Evaluating the Tensile Strength and Elongation Properties of Produced Yarns Using Direct Twist Technique

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Abstract:
The twisting stage is one of the most important preparatory stages for the yarn it begins with the Doubling process in preparation for giving it the suitable twists. A twisted yarn is formed by twisting together two or more singles yarns. The purpose of twist is Increase the specific durability of the yarn, Increase the C.V of the yarn, Production of yarns from mixing two or more yarns together and Production of Fancy yarn. A modern technology was developed in the twist process, achieving advantages at the technical and economic levels, which is the Direct Twist. It has many different twisted techniques, and the aim of the research is to show the best of them in tensile strength and elongation. The mechanical property of the yarn is one of the factors affecting the functional performance of it. This study aims to compare the tensile strength and elongation of yarns with different techniques of direct twist. The results of these tests illustrated that the direct twist technique of covering yarn has better strength than direct twist spun yarn, especially in the technique of covering group 2:2. While the best elongation is due to the technique of covering group 3:1.

Keywords:
Yarn twist, tensile, elongation, direct twist.

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Introduction:
The yarn is the primary and basic unit for building the woven, so the yarn has a great role in determining the properties of the fabrics produced from it, and the properties of the yarns differ according to the nature of the fibers made from them and the method of producing these yarns, and with the continuous development in the field of textile raw materials, the methods of producing these yarns evolved, there are many types of yarns. It has different physical and mechanical properties from traditional yarns, which give a variety of functional and aesthetic effects, including twisting yarns. Twisting improves abrasion resistance, strength, elongation, evenness, luster, bulkiness, reduces hairiness, twist liveliness, and variation in strength[(1)] .so that's a good foundation for producing good-quality core-spun yarns and weaving a yarn[(2)]. A twisted yarn is formed by twisting together two or more singles yarns. A cable and cord yarn consist of many twisted yarns twisted together[(3)]. These yarns are known as multiple strand yarn. If two single yarns are twisted together, the resulting yarn is known as two-twist yarn. If three are twisted together three-twist yarn and so-on[(4) (5)].Twisted yarn is referred to as a yarn in which two or more single yarns in one operation are twisted together[(6)]. In the weaving process, it consists of treated as one, but the strands are twisted together[(7)] .Also from the classification of yarns according to twisting Cord/Cable Yarn; a yarn twisted operation is made, in which twisted yarns are twisted together. Cords are rarely used in clothing fabrics, but are used for fabrics of industrial weight. Cord yarns are composed of two or more twisted yarns combined for is simple cord yarns.[(7) (8)] For a twisted rope, to achieve a balanced structure, the twisting path must alternate between Z and S twisting at distinct structural stages[(9)]. Covered yarns; Covered yarns are processed by covering the inner yarn of the yarn with filaments placed on the outer cover of the yarns, providing better properties during use[(10)]. Other twists; Fancy twists or nub yarns are twisted yarns made from various component types such as nub, loop, and other results. They are assembled using special machines [(4) (6)].

Research Problem:

1- Twisted yarns are produced from more than two yarns by traditional methods in multiple stages, which is reflected in the increase in cost and time required for production.

2- The impossibility of mixing more than two yarns on traditional twist machines in one stage, and in the event of a desire to mix more than two yarns, this is done by adding an application stage, which leads to exposure of the yarns to mechanical stresses during the application and then twisted operations.

Research Objectives:

1- Benefiting from the direct twist technique by achieving the best scientific standards for the production of the twisted yarn.
2- The research contributes to presenting a scientific and experimental study to produce twisted yarns that achieve aesthetic and functional properties.

Importance of research:

1- Designing and producing twisted yarns on a direct twist machine that gives functional values that suit the functional purpose for technical fields.
2- Designing yarns that achieve aesthetic properties by utilization of direct twist different techniques.

Research Methodology:

The research follows the Analytical experimental methodology

Theoretical Framework:

The purpose of twist is Increase the specific durability of the yarn, Eliminate the negative impact of single yarn twists, Increase the C.V of the yarn, Production of yarns from mixing two or more yarns together and Production of Fancy yarn. These are used for ornamental effect[7] [11].

Twisting Methods:

There are many different twist methods, which are done on different machines, each with different technology, in order to achieve the high quality of the required product. There are many machines divided into:[12] [13]. ring twist; This machine works similarly to a ring spinning machine, but instead of a draft zone, feed cylinders are used[11]. There are two methods of twisting: twisting the yarns in their dry state or twisting them after passing them through a basin of water containing wet substances that aid in the absorption of water, such as Turkish oil. When twisting thick yarns, the second approach is generally preferred because it produces a better result as long as the yarns are wet[14]. up twister; The up twister is widely used in the field of filament yarn twisting rather than spun yarn twisting. As this machine differs from the ring twist machine in that the feeding bobbin is mounted directly on the spindle, as opposed to the location in the ring twist, and this position is ideal for filament continuous yarns[11]. two- stage twisting machine; The twisting process is done in 2 stages in this machine: the first stage forms a light twist, and the second stage completes the twisting process. This machine is used when extreme twisting or high twisting is needed. Dual up down –ply- twister; there is no doubling stage on this machine, which involves an up-twister and a ring twist. Two-for-one twisting; Twisting two or more single yarns together is needed to create ply yarns. Pairs of yarns are sometimes twisted using two-for-one twisters after the assembly doubling process[4] .As a result, every turn of the spindle in this machine results in the production of two twists in a yarn. Two-for-one twisters have recently been used to produce synthetic and artificial yarns, especially fancy yarns, elastic yarn covering, sewing thread, and technical yarns[15] [16]. Modern Twist techniques; A modern technology was developed in the twist process, achieving advantages at the technical and economic levels, as a modern twist machine was produced, which is the Direct Twist machine, which is produced by the Turkish company AG TEKS[17] .It has many different twisted techniques, and the aim of the research is to show the best of them in tensile strength and elongation.

Effects twist on physical, mechanical and aesthetic properties of yarns.

The twisting methods influence the physical, mechanical and aesthetic properties of twisted yarn[18] .Some specifications can be obtained in twisted yarns they are difficult to find in single yarns, and these specifications include the following specifications. The twisted yarn's count is thicker than its individual components , in most cases, the twisted yarn is more regular than its individual components, twisting increases the abrasion resistance of the threads[19], Twisted yarns, if used as warp yarns, do not need sizing, the twisted yarn is bulkier than the individual components thereof, the twisted yarn has higher scale of quality and greater coverage[20], twisted yarns offer a better aesthetic shape than the twisted yarns that make up them (raw materials- mixing ratios- spinning methods- foundations and directions of twist- count- colors), twisted affects the softness of the yarn, giving it a smooth, hair-free surface, the luster of the yarns decreases with the increase of the twist and The elasticity of the yarn decreases as the twist increases. As we have achieved most of them in the research.

2- Materials and Methods:

Materials:

Four different yarns' materials were used, in order to study the effect of twisting different materials on the final mechanical properties of produced twisted yarns. Table(1) shows the specifications of the used yarns used in the execution of the yarn samples for

the study. The Samples' production were carried out at "National Research Center, Egypt" by using a direct twist machine with the specification that is shown in table (2).

Two different parameters were used the different materials and the direct twist technique. All of the samples were generated with the fixed parameters:

1- Material count
2- TWIST/M = 150 T/M
3- TWIST/DIR = Z DIR

The research samples are made up of 19 samples.

Direct twist machine is a new twist technique that was launched in 2019 by the AGTEXS Company in Turkey. It has a range of advantages that make it stand out like:

- The doubling stage before twisting be skipped, when twisting more than two yarns.
- The capacity to twist up to eight yarns at the same time.
- Capacity to manufacture covering yarns (core and sheath).
- Economic benefit is achieved, due to the provision of time needed for twisting the yarns.

In this study, samples of yarns that produced using the raw materials mentioned in Table (1) and the techniques of various direct twist machines, a group of twisted yarns was created. First, the covering technique was used on the direct twist machine, for the production and design of a various group of yarns divided into three groups.

Group one contains yarns that is twisted using one yarn materials a core and three different yarns' materials covering yarns. In this group, four different yarns were produced as indicated in table 3.

Group two contains yarns that is twisted using two different yarns materials a core and two different yarns' materials covering yarns. In this group, six different yarns were produced as indicated in table 3.

Group three contains yarns that is twisted using three different yarns materials a core and one yarns' material covering yarn. In this group, four different yarns were produced as indicated in table 3.

Second, was used the direct twist technique on the direct twist machine, create one yarn.

Four yarns were also generated on this machine using the second method, which is the direct twist method for the four raw materials without mixing them together.

Table (1) the specifications of the original yarns

Material	Count	Tensile Strength (cN/Tex	Tensile Strain (%)	Color	Code in the study
PET microfiber	70/108 D	41.30	22.24	Different colors	P
cool max	75 D	35.94	18.52	White	X
Viscose	75 D	12.11	12.47	Crystal	V
Modal	106 D	15.53	9.07	Different colors (original color was white but it has been dyed)	M

Table (2) specifications of Direct twist machine

Manufacturing Company	AGTEKS
Manufacturing Country	TURKEY
Date of Manufacturing	2019
Model	Direct Twist-2C6"
Capacity of yarn spindle	8 yarn spindles and 4 spindles used for the design
Machine Speed	800 T/M: up to 14000T/M

Table (3) yarn and fabric samples

Sample Technique	Sample group	Sample	Core	Sheath	Code
Covering Technique	Group One	S1	X	V,P,M	X/VPM
		S2	V	X,P,M	V/XPM
		S3	P	X,V,M	P/XVM
		S4	M	X,V,P	M/XVP
	Group Two	S5	X,V	P,M	XV/PM
		S6	X,P	V,M	XP/VM
		S7	X,M	V,P	XM/VP
		S8	V,P	X,M	VP/XM
		S9	V,M	X,P	VM/XP
		S10	P,M	X,V	PM/XV
	Group Three	S11	V,P,M	X	VPM/X
		S12	X,P,M	V	XPM/V
		S13	X,V,M	P	XVM/P
		S14	X,V,P	M	XVP/M
Direct Twist Technique	------	S15	-	-	DT Direct Twist 4*1
	Single Material Group	S17	-	-	X
		S18	-	-	P
		S19	-	-	V
		S20	-	-	M

*X=PET cool max- P=PET microfibers- V=viscose - M= modal

Samples Testing:

Tensile and elongation were carried out in the National Research Centre, Textile Research and Technology Institute. Tensile and elongation tests were performed to study the effect of twisting different yarns' material on the final twisted yarn and also to study the effect of the twisting technique on the strength and strain of the final twisted yarn. Samples were kept under standard conditions of temperature (20°C±2°C) and humidity (65%±5%) for 24 hours before testing according to ISO 139:2005.

Tensile and elongation test were carried out by using Uster Tensorapid device and the test were carried out according to the American Standard Specification of (ASTM D-2256).

3- Results and Discussion:

Table (4) Specification of the yarn samples and applied lab tests

	Yarn specification					Applied lab Tests to the samples	
Sample	Code	Core	Sheath	Twist /meter	Twist direction	Tensile Strength (cN/Tex)	Tensile Strain (%)
S1	X/VPM	X	V,P,M	150 T / M	Z Direction	19.79	10.40
S2	V/XPM	V	X,P,M			19.63	10.30
S3	P/XVM	P	X,V,M			19.28	10.99
S4	M/XVP	M	X,V,P			18.92	9.96
S5	XV/PM	X,V	P,M			19.52	11.10
S6	XP/VM	X,P	V,M			19.65	10.32
S7	XM/VP	X,M	V,P			20.72	11.20
S8	VP/XM	V,P	X,M			19.59	11.47
S9	VM/XP	V,M	X,P			20.21	10.83
S10	PM/XV	P,M	X,V			19.63	15.29
S11	VPM/X	V,P,M	X			18.76	15.01
S12	XPM/V	X,P,M	V			19.35	11.40
S13	XVM/P	X,V,M	P			19.72	12.02
S14	XVP/M	X,V,P	M			18.67	10.22
S15	DT Direct Twist 4*1		-			18.99	11.84
S16 (Single material)	X		-			35.94	18.52
S17 (Single material)	P		-			41.30	22.24
S18 (Single material)	V		-			12.11	13.30
S19 (Single material)	M		-			15.53	9.07

Tensile Strength Results:

Tensile test was performed on 19 samples that present the twisted yarns. Figure (1) shows the results of the tensile strength for the 2 techniques of twisted yarns (direct twist technique and covering twist technique). The tensile strength results shows that the direct twist technique for sample 15 has value of 18.99 cN/Tex. On the other hand, the results of tensile strength of the covering technique samples for the 3 groups are as follow; for group one (1 core: 3cover) the highest result value is recorded for sample 1 with value of 19.79cN/Tex, while the lowest result value is recorded for sample 4 of value 18.92 cN/Tex. for group two (2 core: 2cover) the highest result value is recorded for sample 7 with value of 20.72cN/Tex, while the lowest result value is recorded for sample 5 of value 19.52 cN/Tex. for group three (3 core: 1cover) the highest result value is recorded for sample 3 with value of 19.72cN/Tex, while the lowest result value is recorded for sample 14 of value 18.67 cN/Tex. While figurer[2] shows the results of the tensile strength for the 4 single materials' twisted yarns.

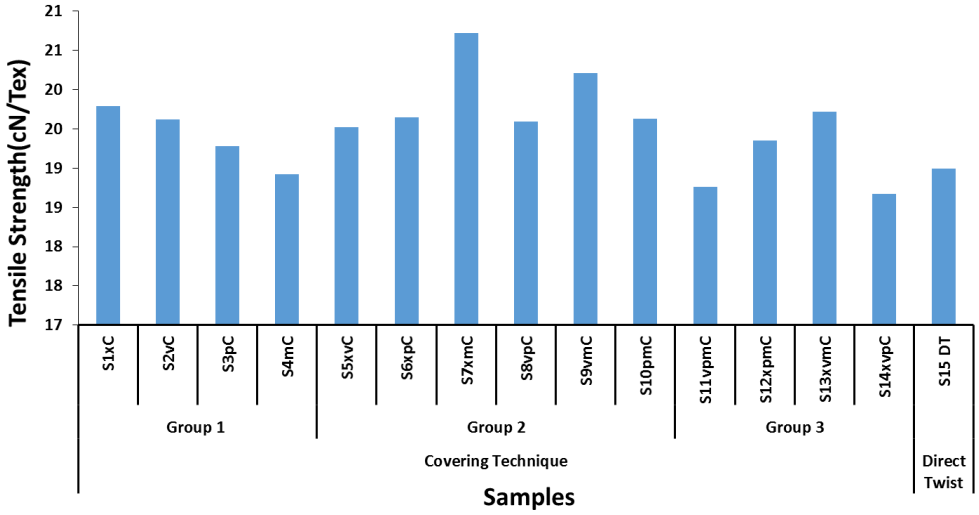

Figure (1) Results of yarn Tensile Strength (cN/Tex)

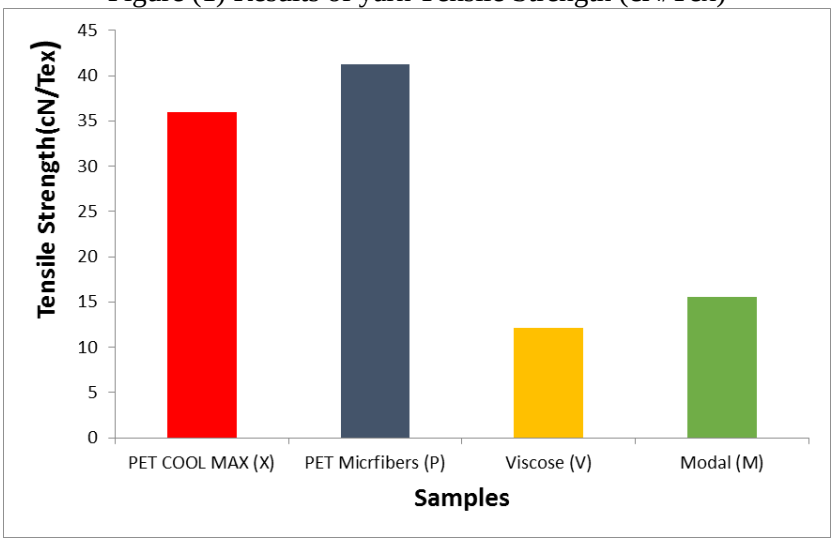

Figure (2) Results of yarn Tensile Strength (cN/Tex) to original samples yarn.

The results of tensile strength in Table (4) and Figure (1) show that the highest yarn tensile strength is recorded by sample 7 (X M core &V P cover) with value of 20.72 cN/Tex which produced by covering technique (group (2) 2:2). This may attribute to the utilization of PET microfiber as a cover yarn. As according to Figure2, the PET microfiber shows the high tensile strength.

Although, results presented the lowest yarn tensile strength is given by sample 14 (X V P core & M cover) with value of 18.67cN/Tex. This may attribute to the presence of Modal fiber as cover

The difference is due to the mechanism of measuring the tensile strength of the yarn that occurs when cutting the first yarn formed from the twisted yarn. It also refers to the degree of Polymerization present in the original material composing the yarn the direct relationship between the degree of crystallization and the tensile strength of the yarn[21].

Tensile Strength of sample 7 is higher than the tensile strength of (sample16) which has recorded tensile strength of 18.99 (cN/Tex) by using direct

twist technique. Tensile Strength of sample 14 is lower than the Tensile Strength of (sample16) direct twist technique but the result is close to each other.

Elongation Results:

Elongation test was performed on 19 samples that present the twisted yarns. Figure[3] shows the results of the elongation for the 2 techniques of twisted yarns (direct twist technique and covering twist technique). The tensile strength results shows that the direct twist technique for sample 15 has value of 11.84%. On the other hand, the results of elongation of the covering technique samples for the 3 groups are as follow; for group one (1 core: 3cover) the highest result value is recorded for sample 3 with value of 10.99%, while the lowest result value is recorded for sample 4 of value 9.96%. For group two (2 core: 2cover) the highest result value is recorded for sample 10 with value of 15.52%, while the lowest result value is recorded for sample 6 of value 10.32. For group three (3 core: 1cover) the highest result value is recorded for sample 11 with value of 15.01%, while the lowest result value is recorded for sample 14 of value 10.22%. While figurer[4] shows the results of the elongation for the 4 single materials' twisted yarns.

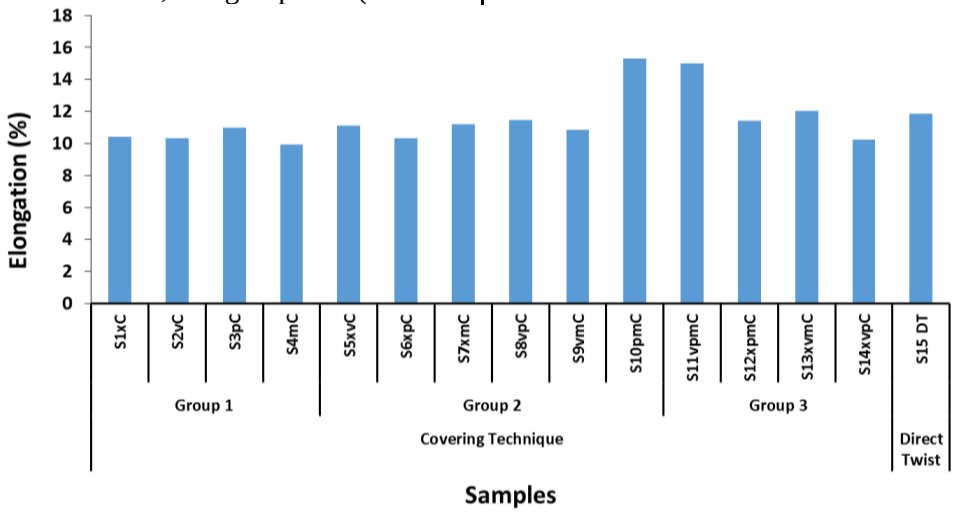

Figure (3) Results of yarn Elongation (%)

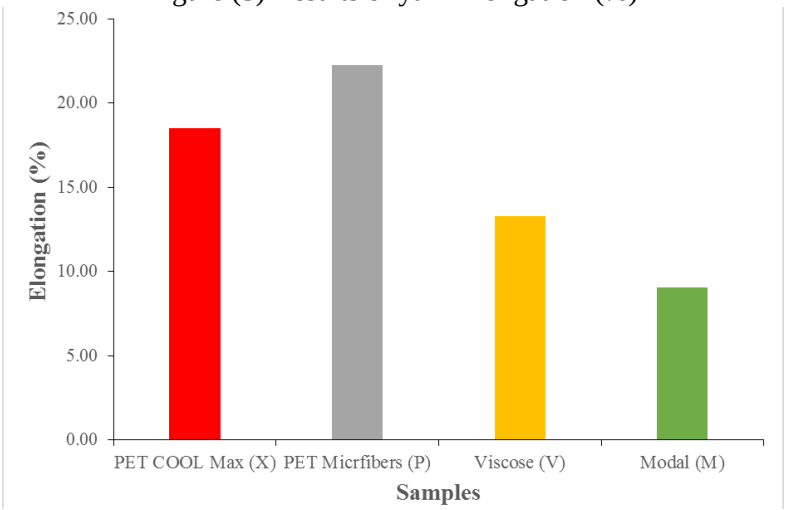

Figure (4) Results of original yarn Elongation (%)

The results of elongation in Table (4) and Figure (3) show that the highest yarn elongation is recorded by sample 10 (P M core &XV cover) with value of 15.29% which produced by covering technique (group (2) 2:2). This may attribute to the utilization of PET microfiber as a core yarn. As according to Figure4, the PET microfiber shows the highest elongation. Although, results presented the lowest yarn elongation is given by sample 4 (M core & X V P cover) with value of 9.96%. This may attribute to the presence of Modal fiber as core yarn. As according to Figure4, the Modal shows the lowest elongation.

The difference is due to the mechanism of measuring the elongation of the yarn that occurs when cutting the first yarn formed from the twisted yarn. It also refers to the degree of Polymerization present in the original material composing the yarn the indirect relationship between the degree of crystallization and the tensile strength of the yarn[21].

Elongation of sample 10 is higher than the tensile

strength of sample 15 which has recorded elongation of11.84% by using direct twist technique. Elongation of sample 4 is lower than the elongation of sample 15.

4- CONCLUSION:

The results can be summarized as follows; the results are which the twisted yarn is produced by a direct twist machine. The twisted yarn was produced with different twist techniques on the direct twist machine from 4 yarns, each of a different material (viscose, modal, polyester microfiber and polyester cool max), the twist techniques used are as follows; the first is the production of a twist yarn using the covering technique, so 14 samples were produced for 3 different groups ;The second is direct twist, in which the four yarns were used together in one step, in contrast to the customary requirement of two or more processes to produce the twist yarn from four different yarns. in the distribution of 4 basic yarns of different raw materials.

The results showed that twist techniques and yarn materials are the main factors that affect tensile strength and elongation.

- The best results for the tensile strength and elongation were for the twist covering technique in group two, as the effect is due to the cover in tensile strength while the effect is due to the core in elongation, as well as the use of the main yarn of the best material in the tensile strength in cover and in the core with elongation.
- The tensile strength gives the best result when using 2 yarns in the core and 2 yarns in the cover (group 2: 2) when using Cool Max polyester yarn with modal in the core, viscose and polyester microfiber in the cover.
- The elongation gives the best result when using the group 2, which are 2 yarns in the core and 2 yarns in the cover when using modal and polyester microfiber in the core, viscose yarn, and cool max polyester in the cover.

References:

1- A. Peer Mohamed and Palaniswamy, N. K."Effect of Single Yarn Twist and Ply to Single Yarn Twist". Journal of Applied Polymer Science, 2005, Vol. 98.

2- Gong, R. H. "Specialist yarn and fabric structures Developments and applications". Oxford Cambridge Philadelphia New Delhi : © Woodhead Publishing, 2011. 123.

3- Wang, Xungai. "Fundamentals of Yarn Technology". New England University : WOOL, 2009. 482/582 Wool Processing.

4- Lord, Peter R. "Handbook of yarn production. Cambridge England" , WOODHEAD PUBLISHING LIMITED, 2003. WP1781.

5- Ramesh N, Narkhedkar ."Influence of twist direction on tensile properties of double yarns". Melliand International, 2014, Vol. 20. 5.

6- R, Fangueiro. "Fibrous and composite materials for civil engineering applications". cambridge : Woodhead , 2011. 104.

7- Wright, R H Gong and R M. "Fancy yarns Their manufacture and application". Cambridge England : Woodhead Publishing Ltd, 2002. 1550.

8- Introduction to clothing. studylib. [Online] https://studylib.net/doc/8301954/1.-introduction-to-clothing. [Cited: 3 8, 2021.]

9- PAN, NING and BROOKSTEIN, DAVID . "Physical Properties of Twisted Structures.II. Industrial Yarns, Cords, and Ropes". Journal of Applied Polymer Science, 2002, Vol. 83.

10- Eid, Yaser Mohamed. "Textile filament yarn technology. books world". [Online] https://books-world.net/?p=4323, May 3, 2018. [Cited: Feb 7, 2021.]

11- R, Ayman ELSaid." A comparative study for the properties of shirts fabrics light weight produced from blend boubled yarns". MSC, Faculty of Applied Arts, Helwan University, Egypt,2003.

12- D.Shanmuganandam." Study on Two-For-One Twisting (TFO)". The South India Textile Research Association, Coimbatore - 641 014 : fibre2fashion.com .https://www.fibre2fashion.com/industry-article/1449/study-on-two-for-one-twisting, Jan 2007.

13- Nikolić M, Skenderi Z, Šajn Gorjanc D. "Two-ply Cotton Yarn Production on Ring Spinning Machine and its Quality". Book of Proceedings of the 5th ITC&DC, 2010. 253.

14- Ali, Husain Said." Function achievement in the suit fabric gents and women to utilize of overstocks yarns by using ring twist" . PHD, Faculty of Applied Arts, Helwan University, Egypt,2014.

15- RATTI Luino S.r.l. . RATTI Company. s.l. : info@rattiluino.com - www.rattiluino.com.

16- Al laithy, Amr ."An optimum standard techniques of Two-For-one-Twister m/c for combed cotton yarns". International Design Journal, January 2018, Vol. 8.

17- DirectTwist. http://www.agteks.com/page/comparision/3/directwist. [Online] AG TEKS. [Cited: sept 10, 2020.]

18- O, Ozdemir and S, Sardag." Effect of twisting methods on plied yam properties". Indian journal of fiber and textile Research, sep 2006,

Vol. 31.
19- H.M.Behery. "Advances in Yarn Spinning Technology". Woodhead Publishing Series in Textiles, 2010.
20- Elmogahz, Yehia E. Engineering Textiles (Second Edition). s.l. : Science Direct, 2020.
21- BASIT , Abdul and LATIF, Wasif. "The Mechanical and Comfort Properties of Viscose with Cotton and Regenerated Fibers Blended Woven Fabrics". MATERIALS SCIENCE (MEDŽIAGOTYRA), 2018, Vol. 24.