THE IMPACT OF NEW SPINNING TECHNOLOGY ON THE ENGINEERED YARN QUALITY FACTOR OF EGYPTIAN COTTON. PART: I CONDENSED SPINNING

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Abstract

In the present work a data mining [DM] of condensed spinning that runs in the Egyptian spinning mills were extracted and manipulated to produce tables & exhibits where they reveal the Egyptian yarns quality levels via Engineered yarn quality factor. The latter one gives a figure about the percentage improvement or loss in the compact spun yarns quality. For the processed cottons in the spinning mills it was found that the EUG – FQI (Engineered upgraded fiber quality index) was ranging from highest value (40k) for G80 to the lowest value (31k) for G70.

The definition of the new quality measures are:

$$EUG - FQI\ (GQI) = T(fiber\ strength\ in\ Mpa) \times (UHML\ (mm) \times U.I)\left(\frac{M`}{M}\right) \times (Rd \times b^{+})^{[6]}$$

$$EUG - YQF\ = \frac{(Yarn\ strength\ in\ Mpa)\times(strength\ in\ CSP)}{U\ \%}$$

$$EUG - RYQF\ = \frac{(EUG-YQF\ )_{cond.}}{(EUG-YQF)\ _{ring}}$$

For weaving - high twist yarns, the value of $EUG - YQF$ is ranging from 69 k -102k for compact yarns & from 49k – 86k for ring yarns for texs 7 to 15 respectively, The % improvement in yarn quality varies from 40 % - 19% (average%=30%) The high improvement for tex 7 i.e for fine yarns. For low twist (knit) yarns the value of $EUG - YQF$ is ranging from 75 k – 96k for compact yarns while for ring yarns it ranges from 47k – 66k, for texs 10 – 15. The % improvement in the yarn quality is ranging from 60 – 40% (average %=50%) respectively. The great improvement is remarkable w.r.t relatively highly twisted yarns.In the work it was concluded that the compact- condensed- combed single yarn can replace: ring single combed yarn and plied carded ring yarns. The % improvement is about 33% average value for the single but for plied carded it is 19%. The carded compact single yarn could not replace combed ring single yarn where the average % loss in quality is about 30 %. The EUG – YQF for special ultra fine yarns was ranging from 24 k to 93k for yarn texs 2.6 to 7.4 i.e the yarn with a large diameter (tex) gives high values. The % improvement is about 33% due to compat spinning. The use of Egy. cotton with high EUG – FQI improves the quality by about 5%. The plied compact combed have EUG – YQF that varies from 170k to 167k for plied yarn texs $10 \times 2 - 11 \times 2$ respectively. The% gain in quality is 55% due to compacting.

Introduction

The concept of quality in textiles: Fibers, yarns or fabrics has studied & explained in several works, Peter lord, 2012, [15], Elmogahzy, etal, 2001, [4], Lawrence, 2010, [10], Sinclair el-al, 2016, [17], Elhawary, 1987, [3], and Ibrahim Elhawary et – al, 1994, [7],etc. In the present work, the quality will be divided to: A. fiber quality & B. yarn quality.

Fiber quality

The quality index of the Egyptian cottons was studied in Elhawary work, 2011, [6]. where it was ranging from 26G to 49G for G86 & G77 xS6 cotton fibers. Peter, 2012, in his hand book [17] has written that the case with which the yarn can be manipulated in making fabric is often related to yarn strength, fault rate and hairness. Yarn strength is mostly a matter of fiber strength. Harrison, 1979, in his conference [2], has combined the fiber properties, into a newly generated single index that is named F. Q. I, that depends on fiber length, fiber strength, fiber maturity ratio & micronaire value. Hawary, 1987, in his work has written that the interaction between Egy. Cotton fibers properties and yarn properties, could be predicted mathematically via Salavev`s equations, 1987, [3]. Elmogahzy et – al, 2001, [4], have given an intensive information concern basic quality of cotton fiber as fiber fineness, maturity, etc.

Yarn Quality & new spinning systems

Referring to the new spinning systems, they were highly appreciated in the work of Ibrahim A. Elhawary et – al, 1972. [8], Elmogahzy et – al, 2001, [4], Lawrence, 2010, [10], Sinclair et – al, 2016, [17] and Ibrahim A. Elhawary et – al, 1994, [7],…etc.

Vedant et – al, 2013, [19], have proposed the yarn quality requirements for high speed weaving machines. that run with speed less than 500 RPM and with fabric ends / inch ≥ 100. For higher speed, the yarn quality must

follow 5% Uster Norm. Kulkarni et–al, 2010, [11]. Have stated that in ring spinning the fiber migration is acknowledged, due to tension variation in the spinning triangle. In compact spinning, tansion difference is to be smaller those in ring spinning. The elimination of spinning triangle have reduced the migration parameters by 25%. Yadav, 2013, [20] has stated that the impact on quality after converting single yarn into two – ply yarn is: yarn becomes stronger and inhibit, more elongation & hairness that increases in case of TFO twisted yarns. Pravil, 2008, [16] has stated that tensile properties of jet ring yarns found better that pure ring yarns, productivity in increased by 42% for yarn count 42`s in case of jet ring system, where yarn quality is improved by this new combination. Sudhir, 2008, [18] mentioned that compact spinning is well established & accepted technology – where it offers, yarns with lower hairness & higher strength with elongation. The weaving performance is improved accordingly, beside the quality of fabric after processing is significantly influenced. Aryan, 2007, [1], has written that compact yarns offer a much cheaper and easier solution to producing value added fabrics which prove good feel & luster. Eli twist yarns are produced today by many Indian mills where it will substitute Eli yarns for doubled TFO yarns which much more expensive. Vasant, 2009, [14], stated that on a ring spinning frame, yarn production is very low: 8m./min for yarn count 140`s. where the limit factors are the spindle speed and ring & traveler life. A special ball bearing developed to revolve the ring in same direction of the spindle. Therefore 6% production increase was attained.
Manal et–al, 2010, [12] & Mohamed, 2009, [13] have studied & investigated the quality of the carded compact & combed compact either single or plied respectively. Both of the yarn quality factor & the relative yarn quality factors were explained & investigated for rotor Egy. Cotton yarn in the work [8]. The upgraded yarn quality factor was written in the research work [6].

Experimental Work

It is divided to two parts: spinning procedure & testing procedure for fibers & yarns. The spinning procedure includes the following:

1- Reiter Blow room
2- Carding M/C`s Reiter C51 (With autoleveller)
3- Reiter breaker drawing (without leveling)
4- Reiter unilap & combing
5- Reiter finisher drawing (with leveling)
6- Reiter speed frame
  (a) Conventional spinning
  (b) Compact [condensed]spinning
7- Winding
8- Doubling
9- Twisting (TFO)

The testing procedure is divided to: Part (A) & part (B). Part (A) concerns with the fiber testing: the fibers tests were done in a standard atmosphere due to A.S.T.M. All the fiber characteristics were measured by using HVI Spectrum II (12 fiber properties were recorded) and taking into consideration Uster instrument application hand book, Uster zellweger (13). Part (B) concerns the yarns testing. All the tests were carried out in a standard atmosphere. The yarns mass variation were measured by Uster tester (U T4) where yarn hairness & total IPI could be checked. The yarns tensile properties were measured by Uster Tensorapid 4 (UTR4), but the yarns tensile strength in poundf (Lbf) was measured via a pendulum type tester.

Results & Discussions

Cotton fiber characteristics in table 1 show the physical & mechanical characteristics of the samples as measured by HVI. The table includes 12 properties of total 17 properties, HVI-based measurement; these 12 properties are necessary for the Egyptian cotton spinning mills. The following notes are important:
The spinning consistency (SCI) is ranging from 200 to 214.
The range of the micronaire reading or micronaire value (MIC) in μg/in varies from 3.2 to 4.66 ≐3-5.
The maturity percentage (Mat) is ranging from 80% to 95%.
The upper half mean length UHML (Len) varies from 31.74 mm to 35.4 mm≐ 32-35 mm.
The uniformity index (Unf) varies from 56.9 to 87.1 ≐87 to89.
The short fiber index (SFI) is ranging from 5.5 to 5.8.
The strength (gm / tex – cN/tex – M.pa mega pascal) varies from 41.5 to 45.4 cN/tex [629-688 Mpa].
Elongation % [Elg] is ranging from 5% to 6.2% .
Color reflectance or reflectance (Rd) varies from 66.7 to 75.54.

Yellowness (b) is ranging from 8.8 to 11.6, our pov (point of view) for the egy. Cotton where $b \leq 10$, cotton color is white while when $b \geq 10$, cotton color is creamy.
Trash area [Tr. Area] varies from 0.4 – 0.6.
Trash count [Tr. Cnt] is ranging from 19 to 46.
The engineered fiber quality index EUG – FQI for the processed cottons is ranging from 31,330 [31k] for G70 to 39,628 [40k] for G86.

Table 1: Physical fiber properties of Egyptian cottons, measured by HVI spectrum

Property \ Variety		Extra long staple				Long staple
		G45	G87	G88	G70	G86
SCI	Spinning Consistency Index	214	213	211	207	200
Mic.	fineness(μg/inch)	3.2	3.34	4.04	4	4.66
Mat. –	Maturity %	80	88	86	92	0.95
Len	Upper half mean length(mm)	35.1	35.1	35.4	35.1	32.42
Unf.	Uniformity index	87	87.1	-87.3	89	0.869
SFI	Short fiber index	5.8	5.6	5.8	5.8	5.78
Str.	Strength (gm / tex)	42.4	42.7	45.1	41	45.4
Elg.	Elongation %	6.2	5.7	5.7	5	5.78
Rd.	Reflectance	73.7	72.1	66.7	70.2	75.54
$^{+}$b	Yellowness	9.1	9.3	11.6	10	9.29
Tr. Area	Trash Area	0.6	0.6	0.6	0.6	0.4
Tr.Cnt	Trash Count	46	38	38	44	21
EuG – FQI (k)		32,889 (33)	34,939 (35)	34,689 (35)	31,330 (31)	39,628 (40)

Table 2: The results of relative high twist single combed yarns (condensed & ring).

	Q.P (tex)	a_{tex}	U%	Thin -50% / Km	Thick +50%/ Km	Neps 200% / Km
Compact Spinning	15	3630	9.49	0.48	9.13	7.24
	12	3780	9.84	1	16.05	12.5
	11	3660	9.48	1.13	9	22
	10	3680	9.82	1.67	11.42	19.57
	8	3970	10.15	3.90	18.10	35.6
	7	3820	11.65	22.62	34.40	42
Conventional Ring Spinning	15	3820	9.68	1.09	7.55	8.95
	12	3850	10.28	3.04	16.30	17.42
	11	3660	9.93	2.90	9.10	25.5
	10	3820	10.60	9.90	23.09	43.2
	8	3960	11.22	22.2	31	43.75
	7	4040	11.83	57.80	49	47.6

Table 2 (continued).

	Q.P (tex)	Total (IPI)	H	Elongation %	Tenacity (cN / tex)	CSP
Compact Spinning	15	16.85	3.13	4.99	26.09	3724
	12	29.55	2.76	4.76	26.2	3715
	11	32.13	2.87	4.48	25.28	3584
	10	32.66	2.5	4.73	26.38	3720
	8	57.6	2.4	4.70	25.10	3496
	7	99.02	2.46	4.41	24.17	3360
Conventional Ring Spinning	15	17.59	3.86	4.64	24.27	3440
	12	36.76	3.63	4.43	23.04	3250
	11	37.5	3.75	3.92	22.62	3136
	10	76.19	3.63	4.09	21.9	3060
	8	96.95	3.38	4.18	20.99	2880
	7	154.40	3.33	4.22	20.70	2800

Different cotton yarns: single, plied, carded, combed, compact & ring spun:
Relative high twist yarns:
Table (2) shows the experimental work results that concern combed relative high twist yarns condensed & ring spun characteristics. The following remarks are worthy to be red:
The range of yarns counts is 15-7 tex, Ne (40-84), with twist factors vary from $\propto_{tex}= 3630 - 3820$ respectively for compact spinning where they are ranging from 3820 to 4040 for ring spinning.
The teacity in cN/tex is varying from: 26 – 24 (comp), 24-21 (ring).
The CSP is varying: from 3724 to 3360 (comp) & from 3440 to 2800 (ring).
The elongation at break varies from: 4.41to 4.99 (comp0 & from 4.22 to 4.64 % (ring).
Mass variation (Uster value) U% is ranging from 9.49 – 11.62 % (comp) & from 9.65 -11.83 (ring).
The total IPI varies from 16.85 to 99.02 ≐ 17-99 (Comp.) & from 17.59 to 154.4 $\doteq (ring)$
The hairness index is ranging from 2.40 to 3.13 (comp.) from 3.33 to 3.86 (ring).
From table (2),different tables were produced as table (2-a), gives the yarn count in texs & Ne with their CSP (count – Strength products for single combed compact spun yarn & Eng. upgraded yarn quality factor: EUG – YQF where it is ranging from 102,419 (102k) for yarn tex 15 to 69.218 (69) for yarn tex 7. The definition of EUG – YQF could be written as follow:

$$EUG - YQF = \frac{yarn\ strength\ in\ M.P.a \times yarn\ count{-}strength\ product}{U\ \%}$$

$$= M.pa. \times \frac{CSP}{U\ \%} \qquad (1)$$

Where,
EUG –YQF – Eng upgraded yarn quality factor, M.pa – Mega pascal of yarn strength.
CSP – yarn English count × yarn strength in pund f (lbf) (yarn strength). The tables data are exhibited in fig.3.

1. It could be concluded that the gain in quality of the yarns is higher for fine yarns.

Table (2-b) gives the yarn count in texs & Ne with their csp & EUG – YQF for combed ring (high twist) yarn. Tables (2-a) & (2-b) are exhibited in fig.2. Table (2-c) shows the EUG – RYQF for single combed yarn (comp & ring).

Table (3-a) Engineered: Properties of combed compact single weave yarn:

Yarn tex (Ne)	Yarn CSP	EUG – YQF (k)
15.0 (40)	3724	102, 419 (102)
12.0 (50)	3715	98, 915 (99)
11.0 (56)	3584	95, 648 (96)
10.0 (60)	3720	1000, 008 (100)
8.0 (76)	3496	86,452 (86)
7.0 (80)	3360	69, 218 (69)

Table (3-b) Eng. Properties of relative high twist single combed ring-spun yarn:

Yarn tex (Ne)	Yarn CSP	EUG – YQF (k)
15.0 (40)	3440	86,350 (86)
12.0 (50)	3256	72,714 (72)
11.0 (56)	3136	74,847 (75)
10.0 (60)	3060	62,354 (62)
8.0 (76)	2880	53,903 (54)
7.0 (80)	2800	48,994 (49)

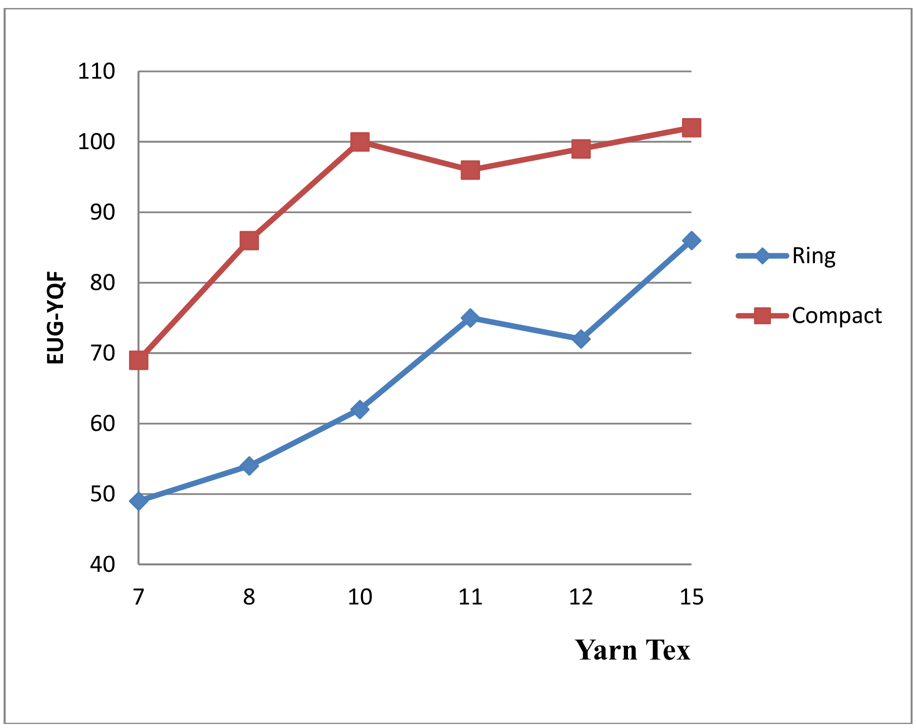

Figure 1. YQF vis Yarn tex for single weave combed yarns

Table (2-c) Eng. Upgraded Relative yarn quality factor EUG - RYQF for single highly twisted (weave) combed yarn:

Yarn tex (Ne)	Yarn EUG – RYQF	% yarn quality upgrading
15.0 (40)	1.186	19
12.0 (50)	1.36	36
11.0 (56)	1.28	28
10.0 (60)	1.61	61
8.0 (76)	1.59	59
7.0 (80)	1.40	40

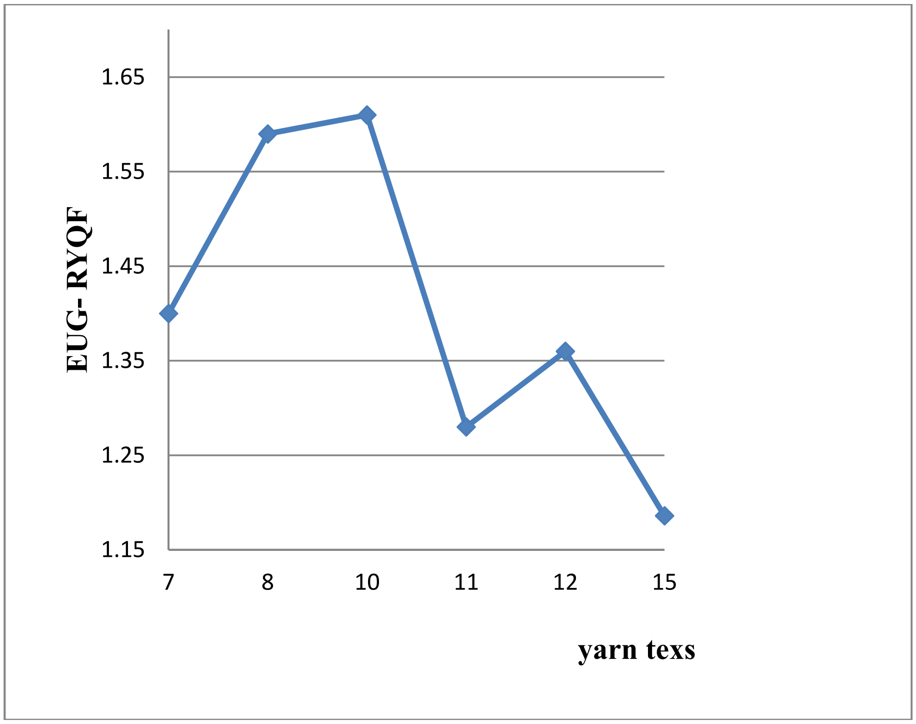

Figure 3. Relative YQF viz Yarn tex, for single weave combed yarns

Table (3) shows the results of the executed experiments of low twist (knit) yarns either compact – spun or ring – spun. The next remarks are important.

The produced counts are ranging from 15 to 10 texs (40,5 – 60`s), with$\propto_{tex}= 3350 - 3340\ (comp)$& from 3350 to 3345 (ring).

The yarns tenacity varies from 25 – 23 cN / tex (comp.) & from 21.6 to 19.4 cN / tex for (ring).

The value, of elongation % are ranged from 4.6 – 5% (comp.) & from 4.2 – 4.7% (ring).

The Uster value U% is varying from 9.3 to 10.3% (comp.) & from 10-11% (ring).

The total IPI is varies from 18 to 61 (comp.) & from 28 – 93 (ring).

The hairness index is ranging from 3.1 – 4.2 9comp.) & from 4.7 – 5.3 (ring).

The EUG YQF for compact spun yarns is varying from 95.807 (96k) to 74,650 (75k), it is higher for coarse counts while for ring spun yarns varies from 66.52 (67k) to 47,177 (47k) i.e it is higher for coaser counts, consequently the relative yarn quality factors (EUG - RYQF) are ranging from 1.4401 to 1.5 823 i.e the % increase is ranging, from 40 – 60% for texs 15 to 10 respectively.

As mentioned previously in sec in (relative high twist yarns), three tables will be deduced, table (3 – a), table (3-b) & table (3-c). Table (3-a), concerns the yarn texs & Ne for single low twist combed compact spun – yarn EUG - YQF where it varies from 95,807 (96k) for tex 15 to 74,650 (75k) for tex 10. This indicates that the coarse yarn count has higher EUG – YQF, with respect to fine counts. Table (3-b) concerns the yarn, texs & Ne for single knit combed ring spun yarn, with Eng. upgraded yarn quality factor EUG – YQF that varies from 66,528 (67k) for yarn tex 15 to 47,177 (47k) for yarn tex 10. This means that the coarse yarn count has greater EUG - YQF with respect to finer yarn tex both tables (3-a) & (3-b) are graphed in Fig.4. Table (3-c) gives the yarn in tex & Ne with EUG – RYQF that varies from 1.44 to 1.60 with the increase of 44% - 60% the improvement is higher for the fine counts that means that the gain is high for compact fine spun – yarns Fig.5. shows the graph for table (3-c). The table (3-a), (3-b) & (c-3) are presented graphically in Figs (4) &(5).

Table (3-a) Eng. charact. of single combed low twist (compact) yarn:

Yarn Count tex (Ne)	Yarn CSP	EUG – YQF (k)
15.0 (40)	3564	95.807 (96)
12.0 (50)	4355	86.909 (87)
10.0 (60)	3300	74.650 (75)

Legend:
EUG – YQF – Engineered upgraded yarn quality factor

Table (3-b) Eng. Charact. Of single combed low twist yarn (ring):

Yarn Count tex (Ne)	Yarn CSP	EUG – YQF (k)
15 (40)	3080	66.258 (67)
12 (50)	2950	60.146 (60)
10 (60)	2675	47.177 (47)

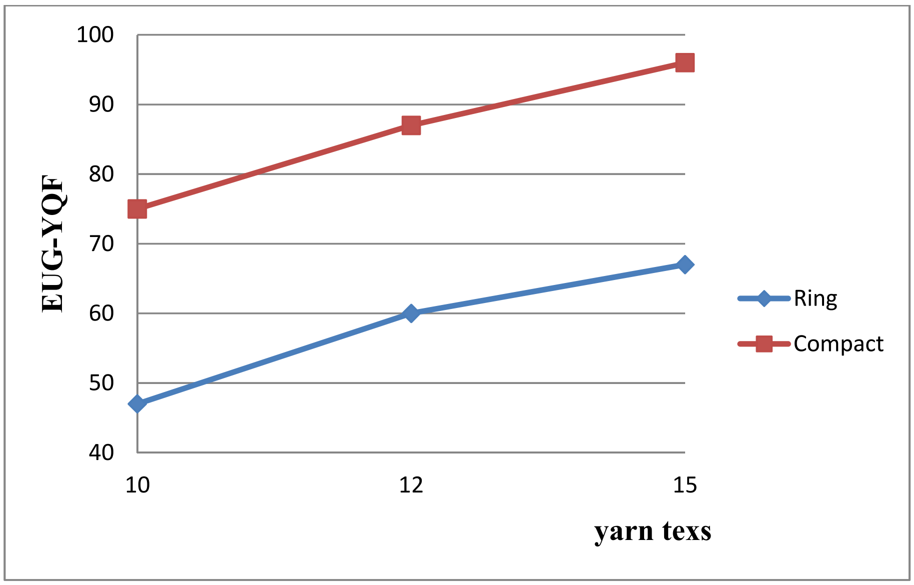

Figure .4. EUG-YQF viz Yarn texs, for single knit combed yarns.

Table (3-c) EUG - RYQF for single combed low twist yarn: compact & ring:

Yarn count		EUG - RYQF	% Improvement
Tex	Ne		
15	40	1.44	44%
12	50	1.45	45%
10	60	1.60	60%

Legend:
EUG - RYQF – Eng upgraded relative yarn quality factor.

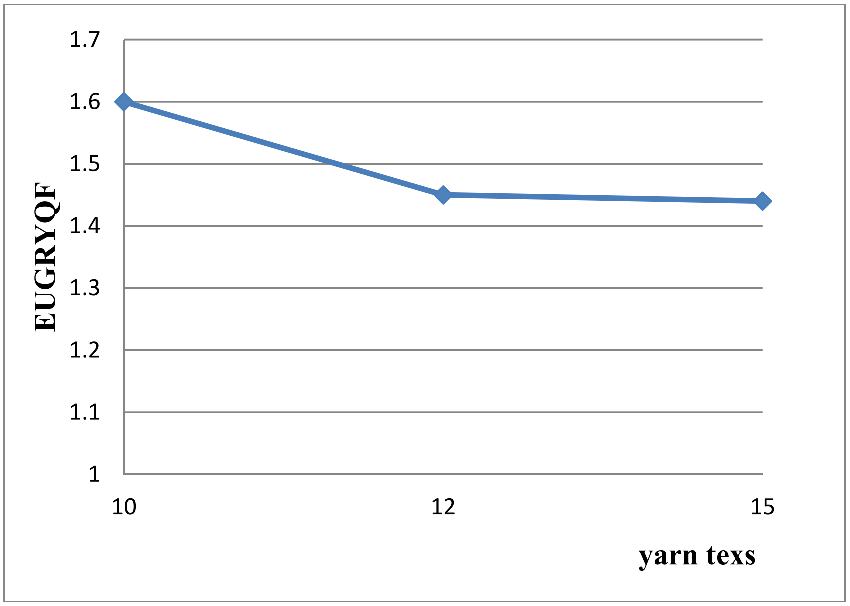

Figure 5. YQF viz Yarn texs, for low twist single combed compact & ring spun yarns

Conclusions

From the previous results & discussions and within the range of our experimental work, the following conclusions can be drawn out:

The YQF is ranging from 69k to 102 k for single high twist combed compact spun yarn, with yarn tex 8(80) – 15(40) respectively while for the same range of texs for single weaving combed ring spun yarns, it was ranging from 49k to 86k.

The EUG – YQF increase with the increase of the yarn tex.

The EUG – RYQF for single high twist (weaving) combed yarn is ranging from 1.19 to 1.61 with increase percent 20% - 60% with average value 35%.

For single combed compact low twist (knit) yarn, the EUG – YQF varies from 75k to 96k for yarn tex 15 – 10 respectively. The bigger the tex, the higher value of the EUG – YQF, while for same tex, the EUG – YQF of single combed ring spun yarn is ranging from 67 k to 47k respectively.

The EUG – RYQF for single combed low twist (knit) yarn is ranging from 1.44 to 1.60 i.e with average increase % =32%. The increase % is higher from small yarn tex.

The future visions mean the calculation of another new measure for cotton yarn quality that takes into consideration the variability in the properties of the yarns. It is named: nano – yarn quality index nYQI. Also, the other new spinning systems as: rotor spinning, Murata spinning techniques: Air – jet spinning MJS, Twin spinning MTS and Vortex spinning MVS must be incorporated in the body of the future research works.

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