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Short Communication

Bursting Strength and its Relevance for Textile Testing: An Exploratory Study

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Introduction

Sportswear accepted knitwear in 1970s and 1980s. The consumer gravitated toward casual apparel that provided comfort and easy care. Textile and clothing construction research continued to work independently. In 1990s casual Fridays brought a new revolution in the lives of consumers. Eventually this trend resulted in casual lifestyle nationwide in the United States. Even though, aesthetics, care, comfort, and durability continued to dominate the world of textiles, it was evident that knit construction and addition of spandex added more comfort and stretch in the textile.

Breaking/tensile strength had been used extensively for determining the durability of the textiles by the textile industry. Breaking and tensile testing determines the strength based on the linear strength. As evident from the published literature, breaking strength can be determined by grab test standards ((ASTM D5034-2017) and strip testing (ASTM D-5035) for woven fabrics including felts and nonwoven materials. These tests used Constant Rate of Extension (CRE) method. However, bursting strength measure the circular pressure before rupture. It is important for using textiles in the areas of the garment where pivoting occurs. Som examples could be elbow and knee areas.

Very limited published work has focused on testing the bursting strength. Previously, ASTM D 3686 [1] and ASTM D-3687 [2] have been used using hydraulic and non-hydraulic tests using Constant Rate of Traverse (CRT) test, Therefore, results differed and did not show consistency. In 2015, ASTM D-6797 [3] was introduced to measure both woven and knitted fabrics. Merkel [4] and Collier and Epps [5] reported that historically bursting strength was recommended for the knitted fabrics.

For the reported study, newly introduced standard ASTM D-6797 - 2015 [3] was used. An attempt was made to see its relevance for both woven and knitted fabrics. This paper compared the published studies on bursting strength and explored possibilities for future research that could benefit textile and apparel consumers, manufacturers, and retailers for both knitted and woven fabrics.

Literature Review

Relevant literature was reviewed on bursting strength from consumer and industrial publications as well as academic journals. Even though the textiles industry has tested bursting strength using the diaphragm method and CRT technique, it has limited information for CRE technique. The review utilizes both knitted materials and use of Spandex to induce stretch and comfort, as well as knit structures. It is assumed that this information will help academician to understand the strength of knitted fabrics and those with spandex batter. It is known fact that bias cut in woven fabrics can also increase stretch and comfort in apparel. None of the reviewed literature addressed this aspect.

Merkel [4] reported that a round hole is created on weft knitted fabrics that simulates the hole made in the sweater at the elbow level due io its pivoting. He also purported that industry has used both ASTM D 3786 [1] and ASTM D 3787 [2] for bursting strength. However, both tests did not measure serviceability optimally. Merkel [4] further asserted that using knitted yarns may help with understanding this relation better than with fabrics. He further noted that in unbalanced knit structures, weaker sections show more damage than the stronger numbers. Damage occurs in both directions for the balanced knits.

It is relevant to note that historically comfort was introduced through Spandex by Dupont in 1958 with tradename of Lycra that is used extensively with jeans today for comfort and better fit than ever before [5-9]. These references just reinforce the increasing popularity of using spandex and knitted materials over time. One of the perceived fringe benefits was to bridge the gap between textile and apparel research.

Chowdhary [10] compared price and quality of different jeans for price and quality of the jeans (antique, sandblasted, and stonewashed. based on structural and performance attributes of textiles. The author also examined both fabric and seam strength to determine seam efficiency of an apparel product. In this research, all fabrics were 100% cotton with twill weave, Kadolph [11] and Chowdhary [12] reported that breaking strength and elongation have inverse relationship.

Uyanik et al. [13] and Yesmin et al. [14] reported that stitch length is related to bursting strength. They found that an increase in stitch length decreases the bursting strength. However, neither of them mentioned it for bursting strength and elongation. Degirmenci & Celik [15] did not find any relationship between bursting strength and elongation.

ASTM D 3786 - 2016 [1] does the same with hydraulic system. It is developed for knitted, non-woven and woven materials for different end-uses. It uses hydraulic tester. ASTM D 3787 - 2016 [2] is described to measure bursting strength with a ball burst strength tester for textiles or apparel that has high degree of elongation using CRT ball burst. Sample size is 5" x 5". This test does not specify fabric construction. The manual suggests that this test can be used for both woven and knitted fabrics from the rolls or the garments. It can be used for both woven and knitted fabrics. Results can be reported in psi as well as lbf.

Emirhanova and Kavasutran [16] reported that knit structures can impact the bursting strength. None of the previous researchers used ASTM D 6797. Clobanu et al. [17] compared bursting strength of the knitted fabrics for the sandwiched fabrics. The found that adding Kevlar rather than linen could reduce the performance cost. Their three conclusions suggested that stitch density, increased velocity, and in-lay yarns impacted the bursting strength of the knitted fabrics. The strength decreased with increased velocity and increased with the remaining two. Longer stitches had lower bursting strength than the shorter stitches. In Yesmin et al. [14] study, Single Lacoste (jersey) had the highest bursting strength and double pique knit the lowest. Sadek et al. [18] and Eryuruk and Kalaoglu (2016) reported that increase in the percentage of Lycra increased enhanced the bursting strength.

Chowdhary et al. [19] examined seventeen knitted fabrics using the newly developed standard ASTM D-6797-2015 [3] for their bursting strength in interlock, jersey and pique constructions. Their findings revealed that the bursting strength was the highest for poly/spandex blend and lowest for the rayon/Lycra blend. Among jersey construction, it was highest for cotton polyester blend (60/40) but the lowest for rayon/spandex (95/5). Among pique knits, it was highest for the 100% polyester and lowest for the 100% cotton. Variability was evident for both fibre content and fabric structure. Hoque et al. [20] reported that fabrics with more % of polyester are likely to have higher bursting strength than less percentage. Ghosh [21] found that stitch length, stitch density, fabric density, loop factor, and porosity were the influencing factors. The results also showed that GSM and porosity impact bursting strength individually. However, GSM explained 83 to 94% of the variance.

Elias et al. [22] found that increase in polyester content enhanced the bursting strength of fabrics. Authors tested one to 1% to 5% Spandex and found that no relationship was found between Spandex percentage and bursting strength. The unit of bursting strength used by the researchers was Kilopascals (kPa). Kilopascal can be changed into psi by multiplying it by 0.145038. Mahmoodbadi et al. [23] stressed that use of inlay yarns changed the tensile properties of the hybrid knit structures [24].

Results

This section is presented in two sections. Part I focusses on results from published work. However, Part II draws from the studies conducted by the author and graduate students and graduate research assistants.

Part I facts from literature review

1. Fiber content, in-lay yarns, stitch density, types of knit construction and velocity impacted the bursting strength of fabrics.

2. Mixed results were reported for contribution of Lycra percentage on the bursting strength.

3. An increase in polyester percentage increased the bursting strength.

4. Most of the prior work focused on the knitted fabrics.

Part II: findings from the reported study

This section is divided in knitted, woven and knitted/ woven fabrics.

A. Knitted Section

a) Medium weight cotton jersey had higher bursting strength than the lightweight cotton jersey.

b) 2x2 medium weight rib knit had higher bursting strength than the 1x1 medium weight rib knit construction.

c) Light weight 100% cotton and cotton/Lycra blend did not differ significantly for their bursting strength.

d) Light weight 100% cotton and cotton/Lycra blend did not differ significantly for their bursting strength.

e) Medium weight 100% polyester fleece and cotton/poly fleece did not differ significantly.

f) Pique knit had significantly higher bursting strength than the plain jersey and 1x1 rib knit.

B. Woven Fabrics

a) Nomex on the straight of grain did not differ significantly from the bias-cut at 45 degrees.

b) Bursting strength of 100% (3x1) cotton denim did not differ significantly for on grain and bias-cut pieces.

c) Even though bias-cut had higher bursting strength than the on-grain cut for the olefin blend, they did not differ significantly from each other.

d) 100% wool did not differ in straight and bias-cut forms for the bursting strength.

C. Knitted /Woven

a) Heavy weight terry did not differ for bursting strength from heavy weight denim with 3x1 twill weave.

b) Medium weight viscose had significantly higher bursting strength than the medium weight cotton jersey.

The exploratory study revealed that bursting strength test can be used for both knitted and woven textiles, this conclusion is contrary to the conventions of Merkel [4] and Collier and Epps [5] who reported that bursting strength is used for knitted material. Even though it makes sense that knits have multidirectional stretch and using circular testing provides meaningful results. Woven textile has also been used for making bias cut clothes that can have multidimensional rather than linear impact. It can be more critical for the body parts that pivot like elbows and knees. In the reported study, even though differences were observed in straight cut and bias-cut wovens, results were not consistent and need further investigation. Likewise, results were not compelling to infer that knitted and woven materials yielded similar/different results.

It will be useful to extend the research on bursting strength for both woven and knitted materials under controlled conditions to enhance the reliability of the results. Controlling for fabric construction, fiber content, fabric count, fabric thickness, fabric weight, stitch length, twist, and yarn type will yield more meaningful results for the apparel manufacturers and retailers to create quality apparel products for various end-uses. Breaking strength tests linear strength and bursting strength tests circular strength. Circular strength takes into consideration both warp/ weft and Wales/courses.

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