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THE INFLUENCE OF ELASTANE RATIO ON BURSTING STRENGTH PROPERTY OF KNITTED FABRICS

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ABSTRACT

Elastane fibers represent a further high point in the development of man- made fibers. These fibers exhibit rubber like behavior with high reversible extension as high as 400-800%. Knit fabric properties can be changed due to use of various count of yarn, type of yarn, loop length, structural geometry, fiber composition of yarn etc. An investigation was carried out with the fabrics knitted on a basis of Jersey, Rib 2×2, Interlock, and Lock nit warp knitted structure on circular weft knitting machines and Tricot machine. In this investigation, the approach is to determine the structural parameters and the ratio of Elastane affecting the bursting strength property of various knitted fabrics constructions. The obtained results showed that Elastane proportion inside fabric has an incidence on fabric bursting strength property. The origin of this behavior has been discussed.

Keywords: Bursting Strength, Elastane, Interlock, Lock nit structure, Loop Length, Tricot Machine.

I. INTRODUCTION

Elastane is used in all areas where a high degree of permanent elasticity is required; for example, in tights, sportswear, swimwear, corsetry, and in woven and knitted fabrics. Elastane is a prerequisite for fashionable or functional apparel, intended to cling to the body making it remain comfortable. Worldwide spandex consumption and growth is 30 - 40 % per year and is expected to grow high [1].

Elastane fibers, better known under their trade names such as lycra, spandex and dorlastan, represent a further high point in the development of man-made fibers; invented in 1937 in Germany, elastane has properties not found in nature, the most important having an extraordinary elasticity . Spandex is a generic term used to designate elastomeric fibers which have an extension-at- break greater than 200 % and also show rapid recovery when tension is released. These fibers exhibit rubber like behavior with high reversible extension as high as 400 - 800 %. The name Spandex is an anagram of the word expands and is known as Elastane.

Cay et al. [2] explained that the structure of elastic fibers is extracellular matrix macromolecules comprising an elastane core surrounded by a covering of fibrillin-rich microfibrils. The structure of elastic fibers is complex because they have multiple components, tightly regulated developmental depositions, a multi-step hierarchical assembly and unique biochemical functions. Han Sup Lee et al. [3] studied the internal structure and orientation

behavior of two series of Elastane fibers, which were made with different spinning methods using different soft and hard segment types by Fourier Transform Infrared Spectroscopy (FTIR), polarizing light microscopy and Instron. The results concluded that dry spun fibers exhibit better elastic recovery than melt spun fibers. The mechanical hysteresis gave consistent results with those of FTIR and birefringence measurements.

Elastane is readily compatible with other common fibers including nylon, polyester, acetate, polypropylene, acrylic, cotton, wool and rayon [4]. In general, breaking strength of Elastane fiber is 0.7 g / den and elongation before break ranges from 520% to 610 %. Elastane fiber is white and dye able with disperse and acid dyes. It has good resistance to chemicals and withstands the action of perspiration. It may degrade and turn yellow when it is treated with chlorine. It can be washed at 60 ^{0}C and tumble dried at 80 ^{0}C. The fiber has moisture regain of about 0.3 % with melting point of 250 ^{0}C, but starts sticking at 175 ^{0}C [5]. Elastane yarns contribute significant elastic properties to all types of fabrics like circular knit, warp knit, flat knit, woven, nonwoven, lace and narrow fabrics [6]. It is sufficient to provide the desired stretch properties of a woven and knitted fabric even with lower percentages like 2 – 3 % of elastane [7]. Normally, elastic knitted fabrics in grey stage are relaxed and further the fabric is heat set, bleached, dyed and compacted in the wet processing treatment.

Knitting is the process of forming fabric by interloping yarn in a series of connected loops using needles. In warp knitting all needles knit simultaneously for all yarns, while in weft knitting the needles knit in sequence for each yarn. Knit fabrics provide outstanding comfort qualities and have long been preferred in many types of clothing. In addition to comfort imparted by the extensible looped structure, knits also provide lightweight warmth, wrinkle resistance, and ease of care [8].

In weft knitting structures, Plain (Single Jersey) is produced by the needles knitting as a single set, drawing the loops away from the technical back and towards the technical face side of the fabric. Plain is the simplest and most economical weft knitted structure to produce and has the maximum covering power. In Rib structure, two sets of needles are operating in between each other so that wales of face stitches and wales of reverse stitches are knitted on each side of the fabric. Single or simple ribs have more than one plain wale but only one rib wale, such as 2×1, 3×1,etc. The extensibility of the fabric widthwise is approximately twice that of single jersey. The lengthwise extensibility is essentially the same as in single jersey. Interlock structure is composed of two 1×1 rib fabrics locked together. It has the technical face of plain fabric on both sides but its smooth surface cannot be stretched out to reveal the reverse loop wales [9]. In warp knitting structures, the use of two guide bars gives a wider scope for patterning than is available with single guide bar fabrics. In Locknit structure, due to free-floating underlaps the fabric has a smooth back and good elasticity. In general, warp knitted fabric are more stable than weft knitted fabric [10].

The physical and mechanical properties of knitted fabrics are very important in many ways. Among these properties, the bursting strength is extremely important. Bursting strength is the force that must be exerted perpendicularly on the fabric surface to break off fabric. Since measurements of the tensile strength in the wale and course directions in knitted fabrics are not suitable, testing the bursting strength, which is the strength against multi directional forces, becomes important especially for knitted fabrics [11]. In the present paper, the effect of Elastane ratio and fabric parameters on the bursting strength of knitted fabric was determined and the origin of this behavior has been discussed.

II. MATERIALS AND METHODS

2.1. Materials and Sample Specifications

Fabric construction methods can affect the appearance, texture and properties of the fabric. Together, fiber content and method of construction create the final properties of the fabric. The development of knitted fabrics with incorporated Elastane has increased in recent decades. Knitting with these elasticized yarns usually results in a very compact structure.

The experimental weft knitted samples were knitted on a 24 Gauge 30" diameter high speed circular knitting machine equipped with positive feeders while the experimental warp knitted samples were knitted on a 32 Gauge KRS 2-3E Tricot machine by 3500 rpm with two guide bars. Ne 30/1 ring spun cotton yarn and 44 dtex spandex were used in the research to produce weft knitted samples while 44 dtex polyamide 6and 4o dtex spandex were used in the research to produce warp knitted samples.

Knitted fabrics form by loops and the characteristics of the loops inside the fabric like density, shape and the numbers change the structure of the fabrics. Beside these characteristics the weight and the thickness of the knitted fabrics are distinctive on the performance properties of them. For this aim all the structural analyses of them were done and illustrated on Tables (1) and (2). Table (1) shows the specifications of the weft-knitted samples while Table (2) represents the specifications of the warp-knitted samples.

Table 1 The Specifications of the Weft-Knitted Samples

Sample No.	Fabric Structure	Fabric Composition	Fabric Thickness mm	Fabric Weight Gm/m^2	Courses / cm	Wales / cm	Loop length mm
1	Plain (S.J) 	2% Elastane 98% Cotton	0.6	190	18	23	3.35
2		3.5% Elastane 96.5% Cotton	0.64	210	21	24	3
3		5% Elastane 95% Cotton	0.68	230	24	25	2.7
4	Rib 2*2 	2% Elastane 98% Cotton	0.88	235	19	10	6.8
5		3.5% Elastane 96.5% Cotton	0.95	250	20	12	6.2
6		5% Elastane 95% Cotton	1.1	270	21	15	5.7
7	Interlock	2% Elastane 98% Cotton	0.84	285	25	14	3.9

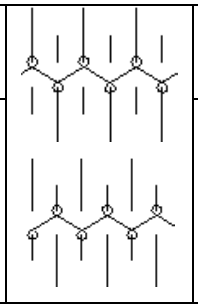
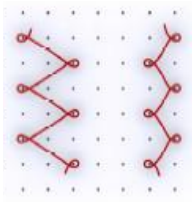
8		3.5% Elastane 96.5% Cotton	0.89	294	29	16	3.6
9		5% Elastane 95% Cotton	0.92	305	31	19	3.1

Table 2 The Specifications of the Warp-Knitted Samples

Sample No.	Fabric Structure	Fabric Composition	Fabric Thickness mm	Fabric Weight Gm/m^2	Courses/ cm	Wales/ cm
10	Locknit  GB1 GB2	15% Elastane 85% Cotton	0.6	180	39	27
11		20% Elastane 80% Cotton	0.64	192	44	29
12		25% Elastane 75% Cotton	0.68	220	50	31

2.2 Laboratory Testing

2.2.1 Determination of Fabric Weight: This test was carried out by using Mettler H 30 apparatus according to the American Standard specifications of (ASTM D3776 / D3776M - 09a) [12].

2.2 .2 Determination of Wale & Course Density: This test were determined at ten different places on every sample calculated with a magnifying glass, and the average values were calculated.

2.2.3Determination of Fabric Thickness: This test was carried out according to (American Standard specifications of (ASTM D1777- 96(2011) e1) [13].

2.2.4 Determination of Bursting Strength: This test was carried out by using, Bursting Tester for clothing, according to (ASTM D3786 / D3786M – 13) [14].

III. RESULTS AND DISCUSSION

The type of fabric and its end use determine the amount and type of Elastane required ensure optimum performance and aesthetics. As little as 2 percent Elastane is enough to improve a fabric's movement, drape and shape retention, while fabrics for high performance garments such as swimwear and active sportswear may contain as much as 20-30 percent Elastane.

3.1 Fabric Weight

It was obvious from Figure (1) that, the loop length has a significant effect on the fabric weight for all weft knitted samples, as the loop length increases, the fabric weights were decreased, this means that the higher the loop length, the lower the fabric weight.

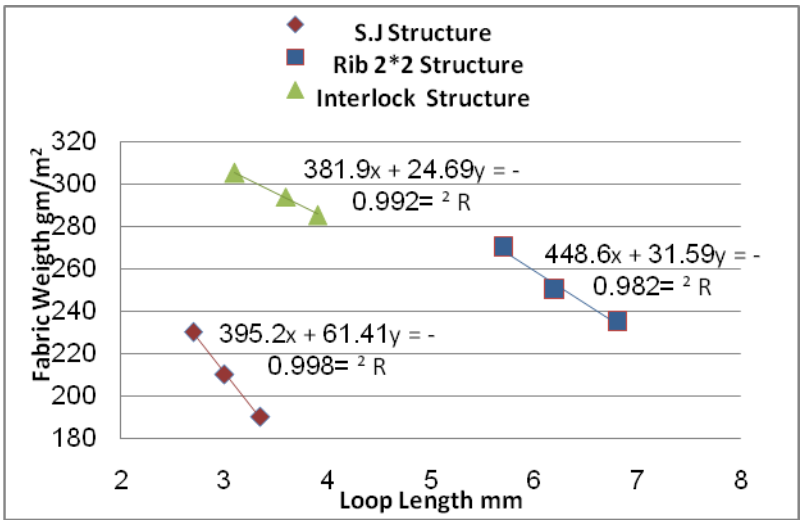


Figure 1 The Relationship between the Fabric Weight and Loop Length for Weft-Knitted Structures

The significant effect of loop length on fabric weight for all tested fabrics can be attributed to the decrease in the loop length help to increase in stitch density which lead to increase to fabric weight.

Figures (2), (3) showed that, the there is direct relationship between Elastane ratio (from 2% to 5%) and fabric weight as the amount of Elastane increase the fabric weight increase, because the greater the amount of Elastane, the tighter the fabric weight.

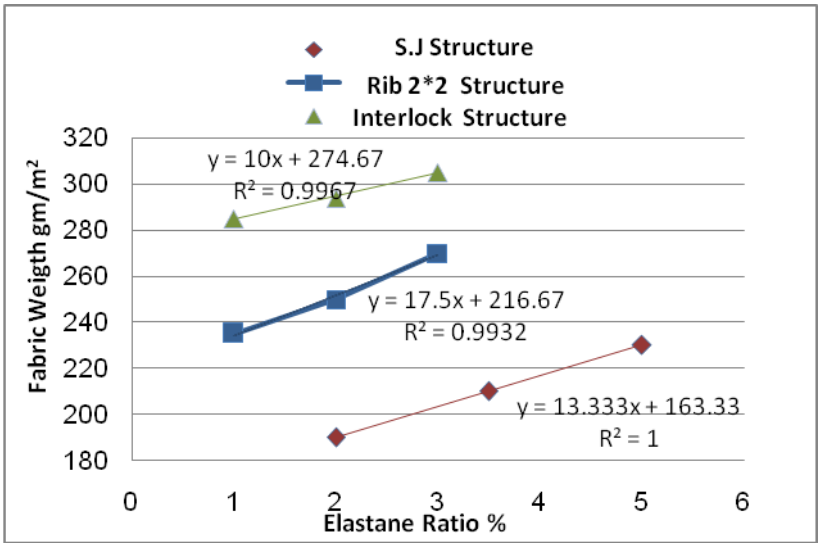


Figure 2 The Relationship between the Fabric Weight and Elastane Ratio for Weft-Knitted Structures

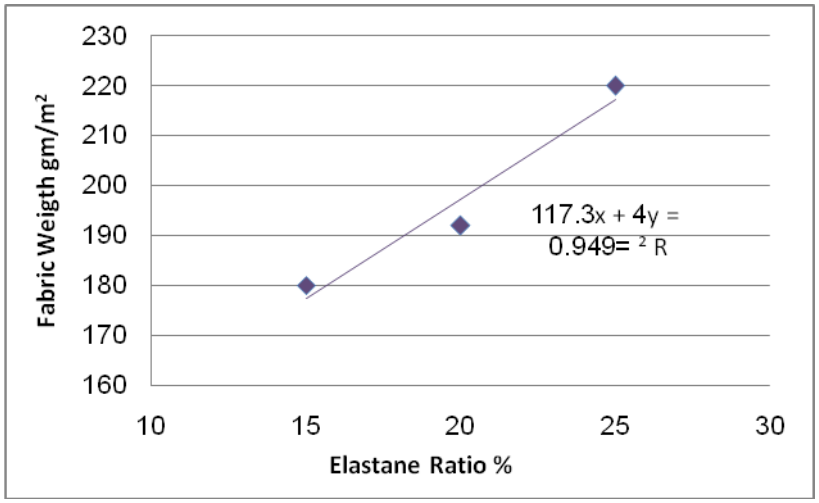


Figure 3 The Relationship between the Fabric Weight and Elastane Ratio for Warp-Knitted Structures

3.2 Stitch Density

Knitted fabrics form by loops and the characteristics of the loops inside the fabric like density, shape and the numbers change the structure of the fabrics. Figures (4), (5) illustrates the relationship between the amount of Elastane and the stitch density for different loop length . It is shown that, the amount of Elastane is significant effect on the stitch density for all tested fabrics. The greater the amount of Elastane, the higher the stitch density is. This can be due to the fabric construction as all the other properties.

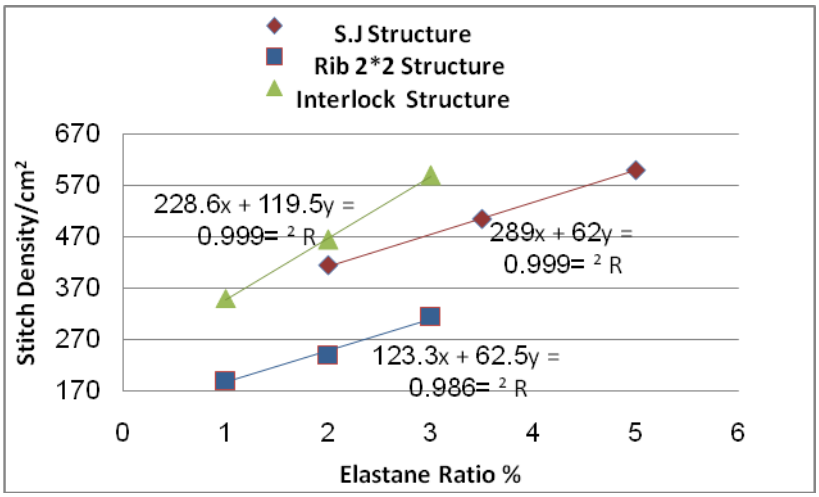


Figure 4 The Relationship between the Elastane Ratio and the Stitch Density for Weft-Knitted Structures

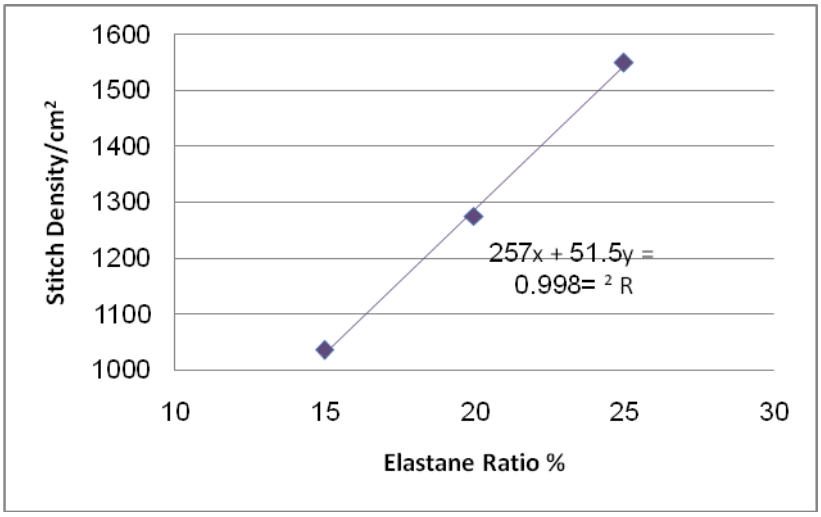


Figure 5 The Relationship between the Elastane Ratio and the Stitch Density for Warp-Knitted Structures

3.3 Bursting Strength

Strength is very important parameter for all textile structures. Because of these knitted fabrics are produced to design as denim, the importance of strength become prominent more. The strength of sample knitted fabrics was measured by bursting strength test method. In the bursting strength property of the fabric the elongation and the strength of the yarn, the structure of the fabric are the effective parameters. Bursting strength average test results were examined and illustrated in Figure 6.

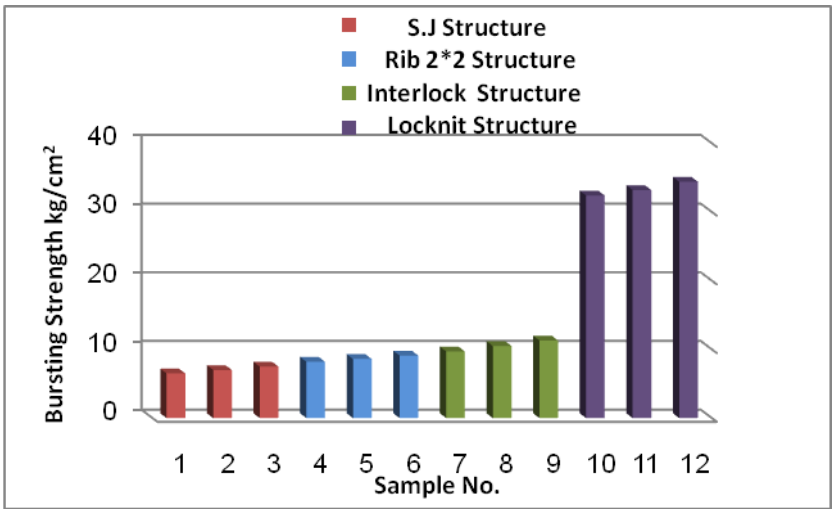


Figure 6 Bursting strength Test Results

Figure (6) illustrates that, Locknit structure records the best bursting strength result with 30% of Elastane ratio while plain structure records the worst bursting strength result with 2% of Elastane due to the construction of the fabric. In locknit structure, Two separate warps feed into these fabrics, each going through different lapping motions. The relative movement of the two guide bars along with the magnitude of shogging, determines the appearance and properties of the fabrics. Interlock structure records better bursting strength results compared

with Plain and Rib 2*2 structure because it is a balanced, smooth and stable structure. In Interlock structure wales on each side are exactly opposite to each other and are locked together

Figures (7). (8) illustrate that, the amount of Elastane is significant effect on the bursting strength for all tested fabrics, as amount of Elastane increase, the bursting strength increase, because the greater the amount of Elastane, the tighter the fabric.

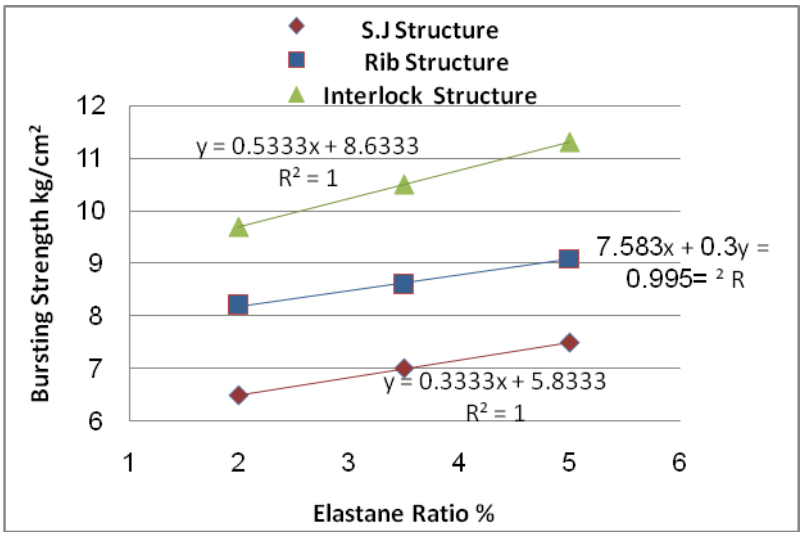


Figure 7 The Relationship between the Elastane Ratio and the Bursting strength for Weft-Knitted Structures

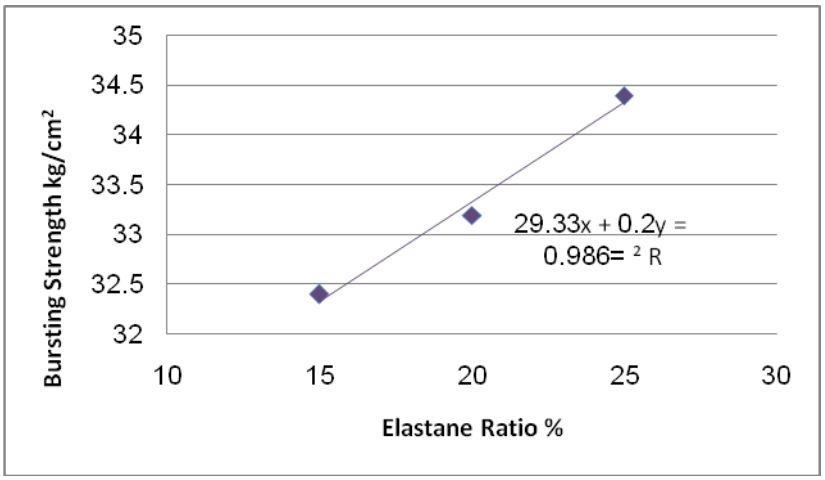


Figure 8 The Relationship between the Elastane Ratio and the Bursting strength for Warp-Knitted Structures

Figure (9) showed that, the there is inverse relationship between loop length and bursting strength as the loop length increase the bursting strength decrease. The significant effect of the loop length on the bursting strength can be attributed to the less loop length associated with increasing the fabric weight which leads to higher bursting strength.

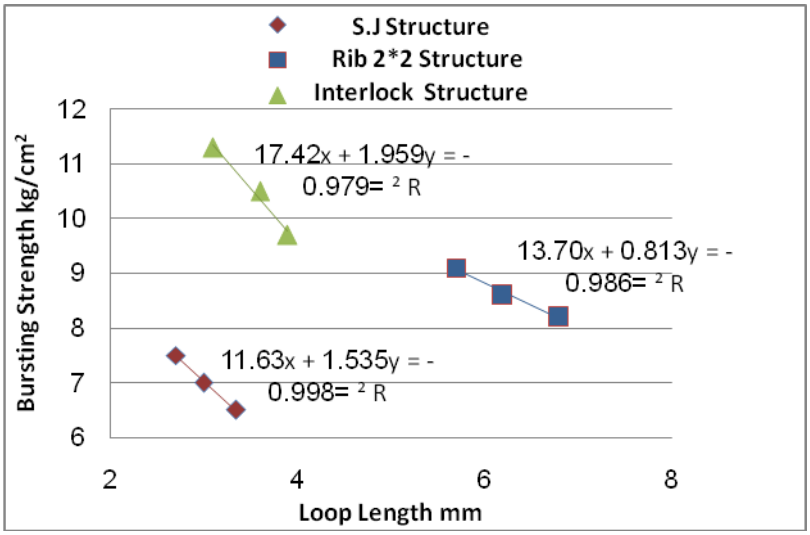


Figure 9 The Relationship between the Stitch Length and the Bursting strength for Weft-Knitted Structures

IV. CONCLUSIONS

Bursting strength is an alternative method of measuring strength in which the material is stressed in all directions. The physical and mechanical properties of knitted fabrics are very important in many ways. Among these properties, the bursting strength is extremely important. In this investigation, the approach is to determine the structural parameters and the ratio of Elastane affecting the bursting strength property of various knitted fabrics constructions. The following result are given as under:

All the parameters under study were significantly affected by the amount of Elastane in the fabric and the loop length.

It was found that, bursting strength has been improved significantly by increasing in Elastane ratio.

Loop length had a significant effect on the bursting strength, stitch density and fabric weight.

Locknit structure records the best bursting strength result.

Interlock structure records better bursting strength results compared with Plain and Rib 2*2 structure with using the same Elastane ratio.

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