AN EVALUATION OF DENIM FABRIC FOR COMFORT PROPERTIES AND EFFECTS OF WEAVING

Capstone Project

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1. Introduction:

1.1 Topic

The topic of our final project is to test the different weave of denim for comfort.

1.1.1 Theme

"How to make denim fabric comfort"

The project involves the testing of denim fabric for its comfort properties. Comfort is the main objective for every manufacturer around the world. The project illustrates that how we can achieve comfort for denim fabric hence it covers the factors which effect the comfort properties. Denim is a worldwide product and its demand is increasing day by day. The testing of denim is carried out for one or several reasons and several stages in the production of goods. Several methods are available for testing of denim but this project covers the methods available in the laboratories of Pakistan. The tests are conducted on the basis of buyers/customers requirement.

2. Literature Review

2.1 Denim:

Traditional blue denim is a 'warp-faced' cotton fabric in a 3/1 or 2/1 twill construction. Coarse yarn is used both in warp and weft and the weave is usually left hand twill. The warp is dyed in a solid color, usually indigo and the weft is left un-dyed. Because of being warp faced, the denim fabric is bluer on the surface and almost white on the back. In case of denim it is important to describe the face of the fabric. In twill weave the weft yarn interlaces with more than one yarn but never more than four, as strength would be sacrificed by doing so. In this way diagonal lines are formed.
Denim the fabric can be defined as warp faced twill fabric made from 100% cotton, containing heavy weight indigo dyed warp yarn and un-dyed weft yarn. The count of yarn used varies between 6's to 16's.

2.1.1 History of Denim

Durable twill woven fabric with colored (usually blue) warps and white filling threads; it is also woven in colored stripes. The name is said to have originated in the French serge de Nimes. Denim was yarn dyed and mill finished and is usually all cotton, although considerable quantities are of a cotton synthetic fiber mixture. Denim is used for leisurewear in the late 20th century also called blue jeans, dungarees, DENIMS, or LEVIS, trouser in the mid 19th century as durable work clothes.

In early days of denim existence was only considered as the work cloth and sportswear but now denim and jeans are particularly identified as a standard item of "western" apparel worn by the American cowboy. After the mid 20th century, various adaptations became internationally a characteristics part of clothing for both men and women.
In the past, natural indigo extracted from Indigofera plants was used for dyeing denim. It was Adolf Von Baeyer, who won the Nobel Prize for Chemistry in 1905, who provided the crucial movement and showed in principle that indigo could be synthesized on an industrial scale.
In denim sulphur dye is also most commonly used, because sulphur traditionally dark shades like black, navy shade. Now a day in denim variety of shades are being used like mustard, rust, yellow shade.

2.1.2 Appearance of Denim

Denim has a look like a fabric with running lines as all twill weave fabric have, it is usually blue in color, but it is now available in many different colors and styles. It has become the most popular fabric over the span of time. Denim is sometimes also weaved as plain weave or twill but this only done in rare cases for the sake of fashion. There is no hard and fast rule that a denim fabric must have blue warp and white filling twill weave but whenever we talk about typical denim it is that way. It has a very strong look and by simply looking at it we can say that it is a fabric that we can wear ruff and tuff

2.1.3 Types of Denim

i. Open end Denim
ii. Ring spun Denim
iii. Single Ring Spun Vs Double Ring Spun
iv. Bull Denim
v. Short-Gun Denim
vi. Snow Wash Denim
vii. Stretch Denim
viii. Thermo Denim

2.1.4 Uses of Denim

Denim is a popular fabric and its uses are widely recognized it is being used in industries beyond the imagination of a human mind. Lists of few uses are as under:

i. Trouser
ii. Shirts
iii. Jackets
iv. Hand and School Bags
v. Purses
vi. Sports Wear
vii. Curtains
viii. Skirts
ix. Collars and Cuffs

2.2 Preparation for Denim

2.2.1 Warping

WARPING is the transferring many yarns from creel of single-end packages forming sheets of yarn to be wound on to beam or section beam. Warping machines can process all types of materials including coarse and fine filament and staple yarns, monofilaments, textured, smooth yarns, silk and other synthetic yarns such as glass. Usually a static eliminator device is recommended for yarns that can generate static electricity.

The warp beam that is installed on a weaving machine is known as weaver's beam. A weavers beam contain thousands of ends, but in denim production a beam obtain from warping is known as Section Beams (warper's beam) because the denim is made from dyed yarn that's why first section beam can be obtained and then these section beams are combined on the stage dyeing and sizing to get required numbers of ends for weaving process. These combined sheets finally wound on a weaver's beam.

Generally there are three types of warping process

a) Direct Warping
b) Indirect Warping
c) Ball Warping

a) Direct Warping

In direct warping, the yarns are withdrawn from the single end yarn packages on three creels and directly wound on a beam. Direct warping is used in a two ways:

i. Direct warping can be used to directly produce the weaver's beam in a single operation. This is especially suitable for strong yarns that do not require sizing. And when the no. of warp ends is relatively small.
ii. Direct Warping is used to make smaller intermediate beam called Warper's beam. These smaller beams are combined later at the slashing stage (in case of denim production they will combine at the stage of dyeing and sizing range) to produce weaver's beam. This process is called beaming.

b) Indirect Warping

In indirect warping, a section beam is produced first used for section warping is pattern warping, band warping or drum winding. The section beam is tapered end of the beam. The same length of yarn is wounded on a each section which is measured by a measuring roller. The warping speed can be adjusted in the range of 20 to 800 m/min.

In this system of warping, the warping beam is prepared in two stages

i. Winding of number of ends required from yarn packages to section drum.
ii. Winding of sectional yarn sheet from section drum to warping beam.

Winding is the required number of ends in a section on the drum which has tapered (conical) at one end. Each such sheet is called a section. The sectional warping is used for the yarns and qualities which are not be sized, coarser and plied yarn.

c) Ball Warping

In this system of warping the yarns are wound on a large cylindrical roll (called ball or ball beam) in the form of a twist less rope in cross wound winding system, by hand or by mechanical balling system. The usual form is a cross wound in which multiple ends are wounds at the same time in a ribbon which contains 50 to 100 ends. The balls are used for dyeing of denim fabrics. After dyeing process the roll ends are separated and wound another warp beam, this step is called Long chain beaming. The warp beams so produced are then combined on sizing for applying the sized and making the weavers beam.

2.2.2 Warping program

Warping has done through the warping plan which is designed to the requirements of the lot. Following are considered in designing the plan:

i. Yarn Count.
ii. Yarn Quality.
iii. Types of Yarns.
iv. No. of required Beams.
v. Length of Yarn Sheet.
vi. Required no. of Ends.

2.3 Dyeing Process of Denim

2.3.1 Introduction

Dyeing with vat dyes is based on the principle of converting a water soluble Keto-substituted colorant by reduction to a water soluble enolate leuco compound that is substantive to cellulose. This penetrates into the fiber where it is reoxidized back to original insoluble form. All these dyes contain two or more keto (C=O) groups, separated by conjugate system of double bonds. Vat dyes are used for dyeing of cellulosic material , although the leuco dyes also have substantively for wool and nylon.

2.3.2 Dyes Used for Denim

Following types of dyes are used for denim;

i. Sulphur dyes(black and khaki)
ii. Indigo Dyes

2.3.2.1 Sulphur dyes(black and khaki)

Sulphur dyes are relatively cheaper class of dyes for the cellulosic fibers and are quite easy to apply. These are available in a fairly large range of shades like blue, navy, brown, olive, and khaki. The most popular dye of the range is black which gives deep and rich dark shade unsurpassed by dyes of another class. Sulphur dyes are applied knit and pile fabrics made from cellulosic fibers and their blends with polyester, nylon and acrylic.

a) Chemistry of Sulphar Dyes

The Sulphur dyes were originally marketed as water- insoluble powders that like vat dyes are dissolved in water under alkaline reducing conditions and after absorption. The dye- pigment regenerated inside the fibers by oxidation. The pigment being mechanically held inside the fibers make Sulphur dyes fast o wet treatments. Yarn is dyed in the form of warp beams for denim and by exhaustion and fully continuous process for fabrics.

2.3.2.2 Indigo

Indigo is a blue vat dyestuff that was originally taken from the "Indigofera tinctoria" plant by fermenting the leaves of shrub. In 1897, fourteen years after Adolf von Bayer identified the chemical structure of indigo, the chemical became synthetically manufactured. Natural indigo dyes were used throughout history, and have been found in Africa, India, Indonesia, and China.

Indigo is always blue although there are various casts of blue indigo available. Dyestuff manufacturers have tried to make colors that duplicate indigo's special features but no other color fades or avoids full fiber penetration. Indigo inherent features are good colorfastness to water and light, a continually fading and its inability to penetrate fibers completely. This allows blue color in jeans made from indigo to always look irregular and individual. Not only cotton but wool, acetate, rayon, tencel, and polyester yarns that accepts indigo.

b) Chemistry of Indigo

Formula ($C_6H_{10}N_2O_2$)

Indigo is a powder, insoluble in water, with a melting point higher than 30CC. It absorbs light in the yellow region of the spectrum (maximum at 602 nm), which gives it its intense blue color. The indigo molecule is relatively small with molecular weight of 262.27 atomic units of mass. In the molecular models illustrated on this page carbon is shown in grey, oxygen in bright red, nitrogen in blue, bromine in deep red and hydrogen in white. Blue indigo does not react with and will not bind chemically to fabric fibers, as most dyestuffs do. An indigo dye vat provides a reducing environment to keep the dye in solution.
By the end of the 19th century the demand for blue indigo dye began to exceed the supply available from the indigo plantation of India. The German chemist Johann Friedrich Wilhelm was the first person to determine the molecular structure of indigo.

2.4 Dyeing Methods

There are three types of dyeing techniques most widely practiced in denim manufacturing sector

a) Rope form dyeing
b) Sheet form dyeing
c) Looptex dyeing
d) Ben-Indigo dyeing

a) Rope form dyeing

Accounts for a large percentage of the yarn dyed for denim warps. The rope dyeing technique allows for the simultaneous production of more than one warp set in one run. This maximizes continuity of shades and minimizes the danger of side-centre-side shade variation. In such a type of machine, long chain warps are made up on a ball warp mill and consists of bundles of 320 to 380 ends of warp yarn.

b) Sheet form dyeing

In this technique, a sheet of single end of yarns, sufficient for one piece of denim, passes through the machine. In the operation they are dyed, oxidized, dried, sized and after a further drying step, assembled into warp.

c) Looptex dyeing

This is a new type of dyeing technique. Dyeing is carried out wet following pre-wetting or mercerizing. During the dyeing process, the pre-wet warp thread in loop form run through the dye trough several times, oxidation being facilitated by the loop normally immersion and oxidation is carried out four times with the process; This correspond to the dyeing result, as regards degree and fastness of color that are obtained by immersing and oxidizing six times on a normal warp dyeing range.

d) Ben-indigo dyeing

This is a modified technique used for dyeing of warp yarn. This process differs from other processes on account of nitrogen reactor. Nitrogen reactor can be used with any of the above processes

2.5 Weaving of Denim

2.5.1 Introduction to Weaving

Weaving is the interlacing of warp filling yarns perpendicular to each other at 90°. There are practically an endless number of ways of interlacing warp and filling yarns. Each different way results in a different structure. Weaving is a convenient way of describing the series of processes which collectively convert yarn into loom-state fabric, which is then inspected and suitability prepared for the finishing processes or loom-state use.

2.5.2 Yarn Used

Yarn specifications for production of denim fabric are

i. Minimum staple LENGTH 2.7 cm
ii. Proportion of short fiber less then 12 mm long 40%
iii. Usual count range denim warp yarn is 12 Ne-7Ne for weft yarn is 75 to 120 tex ; finer yarn as fine as 25 tex in twill or plain weave are often used in denim shirts.
iv. Twist factor, 4.5 to 5.0 for warp yarns, and 4.2 for weft yarn.

2.5.3 Types of Weaving in Denim

Denim weaves can be done through various patterns of interlacing yarns for fabric woven on a loom.

i. 3/1 coarse
ii. 3/1 staggered
iii. 2/1 fine
iv. 1/1 chambray
v. hearing bones
vi. cross hatch

2.5.4 Classification of Loom

i. Rapier
ii. Projectile
iii. Air jet
iv. Water jet

We can weave the denim fabric with the help of different types of looms but the most widely used loom is Air Jet due to its many advantages over the other looms. The brief description of Air jet loom is given below.

a) Air jet Weaving Machine

The air jet weaving machines are the weaving machines with the highest weft insertion Performance and are considered as the most productive in the manufacturing of light to medium Weight fabrics, preferably made of cotton and certain man-made fibers (sheets, shirting fabrics, Linings, taffetas and satins in staple yarns of man-made fibers); it has anyway to be pointed out that technically positive results are obtained at present also with heavy weight fabrics (denims) and that some manufacturers produce also machine models for terry production. These machines are the ideal solution for those who wants to produce bulk quantities of customized fabric styles.
The weaving widths range generally from 190 to 400 cm. As regards the multicolor weft carrier, up to 8 different wefts can be fed.
The air jet weaving machines require a high energy consumption to prepare the compressed air and that this consumption rises definitely with increasing loom width and running speed. The reduction in the energy consumption is in fact one of the main concerns of the manufacturers, and builds for the user an important selection criterion.