A Comparison Study of Yarns Produced by Ring Spinning System, For Native and Foreign Cotton Types

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Abstract
The garment's end used depends on the fabric properties, whilst the fabric property depends on the properties of the constituent yarn. Therefore, with the diversification of the market, spinners are forced to produce quality yarn. Hence modern system gradually changed to Ring, Rotor, and compact spinning as widely used as a spinning system. Ring spinning is the universal system covering the widest area of yarn production.

The yarn produced by Ring, Compact, and rotor spinning systems belong to different structures and properties. The present research focused on yarn made as Ne '30s, 100% cotton yarn from five types of cotton materials such as G92, G94, Greek, and American as their properties have been tested. However, the present research focuses on comparing the yarn properties of the different cotton materials. It has been tested by Titan Universal strength tester as well as USTER® HVI 1000 (U%, CVm%, Neps, Strength, elongation, break force and break work) of the ring-spun yarn system. A comparison between the five cotton types of material has been observed.

Keywords:
Cotton G92, G94, Greek, American, Strength, Elongation, Break Force And Break Work

Introduction

Terms of the research

Spinning:

The process of spinning consists of three stages:

- Yarn Reduction thickness from the roving (or sliver) strand to the required yarn count.
- By twist insertion to prevent any further fiber slippage
- Then Winding the Poppin on to package to be convenient for handling and protecting the yarn damage

yarn

Referring to Textile Institute, “a product of substantial length and small cross-section consisting of fibres and filaments with or without twist insertion is called yarn.” A staple spun yarn is a linear assembly of fibres where the individual fibres are small cross-sections and short in length (usually a thousand times longer than diameter). It is held together usually by the insertion of a twist to form a continuous strand.

Yarn evenness:

It concerns the variation of yarn fineness. This property usually measured as the divergence in mass per unit length alongside the yarn. Since it can affect so many properties of the yarn and fabric made from it, it forms an essential foundation and substantial part. However, such

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divergences are unavoidable because they emerge from the fundamental nature of textile fibres and their consequences arrangement.

U%:

It is concerning the median variance from the mean value. It expressed as a percentage of the overall mean value and so-called rate of mean deviation (PMD) and is termed U% by the user.

Tenacity

Tenacity defined as the specific stress corresponding with the maximum force on a force/extension curve.
From: Physical Testing of Textiles, 1999.

Previous work

Ring spinning accounts for about 75% of global long and short-staple yarn production. The main reason for the success of ring spinning over other spinning systems is the superior quality, notable strength, and evenness of ring-spun yarns over those produced by other methods (Gordon & Hsieh, 2007). Other spinning technologies developed are higher in productivity but lack many aspects of the yarn’s desirable characteristics. Ring spinning remains a popular spinning system due to its versatility in terms of yarn count, fiber type, superior quality and yarn characteristics resulting from good fiber control and orientation. The major reason limiting the twisting rate is the heat generation due to traveler friction with the stationary ring.
Sardag et al (2011) [4] researched the effect of conditioning on the tenacity properties of cotton and viscose yarn. They found significant changes after conditioning. Such as, after conditioning a 16 Ne at 80°C for 30 minutes, they got a 9.31% increase in breaking load and a 2.16% increase in breaking tenacity.
Khalid (2012) [6]. analyzed the tensile properties of different fabrics in different relative humidity and found that after increasing the relative humidity from 55% to 85% through conditioning, tensile strength of cotton fabric increased around 20% in warp direction and 33% increase in weft direction [6].
The end-use of a garment depends on the properties of a fabric. A fabric property depends on the properties of the constituent yarn. With the diversification of the market, spinners forced to produce quality yarn. Cotton fibers exhibit variation in their measured physical properties. In the past, these properties were measured and differentiated by cotton classers and later by High Volume Instrumentation (HVI™). However, the generated results are complex and multifaceted. The selection of optimum cotton fibers for a textile mills end product is a constant challenge and customarily more of an art than a science. This report will explore the development of a quality index and how cotton fiber qualities will help predict its ideal utilization. These properties are measured on different scales and may not be of equal importance. Several possible ways exist to compare and combine the expected measures.

Majumda (2001). Reported that, the higher rate of extension courses a lower rate of breaking extension for all types of cotton yarns

Today it is much more difficult to choose the suitable yarn for the optimal quality and economic effect of a certain final product since rotor and air-jet spinning are also commercially widespread. The present research is to recognize the essential differences between the ring, rotor, and air-jet spun yarns according to their structure, mechanical and physical properties, which must be taken into account while planning and designing flat textiles.

Flat textiles (woven and knitted fabrics) for textile purposes have to fulfil certain mechanical, physical, textural, aesthetical, and economic demands and some special requirements for technical end-uses. Their design and construction need interdisciplinary cooperation of spinners, weavers, knitters, garment manufacturers and fashion designers due to the wide range of properties. The choice of yarns for different purposes was very simple until 1963 because only ring spinning was used for the spinning of cotton type staple yarns. Today it is much more difficult to choose the suitable yarn for the optimal quality and economic effect of a certain final product since rotor and air-jet spinning are also commercially widespread. *(13) (PDF) Influence of a Spinning Process on Spun Yarn Quality and Economy of Yarn Production*.

(13) (PDF) Influence of a Spinning Process on Spun Yarn Quality and Economy of Yarn Production. Available from: https://www.researchgate.net/publication/243972912_Influence_of_a_Spinning_Process_on_Spun_Yarn_Quality_and_Economy_of_Yarn_Production [accessed May 29 2021].

Mechanical Model of Ring-spun Yarn Formation Figure 1 shows the model of yarn formation by the ring spinning frame. The roving is thinned by draw frames, fixed (twisted) and at the same time wound to the tube by the ring-traveler-spindle system. The torsion energy (i.e., twist) of the ring-spun yarns is transmitted from outside of the continuous fiber bundle to its interior by helical twisting of fibers at the spinning triangle. Fib resin the yarn are maximally straightened, paralleled, longitudinally orientated and axially tensioned. Its characteristic for the ring-spinning process that fibers in the yarn evenly take over helical twisting around the yarn axis. The torsion energy is therefore equally distributed across the ring-spun yarn cross-section (Plate 1). Fibers in the yarn skin are more axially stressed due to the higher length of helical twisting. These fibers take over the radial stress while the yarn core fibers bear axial stress.

(Ramesh N. Narkhedkar)In the recent days every textile technologist requires the production of yarn with higher quality and high yarn realization which can be made possible if the textile technologist takes the improvement steps on the machine as well as processing parameters. Now everybody is looking for encouraging the yarn quality by improving processing parameters. Generally, the yarn quality parameters are affected by the physical structure of the yarn. The yarn cross-section shape is the very important yarn physical parameter which has a dominant effect on the physical structure of the yarn. In the past days no such studies have been conducted on the yarn cross-section studies due to the various limitations of the yarn cross-section measuring or testing instruments. Here author studied four factors are affecting the yarn cross-section i.e., twist multiplier, roving hank, spinning system and doubling technique.

Ideal for: Cotton is light and breathable. Making it the perfect choice for dream summer knits, dishcloths, potholders, and scrubbiest.
The radial pressure is transferred from fibers in the skin towards the core fibers with the radial stress increment. Such distribution of radial stress in ring-spun yarn enables all fibers to bear the axial forces. This is the reason for the high strength of ring-spun yarns, i.e. the high efficiency of substantial strength of a fiber bundle. Free movement of the fiber bundle composing the yarn in the area between the take-away rollers and the traveler and also the inertial field of forces active in the yarn balloon cause stronger hairiness with a higher number of fibers protruding from the yarn. The structure of ring-spun yarn has the following good properties due to the continuous connection between the fibers, high radial stress of skin fibers and the twist transfer from outside to the interior of the yarn cross-section: high number of straightened fibers, parallelization and orientation of fibers with helical twisting from outside to the interior; relatively closed yarn structure and therefore smaller friction coefficient; increased yarn hairiness; low yarn rigidity; worse insulation properties; medium abrasion resistance; less pronounced pilling effect.
(13) (PDF) Influence of a Spinning Process on Spun Yarn Quality and Economy of Yarn Production.

Types of Sourcing in yarns Industry could be classified as follow:

- **Local manufacturer**:
  By using local infrastructure raw cotton manufactured locally in the industry.
- **Extensive sourcing**
  As a portion of extensive sourcing master plan yarns are made with parts sourced from abroad.
- **Worldwide or International sourcing**
  All raw material required to make yarns are sourced from other country.
- **Global manufacturing**
  Manufacturing of yarns is done in other country.
- **Conventional manufacturing**
  Internal yarns exported to the fabric manufacturing countries.

Ring spun vs Regular Cotton:

What is Regular Cotton?

The process of making regular cotton consists of twisting together soft vegetable fibres into yarn. The yarn is then woven together to create regular cotton material. This type of cotton is the most widely used, though ring spun is becoming increasingly popular. Manufacturing regular cotton is less expensive than ring spun, and while it offers breathability, the softness pales in comparison to ring spun cotton. Even still, regular cotton continues to be an industry staple and is widely sold in both the wholesale and retail markets.

What is Ring spun Cotton?

The term ring spun was coined because of the process used to manufacture this type of cotton. The yarn that is created for ring spun cotton is spun in a way that produces stronger, longer strands that are soft, extremely durable and free from the rough texture of standard raw cotton. The process of continuously spinning, twisting, and thinning the cotton strands is what yields long, soft strands. Additionally, during this process, the threads are compacted in a way that produces a very strong and durable material.

When the time comes to determine which type of cotton is the “best”, it depends entirely on what you'll be using it for. Both types of cotton are wildly popular for very good reasons. If you’re looking for a new favourite tee that’s fashionable and soft, or an option for your new clothing line, ring spun cotton tees are your best bet. But, if you’re looking for a quality t-shirt for a fundraiser, donation, or simply want a standard t-shirt to withstand the wear-and-tear of lots of use, you can’t go wrong with regular cotton.

As with any purchase, you must determine what’s most important to you, what you’ll be using your shirts for, and how much you want to spend. Though ring spun cotton is generally a bit more expensive, the added cost is minimal and will not break the bank. As the old adage goes, buy nice or buy twice.

Gordon & Hsieh (2007) Reported that Ring spinning accounts for about 75% of global long and short staple yarn production. The main reason attributed for the success of ring spinning over other spinning system is the superior quality, notable strength, and evenness of ring-spun yarns over those produced by other systems.

Experimental work

Methodology

There are five types of cotton yarns extra-long staple (ELS) cottons, Giza 92(G92-34.5 mm), Giza94(G94- 33.5mm), Greek (GR- 33mm) and two American types coded UL-TIMA(TM)(35mm) +SUPIMA (SU 34 mm) have used as Experimental Type research. The: - Yarn production - Sample preparation - Test Ne 30 yarns are produced by Ring, from same raw materials. Produced yarns are then tested by Uster Tester 5 and Titan-Universal strength tester machines [ ]. All the production and experiment are done in Mahalla Kupra Spinning Mills Ltd, a leading Textile mill in Egypt. Also, a clear comparison is shown among different parameters like U%, CV%, Imperfection Index (thick/km, thin/km, Neps/km), tenacity and elongation of ring -spun yarn.

Using patented technology, the USTER® HVI 1000 rapidly provides full reports on full important quality characteristics.

Spinners need to have confidence in the quality of the raw cotton they are sourcing. The ability to test and class cotton accurately using the USTER® HVI 1000 is vital to take decisions. The USTER HVI 1000 measures the most important cotton fiber properties for cotton classing purposes (and high-throughput requirements for spinning mills.

Ambient Conditions:

According to ISO 139, the following ambient conditions is considered to be maintained in the laboratory in order to get repeatable and comparable test results:

- Temperature: 20±2°C; 65 °F to 72 °F
- Relative Humidity: 65±2%

For consistent test results, yarn samples should be conditioned in the laboratory environment with the above-mentioned ambient conditions for 24 hours. Samples should be laid out openly in the laboratory, and taken out of plastic bags, in order for the cotton to fully condition to the environment.

Basic statistic: When analyzing test result of the USTER HVI 1000 some basic statistic is important. The three terms used most often in analyzing test results are:

- Average or mean value
- Standard deviation
- Coefficient of variation or CV value

The result of testing is reported at table (1)

Cotton Type	G92	SU	GR	G94	TM
U (PMD) %	7.02	8.01	8.03	8.03	9.42
CV%	8.8	10.07	10.10	10.10	11.86
Neps	7.0	6.0	5.0	5.0	13.0
Tensity Gf	26.73	26.38	17.63	24.38	20.45
Elongation %	6.12	5.76	5.24	5.3	5.72
Break Force Gf	526.1	519.3	347.0	479.5	402.6
Break Work of rupture	749.5	690.1	569.2	655.1	626.1

U% & CV%

These are the mass variation calculations along yarn length. Testing machine measures the mass of each centimetre of yarn, hence U% and CVm% values are calculated using the formula below as are used to determine how uniform or even the yarn is. The average value of all the deviations from the mean which is expressed as a percentage of the overall mean as called Percentage of Mean Deviation (PMD). The term

CV % by the uster is theoretically equal C.V.=1.25 U (P.M.D) which it gave the same results.

A coefficient of variation CVm% is a statistical measure of the dispersion of data points in a data series around the mean. The coefficient of variation represents the ratio of the standard deviation to the mean. It is a useful statistic for comparing the degree

of variation from one data series to another, even if the means are drastically different from one another. The higher the CV% value, the more irregular the yarn as shown in fig (1). The American cotton (TM) followed by SU is showing the higher value of CV% with 26 % and 14.8% consequently versus the lowest value showed by the Egyptian cotton G92.

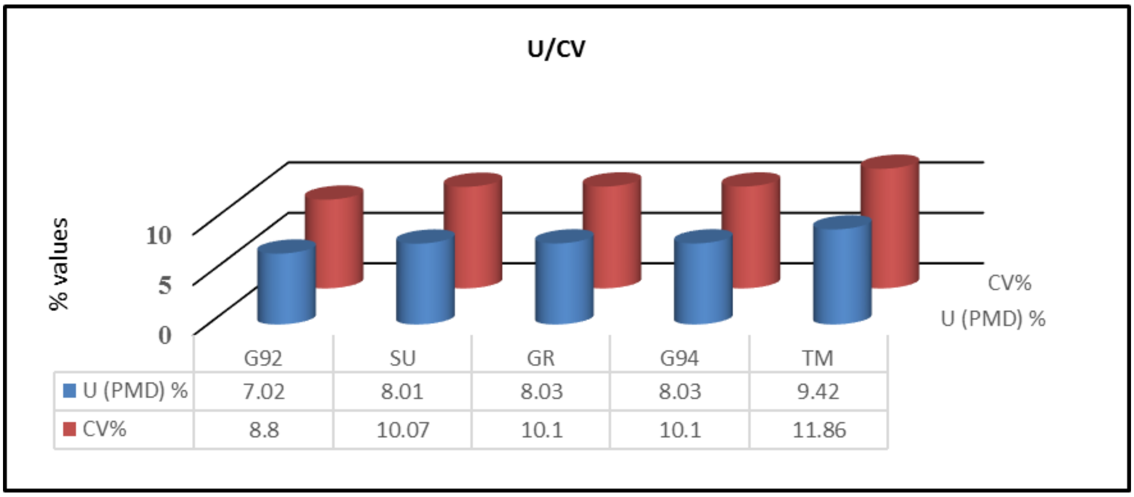

Fig (1)

Neps:

The biggest problem in spinning is the nep. Entangled cotton fibers that form Neps have two sources: those that occur naturally as the cotton fiber develops on the plant into lint as ready to be harvested and those that arise from mechanical action in harvesting, ginning, cleaning. in order to reducing the Neps in the sliver in the carding process is to achieve "fine card, tight distance, sharp needle/tooth; achieve strong carding, control floating, reduce sputum, rub, less production, more exclusion. to ensure the on-board process, the fine flat-loading machine carries out special parts repair to enhance the dynamic and static balance of the cylinder. beside the thorn roller, the doffer, the roundness and the flatness of the needle surface of the cover [].

[]How To Deal With The Neps On The Yarn - News - Wenzhou Huanyu Textile Co.,Ltd (hyyarn.com)

Zahidul (2019) reported that the periodically occurring yarn faults are thin place, thick place, and Neps. These faults defined as those deviating from the average value by a predetermined reference value. Generally, these imperfections measured at a negative sensitivity level (-50%) of the average yarn size. Concerning these levels, a thin place is a region where the yarn cross-section is less than half the cross-sectional size of the middle portion. A thick place similarly is that region where the cross-sectional size is bigger by (+ 50%) of the average size. A small but sharp wide area defined as Neps (+200%), where these values mean the average value of mass plus the mentioned percentage of that mass. In fig (2), the lowest Neps is reported by G4 whist the highest level reported by TM cotton, while the G92 occupy the third level counting Neps.

[] Zahidul Islam, Comparing Quality Parameters of Yarn Produced by Ring, Rotor, and Compact Spinning System. European Scientific Journal January 2019 edition Vol.15, No.3 ISSN: 1857 – 7881 (Print) e - ISSN 1857- 7431.

Modern yarn spinning mills are increasingly trying to monitor both Neps and short fibres. For example, yarn quality at each spinning position is monitored by ‘yarn clearers. Also, some carding machines may be equipped with an instrument that monitors Neps in the card web[].

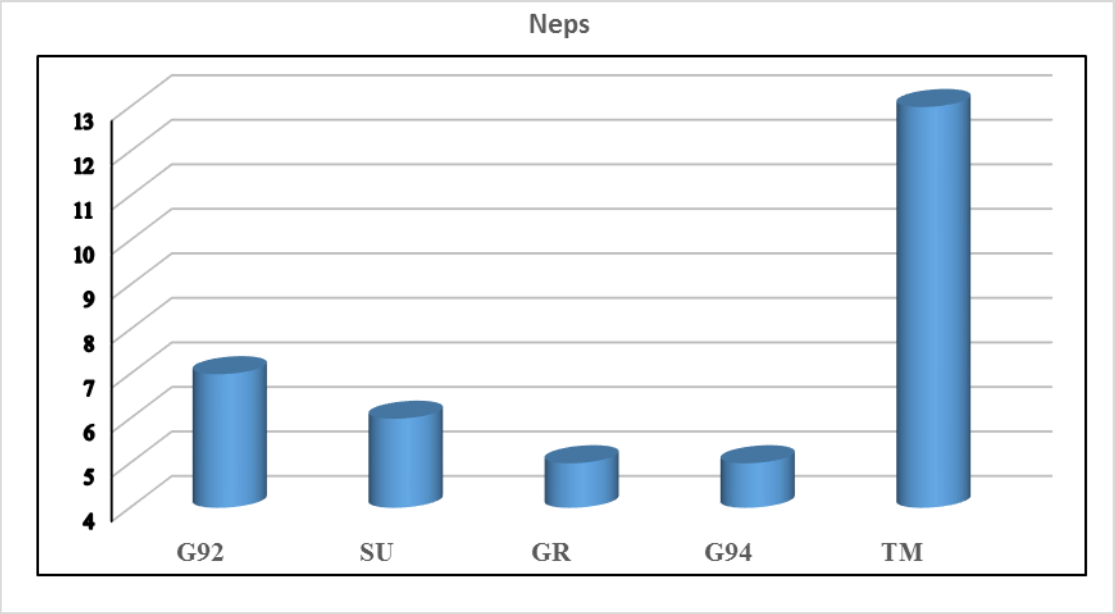

Fig (2)

Tenacity.

Khan et al. (2017) reported that to analyze how the activity has a significant impact on yarns moisture content, tenacity, elongation at break and hairiness of yarn, found that yarn made from different fiber tested before and after conditioning, around 5% increase in moisture content, the result was around a 4 to 6% decrease in hairiness. On the other hand, a 12 to 13% increase in elongation at break and a significant change in yarn tenacity.

(Gowda, 2003) reported that the yarn produced in ring spinning has good strength and unique structure, but the integration of many fibers is poor, and such fibers tend to generate hairiness that does not contribute to yarn strength. In conventional ring spinning, fibers in the strand emerge from, and because of the restriction to twist flow by the spinning triangle, the front roller nip does not fully integrate into the yarn. These fibers show up partly as protruding hairs or as wild fibers. The spinning triangle exists because of the higher width of the strand compared to the final yarn diameter. Further, the fibers are tensioned to a varying extent depending on their position in the spinning triangle. As a result, the full realization of fibre strength does not achieve in the yarn.

Natural fibers are becoming growing important owing to their desirable ecological properties. The tensile behavior of these fibers is influenced by plant growth and processing conditions and their microstructure [Thamae].

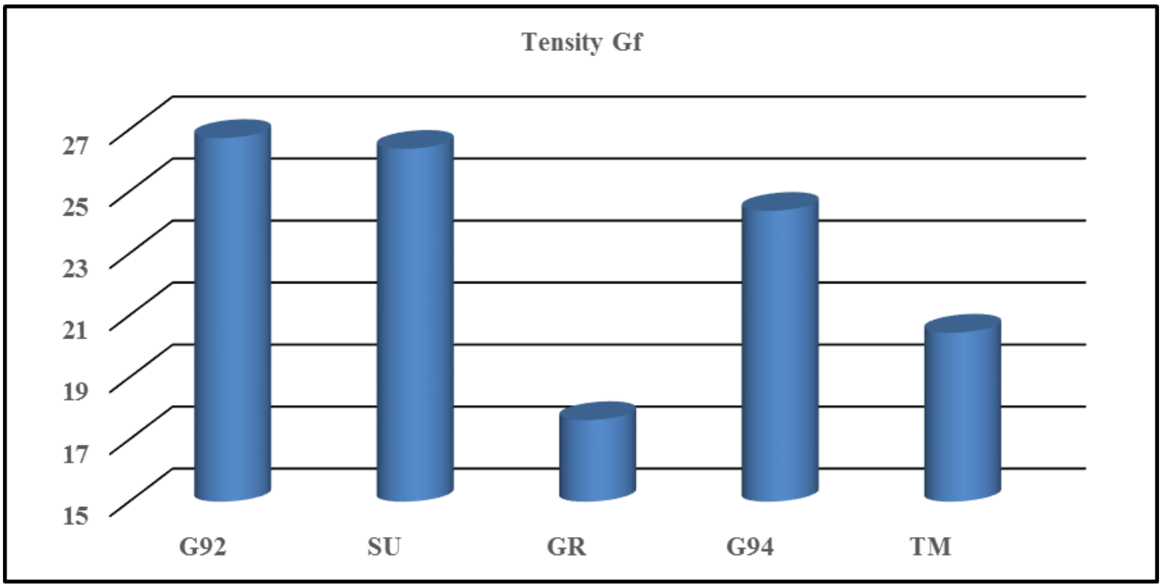

Fig (3)

Elongation

Ruvini et al. (2020) reported that developing cotton fibres with improved tensile properties is important because fibre breakage during processing from field to yarn can impart imperfections in the finished product by degrading fibre quality. Cotton fibre strength is often the focus of germplasm development, while the degree of fibre elongation before rupture under load has been neglected. Nevertheless, the degree of fibre bundle elongation is heritable. Isolating the significance of the specific mechanical property in resisting breakage during processing is hard in a naturally produced fibre whose quality attributes controlled by genetics and environment. Lower elongation fibres break more regularly or habitually during processing. Yarns made from these lower elongation samples exhibit work to break as much as 32.3 % lower than the paired high elongation sample.

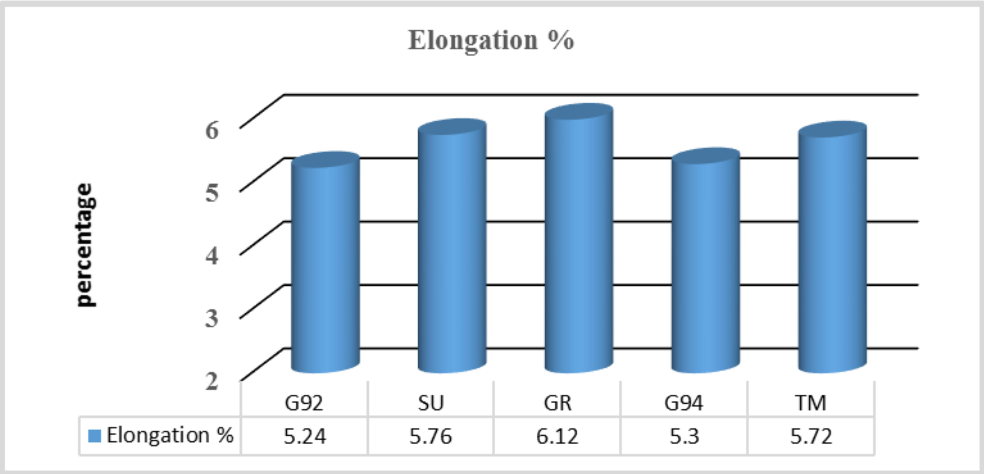

Fig (4)

Breaking tenacity is estimated in grams per denier. In the extreme, low forces are encountered in evaluating fibre properties, instrumentation requesting a gram level accuracy. Similar tests for the evaluation of spun yarns are common. The engineering properties of many yarns depend on the rate of application of the applied load and the environmental conditions.

Harmonious testing results require accurate control of the applied loading and controlling the test environment. For many sports, a concern of sports apparel is the ability of the material to resist tearing used in the garment—the force required to start or continue to tear a fabric under specified conditions defined as tear strength. The resulting test curve is often quite jagged, as far as textiles are not typically uniform materials. Test parameters recorded during these tests include tearing strength.

The work of rupture, sometimes called the toughness, is defined as the energy needed to break the spacemen. In fig (5), although Majumdar (2001) [] it is observed that the higher rate of rupture causes lower breaking rupture for all types of cotton yam, the present tested experimented different results. The higher extension rate, the higher the breaking extension, as shown in table (2) and fig (6), where the most elevated extension is G92, and the lowest in the GR. The difference in results between Majumdar and the present research the yarn samples of him is made of 100% cotton of vary-ing count, were collected from spinning mills, whilst the present study, the 100% cotton materials are in different types.

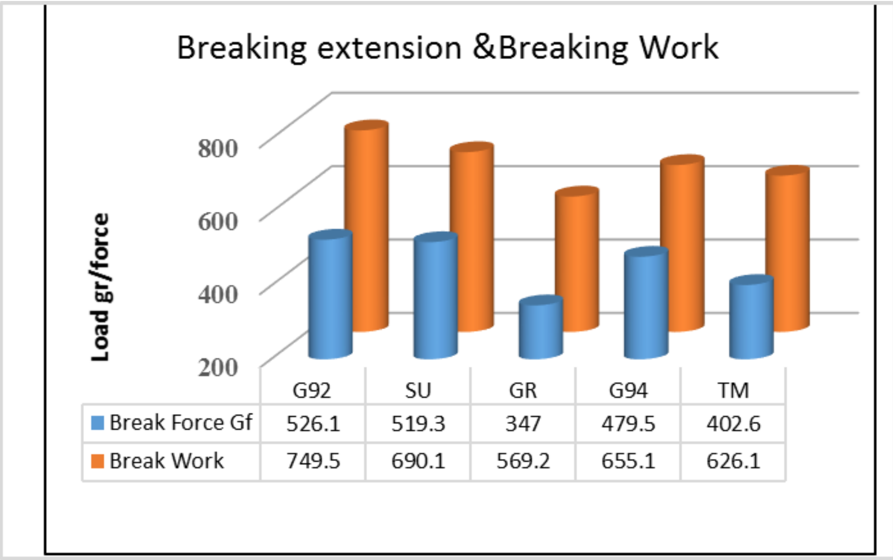

Fig (5)

table (2)

Cotton Type	G92	SU	G94	TM	GR
Break Force Gf	526.1	519.3	479.5	402.6	347.0
Break Work of rupture	749.5	690.1	655.1	626.1	569.2

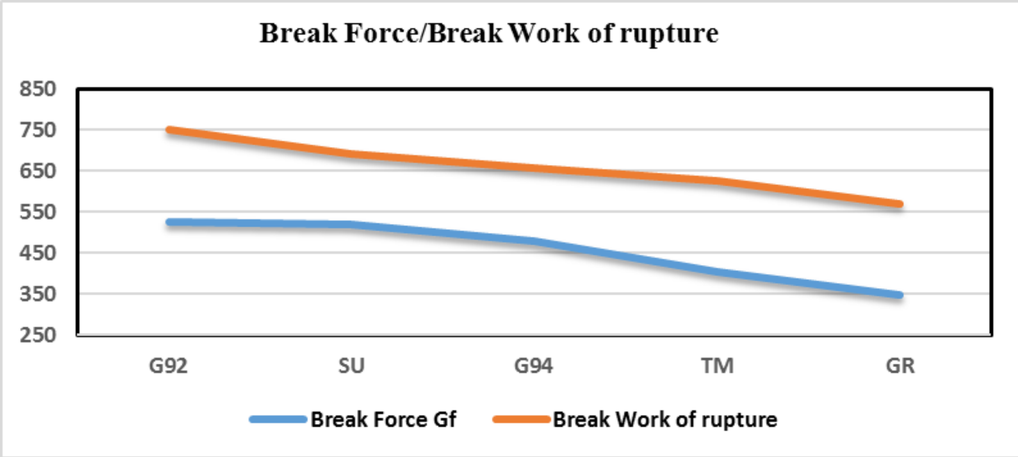

Fig (6)

Table (3)

priority	1	2	3	4	5	6	7
	properties						
Cotton Type	Tenacity Gf (+)	Elongation% (+)	CV% (-)	U(PMD)% (-)	Break Force Gf (+)_	Break Work of rupture (+)	Neps (-)
G92	26.73	6.12	8.8	7.02	526.1	749.5	7.0
SU	26.38	5.76	10.07	8.01	519.3	690.1	6.0
GR	17.63	5.24	10.10	8.03	347.0	569.2	5.0
G94	24.38	5.3	10.10	8.03	479.5	655.1	5.0
TM	20.45	5.72	11.86	9.42	402.6	626.1	13.0

The reported values is transferred to a % values according to the positive or negative property

According the following equation=$X(+ve) = \frac{\delta i}{\delta max}$ **or** $=X(-ve) = \frac{\delta \min}{\delta i}$

Where = δi the measured values

$\delta max = maximume\ values$

$\delta min = minimum\ values$

Table (4) Relative values of physical and mechanical properties and quality parameters of the different cotton materials

Cotton Type	properties							Quality factor (%)
	Tensity Gf	Elongation %	CV%	U(PMD) %	Break Force Gf	Break Work of rupture	Neps %	
G92	100	100	100	100	100	100	84.62	93.41
SU	98.69	94.12	89.29	89.49	98.71	92.07	92.31	66.30
GR	65.96	85.62	89.04	89.28	65.96	75.94	100.00	81.68
G94	91.21	86.60	89.04	89.28	91.14	87.40	100.00	90.67
TM	76.51	93.46	74.20	74.52	76.53	83.54	38.46	73.89

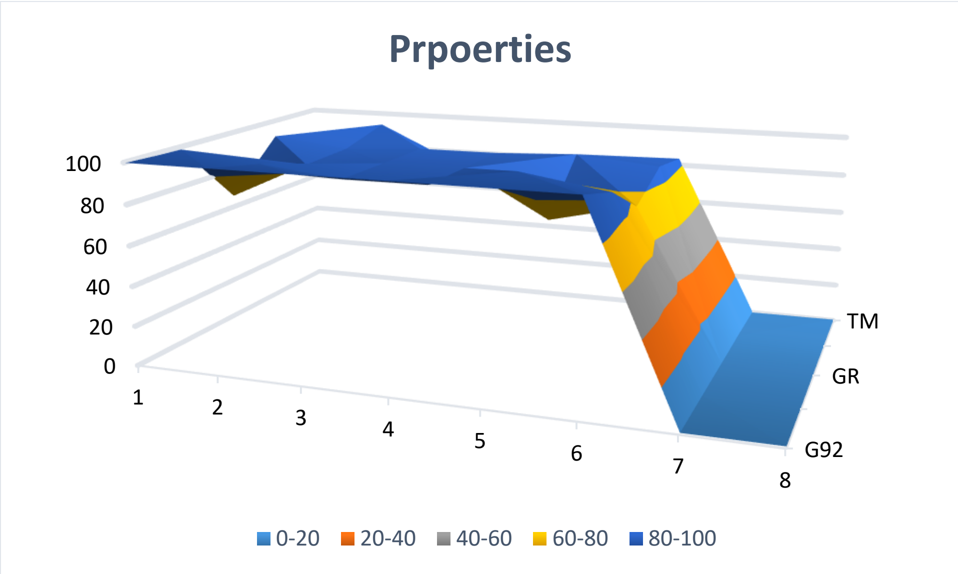

Fig (7)

It is cleared that the highest quality factor is reported by Egyptian cotton G92 followed by G94, whilst the lowest quality is the American cotton SU.

Conclusion

In the fabrics and crafts industry, cotton is an all-round favorite which is available in various textures and thickness. Its high tensile strength makes it strong, durable and less likely to rip or tear. It washes and dries easily and may be washed repeatedly as needed. But with so many different types of cotton fabric to choose from, it can be difficult making a final decision. So, to help producers, to put this guide together on the different types of cotton fabric.

The choice of yarns for different purposes was very simple until the year 1963 because only ring spinning was used for the spinning of cotton type staple yarns. Today it is much more difficult to choose the suitable yarn for the optimal quality and economic effect of a certain final product.

The tensile properties and TPI of yarns are reported in Table 1. It can be seen from the table that present yarns have very good strength. One salient feature for yarns of all fineness is the very low yarn count CV % ranging from 8.8 to 11.8. Presently most of the mills producing high quality yarns use Autolevelers on draw frames and on cards. This has resulted in reduction in count CV %. The mean elongation at break value mostly lies between 5.24 and 6.12%. Though the mean values show higher extension. For warp yarns twist multiplier, (TM) 3.73 to 3.92 are being used and for hosiery yarn it is around 3.20.

Recommendation

A suggested option to These Different Types of Cotton Fabric:

Cotton lawn fabric fig (7) is a thin, relatively sheer, high thread count cotton fabric made using a tight weave but with a finer thread. This creates the buttery smooth surface texture, making it perfect for clothes, blouses, skirts, lightweight maxi dresses, or a gorgeous summer blouse and other clothing pieces for the warmer months.

Cotton jersey fabric fig (8)

Known because of its stretchiness and softness, cotton jersey fabric is a staple to make the favorite cotton tee-shirts. It's a very low maintenance fabric that is incredibly soft and comprises predominantly cotton with some elastane. One of the huge benefits of using a jersey is its versatility as it can be worked into most dressmaking projects - from breathable summer tops to base layers for the winter months.

Cotton poplin fig (9)

It is plain-weave cotton with lightweight fabric that can be used to make various clothing items and be worn during the year. It is often used in men's shirts as it is soft with lightweight, and relatively crease-free. It is also used in women's dressmaking as well as sportswear and raincoats. Cotton poplin is known for its distinctive ribbed texture and tightly closed weave, making it very lightweight but still retains its strength. Poplin has always been a staple fabric for its versatility, as it is a comfortable but stylish fabric for all manner of casual and formal wear.

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Fig (7)

Fig (8)

Fig (9)

Fig (10)

Fig (11)

Fig (12)

Fig (13)

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