Factors of Weft Knitted Fabrics Related to the Bursting Strength

Mohammad Mobarak Hossain, Farhan Haque, Joyunta Banik, Abdullah Shohel Rana

Abstract— In this study the different parameters of the weft knitted fabrics like stitch length, yarn count, course and wales per unit length, GSM and porosity are considered to know their influence on the bursting strength. As, bursting strength is important for weft knitted fabrics due to its dimensional properties, shrinkage percentage is also drawn in attention. Key part of this study is to eliminate the less important parameters which have no significant relation to the bursting strength of the weft knitted fabrics. This study supports that, the bursting strength of the fabric is dependent on stitch density, stitch length and shrinkage percentage of the weft knitted fabrics. It also supports that it depends on all of these three parameters more than that of their separate impact. This study will help in producing fabrics with higher strength with respect to these parameters.

Index Terms— Bursting Strength, Stitch density, Stitch Length, Srinkages, Porosity.

1 Introduction

DIMENSIONAL properties of the knitted fabric is inferior than woven fabrics. These properties mostly rely on the machine parameters, selection of yarn count and stitch length and so on [1]. Due to the different process sequences after the take-down of the grey fabric from the machine, the characteristics of the plain weft knitted fabric change. But, all the parameters cannot be controlled during the manufacturing process. This study will try to find out the key predictors for bursting strength of the weft knitted fabrics. This study found significant relation of the different parameters like stitch length, stitch density and shrinkage percentage of plain weft knitted fabrics to the bursting strength. This finding will help the manufacturer to use the most significant parameters that will help to set the bursting strength of the weft knitted fabrics hence the durability phenomenon [2].

The aim of this study to fit a regression model for the bursting strength of the weft knitted fabrics. In this regard, correlation and regression method is used here by manufacturing 19 weft knitted fabrics in a different setting, machine specification, yarn count and stitch length. First correlation coefficients are analyzed and significant factors are determined at 1% and 5% level of significance. And regression models are developed for bursting strength to understand the goodness of fit of the model.

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2 Literature Review

Scholars have tried in many ways to know the relation between different fabric parameters and their dimensional properties. Some parameters influences dimensional properties positively and some others negatively. They also tried to find the effect of fabric structures. Intermeshing of loops with the loops adjacent to it on both sides and above and below it is the basic of knitted fabrics. Knitted fabrics are divided into two main groups, weft and warp knitted fabrics. Gauge, number of needle, gsm, yarn diameter, fabric thickness, stitch length, stitch density, porosity are very important factor in terms of circular knitting machine [3-4]. These fabric parameters effect the properties of fabrics like gsm, porosity, strength, extensibility, elasticity etc. thus have impact on the physical properties of fabrics [5].

Researchers have found many relations in regarding those parameters and fabric structures as well. Lacoste pique can shrink particularly in length direction excessively, due to its comparatively open structure [6]. Some tries to improve the dimensional stability by modifying the fiber, yarn or fabric structure while others rely on surface modification by topical application of different chemicals like polysilocanes and polyethylene emulsions for retaining fabric strength where cross linking agent may increase the stiffness or harsh feeling of the fabrics [7-10]. However, application of some may severely deteriorate the bursting strength of the treated fabric [11-12]. Others also reported that compact yarns perform better than the ring-spun yarns on several performance attributes including the bursting strength [13-14]. Higher fabric counts yield higher breaking strength and lower tearing strength. Strength contributes toward durability and elongation toward comfort. [15]. Other experiments also did not found relationship between bursting strength and extension.

However, study revealed that types of fibres has effect on bursting strength [16]. Knit structure could impact bursting strength too [17]. It is noticed that extension and strength are inversely related to each other [18-19]. Increase in strength results in decrease in elongation. Scholars also draws conclusions regarding the bursting strength: 1) stitch density impacted bursting strength, 2) increased in velocity resulted in reduced strength, and 3) in-lay yarns enhanced the bursting strength [17]. Choice of stitch like location of tuck stitches had greater impact than the stitch length [19-20]. Others examined single jersey, Lacoste and double pique knit in relation to their bursting strength and suggest that bursting strength was highest for 'single Lacoste' and lowest for double pique knit [21].

Jersey, rib and interlock knits made from compact yarns had higher bursting strength, elongation and pilling resistance than those made from ring spun yarns but lower pilling [13, 22]. Furthermore, lycra or elastane content influence bursting strength with fabric weight and fabric thickness; and elongations [23,24]. The amount of recovery depends on the structure of material and the time of applied force. Practically, elasticity determines the permanent elongation or deformation after applied force. If there is no permanent elongation, deformation does not form and material turns back to its original shape [25,26].

Loop length, loop width (wale spacing) and loop height (course spacing), machine gauge, needle type, cam type, yarn feeding system, number of feeders, take down system, cloth rolling or spreading, monitoring and control systems, fabric relaxation condition etc have great effect on fabric quality and the physical, mechanical and dimensional properties of the cotton single jersey knitted fabrics [16]. In this study the influences of the fabric parameters of weft knitted fabrics are studied for different structures with different constructions to find out the relation to the bursting strength.

3 Objectives and Significance of the Study

- To determine the significant parameters that influence bursting strength
- To fit a regression model with the significant parameters
- To understand the goodness of fit of the model.
- This study will try to make understand the significant parameters to predict the bursting strength of the weft knitted fabrics
- To eliminate the insignificant parameters
- To set regression model for individual and combined effect on the bursting strength.

4 Hypothesis

H1: Stitch density has significant influence on bursting strength of the weft knitted fabrics.

H2: Both stitch length and stitch density have significant influence on bursting strength of the weft knitted fabrics.

H3: Stitch length, stitch density and shrinkage have more significant influence on bursting strength of the weft knitted fabrics than their individual influences.

H4: Yarn count, yarn diameter, GSM, fabric thickness and porosity have significant influences on bursting strength of the weft knitted fabrics.

5 Methodology

5.1 Sample Size

In this study 19 samples of weft knitted fabrics has been produced using different yarn counts and stitch length in different machine setting and the final produced fabrics are examined to determine the parameters of the samples.

5.2 Tools and Techniques

In this study, correlation and regression analysis are used to find the influences of parameters of the weft knitted fabrics on the bursting strength. And, following regression model is to fit the experiments.

Table 1: Standards used

Sl. No.	Parameters	Unit	Standard used
1	Stitch length	mm	-
2	Yarn count	Ne	ASTM D 2260-96
3	Stitch density	Per cm^2	ASTM D 3887-2008
4	GSM	gm/m^2	ASTM D 3776
5	Shrinkage	%	ASTM D 7983
6	Fabric Thickness	mm	ASTM D 1777-2011
8	Bursting Strength	kg/cm^2	ASTM D 6797-2015

5.3 Level of Significance

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

5.4 Variables

Dependent variables: Bursting strength and

Independent variables: yarn count, diameter, stitch density, shrinkage, gsm, fabric thickness and porosity.

6 Results and Discussion

The experimental results in this experiment are tabulated in table-2. Here, yarn count, yarn diameter, stitch length, stitch density, gsm, fabric thickness, shrinkage, porosity and bursting strength of the fabrics are shown in table-2 and correlation co-efficient among the variables are shown in the table-3.

Table 2: Data Table for Bursting Strength of Weft knitted fabrics

Sl. No.	Shrinkage %	Count (Ne)	Yarn Diameter (cm)	Stitch Length (mm)	Stitch Density (CPCm×WPCm)	GSM	Fabric Thickness (mm)	Porosity	Bursting Strength (kg/cm²)
1	3.8	32	0.160	2.9	312	130	0.021	0.1025	4.42
2	9.2	28	0.171	2.65	288	150	0.02	0.1377	5.12
3	2.1	24	0.185	3.2	214	175	0.021	0.3232	5.02
4	8.3	30	0.166	2.8	270	140	0.022	0.0969	3.57
5	5.8	26	0.178	3	230	160	0.02	0.2477	4.87
6	7.5	22.22	0.192	3	347	280	0.037	0.057	2.19
7	6.7	28.76	0.169	3	453	300	0.033	0.0321	2.6
8	2.9	27.76	0.172	2.75	456	270	0.028	0.0543	3.42
9	14.6	23.22	0.188	2.85	384	290	0.03	0.0857	2.23
10	12.9	28	0.171	2.6	194	220	0.029	0.0339	5.31
11	4.6	24	0.185	2.8	174	245	0.032	0.0568	7.29
12	4.2	28	0.171	2.75	171	210	0.031	0.0348	4.49
13	8.8	30	0.166	2.95	182	220	0.032	0.0304	5.76
14	0.8	30	0.166	2.8	175	200	0.027	0.0464	5.91
15	5.4	28	0.171	2.7	326	195	0.029	0.0397	5.14
16	5.4	26	0.178	2.7	343	215	0.03	0.0466	5.82
17	6.7	24	0.185	2.75	308	215	0.036	0.0331	5.25
18	6.3	28	0.171	2.55	358	200	0.031	0.0231	5.63
19	4.6	24	0.185	2.65	316	210	0.034	0.036	4.83

Table 3: Correlation co-efficient among variables

	Bursting Strength (kg/cm²)	Srinkage %	Count (Ne)	Yarn Diameter (cm)	Stitch Length (mm)	Stitch Density (CPCm ×WPCm)	GSM	Fabric Thickness (mm)	Porosity
Bursting Strength (kg/cm²)	1	-.328	.132	-.157	-.325	-.632**	-.416	-.092	-.015
Srinkage %	-.328	1	-.148	.149	-.197	.118	.243	.132	-.176
Count (Ne)	.132	-.148	1	-.997**	-.162	-.111	-.447	-.421	-.192
Yarn Diameter (cm)	-.157	.149	-.997**	1	.192	.112	.445	.424	.192
Stitch Length (mm)	-.325	-.197	-.162	.192	1	-.079	.085	-.201	.623**
Stitch Density (CPCm ×WPCm)	-.632**	.118	-.111	.112	-.079	1	.446	.219	-.222

GSM	-.416	.243	-.447	.445	.085	.446	1	.741**	-.442
Fabric Thickness (mm)	-.092	.132	-.421	.424	-.201	.219	.741**	1	-.722**
Porosity	-.015	-.176	-.192	.192	.623**	-.222	-.442	-.722**	1
**. Correlation is significant at the 0.01 level (2-tailed).									

Here, it is found that bursting strength is significantly related to the stitch density (p<.01). Yarn diameter and yarn count is co-related to each other and porosity of the fabric is also significantly related to stitch length and fabric thickness (p<.01).
Now, step wise regression among the variables we found that, all parameters other than stitch density, stitch length and shrinkage are insignificant to the bursting strength of the fabrics. The model summery is explained by table-3 to table-5. Thus, yarn count, yarn diameter, gsm, fabric thickness and porosity have no significant influences on bursting strength of the weft knitted fabrics. That is the ***H4***. And it is rejected at 5% level of significance.

Table 4: Regression model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.632[a]	.400	.364	1.07039
2	.736[b]	.541	.484	.96457
3	.807[c]	.652	.582	.86798

a. Predictors: (Constant), Stitch density

b. Predictors: (Constant), Stitch density, stitch length

c. Predictors: (Constant), Stitch density, stitch length, Srinkage %

Table 5: Summary Table of the models

	(1)	**(2)**	**(3)**
Constant	7.388*	16.164*	18.338*
Stitch Density (per cm^2)	-.009*	-.010*	-.009*
Stitch Length (mm)		-3.077**	-3.602*
Shrinkage%			-.134**
Adj. R^2 (F)	0.364 (11.320)	0.484 (9.437)	0.582 (9.356)
Std. Error (Estimate)	1.07039	0.96457	0.86798
Degree of freedom	17	16	15

From table-4 and table-5, here, the summary result is shown in table-6, that explain the relationship of bursting strength with the stitch density (1); stitch density and stitch length (2); and stitch density, stitch length and shrinkage % (3). These are ***H1, H2*** and ***H3*** and accepted at 1% level of significance. All three models are significant at 1% level of significance. But, the goodness of fit increases with respect to the parameters considered from model 1 to 3 (table-5). Regression co-efficient shows that stitch length influences bursting strength negatively and the impact is large than that of stitch density and shrinkage%.

Model shows that with 1mm increase of stitch length will reduce the bursting strength by 3 to 3.6 times (df =15). On the other hand, unit increase of stich density and shrinkage % the bursting strength will be reduced by 0.009-0.01 times ($p < 0.01$) and 0.134 times ($p < 0.05$) respectively.

Thus, considering stitch density, stitch length and shrinkage% as predictor variables following regression line shows goodness of fit 0.582,

Bursting strength = 18.338 – 3.602 Stitch length – 0.134 Shrinkage% - 0.009 Stitch Density.

7 Conclusion

Weft knitted fabric manufacturing is the most challenging in respect to the recent frequent changes in the demand. Though the gsm is the most important characteristics of the weft knitted fabrics, bursting strength of the fabrics is also now important to define other characteristics like elongation, flexibility, rigidity or stiffness. Thus softness or comfort properties of the fabric and the durability phenomenon can be understood. But, to set the desired value of bursting strength stitch density, stitch length and shrinkage of the fabric should be chosen according to requirements. This study shows their effect to the bursting strength of the fabric. And an equation which is developed here can explain the bursting strength of the fabric at 58.2% accuracy while considering only stitch density or both stitch density and stitch length the model shows less accuracy. Further study is required to understand the parameters which are not taken into consideration to predict the bursting strength. If the unobserved parameters e.g., fibre properties, elongation, rigidity or others are considered the accuracy of the model will be improved. Due to limitation of the sample size the accuracy in the model is less than the desired level, but, it is found significant at 1% level of significance.Unobserved parameters are not taken into consideration which is the limitation of this study.Some other fabric properties e.g., elongation of the fabric or stretch ability, rigidity, finishing conditions, relaxation state etc. are not considered in this study which is a limitation of the study.

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