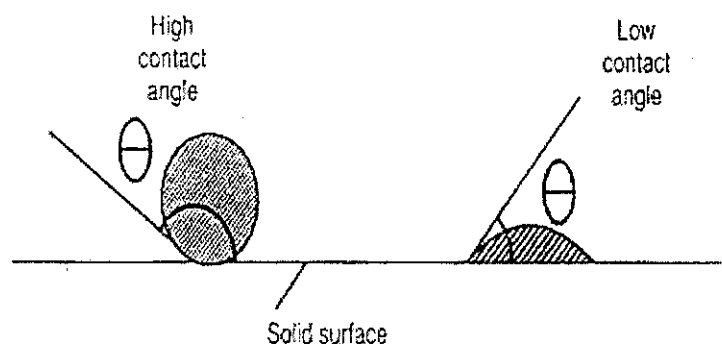

Fig.: Effect of contact angle on wetting

The studies done by Ansari & Haghighat [5] show that yarn characteristics such as fiber fineness, fiber surface smoothness, yarn structure and twist, have considerable effect on the wicking rate of water. The wicking of water decreases with increase in linear density of the yarn and the wicking rise also decreases with the increase in twist factor. But minimum number of fibers required in the fiber strand for wicking is less in case of twisted d fibers. Hiracu and Yoichiro [13] suggested that wicking behavior is strongly influenced by the characteristics of the assembly, such that size and continuity of the capillaries formed within the yarn. It is enhanced with increasing surface hydrophilicity and decreasing the capillary diameter. Discontinuities in the capillary structure tend to disrupt liquid flow. This effect is much more prominent for hydrophilic fibers. Due to the anisotropic structure of the fabric material, different liquid transport properties are observed in different directions and as the capillary network of the fabric is dependent on the direction under consideration, the wicking properties

through the thickness of that fabric may be different from those in the plane of the fabric.

2.10. Air transmission

The effectiveness of textiles to stagnant air and air permeability of the fabric influence its comfort behavior in several ways. If the material is permeable to air, in general it is likely to be permeable to water, in either the vapor or the liquid phase.

The thermal resistance of fabric is also strongly dependent on the enclosed still air. The thicker the air layer, the greater is the heat insulation. Air has approximately eight times less thermal conductivity than fibers. So the materials which are thick and also bulky are better insulator than thinner, flatter materials. Air is stabilized not only within the textiles but also at their surfaces and uneven, hairy or textured surfaces can thus provide more effective insulation than very smooth surfaces. For this reason the rough surfaces also feel warmer to the touch than the smoother ones.

3. AIM OF THE PROJECT;

Although a very considerable work has been done on the effect of alkaline hydrolysis treatment applied on the polyester nonwoven fabric, the investigations were incomplete in the case of non wovens treated in higher concentrations. Scope of this treatment also improves the physical properties of thermal bonded non woven fabric. Therefore this investigation has been undertaken. The treated samples will be investigated for fiber density, material stiffness, absorption capacity, wicking and wetness. Based on the results obtained suitable recommendation will be made. The three main objectives of our project is

- To subject the PET nonwoven fabric treated under controlled condition to alkali hydrolysis with a view of improving fabric properties.

- To evaluate the **improved comfort and Mechanical** properties.

- To compare the properties of treated and untreated nonwoven fabric.

4.0. METHODOLOGY

4.1. MATERIAL SPECIFUCATION

4.1.1. FIBER SPECIFICATION

- ❖ **Fiber length- 64mm**
- ❖ **Fiber denier- 15**
- ❖ **Type- Non Silconise**

4.1.2. FABRIC SPECIFICATION

- ❖ **Type- Thermal Bonded Non woven**
- ❖ **Fiber- Polyester Hollow Fiber**
- ❖ **Gsm- 120**
- ❖ **Fabric Width- 1 Sq. m**

4.1.3. CHEMICAL SPECIFICATION

- ❖ **AGENT: NaOH (SODIUM HYDROXIDE)**
- ❖ **FORM: PELLETS**
- ❖ **TYPE: PRO ANALYSIS**
- ❖ **MAKE: MERCK.**

Also called caustic soda, lye. Sodium hydroxide, chemical compound, NaOH, a white crystalline substance that readily absorbs carbon dioxide and moisture from the air. It is very soluble in water, alcohol, and glycerine. It is a caustic and a strong base. The principal method for its manufacture is electrolytic dissociation of sodium chloride; chlorine gas is a co product. Small amounts of sodium hydroxide are produced by the soda -lime process in which a concentrated solution of sodium carbonate (soda) is reacted with calcium hydroxide (slaked lime); calcium carbonate precipitates, leaving a sodium hydroxide solution. Sodium hydroxide (NaOH), also known as lye or caustic

soda, is a caustic metallic base. It is widely used in industry, mostly as a strong chemical base in the manufacture of vinyl chloride (for PVC), paper, textiles, and detergents. Sodium hydroxide is also the most common base used in chemical laboratories.

Molecular Weight	40.00
Boiling Point	1390 uc
Melting Point	318.4 Uc
Vapor Pressure	1 mm at 739 Uc
Density/Specific Gravity	2.120 at 20/4 Uc (water = 1)

4.2. PROCESS SPECIFICATION

4.2.1. TIME

Weight loss was found to be directly proportional to the Time of hydrolysis as the time of hydrolysis increased, weight loss also increased. Generally the time taken for the alkaline hydrolysis is 15, 30, 45 minutes. The percentage loss in weight of polyester nonwoven fabrics for the first five minutes was very small. The loss in weight was highest during the next increment of time. The reaction appears to slow down with further increases in time of heating.

4.2.2. TEMPERATURE

When a fabric saturated with aqueous alkali is heated at constant external temperature there will be an increase in the concentration of scoured alkali due to the evaporation of water from the fabric phase. The temperature of scoured alkali in the fabric phase, after an initial increase with time will attain an equilibrium value once the loosely bound water is evaporated. For the

improvement of lustre property and comfort property of cotton hot alkali treatment is necessary for the 70°C is preferred.
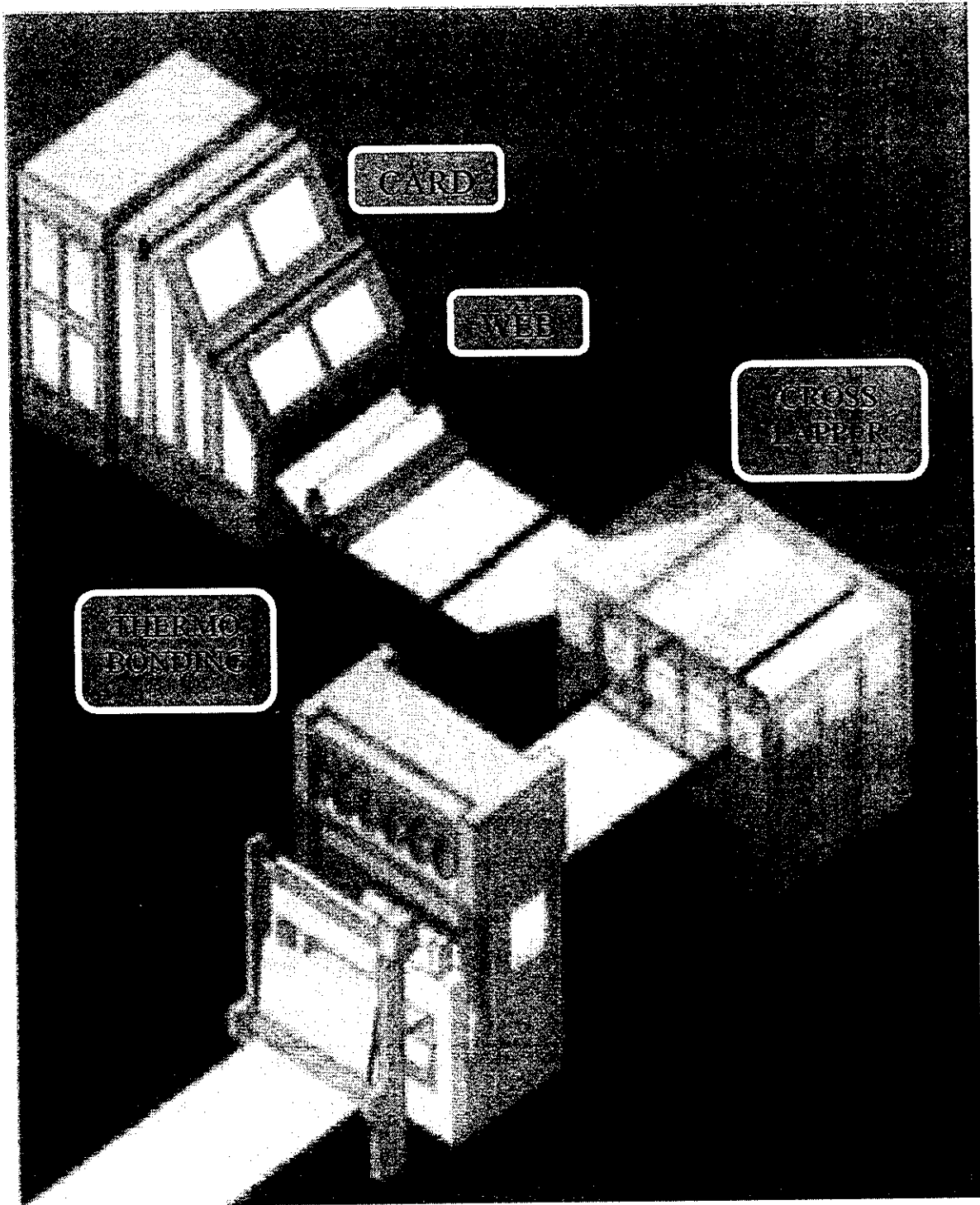
4.2.3. CONCENTRATION

At the higher concentration, the surface of the fiber gets ruptured and the weight loss of the fabric is increased by 25%. At lower concentration the rate of hydrolysis taken more time to attain its equilibrium so that the concentration that are selected are 4%, 6%, 8%.

4.2.4. LIQUOR RATIO

It is observed that at lower bath ratio (w/w), the fabric exhibits an excellent handle value as compared at those at higher bath ratio, thus confirming the potential of low liquor dyeing principles. The effect depends on several factors and the bath ratio is one among them influencing the mechanical properties of the fabric to a greater extent Lower bath ratio will exhibit the properties favourable to a soft fabric so finally the liquor ratio of 1:10 is selected.

SEQUENCE OF PRODUCING THERMAL BONDED NON WOVEN FABRIC

4.2.5 PROCESS OF PRODUCING NON WOVENS

```
┌─────────────────────────────────┐
│          RAW MATERIAL           │
└─────────────────────────────────┘

┌─────────────────────────────────┐
│        KRISCHNER BEATER         │
└─────────────────────────────────┘

┌─────────────────────────────────┐
│             BLOWER              │
└─────────────────────────────────┘

┌─────────────────────────────────┐
│             DUCT                │
└─────────────────────────────────┘

┌─────────────────────────────────┐
│             CHUTE               │
└─────────────────────────────────┘

┌─────────────────────────────────┐
│        CARDING MACHINE          │
└─────────────────────────────────┘

┌─────────────────────────────────┐
│           CONVEYOR              │
└─────────────────────────────────┘

┌─────────────────────────────────┐
│          CROSS LOOPER           │
└─────────────────────────────────┘
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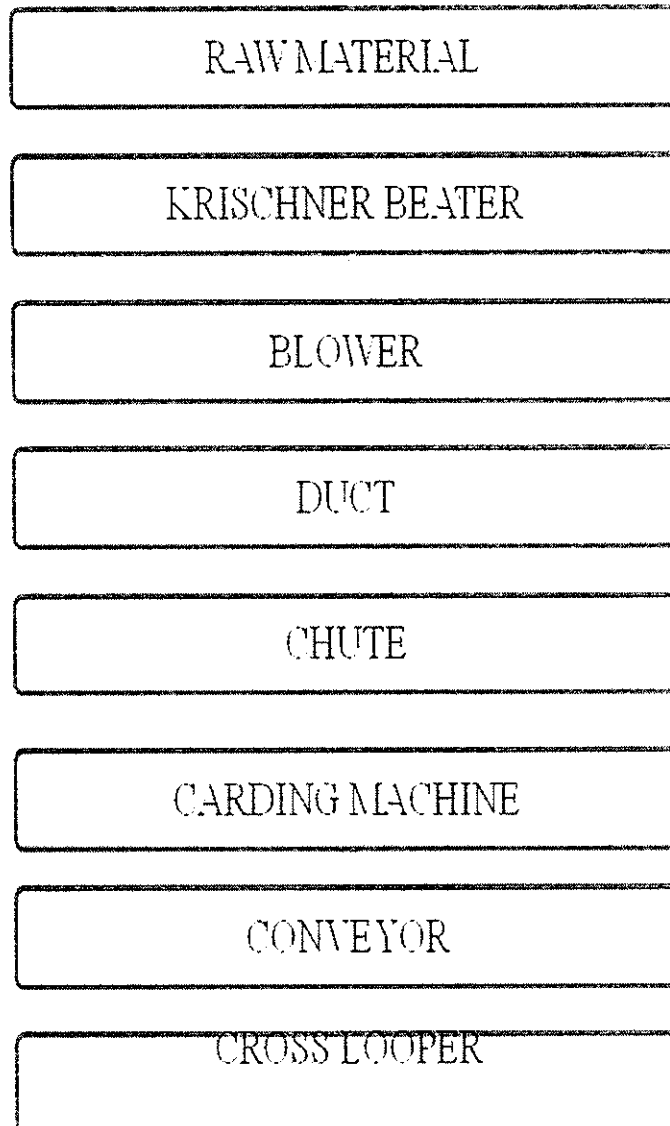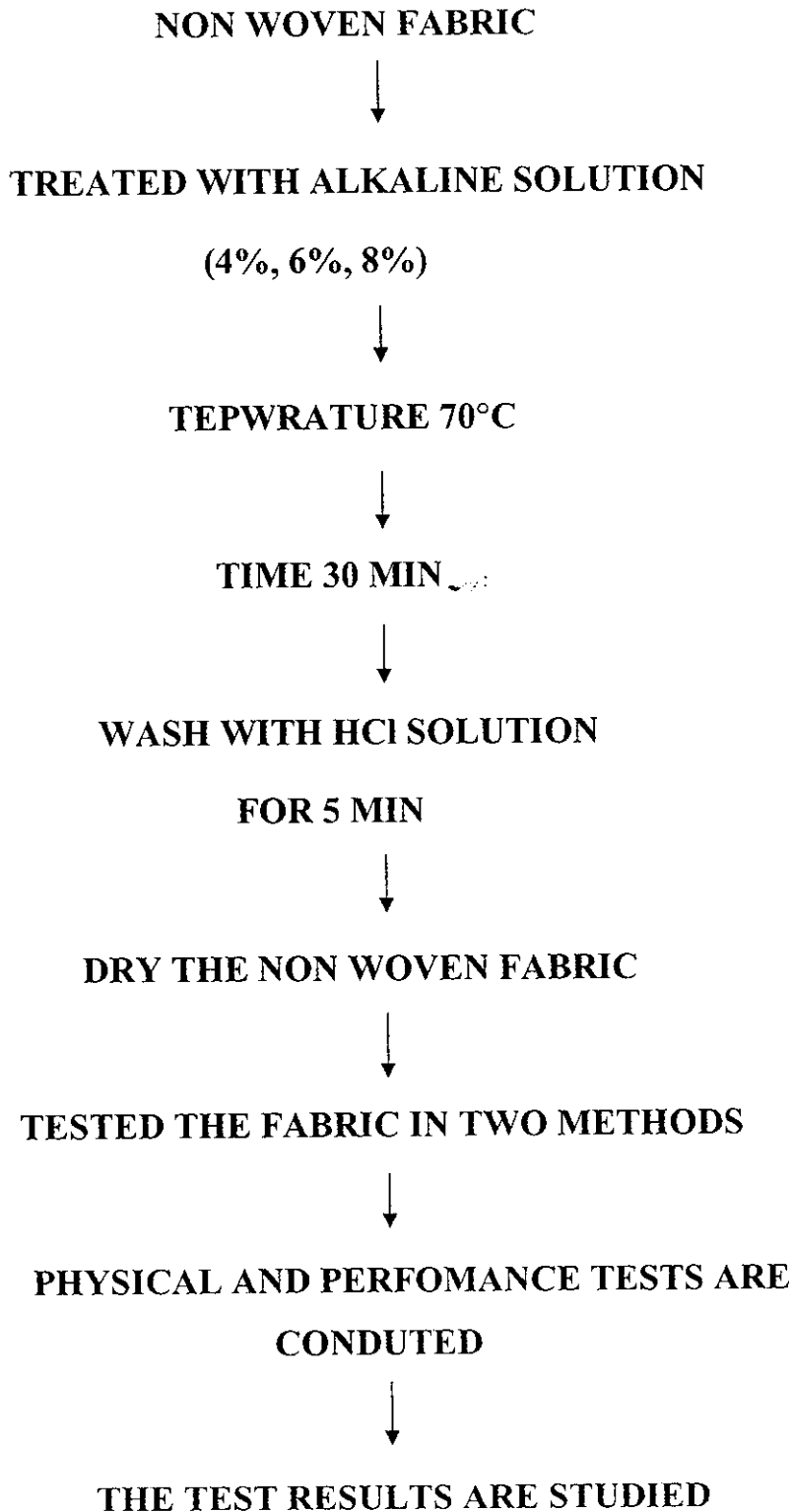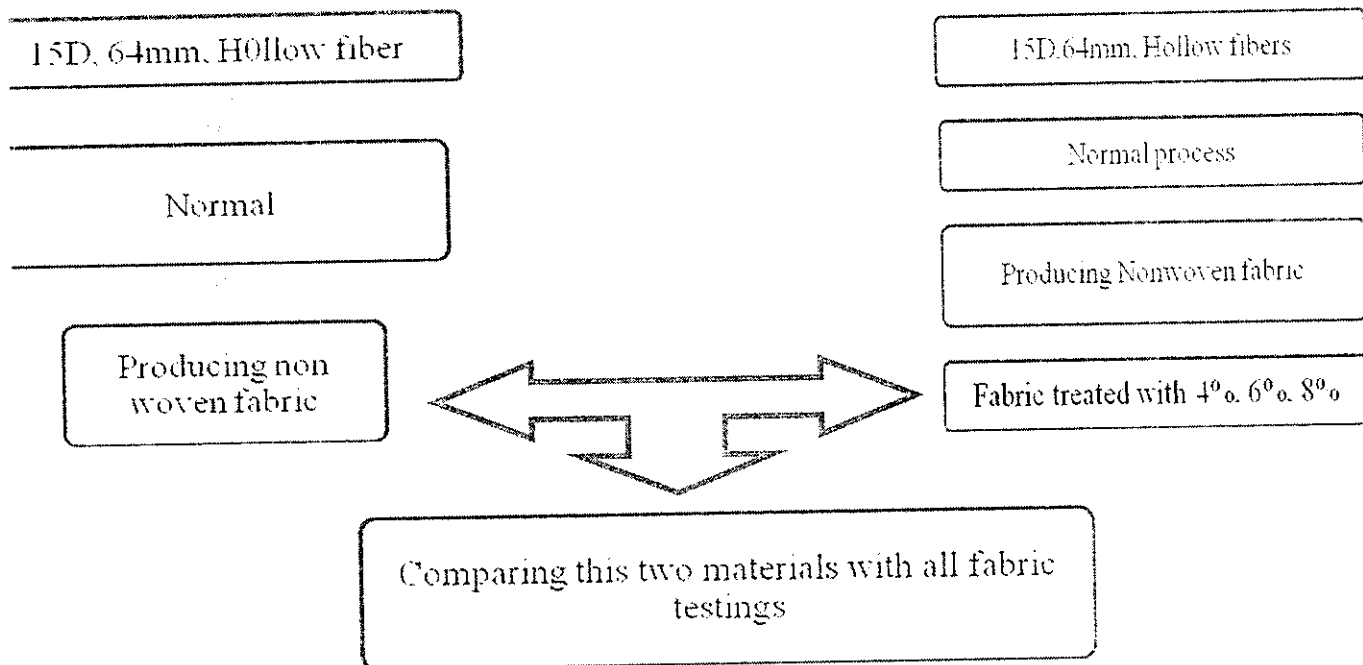
4.3. TREATMENT PROCEDURE

At first the PET non woven fabric is taken, then the fabric is treated with alkaline solution in different concentrations like 4%, 6%, 8% respectively. The following sequence shows the treatment procedure,

NON WOVEN FABRIC

↓

TREATED WITH ALKALINE SOLUTION

(4%, 6%, 8%)

↓

TEPWRATURE 70°C

↓

TIME 30 MIN

↓

WASH WITH HCl SOLUTION

FOR 5 MIN

↓

DRY THE NON WOVEN FABRIC

↓

TESTED THE FABRIC IN TWO METHODS

↓

PHYSICAL AND PERFOMANCE TESTS ARE

CONDUTED

↓

THE TEST RESULTS ARE STUDIED

4.3.1. SPECIAL ASPECTS

```
┌─────────────────────────────┐          ┌─────────────────────────────┐
│ 15D, 64mm, HOllow fiber     │          │ 15D.64mm. Hollow fibers     │
└─────────────────────────────┘          └─────────────────────────────┘

┌─────────────────────────────┐          ┌─────────────────────────────┐
│         Normal              │          │     Normal process          │
└─────────────────────────────┘          └─────────────────────────────┘

┌─────────────────────────────┐          ┌─────────────────────────────┐
│   Producing non             │          │  Producing Nonwoven fabric  │
│   woven fabric              │          └─────────────────────────────┘
└─────────────────────────────┘
                    ⬄                     ┌─────────────────────────────┐
                    ⬇                     │ Fabric treated with 4%, 6%, 8% │
                                          └─────────────────────────────┘

        ┌─────────────────────────────────────────────┐
        │ Comparing this two materials with all fabric │
        │                   testings                   │
        └─────────────────────────────────────────────┘
```

4.4. TESTING PROCEDURE

4.4.1. TESTING

In order to carry out the test the following testing conditions are required which is $25 \pm 1°C$ ($70 \pm 2°F$) and 75 ± 2 % relative humidity.

4.4.2. GSM of the Fabric

Testing Method: D 3776 – 96

Testing procedure:

1. Make all the tests in the standard Atmosphere.

2. Gsm of a fabric is the grams of the fabric present in one square meter.

3. The cloth sample is cut by using Gsm cutter.

4. Then the fabric is hanged in the hook of the quadrant sc ale.

5. So that according to the weight of fabric the pointer moves and shows the value on the marked scale in which fabric weight (meter 2 and weight per sq.yard) are marked.

6. Gsm of a fabric is measured in grams per square inch.

7. Take 10 readings.

4.4.3. Fabric Thickness

Testing method: IS 7702: 1975

Testing procedure:

1. Conduct the test in a standard atmosphere.

2. Fabric thickness is the density of the fabric.

3. Clean the presser-foot and the reference plate. Check that the presser foot shaft moves freely. With the presser -foot so loaded as to exert the appropriate specified pressure on the reference plate, set the thickness gauge

4. To read zero.

5. Raise the presser-foot and position the sample, without tension, on the reference plate so that no part of the area to be measured lies nearer to a selvedge than 150 mm. Ensure that the area chosen for the test is free from creases. Do not attempt to flatten out any creases; this is likely to affect the result.

6. Lower the presser-foot gently on to the sample and not the gauge reading after 30 seconds.

7. Similarly determine the thickness at 10 places on the sample so chosen that each such place contains different warp and weft threads as relevant. 8. Fabric thickness is measured in millimetre.

4.4.4. Wicking

RAISED PLATFORM

ATTACHED SCALE

FABRIC SAMPLE

CLAMP

BEAKER
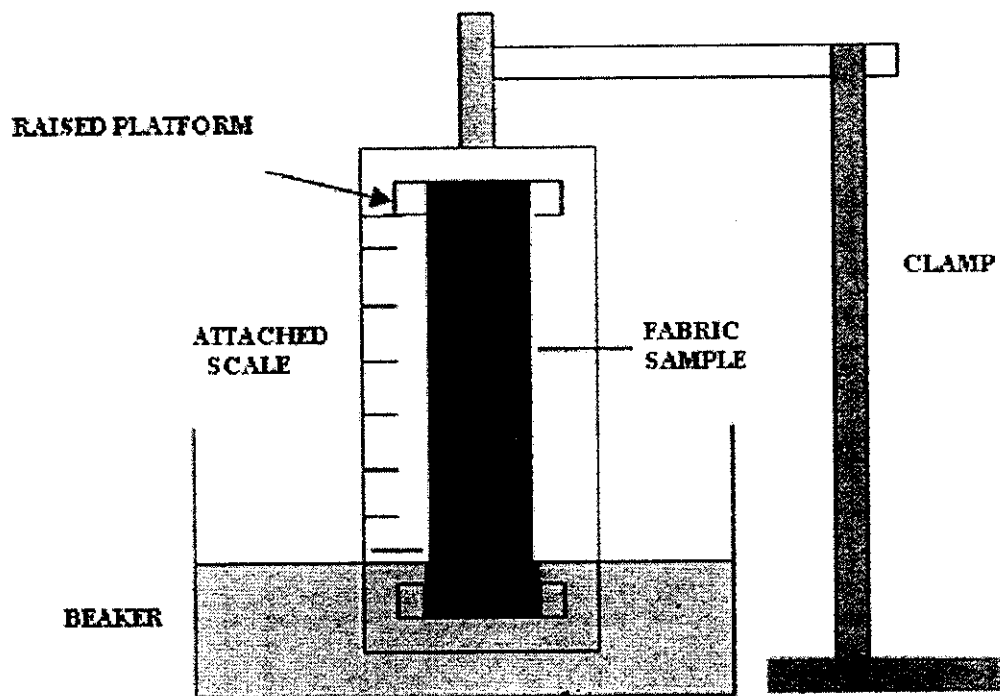
Testing procedure:

1. A simple set up (Fig 1) was made to study the wicking behaviour of Knitted Fabric.

2. A Fabric sample of size 12x2.5cms is wound at constant tension around a frame on which two raised platforms are mounted.

3. The ends on the platform were fixed with a cello tape and the remaining portion of the fabric were cut and removed.

4. The raised portions ensure that there exists a gap between the fabric and the frame so that when the frame is dipped into water, the movement of the water through the fabric is not hindered.

5. A scale was attached next to the yarns on the frame. A single fabric sample was mounted at a time.

6. A beaker containing distilled water with 1% dye solution (Reactive M8b) was prepared.

7. The frame was slowly lowered into the solution so that 2 cm remain submerged in the solution.

8. Simultaneously stop watch was pressed and the rise of dye solution through the yarn was continuously monitored by means of a cathetometer.

9. The distance travelled by the dye solution was noted as a function of time till it become virtually constant.

10. For each fabric 12 fabric samples were studied. The average wicking height of 12 fabric samples at regular interval of time was determined.

4.4.5. Drop Absorbency Test

Testing method: AATCC: 79:2000

Testing procedure:

1. Conduct the test in a standard atmosphere.

2. Water Drop Absorption is the amount of water absorbed by the fabric.

3. Mount the cloth (or smoothed -out portion of yarn) in the embroidery hoop so that the surface is free of wrinkles, but without distorting the structure of the material.

4. Place the hoop about 1.0 ± 0.1 cm (0.375 in.) below the tip of the burette, and allow one drop of distilled or deionised water at $21 \pm 3°C$ ($70 \pm 5oF$) to fall on the cloth.

5. Using a stopwatch, measure the time required, up to 60 sec maximum, for the surface of the liquid to lose its specular reflectance. This point is determined by the hoop between the observer and the source of light such as window or laboratory spot light at such an angle that the specular

reflectance of light from the surface of the flattened drop can be plainly seen. As the drop is gradually absorbed, the area of this tiny mirror

6. 29 diminish and finally vanish entirely, leaving only a dull water spot. At this instant the watch is stopped and the elapsed time is recorded. When the wetting time exceeds 60 sec, 60+ sec should be recorded.

7. Water Drop Test is measured in Seconds.

4.4.6. Moisture Content

Testing Method: The British Standard [12]

Testing Procedure:

1. Content is based on the oven dry mass, which for most fibres is the constant mass obtained by drying at a temperature of 105 ± 20C.

2. Constant mass is achieved by drying and weighing repeatedly until successive weighing differs by less than 0.05%.

3. The successive weighing should be carried out at intervals of 15 min when using a ventilated oven, or at 5 min intervals if using a forced air oven.

4. The exceptions to the above conditions are: acrylic fibres which should be dried in a normal oven at 110 ± 20C for 2h and chlorofibres which should be dried at 77 ± 2 0C to constant mass.

Moisture content of various samples is determined at 65% relative humidity and 25°C. Moisture content can be calculated by using the following equation:

Where:

Moisture Content = W1-W2/ W1

W1 - Weight of the sample before bone dry.

W2 - Weight of the sample after borne dry.

4.4.7. Moisture Regain

Testing Method: The British Standard [12]

Testing Procedure:

1. Content is based on the oven dry mass, which for most fibres is the constant mass obtained by drying at a temperature of $105 \pm 20C$.

2. Constant mass is achieved by drying and weighing repeatedly until successive weighing differs by less than 0.05%.

3. The successive weighing should be carried out at intervals of 15 min when using a ventilated oven, or at 5 min intervals if using a forced air oven.

4. The exceptions to the above conditions are: acrylic fibres which should be dried in a normal oven at $110 \pm 20C$ for 2h and chloro fibres which should be dried at $77 \pm 2\ 0C$ to constant mass.

Moisture regain of various samples can determine at 65% relative humidity and 25°C. Moisture content can be calculated by using the following equation:

Where:

Moisture regain = Wl-W2 /W2

W1 - Weight of the sample before bone dry.

W2 - Weight of the sample after borne dry.

4.4.8. Weight Loss %

Testing Procedure:

1. Make all the tests in the standard atmosphere.

2. Weight loss is the Amount weight lost by the fabric after the fabric is treated with the alkali treatment.

3. Initial weight of the fabric is noted.

4. Fabric is treated with a alkali solution.

5. Final weight of the fabric is noted.

6. Weight Loss is calculated in percentage.

7. Weight loss% is calculated.

RESULTS AND DISCUSSIONS

5. RESULTS AND DISCUSSIONS

PR&PR Nonwovens Pvt Ltd

Wetness test- It is the ability of a fabric to fully absorb liquid through its surface without any external influence. The time taken to fully immerse itself is monitored.

RESULTS:
The various results are tabulated below.

Parameter	Unit	Sample A	Sample B	Sample C	Sample D
Average weight	g/m^2	163.0	335.0	322.0	146.0
Fibre density	g/cm^3	0.0525	0.0985	0.0805	0.0339
Fabric thickness	mm	0.31	0.34	0.40	0.43
Fabric stiffness - bending length	cm	2.1	2.3	1.9	1.8
Flexural rigidity	mg/cm	36.65	75.38	72.45	32.85
Bending modulus	x10^{-6} Kg/cm	472.77	886.76	724.4	305.58
Absorption capacity	g/g	4.24	3.11	3.46	4.87
Rate of absorption	Cm/sec	0.022	0.012	0.019	0.038
Wetness test	seconds	0	6.5	7.0	8.5
Re-wet under load (RUL) (g)	20 g	26.16	22.51	24.5	26.11
	30 g	24.26	23.58	21.19	24.86
Acquisition time under load (ATUL)	Seconds	<5	<5	<5	<5
Wicking - vertical	g.cm.	0.06	0.3	0.5	0.6
Wicking - horizontal	Cm^2	3.79	2.09	3.25	5.34

DISCCUSSIONS:

Four different samples were subjected to various test parameters as shown above. Sample A is an untreated fabric whilst rests of the samples (B-D) were treated with an agent to improve the performance.

It could be noted that sample B and C were bulkier compared to A and D. This can be seen from the values of fibre density and fabric thickness.

With regards to fabric stiffness, sample D has poor resistance to bending on its own weight compared to other samples whose values range from 2.0 -1.9 cm. Sample B - fabric possess high rigidity which means that it has good resistance to bending.
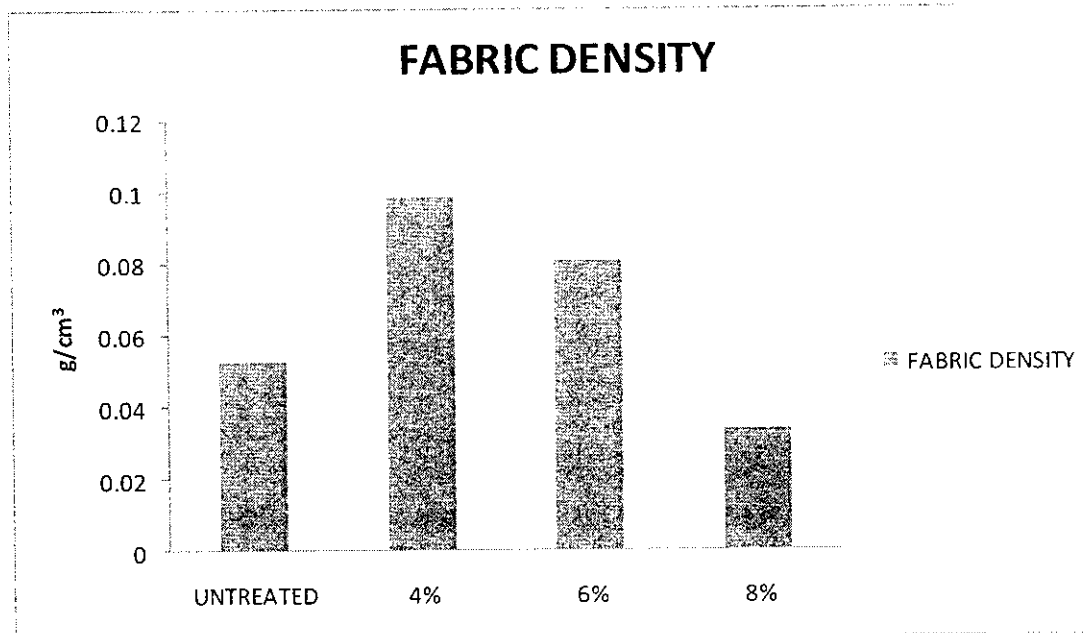
5.1 AVERAGE WEIGHT OF THE FABRIC

INFERENCE

     I. The average weight of the fabric is calculated by weighing the fabric.

     II. The average weight is found to be decreasing with increase in concentration.

     III. From the above graph we infer that the fabric treated with 8% of sodium hydroxide has a considerable weight loss.
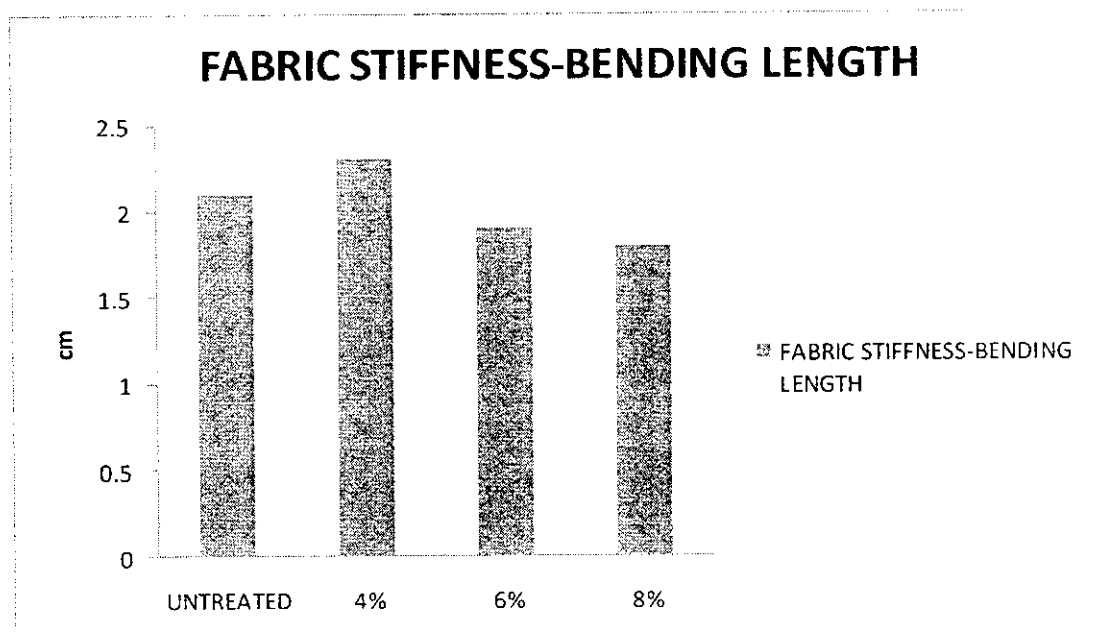
5.2. FABRIC DENSITY

FABRIC DENSITY

(Bar chart showing fabric density in g/cm³ for UNTREATED, 4%, 6%, and 8% samples. Y-axis ranges from 0 to 0.12. UNTREATED ≈ 0.053, 4% ≈ 0.1, 6% ≈ 0.082, 8% ≈ 0.037.)

INFERENCE

I. The density of non woven fabric is calculated by means of areal density and thickness.

II. Fiber density directly gives the volume of fibers occupied in a fabric structure.

III. In all the three planes i.e., X, Y, Z, the volume of fibers occupied can be identified.

IV. The fabric density is found to be decreasing with increase in concentration.

V. From the above graph we infer that the fabric treated with 8% of sodium hydroxide has minimum fabric density.

5.3. FABRIC THICKNESS
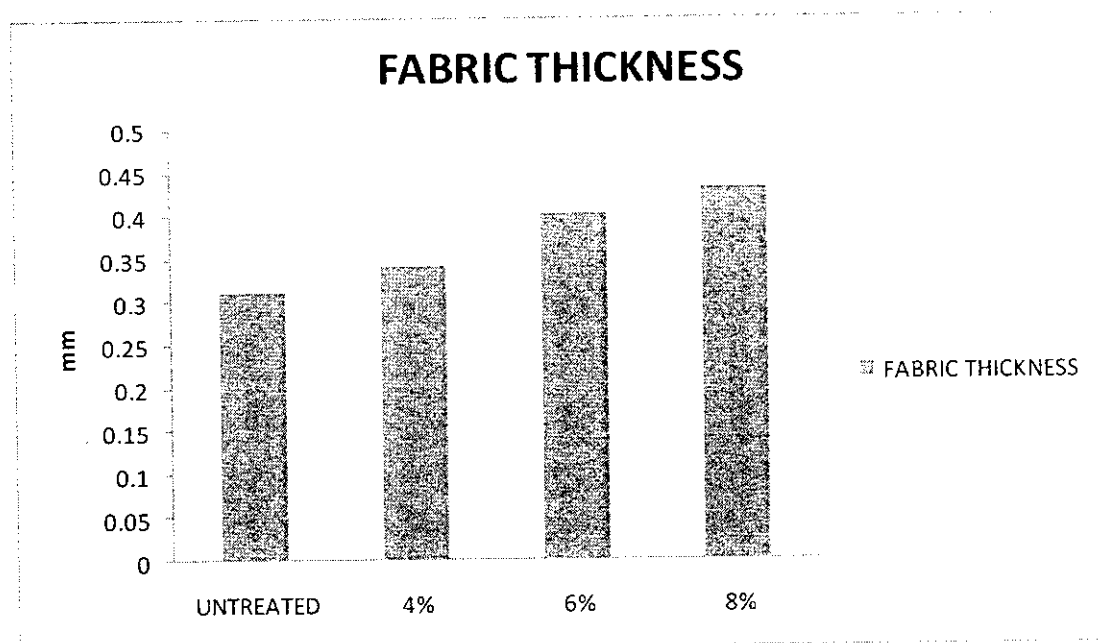
FABRIC THICKNESS

INFERENCE

I. The fabric thickness is found to be increasing with increase in concentration.

II. From the above graph we infer that the fabric treated with 8% of sodium hydroxide has a higher fabric thickness compared to other samples.

5.4. FABRIC STIFFNESS

FABRIC STIFFNESS-BENDING LENGTH

Y-axis: cm (values 0, 0.5, 1, 1.5, 2, 2.5)
X-axis: UNTREATED, 4%, 6%, 8%

Legend: FABRIC STIFFNESS-BENDING LENGTH

INFERENCE

I. The stiffness of the fabric indicates the resistance of fabric to bending.

II. The bending length is found to be decreasing with increase in concentration.

III. From the above graph we infer that the fabric treated with 8% of sodium hydroxide has minimum stiffness considering to other samples.

5.5. FLEXURAL RIGIDITY
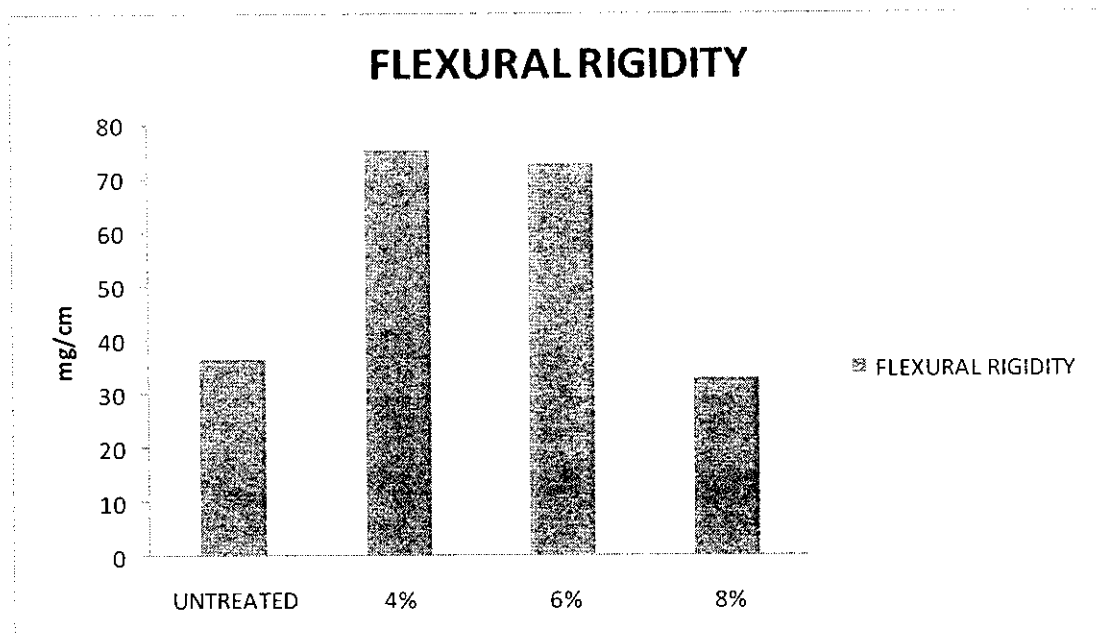
FLEXURAL RIGIDITY

INFERENCE

I.   The flexural rigidity is found to be decreasing with increase in concentration.

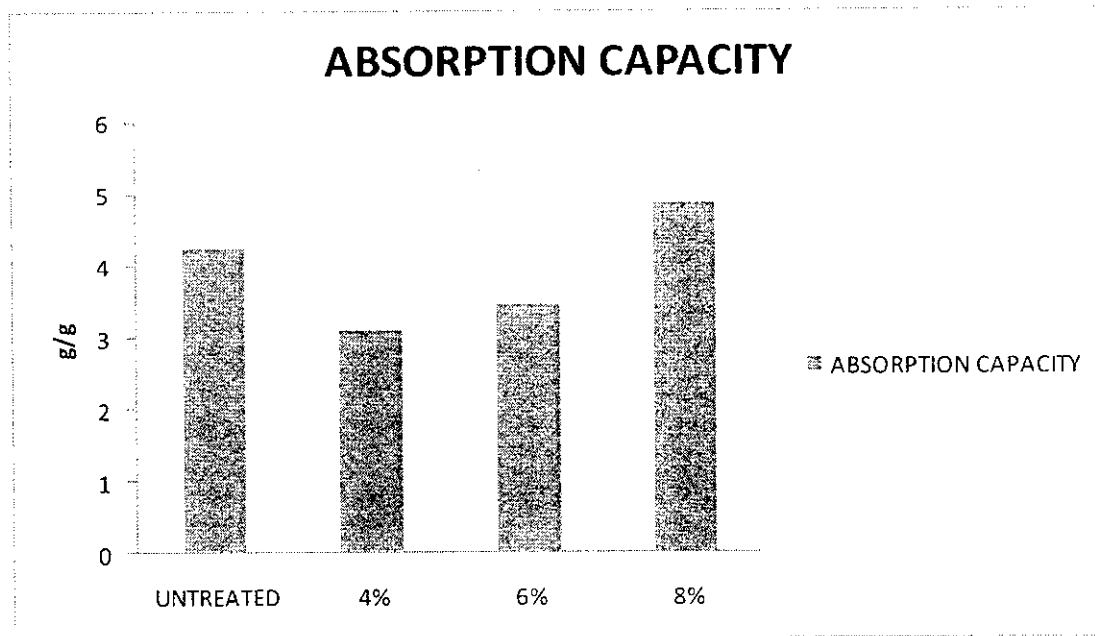II.   From the above graph we infer that the fabric treated with 8% of sodium hydroxide has minimum flexural rigidity.

5.6. BENDING MODULUS

BENDING MODULUS

Y-axis: X10^{-6} kg/cm (0 to 1000)

X-axis: UNTREATED, 4%, 6%, 8%

Legend: ▨ BENDING MODULUS
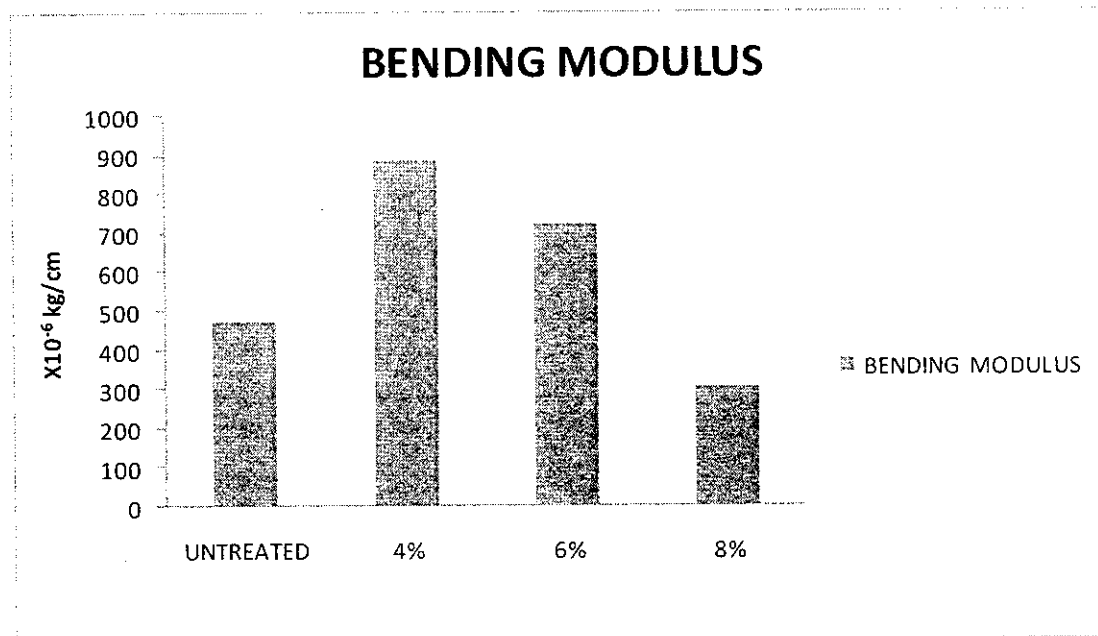
INFERENCE

I. The bending modulus is found to be decreasing with increase in concentration.

II. From the above graph we infer that the fabric treated with 8% of sodium hydroxide has minimum modulus.

5.7. ABSORPTION CAPACITY

ABSORPTION CAPACITY

INFERENCE

I.The absorption capacity can be determined by EDANA method.

II.The absorption capacity is found to be increasing with increase in concentration.

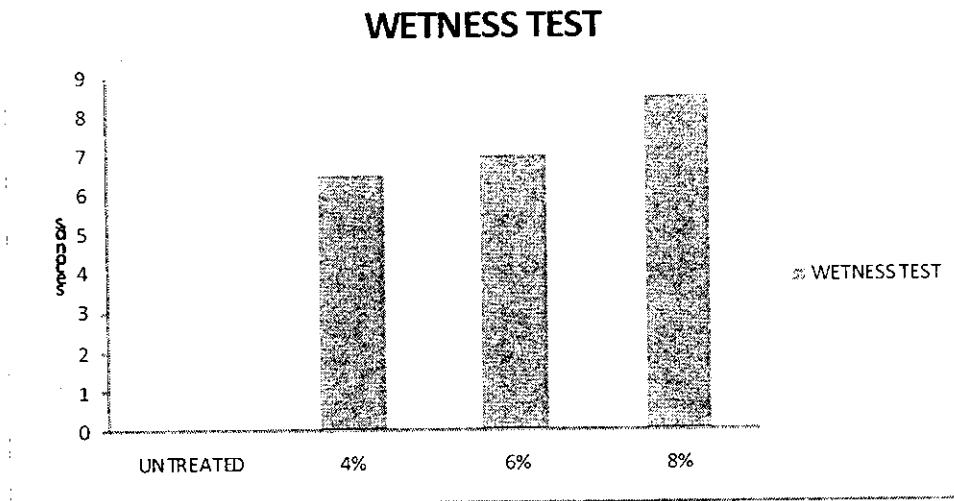III.From the above graph we infer that the fabric treated with 4% of sodium hydroxide has minimum absorption capacity.

5.8. RATE OF ABSORPTION
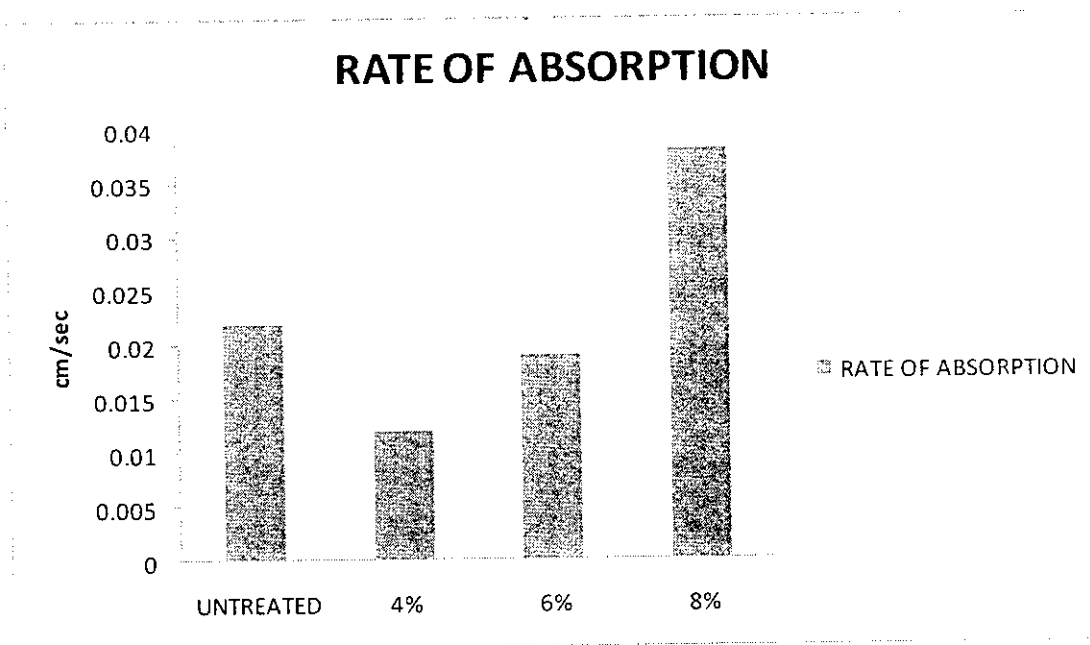
RATE OF ABSORPTION

INFERENCE

I. The rate of absorption is found to be increasing with increase in concentration.

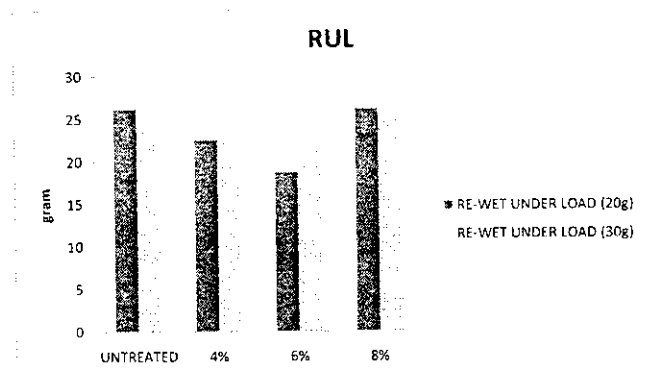II. From the above graph we infer that the fabric treated with 8% of sodium hydroxide has maximum rate of absorption.

5.9. WETNESS

WETNESS TEST

INFERENCE

I.The wetness capacity is found to be decreasing with increase in concentration.

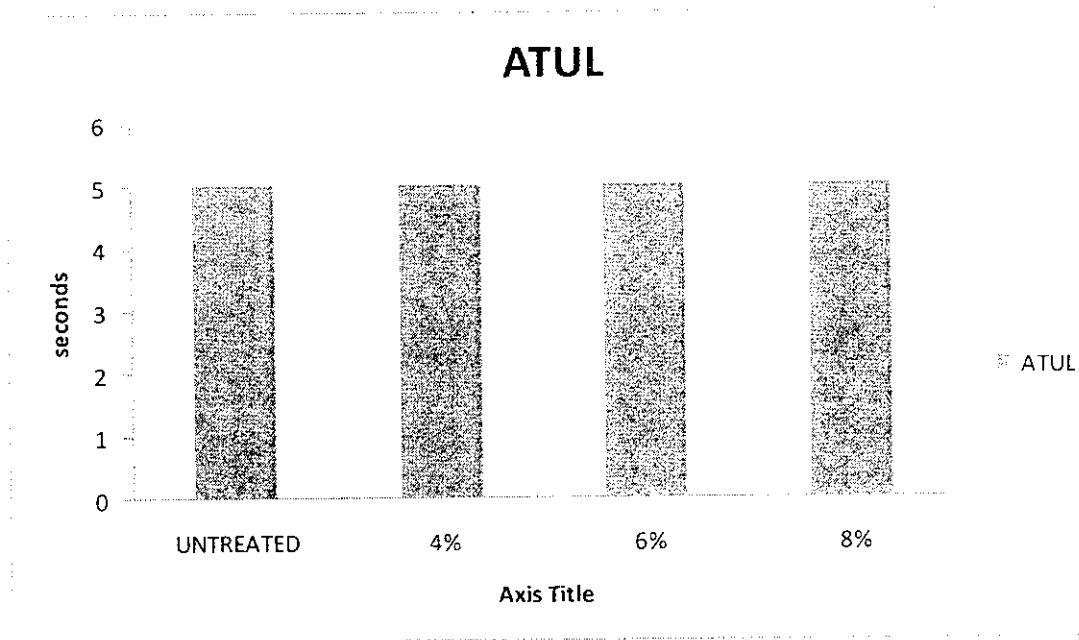II.From the above graph we infer that the fabric treated with 8% of sodium hydroxide has minimum wetness capacity.

5.10. RE-WET UNDER LOAD

RUL

INFERNCE

I. The flexural rigidity is found to be decreasing with increase in concentration.

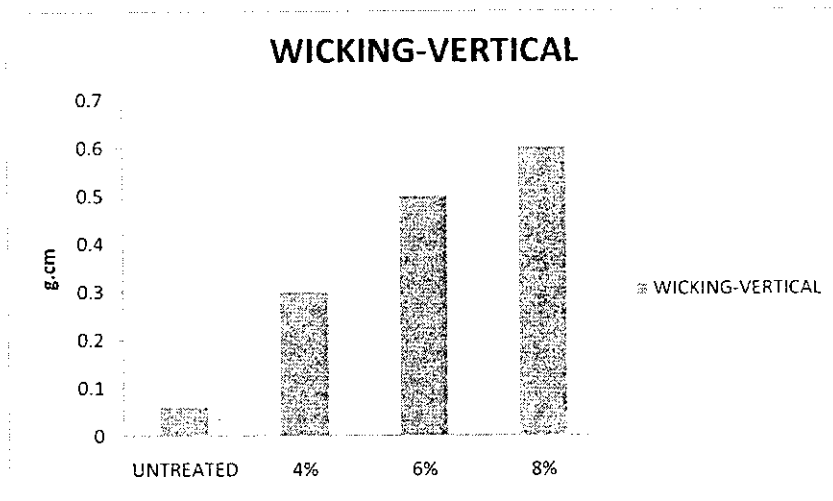II. From the above graph we infer that the fabric treated with 8% of sodium hydroxide has minimum flexural rigidity.

5.11. ACQUISITION TIME UNDER LOAD

ATUL

INFERENCE

I. The acquisition time under load is found to be same with increase in concentration.

II. From the above graph we infer that the fabric treated with 4%, 8%, 10% of sodium hydroxide has same acquisition time under load.
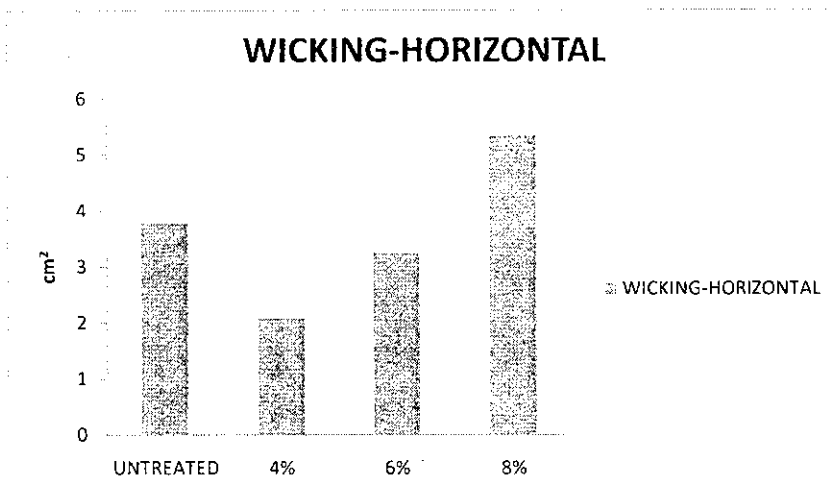
5.12. WICKING- VERTICAL

WICKING-VERTICAL

INFERENCE

I. Wicking is the movement of liquid by capillary action, provided that the liquid wets the assembly of fibers.

II. The wicking property is found to be optimum with increase in concentration.

III. From the above graph we infer that the fabric treated with 8% of sodium hydroxide has optimum wicking property.

5.13. WICKING HORIZONTAL

INFERENCE

I. The wicking results show that increase in absorbance capacity of the particular treated fabric.

II. It can be observed that the vertical wicking behavior is maximum, when compared to the horizontal wicking characteristics.

CONCLUSION

Four different samples were subjected to various test parameters as shown above. Sample A is an untreated fabric whilst rests of the samples (B-D) were treated with an agent to improve the performance.

It could be noted that the sample B and C were compared to A and D. This can be seen from the values of fiber density and fabric thickness.

With regards to fabric stiffness, sample D has poor resistance to bending on its own weight compared to the other samples whose values ranges from 2.0 - 1.9. Sample B- fabric posses high rigidity which means that it has good resistance to bending.

In terms of absorption capacity, sample D has shown better capacity to absorb liquid molecules than its comparator. This can be ascertained due to the treatment with agent. Sample B and C have shown similar absorption capacity.

The rate of absorption measures the distance travelled by the fluid in a known period of time. Sample D had higher values compared to other samples. With the wetness test again sample D took less time to wet itself. Therefore sample D possessed better absorption capacity than the treated and untreated samples.

Acquisition time under load (AQUL) is a good measure of ascertaining the capacity of product to absorb test fluid under the influence of a known weight. ATUL for almost all the samples took less than 5 seconds. The RUL measures the capacity of a product from re-wetting. For RUL measurement two different weights were used viz., 20g and 30g filter paper for absorbing the re-wet from the product. The RUL values for all the test samples showed marginal difference in between them.

All samples have shown average wicking characteristics, except sample D which has shown good horizontal wicking capacity to the rest of the samples. Based on the above battery of assessments it can be ascertained that 'sample D' had outperformed 'sample B and C' and is better than the untreated sample A.