Predicting Yarn Quality Performance Based on Fibers types and Yarn Structure

N. A. Kotb

Department of Technical Education, Faculty of Education, Helwan University, Egypt
nabihakotb@yahoo.com

Abstract: Egyptian spinning factories are faced to deterioration in their quality capabilities in the last years due to instability in cotton fiber types and quantities. This affects Quality and efficiency of knitting and weaving process as they depend on yarn properties. Instead of working with different types of Egyptian cottons the spinning factories had to process imported cotton types and polyester fibers with their trade names, for the first time, without real information's about their specifications. The aim of this work is to model the dependence of yarn quality (tenacity, evenness and imperfections) obtained within the last years at an Egyptian factory on type of cotton and polyester, twist number/factor, plying, linear density and cotton ratio of the yarn manufactured, through linear regression equations. Models concerning the different cotton fibers, blends of cotton and polyester and both the two groups are obtained. Linear regression equations relating the dependence of yarn properties obtained within the last five years at an Egyptian factory on material and yarn structures was determined, this will enable the factory to plan and improve the yarn quality level. Cotton type, yarn count and twist have the higher effect on all the properties studied also the yarn tensile strength and its variation depend on most of the factors studied. Cotton type Giza 86 give the best yarn properties followed by Giza 90 and Greece cotton fibers respectively of all yarns. A fifty percent of polyester fibers in blended yarns improved the tensile properties beside to evenness.
[N. A. Kotb. **Predicting Yarn Quality Performance Based on Fibers types and Yarn Structure.** *Life Sci J* 2012;9(3):1009-1015]. (ISSN: 1097-8135). http://www.lifesciencesite.com. 142

Keywords: Yarn Quality; Performance; Fiber; Yarn Structure

1.Introduction

In the present competitive age, quality of textile product is the most desirable factor at purchase counter for the consumer. It is also helpful in keeping the cost of production within satisfactory level [1]. Therefore, quality is one of the key factors for the Egyptian textile industry's success. Egyptian textile manufacturers need to maintain a high standard of quality [2]. Globally, cotton growing and processing has remained one of the profitable industries, which employs large sections of the populations and also earns foreign exchange [3].

Yarn quality is an essential concept defined by customer which requests the satisfaction of several properties simultaneously [4]. The quality characteristics belong to the input and the output of this industry where as reference values belong to the processing itself. The Optimum operating conditions depends on fibers' characteristic and working conditions [2]. The main cotton fiber properties are length, fineness, strength and elongation. In addition to these properties, maturity and number of convolutions are also important. Furthermore, color, the amount of trash and the humidity that the cotton fiber retains are properties which affect the cotton quality. These properties should be known in order to produce yarns and fabrics of appropriately high quality [5-6]. Among fiber properties, strength has the greatest effect on the yarn unevenness and higher fiber strength lead to a better yarn evenness value of the Egyptian cotton [7].

Yarn strength, which is considered to be the most important property of spun yarns, is largely influenced by the tenacity, length, length uniformity, short fiber content and fineness (micronaire reading) of the constituent cotton fibers [5]. Also a high correlation between fiber and yarn elongation exist [6, 8], also the amount of short fibers increases the yarn strength, hairiness and number of thin and thick places. More neps in the fibers results more neps in yarns [8]. Quality of final yarn is largely influenced (up to 80%) by the specification of raw cotton. However, yarn manufacturing technology determines the level effect of various fiber properties [9].

The homogeneity in raw material has an effect on the uniformity of the end product [1]. Yarn structure (yarn count, yarn twist), unevenness properties (CV% values of unevenness, thin and thick places, neps, hairiness) and physical and mechanical properties (strength, elongation) are the main yarn properties [6]. Many of the yarn quality characteristics are highly correlated with each other, a variation in one characteristic will adversely affect many other yarn properties. Yarn linear density is highly correlated with other yarn quality characteristics [3]. The effect of yarn linear density is significant on yarn properties. As the yarn linear density increase evenness, the number of thin place, the number of thick place and neps values increase, hairiness, diameter, tenacity and elongation values decrease. In carded yarns, increase of twist coefficient increases the evenness, tenacity and elongation values and decreases hairiness [10].

For a given count the yarn strength is high if the evenness is low because the number of weak places is low as well. There is a linear relationship between yarn strength and yarn elongation. The tenacity depends on the twist and the fiber strength [8].

The tensile properties of spun yarn are of the most important parameters for assessment of yarn quality. The tensile properties decide the performance of post spinning operations; warping, weaving and knitting and the properties of the final textile structure; hence its accurate technical evaluation carries much importance in industrial applications [11]. The breaking load of spun yarn is one of the most important properties in determining the yarn quality, since it is directly affect the winding, weaving and knitting efficiency, so the properties of yarn are very important in determining their possible applications [12, 13].

Nevertheless, customers usually require much more quality criterion [4]. The yarn tensile properties depend upon the properties of its constituent fibers, the arrangements of these fibers within the yarn (i.e. on the yarn structure), and the mass distribution of yarn along its length. The structure is primarily decided by the yarn formation mechanism and the process parameters. For a yarn spun from a given fiber, an increase in tenacity is associated with an increase in breaking extension, that is, the tenacity and extension are expected to respond together in a similar fashion. Imperfections usually increase as the yarn becomes finer [14].

Egyptian cotton is the world's finest cotton because it has some noble characteristics apart from other natural fibers. The length of the fiber makes it possible to make the finest of yarns without sacrificing the strength of the yarn. The strength of the fiber makes yarn and fabric more solid and more resistant to stress. Its ability to absorb liquids gives fabrics made of Egyptian cotton deeper, brighter and more resistant colors. Its softness feels like nothing else in the world [7].

The process of converting fibers into yarn is complex, and requires many investigations and new technical & technological solutions. The quality of the spun yarn can be significantly improved, while using equally raw material, by a suitable selection of the spinning system and the type of the spinning machine used [12]. There is no perfect fiber. All fibers have well, far and poor characteristics so blending is the technique to combine fibers which emphasizes the good qualities and minimizes poor qualities of the fibers [15].

Blending of different types of fibers is normally preferred for enhancing the performance as well as esthetic values of fabric. Blend yarns of natural and man- made fibers have the particular advantages such as comfort of wear and easy care parameters, this permit the manufacturer to meet marketing conditions. The blending effect depends on resultant blend components [16].

Blending cotton/polyester fibers is common practice in the textile industry. However, it is a critical problem in fiber blending technology to choose appropriate types of fibers and blend ratios depending on the final product. The properties of the blended yarns cannot merely be explained in terms of the proportions of the different constituent fibers in the blends [17]. The blended yarns have breaking strengths lower than those expected from the summation of the proportioned constituent fiber component strengths [11].

The weaving technology prefers ply yarns than single yarns since unevenness, imperfection, hairiness and protruding fibers are lower, and for that the sizing operation is eliminated. Unevenness of polyester/cotton two-ply yarn increases as single and ply twist factors increase. The increase of ply twist reduces the variation in hairiness [18].

As yarn strength is the principle component yarn quality and the most important index of spinning quality, predicting yarn strength is very important from a technological point of view.

Many mathematical models have been used to understand and predict the complex relationships between fiber parameters and yarn characteristics, and substantial research has been done to determine methods of predicting yarn properties [19].

Up-to-date information of the fiber properties, every year, is needed to guide the textile industry in attaining their maximum utilization, since fiber properties changes due to hybrid of natural fibers or progress in synthetic. This will result in minimum end breakage, maximum yarn quality and production rates in the spinning organizations. The production of fine yarns and high quality ready-made garments from Egyptian cotton lint can be attained [20].

2. Experimental Work

The materials utilized in this study consist of carded yarns produced in an Egyptian spinning mill within the five successive years 2007-2011. In the present study, 3 types of cotton fibers, and six staple polyester types produced by 6 different companies of different country were used to produce one hundred and six yarns on a ring spinning machines (cotton and blended yarns of cotton /polyester 50:50%) different in linear density, twist characteristics, and single and two plied as shown in Figure 1.

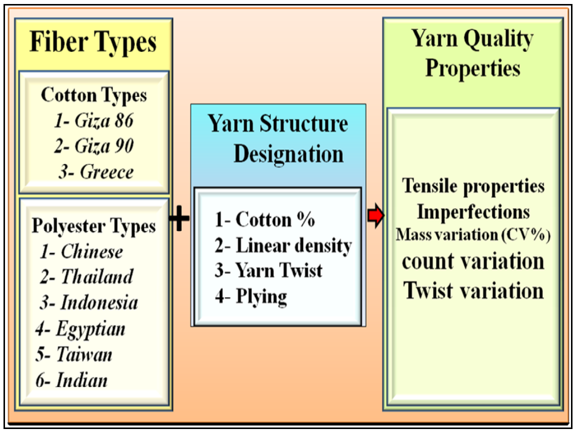

Figure 1. The Experimental Studied Factors and Yarn Quality Properties

The lint cotton varieties Giza 86, Giza 90, and Greece cotton were collected from the running stock of the mills. Physical characteristics of cotton fibers i.e. spun length, uniformity ratio, fineness, strength and trash were determined according to standard methods. The Shirley analyzer was applied for the determination of fiber and trash content, the Sutter Web Comb Sorter was used to determine fiber length properties, the Presley for fiber strength, Micronaire for fineness and for maturity. Fiber properties of the studied cotton varieties are presented in table 1. The data recorded in **Table 1** reveal that the cotton varieties involved in this study differ widely with respect to their fiber properties.

Table 1. Characteristics of Cotton Types

Cotton Types / Parameter Value		Giza 86	Giza 90	Greece
Trash	Fibers%	96.6	90.6	96.3
	Trash%	3.4	9.4	3.7
Fiber Length	Effective Length	34.8	28.8	31.5
	Evenness %	75.8	68.3	73.3
	Short Fiber%	19.6	26.8	23.6
Tenacity	gm/tex	26.1	21.1	17.9
	Mature Guide	83.9	73.7	82.5
Fineness	Microgram/inch	4.33	3.3	3.9
	Denier	1.56	1.2	1.38
Neps/gm		12	20	25

The cotton fibers consisted of three types (Giza 86, Giza 90 and Greece) are coded according to their tenacity from one to three in order. The polyester fibers consisted of six types (Chinese, Thailand, Indonesian, Egyptian, Taiwan and Indian), they are coded from one to six respectively according to their length and extension.

The fibers are processed on this system using standard mill procedures, adjustments and practices on a traditional ring spinning mill. The yarn linear density varies from 16 to 40 (Ne), the twist multiplier for single yarns varies from 3.45- 4.6 and the twist multiplier for two plied yarns from 2.7- 4.2. The qualities of yarns were evaluated for their physical and mechanical properties.

All the yarn variants were tested at the factory laboratory according to the standard methods in order to assess such yarn quality properties as breaking force, R.K.M., elongation at break, variation in strength, variation in linear density, twist variation, unevenness (CV%), and yarn imperfection(thick, thin places and neps).

3. Results and Discussion

A relation for predicting the yarn quality obtained from an Egyptian spinning mill within the last five years was obtained based on the fiber types and yarn structure , the factors under study consist of six factors; four quantitative (cotton percent, yarn linear density, yarn twist and the number of folds) and two qualitative (cotton type and polyester type) . Linear regression equations for the mean property of every count and yarn type within one year were employed. Three groups of regression equations were determined for every property the first group for all the fiber types (106 yarns), the second for the blended yarns (58 yarns) while the third for the hundred percent cotton only (48 yarns).

The results of the regression equations were assessed at significance levels of P value ≤ 0, 05 and significant value ≤ 0, 01.

In the following discussion, the results of yarn quality properties of the regression equations are divided into three main units which are tensile properties, imperfection (the number of thin-thick places, and neps) and unevenness included variation of mass CV%, linear density, twist and strength.

The Yarn Tensile Properties

Tensile properties including yarn breaking strength, Yarn Elongation and Rupture per kilometer (RKM) were tested on the principle of constant rate of extension (CRE). Table (1) demonstrates the equations of tensile properties for the three yarn groups. From table (1) the R Square values are from 0.66-0.93 which confirms a strong relation between the factors under study and yarn strength and RKM. The cotton type and blending ratio dominate all the equations and depends on cotton fiber tensile properties. Giza 86 give better results followed by Giza 90 than Greece fibers. From Figures (2, 3) the distinct influence of cotton type on the yarn strength can be seen.

Table 2. The Equations of Yarn Tensile Properties

	Yarn Strength			RKM			Elongation%		
	All	**Blend**	**Cotton**	**All**	**Blend**	**Cotton**	**All**	**Blend**	**Cotton**
Intercept	1071	755.96	1575.4	30.46	26.36	25.5	10.0	9.6	7.83
Cotton Type	-84.7	-49.23	-123.3	-2.83	-1.91	-3.68			
Polyester Type							0.16	1.7	
Cotton %	-176.4			-6.74			-4.6		
Ne		8.46	-10.22	0.053	0.098	-0.04	0.06	0.04	
Twist Factor	176.9	236.09					1.48	1.07	
Twist No./Meter	-1.28	-1.68	-0.81	-0.003	-.007		-.008	-.008	-.002
Ply	110.9	66.6	108.1	0.98	1.56		-0.41		
R Square	0.86	0.93	0.86	0.74	0.66	0.89	0.84	0.72	0.13

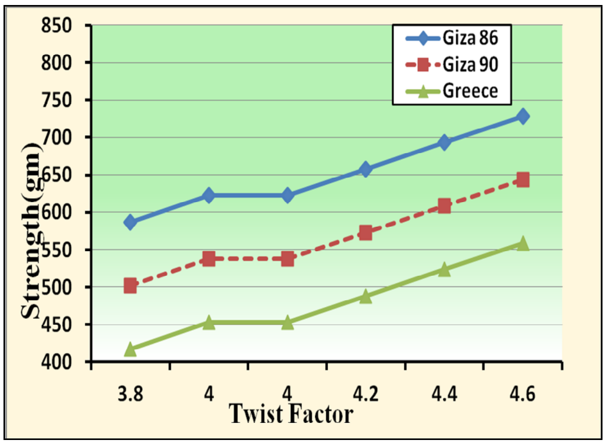

Figure 2. Relation between Yarn Strength of Cotton Types and Twist Factor

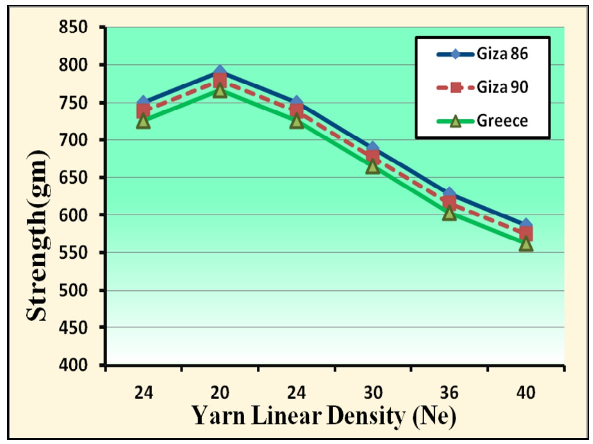

Figure 3 Relation between Yarn Strength of Cotton Types and Yarn Linear Density

No doubt that plying yarns is increasing yarn strength and RKM .Increasing the twist factor, within the working range ,increase yarn strength and tenacity as presented in Figure (2), however increasing the number of twists give an opposite results. This can indicate a quadratic relation since the numbers of twist consist of the twist factor multiplied by the root of the English count.

The coarse yarn would always be stronger than a thinner yarn made from similar fibers and under similar processing conditions however this is only obtained in the equations for the cotton yarns group only as shown in Figure (3) and not the case when blended yarns are involved in the relation. When determining the regressions with the yarn count only as a factor the sign for the yarn count is negative for the three group of relations, the former result can be due to correlation between some factors in case of the blended yarns.

The values of R Square for elongation equations are 0.84 and 0.72 in case of first and second groups respectively which indicate a good predicted relation, while it is only 0.13 for the third relation. This is due to the small difference in percent elongation for the different cotton types. The yarn elongation at break increases with the increase in the twist factor, within the factory working range, which relates to the angle of twist helix the surface fibers have in a yarn. The blended yarn elongation depends on the polyester type as shown in Figure (4); its coefficient is higher for the second group since no cotton yarns enter in the relation.

In contrast to yarn strength and RKM, the obtained relation demonstrate that the elongation at break is smaller for plied yarns than yarn elongation of single yarns, this is obtained since the ply twist direction is the same as the single twist . Adding polyester fibers in yarns is improving the yarn elongation. The influence of polyester type on the value of the tensile and RKM is unimportant but it was significant in yarn elongation.

The Yarn Imperfection Properties

Yarn faults in the shape of thin places, thick places, and neps which are called the imperfections are decisive on the external appearance of yarns and the products obtained from them. A yarn is only as strong as its weakest spot. The Uster evenness tester was used to provide a considerable amount of information about the imperfections. The equations of imperfections by regression analysis were obtained in table (3). From table (3) the dependency of the imperfection on cotton types which were selected was significant. The yarns spun of Greece cotton fibers have the highest imperfections.

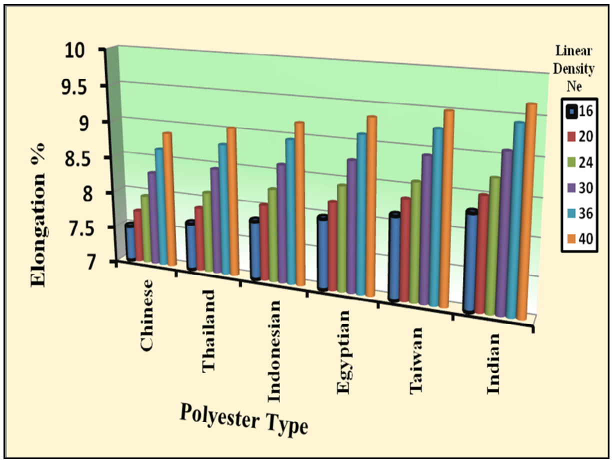

Figure 4. Effect of Polyester type and yarn Density on Yarn Elongation

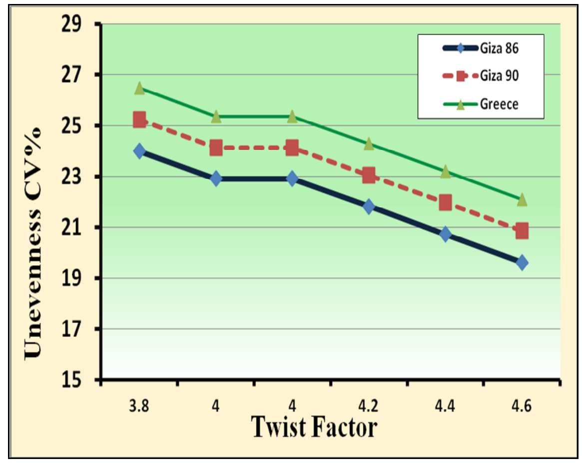

Figure 5. Effect of Twist Factor and Cotton Types on Yarn Unevenness

Table 3. The Equations of Imperfection Properties

	Thin Places			Thick Places			Neps		
	All	Blend	Cotton	All	Blend	Cotton	All	Blend	Cotton
Intercept	-81.0	0.0	-72.7	0.0	0.0	-831	-1315	0.0	-986.6
CottonType	16.67	20.93	10.3	181.1	180	131.4	163.7	215.1	107.17
Polyester Type	-4.5								
Cotton %	-38.3						-267.6		
Ne	1.26					6.64			
Twist Factor		-51.96		-269.3	-385. 5	198.9		-584.1	
Twist No./Meter	0.1	0.25	0.09	1.49	2.1		2.16	3.16	1.47
Ply				-101.8		-242.8			
R Square	0.43	0.63	0.38	0.87	0.91	0.61	0.5	0.81	0.32

In general, the imperfection level is found to increase with the increase in yarn twist number, while the higher twist factor led to the lower yarn imperfections except thick places in cotton yarns. Since the twist factor has different sign in the regression equation for cotton yarns and blended yarns, regression equations for the effect of twist factors only demonstrate the same sign. From that the reverse of the twist sign can be due to the different type of polyester, Further studies has to be taken to attain the real causes. The plied yarns were found to have the lowest thick places, while blended yarns showed lowest number of thin places and neps.

The Yarn Unevenness Properties

Evenness is the most important quality aspect of a yarn, because variations in yarn properties often result in unwanted patterning in fabrics made from such yarns that affects the quality of the resultant fabrics. They also lead to increased ends down during spinning and subsequent processing. Obviously the higher the CV% value, the more irregular the yarn is. Mass variations in a yarn CV% were measured by using the Uster evenness tester. The average values of CV% for yarn linear density, twist and tensile variation were calculated. The relation between unevenness properties and factors under study were modeled in table (4). It shows the regression coefficients of variables and R square

Equations in table (4) indicates that Greece cotton fibers give the highest variations in mass and tensile for produced yarns followed by Giza 90 and G86 cotton fibers in order. This result is shown in Figure (5). The results showed that there were a highly negative correlation between twist number and both linear density and tensile variations. Whereas, the correlation between twist number and yarn evenness CV % were a positive direction. Variation in tensile and yarn linear density is increasing as the number of twist factor increases. The worst results in mass and linear variations were obtained with yarn fineness.

Table 4. The Equations of Variation Properties

	CV% Unevenness			CV% Linear density			CV% Twist			CV% Tensile		
	All	Blend	Cotton	All	Blend	Cotton	All	Blend	Cotton	All	Blend	Cotton
Intercept	20.3	31.1	8.54	0.0	0.0	2.82	0.0	4.23	0.0	0.0	-15.2	0.0
CottonType	1.24	1.03	1.46							0.91	1.32	1.01
Polyester Type												
Cotton %	-1.27											
Ne	-0.24	-0.22				-.071		0.08	-0.04	0.21	0.12	0.33
Twist Factor	-5.46	-8.08		0.827	0.75		0.62			2.67	5.93	3.61
Twist No./Meter	0.03	0.03	0.007	-.002	-.003			-.004	0.004	-.012	-.008	-0.02
Ply			-3.26					-1.06	0.98	-2.9	-2.25	-2.67
R Square	0.63	0.6	0.6	0.94	0.93	0.2	0.92	0.3	0.96	0.95	0.32	0.96

The effect of plying on unevenness results are not similar in all type of yarns observed in this study. As expected, plying yarns improved the evenness of tensile properties. Whereas plying cotton yarns increased the variation in twist.

The quality of factory data is represented by the proposed regressions to a great extent. Only twenty percent of these regressions attain an R-square lesser than 0.5, Sixty six percent of them are in the 100% cotton group. This can be due to the lack in readjustments of machines under different fiber types. In the main time it was better to carry this study taking into consideration material properties and factory working conditions, as the quality of yarns depends on them. But this was not applied due to lack in factory data base.

Conclusion

The proposed regressions describe the factory yarn properties results to a great extent. The yarn quality levels obtained in the studied factory is very low and is in the range of 75%to 95% Uster statistics. This is due to the fact that the factory has no the cultures of working with dynamic variations in cotton or polyester fibers. In addition no real information's about their specification is available when they are purchased.

Although the data base of the factory is uncompleted the effects of the studied factors coincide with the known practices. Predicting the yarn quality obtained from an Egyptian spinning mill within the last five years based on the fiber types and yarn structure was obtained, this will enable the factory to plan any required yarn properties after that. Applying the results of this study the factory can improve the yarn quality level.

Most of the significant regression equations obtained have an R-square more than 0.5. The best results are obtained when working every fiber group separately. The worst results were obtained in the 100% cotton group, this can be due to the constant working conditions for the different fibers, a condition which was difficult to confirm due to factory policies.

Cotton type, yarn count and twist are the factors which have the higher effect on all the properties studied about eighty percent of all the coefficients. Due to that the factory manager has to adjust the processing so that they correspond to these three factors. In the main time the yarn tensile strength and its variation is the properties that demonstrate its dependence on most of the factors studied, about forty percent of the confidents are related to it.

As expected the quality obtained from Greece fibers is the worst, so if using such a fiber or a similar one the factory has to mix him with an Egyptian fiber for better quality and maintaining a reasonable expenses. Also the yarn obtained from 50:50 cotton polyester blend give better yarn properties as expected.

Further improvement in the factory yarn quality if the manager adjusts the working conditions based on the clear understanding of the mechanism of yarn formation and the way the fiber parameters interact for each type of fibers.

Acknowledgment

The author is extremely thankful to Prof. Dr. A. El-Geiheini at the faculty of engineering for consultation and professional advice.

Corresponding author
N. A. Kotb
Department of Technical Education, Faculty of Education, Helwan University, Egypt
nabihakotb@yahoo.com

References

1- Ahmed, M. S, Javed, I., Ahmad, M., Naeem, H.M., and Sarwar, M. (1992). **Application of Statistical Quality Control in Yarn Spinning**, Pak. J. Agri. Sci., Vol. 29, No.(1): pp 25-30

2- Azzam, H. A. and Mohamed, S.T. (2005). **Adapting and Tuning Quality Management in Spinning Industry,** AUTEX Research Journal, Vol. 5, No (4): , December pp 246-258

3- Mwasiagi, J. I. (2011). **Use of SOM to Study Cotton Growing and Spinning,** Self Organizing Maps - Applications and Novel Algorithm Design, pp 577-600

4- Souid, H., and Cheikhrouhou, M. (2011). **Slup Yarn Quality Optimization by Using Desirability Function and Neural Networks**, Journal of Applied Science 11(17) pp: 3204-3208,

5- Hussein, K. M., Hassan, A. H. and Kamal, M. M. (2010).**The Multiplicative Analytic Hierarchy Process (MIAHP) as a Quality Criterion Determining the Technological Value of the Egyptian Cotton Varieties,** American Journal of Plant Sciences, 1: 106-112

6- Karapinar, B. O. and Erdem, N. (2003). **Comparison of Quality Characteristics of Yarns Spun from Aegean Cotton Fibres and Their Mixtures with South-East Anatolian Cotton Fibres,** Fibers and Textiles in Eastern Europe, Vol. 11, No.(4) (43), pp: 26-29

7- Mahmood, N., Tusief, M. Q., Arshad, M. and Azeem, M. (2010). **Physico- Chemical Study of Egyptian and Common Wealth of Independent States(CIS) Long Staple Cotton and Spinning Potential Evaluation at Ring and Compact Spinning Systems under Some Mechanical Variables,** Pakistan Journal of Science ,Vol. 62, No.(4): , pp 2-9

8- Furter, R. (2009). Uster Think Quality, **Standards from Fiber to Fabric, Physical properties of spun yarns,** Uster Technologies AG , 3rd Edition: June SE 586, pp 1-36

9- Majumdar, A., Majumdar, P. K. and Sarkar, B. (2005). **Determination of the Technological Value of Cotton Fiber: A Comparative Study of the Traditional and Multiple-Criteria Decision-Making Approaches,** AUTEX Research Journal, Vol. 5, No(2), June pp: 71-80

10- Altas, S., and Hüseyin Kadoğlu, H. (2012). **Comparison of Conventional Ring, Mechanical Compact and Pneumatic Compact Yarn Spinning Systems,** Journal of Engineered Fibers and Fabrics, Volume 7, Issue (1): , pp 87-100

11- Das, B. R. (2010). **Tensile Behaviour of Spun Yarns under Static State,** Journal of Engineered Fibers and Fabrics, Volume 5, Issue (1): , pp 1-9

12- Jackowska-Strumiłło, L., Cyniak, D., Czekalski, J. (2007). **and Jackowski, T., Quality of Cotton Yarns Spun Using Ring, Compact and Rotor-Spinning Machines,** Fibers and Textiles in Eastern Europe, Vol. 15, No.(1): (60), pp 24-30

13- Elshakankery, M.H., El-Sayed, M.A.M., and Sanad, S. H. (2008). **A Method of Predicting the Breaking Load of Egyptian Extra Long Staple Cotton by Using Neural Networks,** Journal of Applied Sciences Research, 4(11), pp: 1380-1386

14- Chattopadhyay, R., and Sinha, S. K. (2007). **A Study on Spinning Limits and Yarn Properties with Progressive Change in Yarn Count in Friction Spinning,** AUTEX Research Journal, Vol. 7, No(1): , March pp 1-8

15- Bhardwaj, S., and Juneja, S. (2012). **Performance of Jute Viscose/Polyester and Cotton Blended: Yarns for Apparel Use,** Stud Home Com Sci, 6(1), pp: 33-38

16- Mahmood, N., Jamil, N.A., Arshad, M., Tusief M.Q. and Iftikhar, M. (2009). **Interaction Study of Polyester and Multi Bleached Cotton Blends for the Tensile Properties of Rotor Spun Melanage Yarn,** Pak. J. Agri. Sci., Vol. 46(1) pp: 46-50

17- Baykal, P. D., and Erol, O. B. R. (2006). **Prediction of Strength and Elongation Properties of Cotton/Polyester-Blended OE Rotor Yarns,** Fibers and Textiles in Eastern Europe, Vol. 14, No.(1): (55), pp 18-21

18- Palaniswamy, K., and Mohamed, P. (2006). **Effect of the Single-Yarn Twist and Ply to Single-Yarn Twist Ratio on the Hairiness and Abrasion Resistance of Cotton Two-Ply Yarn,** AUTEX Research Journal, Vol. 6, No(2): , June pp 59-71

19- Nurwaha, D., and Wang, X. H. (2012). **Using Intelligent Control Systems to Predict Textile Yarn Quality,** Fibers and Textiles in Eastern Europe, 20, 1(90), pp: 23-27

20- Mohamed, E. A. M., Sanad, S. H., and Arafa, A. S. (2009). **Spinning Performance of ELS Egyptian Cotton,** African Journal of Agricultural Research, Vol. 4 (11), November pp: 1276-1283.

7/2/2012