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Factors Influencing Bursting Strength of Single Jersey Knitted Fabrics

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Abstract
The purpose of this article is to assist engineers in making quick decisions to improve the strength of single jersey knit fabric. This article focused on the different parameters of the single jersey knit fabrics (like stitch length, yarn count, GSM, tightness factor, and fabric thickness) are considered to know their influence on the bursting strength. Five hypotheses have been developed for plain, pique, and fleece knits. Analyses of Variance (ANOVA), correlation coefficient, and regression analysis are executed using the STATA 14.1 program to test the hypotheses at a 5% level of significance. Three of the five hypotheses are rejected. This study supports that the bursting strength of the fabric is dependent on the tightness factor, stitch length, and count of the single jersey knitted fabrics. Here, the stitch length, count, and tightness factor are inversely proportional to the bursting strength. The GSM and fabric thickness have less impact on the bursting strength.

Keywords: Single Jersey Fabrics, Bursting Strength, Stitch Length, Count, Tightness Factor

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Introduction

Weft and warp knit fabrics are widely employed in various fields today, including fashion and industrial uses. The mechanical characteristics of textiles are critical for these applications. Among them, bursting strength is a suitable method that measures strength and elasticity in which the material is stressed in all directions (Değirmenci & Çoruh, 2016). Bursting strength is a significant sort of three-dimensional strain (pressure applied to the fabric surface). Thus, bursting strength is the most suitable technique to measure the strength of various weft-knitted structures (Hossain, Haque, Banik, and Rana 2018). The effect of knit structures on bursting strength is positive, as found by the researcher (Emirhanova & Kavusturan, 2008).

The bursting strength of a fabric is the resistance of many loops simultaneously; more loops result in higher resistance. Since loop length is related to the tightness factor of the fabric, a high loop length translates to a lower bursting strength. CPI, WPI, stitch density, and GSM decrease with the increase in stitch length. Bursting strength decreases with the increase in stitch length (Akter, Faruque & Islam, 2017).

The bursting strength properties of knitted fabrics are related to the raw material, pattern type, elastomer ratio, and yarn count. Polyester also has higher bursting strength values because the strength of the polyester yarn is higher than that of cotton yarn (Değirmenci & Çoruh, 2016).

Usha C, Mohammed M A, and Chin examined seventeen knitted fabrics; among them were blended and the same fiber for their bursting strength and extension. They reported that extension was highest for 100% cotton due to its lightweight (Chowdhary, Adnan & Cheng, 2018).

The single jersey fabrics made from tencel/cotton blended yarns show maximum bursting strength compared with all other fabrics (Badr, Hassanin & Moursey, 2016). An increase in softener concentration resulted in an improvement in the fabric bursting strength (Hussain, Safdar, Nazir & Iqbal, 2013).

Knitted fabrics may be produced with a variety of stitch lengths to generate a variety of fabric tightness factors and stitch densities, and they may also be exposed to a variety of relaxation treatments to reduce the energy level of the knitted structures while relieving internal stresses. The fabric tightness factor and structural parameters such as wale and course densities and stitch density variations strongly depend on the yarn type used for knitting (Herath & Kang, 2008 Marmarali 2003).

The aim of this study is to fit a regression model for the bursting strength of single jersey knitted fabrics. In this regard, the regression method is used here by manufacturing 15 single fabrics in different settings, machine specifications, yarn count, and stitch length.

Experimental Details

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Hypotheses

H1: Count has a significant influence on the bursting strength of the single jersey fabrics.
H2: Both count and GSM have a significant influence on the bursting strength of the single jersey fabrics.
H3: Count, stitch length, and tightness factor has a more significant influence on the bursting strength of the single jersey fabrics than their individual influences.
H4: Count, stitch length, fabric thickness, and GSM have a significant influence on the bursting strength of single jersey fabrics.
H5: Count, stitch length, tightness factor, GSM, and fabric thickness have a significant influence on the bursting strength of single jersey fabrics.
These hypotheses are taken into account in order to determine the major parameters that influence the bursting strength.

Sample Size

In this study, 15 grey samples of single jersey derivatives (plain, pique, and fleece) have been produced using different yarn counts and stitch lengths in different machine settings (Table 2), and the final produced fabrics are examined to determine the parameters of the samples.

Tools and Technique

Material details:

Test Parameters	24’s combed yarn	30’s combed yarn
Tolerance (% +/-)	1.5%	1.5%
Count CV%	1.5	1.5
CSP	2400	2400
Strength CV%	4.5	4.5
TM	3.65	3.65
TPI CV%	4.0	4.0
Thin/km (-50%)	0	0
Thick/km (+50%)	12	15
Neps/km (+200%)	26	40
Elongation %	4.5	4.5
U %	8.2	9.2

Machine details:
Single Jersey Machine: (for plain and pique fabrics)
Machine Dia. = 30 inch
Gauze = 28
No. of feeder = 90
Brand = Well knit
Origin = China

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Fleece Machine: (for fleece fabrics)
Machine Dia. = 30 inch
Gauze = 20
No. of feeder = 90
Brand = Well knit
Origin = China

The study used appropriate test standards for selected structural and performance attributes for the reported study (Table 1).

Loop length is a very small value compared to the length of yarn in fabric. The other name for a loop is stitch and accordingly, the length of yarn required to make a stitch is called stitch length (Ray 2011).

Take a pique fabric sample and count 50 wales by counting glass, then mark with pen 50 wales. Then opened the course and measured the length in cm by scale, multiply this data by 10 millimeters, and measured stitch length. For pique fabrics, the measurement is 50 wales in length in the same course of 13.5 cm. So, stitch length = (13.5/50)× 10 = 2.7 mm.

The bursting strength test is an alternative method of measuring strength and elasticity in which the material is stressed in all directions at the same time and is therefore more suitable for such a material.

Each knitted fabric has its own unique elastic property, which is measured by bursting strength testing methods (Au 2011).

The pressure gauge of the Auto Burst Machine was 0-10 kg/cm2 or 0-28 kg/cm2 (Fig 1).

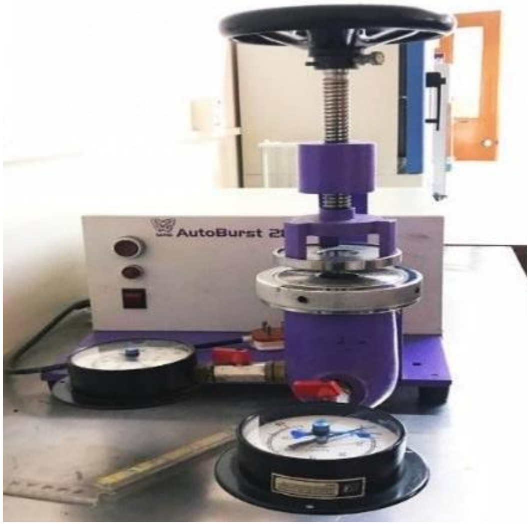

Fig 1. Auto Burst Machine

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The tightness factor (TF) is a number that indicates the extent to which the area of a knitted fabric is covered by the yarn. It actually indicates the compactness of the knitted structure (Ray 2011).

The formulae for calculating tightness factor are as follows:

Tightness Factor = $\frac{\sqrt{Tex}}{stitchlength(mm)}$ or $\frac{\sqrt{(590.5/Ne)}}{stitchlength\ (mm)}$; (Ray2011)

In this study, correlation and regression analysis are used to find out the influences of parameters of the single jersey derivative (plain, pique, and fleece) fabrics on the bursting strength (Table 3 and Table 4). And, the following regression model is to fit the experiments (Equation 1).

Table 1. Standards used

Sl. No.	Parameters	Units	Standard Used
1	Yarn Count	Ne	ASTM D 2260-96
2	Stitch Length	mm	-
3	Tightness Factor		-
4	GSM	gm/m2	ASTM D 3776
5	Thickness	mm	ASTM D1777
6	Bursting Strength	Kg/m2	ASTM D3786

Level of Significance

In this study, a 5% level of significance is considered to achieve the higher goodness of fit of the model.

Variables

Dependent variables: Bursting strength and
Independent variables: yarn count, stitch length, gsm, fabric thickness, and tightness factor.

Results and Discussion

Experimental results in this experiment are tabulated in table 2. Here, yarn count, stitch length, tightness factor, GSM, fabric thickness, and bursting strength of the fabrics are shown in table 2; the standard deviation of variables is shown in table3; the correlation coefficient among the variables is shown in table 4 and the regression model summary is shown in table 5.

Table 2. Data Table for Bursting Strength of Single Jersey fabrics

Sl. No.	Sample	Count Ne	Stitch Length (mm)	Tightness Factor	GSM	Fabric Thickness (mm)	Bursting Strength (kg/cm2)
1	Pique-1	29	2.7	1.67	179	0.6	6.9
2	Pique-2	29	2.7	1.67	180	0.59	6.9
3	Pique-3	29	2.7	1.67	178	0.62	6.9
4	Plain-1	30	2.9	1.53	145	0.43	7

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5	Plain-2	30	2.9	1.53	146	0.42	7.8
6	Plain-3	30	2.9	1.53	142	0.45	7.2
7	Plain-4	27	3	1.56	154	0.44	8.5
8	Plain-5	27	3	1.56	156	0.44	8.6
9	Plain-6	27	3	1.56	153	0.47	8.5
10	Plain-7	24	2.7	1.84	147	0.55	8.5
11	Plain-8	24	2.7	1.84	145	0.56	8.35
12	Plain-9	24	2.7	1.84	145	0.57	8.5
13	Fleece-1	9	3.9	2.08	263	0.98	8.2
14	Fleece-2	9	3.9	2.08	266	0.96	7.5
15	Fleece-3	9	3.9	2.08	261	1	8.8

According to Table 2, fleece fabrics have greater GSM, tightness factor, fabric thickness, and bursting strength than plain and pique fabrics.

Table 3. Standard Deviation of Variables

Sl. No.	Variables	Standard Deviation
1	Count	7.948046
2	Stitch Length	.4610547
3	Tightness Factor	.2105707
4	GSM	46.35988
5	Fabric Thickness	.2054565

According to Table 3, standard deviations are low for stitch length, tightness factor, and fabric thickness; medium for the count and large for GSM.

Table 4. Correlation co-efficient among variables

	Bursting strength (kg/cm2)	Fabric thickness (mm)	GSM	Tightness factor	Stitch length (mm)	Count Ne
Bursting strength (kg/cm^2)	1.00					
Fabric thickness (mm)	0.1168	1.00				
GSM	0.0459	0.9633	1.00			
Tightness factor	0.3063	0.9266	0.8128	1.00		
Stitch length (mm)	0.2772	0.8338	0.8993	0.7037	1.00	
Count Ne	-0.3878	-0.9354	-0.9006	-0.9288	-0.9099	1.00

According to Table 4, there is a positive correlation between stitch length, GSM, tightness factor, fabric thickness and bursting strength of the fabrics. Thus fabric thickness, GSM, tightness factor, and stitch length all increase the bursting strength of the fabric by 11, 4, 31and 28% respectively.

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The bursting strength of the fabric decreases by 39% as the yarn count increases.

Table 5. Regression model summary

Parameter	(1)	(2)	(3)	(4)	(5)
Constant	8.726	16.389	81.151	18.397	70.094
GSM		-0.025		-0.012	-0.017
Count	-0.035	-0.169	-0.856	-0.216	-0.730
Stitch length			-7.315	-0.180	-5.557
Fabric Thickness				-4.488	2.675
Tightness factor			-17.696		-15.344
Adj. R2	0.085	0.577	0.772	0.572	0.761
Root MSE	0.699	0.476	0.349	.479	0.35
Degree of freedom	13	12	11	10	9

The summary result is shown in table 5, which explains the relationship of bursting strength with the count (1); Count & GSM (2); Count, Stitch length and Tightness factor (3); Count, Stitch length, Tightness factor and GSM (4); Count, Stitch length, Tightness factor, GSM and Fabric thickness (5); these are H1, H2, H3, H4, and H5.

The results from ANOVA (Table 5) revealed that H2 and H3 are accepted at the 0.05 level, but H1, H4, and H5 are rejected at the 0.05 level. However, the goodness of fit increases as the parameters from Models (2) and (3) are considered (Table 5).

Findings from ANOVA (table 5) revealed that the Adj. R2 value of Model (3) is higher than Model (2).

Thus, considering count, stitch length, and fabric thickness variables, the following regression line shows a goodness of fit of 0.772.

Bursting Strength = 81.151-17.696*Tightness factor-7.315*Stitch length-0.856*Count ---(equation 1)

Conclusion

The study's implications give knowledge and a better grasp of the degree of flexibility. The correlation coefficient and regression model analysis was done to identify how strong the relationship is and how it affects others. According to the findings, bursting strength decreases as stitch length, count, and tightness factor increase. This model shows the tightness factor is inversely proportional to the bursting strength, which theoretically and practically is not accepted. Further study is required to understand the parameters which are not taken into consideration to predict the bursting strength. The study may be continued by testing, including other properties like spirality, porosity, and other parameters. Some other fabric properties, e.g., elongation of the fabric or stretchability, rigidity, finishing conditions, relaxation state, etc. are not considered in this study, which is a drawback of the study.

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