A Pairwise Comparison Of Cotton-Polyester Blend Yarn's Characteristics Produced With Varying Percentage Of Polyester By Analytical Hierarchy Process.

Shahriar Raian, Md. Humayun Kabir Khan, Md. Lutfor Rahman Shanzid, Tanzeena Refat Tumpa

Abstract: The current study reveals a comparison on the characteristics of cotton-polyester blend yarns, produced with varying percentage of polyester. The research was carried out by producing five types of blend yarns of 30 Ne such as 100% cotton yarn, CVC 60-40 (60% Cotton and 40% Polyester), CVC 55-45 (55% Cotton and 45% Polyester), PC 50-50 (50% Cotton and 50% Polyester) and PC 65-35 (65% Cotton and 35% Polyester) and are tested by Count Tester, Uster Evenness Tester-5 and Lea Strength Tester. The quality parameters varied with the change of percentage of Polyester fibers. With the increase of amount of polyester, the Unevenness and Coefficient of Variation (U% and CV%), Imperfections Index (IPI), Hairiness Index (H), Count Strength Product (CSP) improves due to the characteristics of Polyester such as longer fiber length, higher fiber uniformity, no neps and higher strength. The pairwise comparison by Analytical Hierarchy Process (AHP) of both quality parameters (at level 1) and different blend ratio (at level 2) also indicated the reliability of the work.

Index Terms: Blending and blend yarns; CVC; PC; Pairwise Comparison and Analytical Hierarchy Process.

1. INTRODUCTION

Textile engineering is a vital part of the textile industry which utilizes the art of science to develop all sorts of yarns, fabrics and yarns and other raw materials for fulfilling clothing necessity. The first step of the textile manufacturing process is to converts the fibers into yarns is known as yarn manufacturing(Raian and Hossen 2018). Fibers are the first raw materials of the textile as well as yarn manufacturing. The yarns can be produced from the fibers obtained from both natural and manmade sources. The use of manmade fibers and their blend with natural fibers are increasing day by day because of cost and some other improved physical properties like strength and abrasion resistance. Competitiveness in the global market makes the blending process much more popular nowadays as here there are a lot of scopes of innovation in the case of aesthetics and functional characteristics(Raian, Alam, and Rahman 2018). Blending is termed as the mixing of two different types of staple fibers(CHEN 2000). Textile fibers are blended for obtaining desirable properties in the yarn Blend yarn can make the yarn suitable to incorporate more desirable features of the constituent fibers accompanied by the loss of or reduction in others such as comfort(K. E. DUCKETT, AND H. H. RAMEY 1979). The tensile properties of constituent fibers are incorporated into yarn blends and have received greater attention.

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Strength losses in yarns constructed of .fibers show different stress-strain behaviors, -for example, are largely explained by differences in extensions at break properties of the constituent fibers. Blended yarn provides the combined properties of both natural and man-made fiber components, such as easy-care properties. These advantages can cause stronger marketing and an increased variety of products (Witold Zurek, Izabela Sobieraj 1979). There are a lot of research works has been conducted on blending such as- In 1971, J. Dipietro, H. Stepniczka, and R. C. Nametz studied the Flammability of Cotton, Polyester, and Blend. In 1981, George F. Ruppenicker and Russell M.H. Kullman studied on full-performance-treated fabrics with acceptable strength and abrasion resistance could be produced from blends of 70% to 75% cotton with the fine, high-tenacity polyester(Ruppenicker and Kullman 1981). In 1989, G.F. Ruppenicker et al. research on the advantages of the core-yam fabrics included better cover and abrasion resistance. In 2006, Pınar Duru Baykal, Osman Babaarslan and Rızvan Erol made an extensive study on Prediction of Strength and Elongation Properties of Cotton/Polyester-Blended OE Rotor Yarns(Babaarslan and Erol 2006). In 2007, Ching-Iuan Su1, Jun-Xian Fang and Xin-Hong Chen groundwork on moisture absorption and release of profiled polyester and cotton composite knitted fabrics(Ching-Iuan Su, Jun-Xian Fang 2007). In 2007, Pınar Duru Baykal, Osman Babaarslan and Erol Rizvan quested on Statistical Model for the Hairiness of Cotton/Polyester Blended OE Rotor Yarns using to predict the hairiness of cotton/polyester blended rotor yarns using blend ratios and yarn count as predictor variables (Babaarslan and Rizvan 2007). In 2009, Suat Canoglu and S. Kevser Tanir investigated on hairiness properties of polyester/cotton blended ring-spun yarns made from different blend ratios(Tanir 2009). In 2010, Emrah TEMEL conducted a study on the spinnability of 100% polyester and polyester-cotton blend sirospun yarn(TEMEL 2010). In 2011, Yi Zoua, Narendra Reddya and Yiqi Yang conducted research on developing composites from used polyester/cotton blend fabrics without the need for plasticizers or additional matrix or reinforcing materials(Zou,

Reddy, and Yang 2011). In 2011, C. Prakash, G. Ramakrishnan, and C. V. Koushik researched on the quality characteristics of the blended yarn depend upon the bamboo content in the blend(Ramakrishnan and Koushik 2011). In 2014, Ali Afzal et al. experimented on a statistical model for predicting the air permeability of polyester/cotton-blended interlock knitted fabrics(Taylor et al. 2014). In the above-mentioned studies, the main focusing point is to role blending in the case of producing yarn and their properties as well as the properties of fabrics produced by them. This is the first time in history to work on predicting blend characteristics using Analytical Hierarchy Process (AHP) in regard to achieving optimum quality and cost-benefit. This section reveals valuable information regarding different technical and theoretical aspects, related literature reviews, experimental findings, and background study. Section 2 covers materials and methods and section 3 with data analysis, results, and discussion with the pairwise comparison by AHP and graphical presentation in terms of quality parameters with varying blend ratios. At last section 4 illustrates the conclusion and recommendation for future work.

MATERIALS AND METHODS

Here two types of raw materials are used like as cotton and polyester. At first 100% cotton fiber is used and consequently increasing the ratio of Polyester fiber. The specification and their different properties are given below-

Cotton fibers

Name : Shankar-6
Country : India
Net wt/bale : 160 kg

Table 1: *Important fiber properties of cotton fibers*

Fiber Properties	Value
Upper Half Mean Length UHML (mm)	29
Fineness (MIC)	4.5
Uniformity Index (UI %)	83.8
Strength, Tenacity (cN/tex)	30.5
Short Fiber (SF %)	8.4
Rd%	70.82
+b	9.30
Spinning Consistency Index (SCI)	130

Polyester Fibers

Manufacturer Name : Reliance Industries LTD.
Country : India
Average weight of bale : 350 kg

Table 2: *Important fiber properties of polyester fibers*

Fiber Properties	Value
Avg. fiber length	32 mm
Fiber Fineness	1.4 den

Table 3: *Spinning particulars*

Parameters	Value
Yarn count (Ne)	30 Ne
Yarn Twist (TPI)	20.26
Spindle speed (rpm)	16000 rpm
Traveler number	3/0
Roving hank (Ne)	0.85 Ne
Ring diameter (mm)	38 mm
Spacer type	Yellow

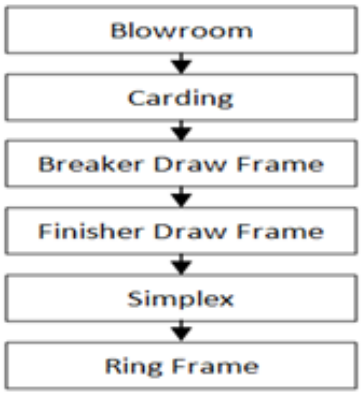
METHODOLOGY

This experiment had been conducted on producing 30's Ne carded knitted yarns on a ring spinning frame in a yarn manufacturing industry. Firstly, all, the fiber properties of the concerned lot were collected by testing in USTER HVI Spectrum. 100% cotton and 100% polyester were processed separately in two separate lines in Blowroom and then blending were done in draw-frame according to different mixing ratios after carding. Then the materials were then passed through finisher draw frame, simplex and finally to ring frame. Five roving samples of five specific flyers from simplex five roving samples were collected for this research after checking quality parameters these rovings were fitted onto the roving holders of the ring frame to spin yarns. This was done separately for different mixing and in every time the doff length was kept constant. Finally, the yarn samples were taken to the quality control department to test with Uster Tester-5 (UT-5) for both U% and CV%, IPI, H and lea yarn strength tester for CSP. The different yarn properties tests were carried out on Evenness Tester (UT-5) by ASTM D1425-96 for Um% and hairiness by ASTM D 5647-01 and Lea Strength Tester by ASTM D 1578-93. All the above-mentioned tests were done under standard atmospheric conditions 27±2 °C and 65% RH. Yarn quality and strength properties are plotted against different blend ratios in graph to observe the trend. Finally, an Analytical Hierarchy Process (AHP) was done for an effective pairwise comparison.

Table 4: *Types of Cotton Polyester blend used*

Serial No.	Yarn Type	Cotton %	Polyester %
1	100% Cotton	100%	0%
2	CVC 60-40	60%	40%
3	CVC 55-45	55%	45%
4	PC 50-50	50%	50%
5	PC 65-35	35%	65%

FLOW CHART FOR SAMPLE PREPARATION



AN OVERVIEW OF ANALYTICAL HIERARCHY PROCESS (AHP)

AHP is a multicriteria decision making approach in which factors are arranged in a hierarchic structure (Saaty 1990). The AHP supports managers in prioritizing specially the supply chain objectives, identifying risk indicators and assessing the potential impact of negative events and the cause-effects relationships along the chain(Gaudenzi and Borghesi 2006). It allows both multi-criteria and simultaneous evaluation(Dag 2008). The fuzzy AHP technique is used to weight the alternatives under multiple

attributes; second Benefit/Cost (B/C) ratio analysis and procurement cost, of each alternative(Aya and Ozdemir 2006). To make a decision through AHP, the below steps are followed.

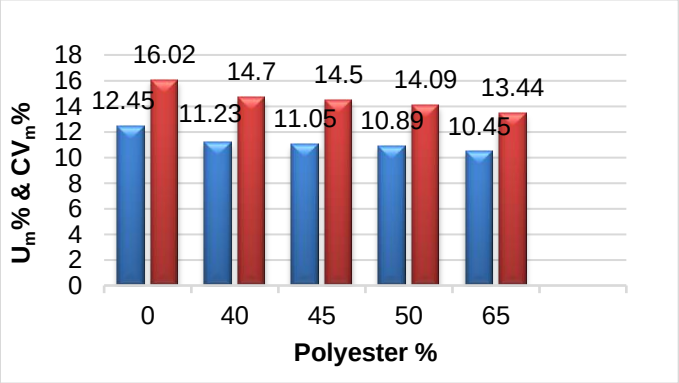
1. Problem and determination of knowledge sought.
2. Give a structure of the hierarchy from the top with the goal to make a decision.
3. A pairwise comparison matric construction in which each element in an upper level is used to compare the elements in the level immediately below.
4. At last determination of consistency ratio (Saaty 2008).

Table 7 The *fundamental relational scale for pair-wise comparisons Intensity (Majumdar, Majumdar, and Sarkar 2005).*

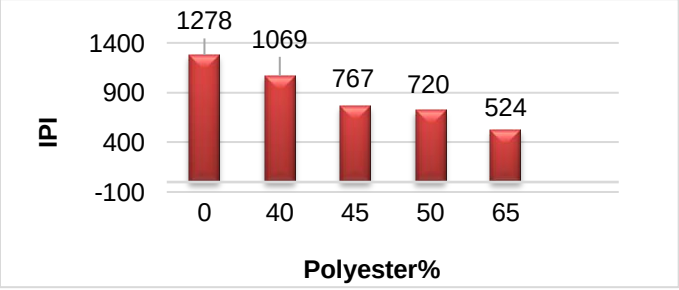
Intensity of importance	Definition	Explanation Equal
1	Similar importance	Two activities contribute equally to the objective.
3	Moderate importance	When activities are slightly favorable to one another.
5	Powerful importance	Experience and judgment strongly favor one activity over another.
7	Very powerful importance	An activity is strongly favored and its dominance is demonstrated in practice.
9	Uttermost importance	The evidence favoring one activity over another is of the highest possible order of affirmation.
2, 4, 6, 8	In between two adjacent judgment	When compromise is needed.
Reciprocals	If a task x has one of the above numbers assigned to it when compared with activity y, then y has the reciprocal value when compared with x.	

RESULTS AND DISCUSSIONS

Impact of polyester% on u_m% & cv_m% of cotton polyester blend yarn

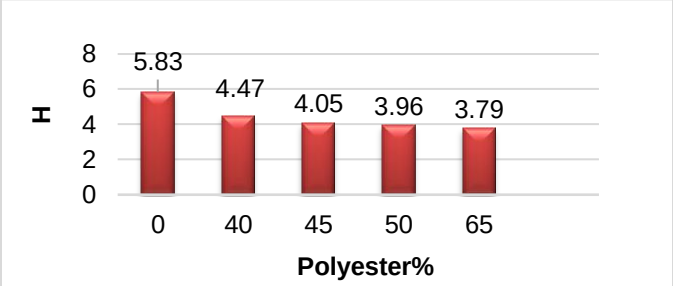


From this above graph, it is shown that both U_m% and CV_m% decreased with the increase of the percentage of polyester fibre as polyester fiber is more regular in shape and staple length, not varied. Impact of Polyester% on Imperfection Index (IPI) of Blend Yarn



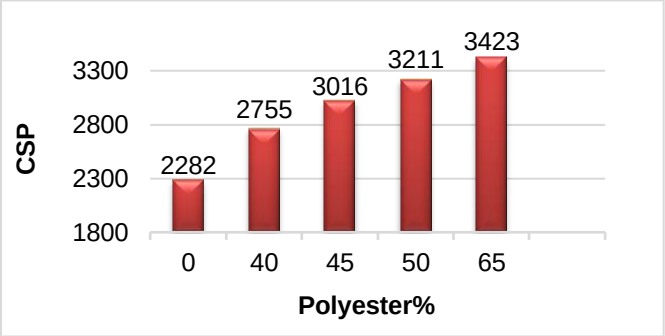
However, it is observed that imperfection in the yarn decreases with the increases of the polyester percentage in the blend yarn. This occurs due to the higher length and length uniformity, absence of short fibers and neps of polyester fibers than those of cotton.

Impact of Polyester% on Hairiness of Blend Yarns



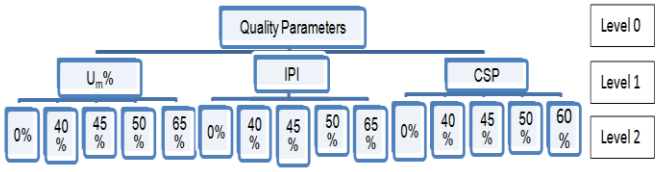
The graph reveals that the increase in polyester proportion decreases the hairiness value of cotton-polyester blend yarn. It occurs because of polyester is a regenerated man-made fiber whose length is longer than cotton fiber. It contains no short fibers compared to cotton. Hence increased polyester percentage decreases the hairiness in the blend yarn.

Impact of Polyester% on CSP of Blend Yarn



This Figure shows the CSP values of the various blend yarns. The graph shows that with the increase in polyester proportion increases the CSP value of cotton-polyester blend yarn. This occurs because of the higher strength of polyester fibers (polyester fiber 35-60 cN/tex, cotton 15-40 cN/tex). Resultantly, the increase of polyester percentage increase in yarn strength of blend yarn.

Pairwise Comparison by AHP Analysis



Here, 0% indicates 100% cotton yarns, 40% indicates CVC 60-40, 45% indicates CVC 55-45, 50% indicates PC 50-50 and 65% indicates PC 65-35.

Table 8 Pairwise *Comparison Chart for Quality Parameters (Level-1) by using Microsoft Excel*

Criteria	U_m%	IPI	CSP	Priority Vector	Largest Eigen Value
U_m%	1	1	7	51.09%	3.1
IPI	1	1	3	38.97%	
CSP	0.14	0.3	1	9.93%	

Consistancy Index (CI) = 0.047013132

Random Consistancy Index (RI) = 0.9
Consistancy Ratio (CR) = 5.22%
As Consistancy Ratio is less than 10% so it is ok.

***Table 9 Pairwise** Comparison Chart for Polyester % in the Blend (Level-2) by using Microsoft Excel*

Alternatives	0%	40%	45%	50 %	60%	Priority Vector	Largest Eigen Value
0%	1	3	3	2	2	37.01%	
40%	0.3	1	1	2	2	18.24%	5.35
45%	0.3	1	1	3	3	22.68%	
50%	0.5	0.5	0.3	1	1	11.04%	
65%	0.5	0.5	0.3	1	1	11.04%	

Consistancy Index (CI) = 0.088
Random Consistancy Index (RI) = 0.9
Consistancy Ratio (CR) = 9.69%
As Consistancy Ratio is less than 10% so it is ok.

CONCLUSION

The study shows that the ratio of the constituent fiber in the composition of the blend was found to be markedly influenced by both quality and strength properties of the blend yarns such as increasing of lea yarn strength and decrease meant of irregularity values, imperfections, and hairiness. AHP analysis had also been established the reliability of the comparison and the suitability of the blend characteristics.

RECOMMENDATION FOR FUTURE WORK

In future the pairwise comparison can be carried out by other Multi Criteria Decision Making (MCDN) and with other fibers.

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