

A Review on “The Structural Geometry of Textile Fabrics”

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Abstract: The overall performance and functionality of the textile fabric depend on the geometrical properties of the fabrics. This article explores key geometrical parameters such as yarn density, fabric thickness, fabric structure, GSM of the fabric, texture, etc. Understanding these structural characteristics is essential for the development of innovative fabric design and so influences the end use. The study provides valuable insights for the textile designers and researchers in the selection or development of textile fabrics for the particular functionality.

Key Words: Yarn Density, Weaving, GSM., Fabric performance, Woven fabrics

I. Introduction:

Textiles are a fundamental part of human civilization, playing a critical role in clothing, shelter, industry, and art. From the earliest woven fabrics to modern high-tech textiles, these materials have evolved to meet the changing needs and demands of society. Understanding the properties of textile fabrics is essential for various applications, from fashion design to technical textiles used in medical and industrial fields.

One of the most important aspects of textile fabrics is their geometrical properties. These properties, which include yarn density, thread count, weave patterns, fabric thickness, surface roughness, porosity, and air permeability, determine the performance, appearance, and suitability of a fabric for specific uses. By analysing these geometrical characteristics, manufacturers and designers can create textiles with desired attributes, enhancing their functionality and aesthetic appeal.

The study of textile fabric's geometrical properties is crucial for innovation and product improvement, driven by technological advancements that enable precise control and manipulation of the properties.

Geometrical Properties of Textile Fabrics

1. **Yarn Density and Thread Count:** Yarn density is the count/number of yarns per unit area of fabric, measured in TPI or TPC. Higher thread counts indicate finer, denser, and smoother fabrics, often used in luxury bed linens and garments.
2. **Weave Patterns:** The weave pattern, consisting of plain, twill, and satin weaves, significantly influences a fabric's properties, including drape, texture, and mechanical properties, with each pattern offering unique characteristics.
3. **Fabric Thickness:** Fabric thickness, measured by the distance between surfaces under pressure, influences thermal insulation, weight, and durability, offering better insulation but potentially being heavier and less flexible.
4. **Fabric Weight:** Density, or grams per square meter (gsm) of a fabric, is known as fabric weight. Fabric weight directly depicts the durability and thickness of fabric. And the end use of fabric also depends on the fabric's weight.

The spinning twist influences the yarn thickness and compression in plain-woven fabrics such as yarn linear density, twist factor, and weft cover factor, significantly affecting major radius. [1]

Twisting is a crucial process for creating continuous yarn from discontinuous fibers such as cotton or wool. It influences structure, mechanical strength, rigidity, thermal conductivity, and surface characteristics. [2]

From a business perspective, sustainability encourages energy minimization and waste efficiency, reducing negative effects on the human race. The study covers the specifics of woven diagrams, transformation methods, and the effects of transformation factors on fabric views and overlaps over a single thread. [3]

The structure of the weave also plays a role in fabric mechanical properties. Research has demonstrated a correlation between the fabric's characteristics, including shear, crease recovery, tensile strength, bending, and air permeability. [4]

A study done on the importance of surface texture in fashion and textile design; the study highlights the texture in innovative creations and its evolution through technological advances. And so, the texture of the fabric impacts the visual effect. [5]

Fabric weight can be determined by using grams per square meter. A fabric cutter and a weighing machine are the apparatus used. A fabric a GSM is checked by GSM cutter. It is mainly used for woven, nonwoven, and knitted fabrics. It has been found that the weft density, the number of fabric layers, and the quantities are the most crucial factors when adjusting the fabric width. The stretch in fabric breadth is greater; rips have the biggest fabric width, whereas plain textiles have the lowest width. Regression research revealed a negative relationship between the weft tensile strength of single- and double-layered materials. [6]

The end use of the fabric also depends on the mechanical properties. Fabric performance is influenced by mechanical properties like tensile, bending, shear, buckling, and compression. Fiber components like morphology, twist, length, and orientation also affect fabric properties. Woven fabrics are highly anisotropic, non-linear, and flexible, allowing for flexibility and intricate designs. Shear behavior and weave structure also impact fabric mechanical properties. The phenomenon of bulk qualities, such as Young's modulus, flexural stiffness, and fabric weave pattern, are crucial in textile applications. [4].

In the textile industry, the common factors that influence the geometry of the textiles are (1) yarn count, (2) yarn twist, (3) threads per inch, (4) weave, and (5) crimp. (Os & Stanley Backer, n.d.)

A new geometrical modelling tool has been invented to predict the elastic stiffness properties of 2D orthogonal and 2.5D woven interlock composites. The study confirmed the weaving parameters and mechanical behaviors of the textile fabrics are interrelated. [5]

Fiber structural arrangements, thickness, cross-section, and other properties determine the fabric, as well as other characteristics of fabric. [7]

The interlacement of the warp and weft is called the weaving pattern. The plain weave is the basic weaving, featuring a warp and a weft yarn passing under one another.

The thread density is calculated as the average number of threads per unit length. It reflects the density (compactness) of the fabric structure. A distinction is made between the density of warp and the density of weft. The linear density of yarn is a parameter characterizing the thickness of the yarn, and it is most often expressed in the unit tex. 1 tex corresponds to the mass of 1 km (1000 m) yarn length.

Researchers examined and discussed the use of a contactless measurement method to characterize the surface topography of woven fabrics with various weaves, as well as the impact of weave on the selected roughness criteria of the materials. Weave, warp and weft density, and warp and weft linear density are considered the structure of the textile fabrics, and these are reflected through the surface of that particular woven material. They analyzed the geometric structure of cotton woven fabrics with different weaves using surface topography measurements using the MicroSpy® Profile profilometer, and it is confirmed that use of the profilometer can be recommended to analyze the topography of the fabric surface and highlights the importance of surface roughness parameters in surface quality.[8]

"Kawabata" techniques are an approach that makes the idea that the subjective assessment of a fabric's hand is an amalgamation of numerous physical characteristics such as weight, thickness, flexural, compressive, shear, and surface characteristics that the brain evaluates automatically are used to analyze the "hand" or "feel" of the cloth.[9]

To determine the overall assessment of the textile material, the hand-feel is an important factor. Through electrophysiological methodology, formation mechanisms and cognitive principles were used.[10]

The X-ray diffractometer should be used to measure the XRD pattern of nanoparticles deposited in textile fabric, enabling the identification of their crystal structure and size. FTIR should be used to analyze chemical changes and bonding interactions in fabrics treated with nanoparticles. [11]. [12].

X-ray diffraction/XRD was employed to distinguish between textiles in forensics to differentiate between natural and artificial fabrics using the crystal structure. [13]

XRD was effectively used to provide novel ultrastructural information on stinging nettles as well as unique archaeological and historical bast fibers.[14]

The study utilized XRD as one of the characterizations and explored a natural, non-invasive method for cleaning historic textiles using lye, a substance with antifungal properties. It uses artificial intelligence techniques to analyze traditional women's shirts, revealing a decrease in microorganism colonies and dust.[15]

The importance of various electroconductive compounds in different fields, including the fashion and textile industries, is explained in the study, and the use of XRD characterization was also discussed.[16]

Latest Approaches in Textile Manufacturing:

According to past studies, it is confirmed that the industry is transposing into more automated, as well as the demand and the market for advanced textiles increasing day by day.[17]

The textile industry is transforming into a digital and sustainable one because of the adoption of creative and modern technology in the sphere, from the stage of fiber and yarn to the weaving and finishing of the fabric. And so, the industry is able to produce more than just apparel, like smart and technical textiles, incorporating electronics and modern devices such as sensors in the textiles, etc. [18]

The textile industry is focusing on giving proper functional properties depending on the end use. The antimicrobial finish, moisture management, use of microfiber in the development of fabric, and application of nanoparticles are some of the advanced technologies used in the industry. [19]

The industry is efficiently turning the challenges into opportunities. by applying digitalization in all the spheres of the production of the fabric. [20]

The textile industry is trying to balance the digital revolution with the cultural heritage.[21]

Nanotechnology has become a part of industry. [22]

II. Conclusion:

The geometrical characteristics of textile fabrics, such as yarn, fiber, spinning, weaving, fabric thickness, texture, etc., impact the end-use performance of the fabric. Understanding of the geometrical factors plays an important role in the selection of fabrics for specific applications, such as medical textiles, self-cleaning textiles, textiles for apparel and upholstery, etc. The accurate evaluation of geometrical characteristics of the fabric is more important to the development of innovative and functional fabric solutions. In the textile industries, X-ray diffraction is frequently used in conjunction with other analytical methods to analyze the necessary elements.

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