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[*Akter * et al., 5(2): February, 2018*] ISSN: 2349-5197
Impact Factor: 3.765

INTERNATIONAL JOURNAL OF RESEARCH SCIENCE & MANAGEMENT

VALIDATION OF WEAVABILITY FOR FINER COUNTS OF COTTON YARN

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DOI: 10.5281/zenodo.1185603

Keywords: Weaveability limit, Warp breakage, Fabric structure, finer cotton yarn.

Abstract
Weavability limit is a significant factor to determine whether or not a particular fabric construction can be produced on a loom. In this study, the weavability limit of finer cotton yarns is assessed for two different fabric structures (plain, $\frac{1}{\;}\!_3$twill). For this purpose, the acceptable weavability limit of three different cotton yarns (60 Ne, 72 Ne,and 80 Ne) are determined. The maximum weft density that can be achieved for a specific structure upto frequent breakage is defined as the weavability limit for that particular count. Indeed, the yarn count plays a significant role in determining the weavability limit. The finer the yarn, the more weavability limit can be attained. The reason behind this phenomenon is that more PPI can be inserted in a given space in case of finer yarns rather than the coarser yarns. Moreover, the weavability limit varies for different fabric structure. This variability of the weavability limit values for plain and twill structure is demonstrated andrationalized by fabricgeometry analysis.

Introduction
Weaving is one of the most significant fabric manufacturing process. The main purpose of weaving is to develop new fabric designs to achieve the most appropriate characteristics for desirable end-use applications. One of the conditions of weaving fabric is that the designed fabric must be within the weavability limit. One might wonder about the real significance of weavability limit. The weavability limit can be defined as the maximum weft density for a particular construction without interrupting the weaving continuity. It is important to decide whether or not a particular fabric construction of a specific count can be produced on a loom. Since the last century, extensive studies regarding weavability and weavability limits were carried out in both theoretical and experimental basis.

(Turhan & Eren, 2012) has defined the weavability limit by the maximum weft density for a given fabric construction without weaving interruption. The influence of various loom setting parameters on weavability limit were investigated in this study. (Kumpikaitė, Eglė&milašius, Vytautas, 2003) investigated the influence of fabric structure parameters and yarn count on weavability. (Nosek & Republic, 1994) defined the weavability as the measurable quantity of weft slip into the fabric during beat-up. The deeper the weft can be pushed into the fabric, the denser the pick spacing arises and the weavability is higher. (Chen, 2005) put forward the relation of fabric weavability to cloth formation area. It was reported that cloth formation area should be small to increase weaving effectiveness. (Seyam & el-Shiekh, 1993) concluded that the maximum weavability limit depends on the warp and weft count, fiber type & packing in the yarn, weave design, loom type & loom setting parameters and yarn uniformity. (Haque Md. Mahbubul, 2009) assessed the effect of weft parameters on weaving performance and fabric properties. (Mills, 1982) determined the maximum weavable weft density for any given warp sett in case of plain weave and the experimental results were compared with the theoretical values obtained by Law and Brierley. A likewise research was conducted by (Sharma, Sharma, Sharma, Kumar, & Garg, 1984) for twill weave an year later. Furthermore, a study on the variability of the weavability limit values between practical and theoretical results were conducted by (John B. Dickson, 1954).

Although many researches have been conducted earlier regarding the weavability limit, but most of the studies were carried out for relatively coarser yarns. This study, therefore, aimed at investigating the weavability limit of finer cotton yarns and demonstrating the variability of the weavability limit values for plain and twill weave as a whole.

Materials and methodology

Materials
100% Cotton 60 Ne, 72 Ne, 80 Ne ring spun yarn has been used for both warp and weft. The maximum weft density has been determined for 60 Ne, 72 Ne,and 80 Ne yarn respectively. Our purpose was to check the weavability of finer yarns. The reason behind choosing these three specific count of yarn is that these particular count yarns were available to us. Further finer cotton yarns were not available otherwise, we would be able to draw a more general conclusion.

The weave structures used in this study were plain and twill. We wanted to assess a comparative study between the weavability of the most compact structures as it exhibits more interlacing points than other weaves and relatively loose structure such as $\frac{1}{3}$twill. We could not utilize other weave structures due to time limitation.

As part of the preparatory process for weaving, CCI TECH INC Sizing and Warping Unit were used. One shot ready-mix sizing chemical was used with heavy sizing (40% sizing chemical).

Description of the Loom
The brand of the loom used for this study was CCI TECH INC(Weaving Unit) and the origin of this loom is Taiwan. Here, the shedding and beat-up mechanism is done by pneumatic pressure and picking is done by single rigid rapier system. The required pneumatic Pressure for this loom was 6KPa (kg/cm^2). The loom speed was 60 ppm which is the highest for this particular loom and was kept constant for this experiment.

Ends per inch:100
Total number of warp ends: 2000
Reed Count: 100
Fabric Width: 20 inch

Result and discussion

The weavability limit is defined as reaching the maximum weft density for a given fabric construction without interrupting the weaving continuity. In order to assess the weavability limit of 60 Ne, 72 Ne,and 80 Ne, we recorded the maximum PPI that can be inserted without any interruption by weaving fabric for each PPI. The weavability limit of both plain and twill ($\frac{1}{3}$) structure are determined and the variability of maximum weft density for these two structures are rationalized by geometrical analysis.

Table 1: Maximum weft density for Plain structure

PPI	Yarn Count (Ne)		
	Breakage rate for 60 Ne	Breakage rate for 72 Ne	Breakage rate for 80 Ne
40	0	0	0
45	1	0	0
50	1	0	0
55	5	0	0
60		0	0
70		0	0

80		0	0
85		0	0
90		1	0
95		6	0
100			1
105			4

For plain structure, the 60 Ne cotton yarn exhibits smooth weaving performance with 50 PPI whereasincase of 72 Ne and 80 Ne cotton yarn, 90 and 100 PPI can be achieved without excessive breakage.

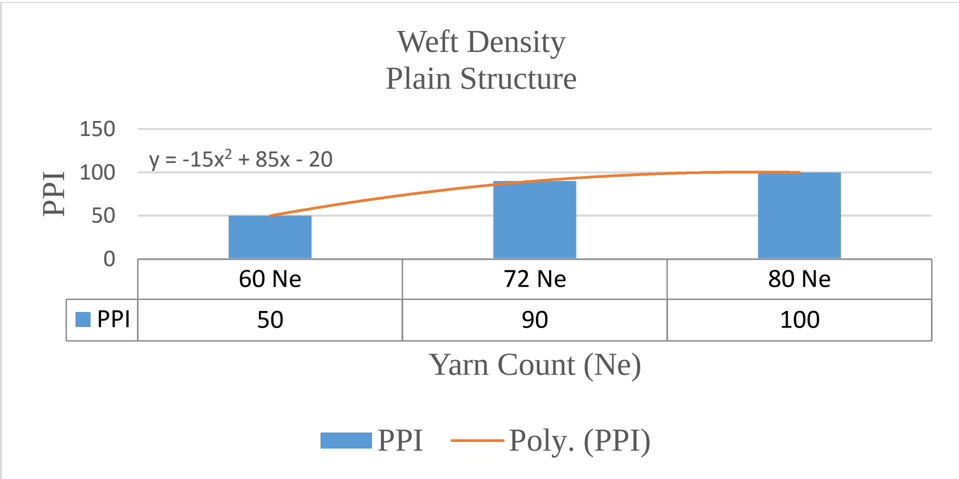

Figure 1: Weft Density for Plain structure

Therefore, the weavability limit of 60 Ne, 72 Ne,and 80 Ne are 50, 90 and 100 PPI respectively for weaving of fabric i.e. the weavability limit is the highest for 80 Ne yarn compared to the other two yarns. Hence, we can say that the finer the yarn, the more is the weavability limit for a particular structure.

Table 2 : Maximum weft density for twill structure

PPI	Yarn Count (Ne)		
	Breakage rate for 60 Ne	Breakage rate for 72 Ne	Breakage rate for 80 Ne
40	0	0	0
50	0	0	0
60	0	0	0
70	0	0	0
80	1	0	0
85	1	0	0
90	2	0	0
95	7	0	0
100		0	0
105		0	0

110		0	0
120		0	0
130		0	0
140		0	0
145		1	0
150		7	1
155			2
160			9

For twill structure, the weavability limit of 60 Ne, 72 Ne,and 80 Ne are 85, 145 and 150 PPI respectively i.e. the weavability limit is the highest for 80 Ne yarn compared to the other two yarns. Hence, we can draw a similar conclusion up here in case of twill structure.

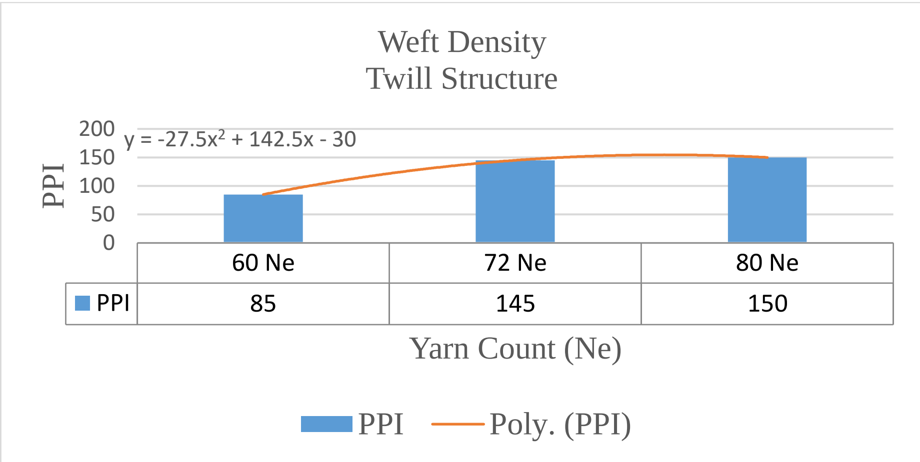

Figure 2: Weft Density for Twill structure

A generalized conclusion can be drawn from the results obtained from the above experiment. The finer the yarn, the more PPI can be given for a particular structure. Hence, the weavability limit of finer yarn is greater than that of the coarser yarns. But the warp breakage increases with the increase in PPI. But in case of plain structure warp breakage rate differs rapidly from twill structure. The reason is the interlacement point between warp and weft yarns. In plain structure, there are two interlacement points with 2×2 repeat number, and in twill structure, there are two interlacement points with 4×4 repeat number. A geometrical analysis is given to explain why more PPI can be obtained with twill structure.

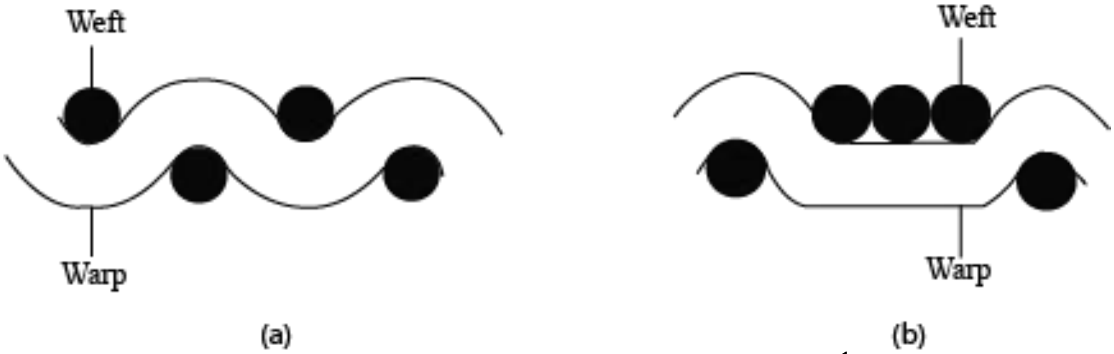

Figure 3: Diagram of weave structure: (a) Plain weave, (b) Twill ($\frac{1}{3}$) weave

It can be clearly understood that the interlacing points of plain is much more than $\frac{1}{3}$twill structure. In plain weave, there are two interlacement points between two consecutive yarns whereas,in case of twill weave, there are two interlacement points in between four yarns. Here, three weft yarns lie together side by side without any interlacement. As a result, the average space between two consecutive weft yarns is more in plain compared to twill weave. In other words, the less space consumed by weft yarns in twill weave leads to more weft density that can be imparted in case of twill weave.

A study conducted by (Lin, 2003) has derived the equation for determining the maximum thread density using the fabric geometry. The equation for the determination of maximum picks/inch is given below:

$$Y = \frac{b \times a \times b'}{a \times b' + b \times c'}$$

Here, Y is the maximum weft density, a (ends), b (picks) are the maximum number of warp and weft yarns capable of being laid out per inch without crossing. a' (ends), b' (picks) are the number of warp and weft yarns per unit weave structure, and c and c' are the number of interlacing points in weft and warp directions per unit weave structure.
a can be calculated from the following equation,
a= $b = \frac{1}{d}$; Here, d is the diameter of the yarn where, $d = \frac{1}{28\sqrt{Ne}}$

As the warp and weft count are equal, the diameter is same for warp and weft yarn.

Table 3: Actual and theoretical PPI for both plain and twill weave

Yarn Count	Plain Weave		Twill Weave	
	Theoretical PPI	Experimental PPI	Theoretical PPI	Experimental PPI
60 Ne	109	50	145	85
72 Ne	119	90	159	145
80 Ne	125	100	167	150

From the above calculations of maximum weft density for different weave structures, it is clear that the maximum theoretical PPI of twill structure is greater than that of plain structure therefore, it agrees well to the conclusion of our experiment. However, the theoretical values significantly greater than the actual PPI.

Conclusion

Yarn count is a dominating factor that guides the weavability limit. The maximum weft density that can be given for a particular structure increases as the yarn becomes finer. Moreover, the weavability limit varies according to different weave structures. The maximum weft density for twill weave structure is higher than that of the plain structure and so exhibits a better weavability. The theoretical weavability limit was assessed by analyzing fabric geometry and compared with the actual results. The theoretical results deviate significantly from the actual results.

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