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Cotton Fibre Attachment Strength
(An Outlook On Meaning And Assessment)

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Abstract

Strength of bond between seed surface and fibers is considered as being one important element among others plays heavy and influential role upon the determination of energy unit costs to extract the fibers out without imposed deterioration in other qualities, such as tenacity, short fibres percentage and recovered elongation.

Attachment strength, then, received little concern over the period that proceeded second world war; and lately, in the 1980's and forward was assumed to be complex and determinant equally with work of rupture. Since then newly developed instrument was put in use, and many criteria were judged against attachment, in order to make clear statement on the intrinsic meaning of this bond, and what factors imprint changes in favorable destinations.

One casual suggestion was forced out to enhance decline in work of detachment with parallel fall in costs of ginning, in which automatic nozzles are fitted in certain cavity of ginning machines, where on friction between the two different components, nozzle heads and seed surfaces produce a mixture of wetting agents (Tergitol) and enzymes (hemicelluloses) or an extract of suspension made out from alcoholic preparation after submersion with fungi of the genus sclerotinia, or simply solution of detergent with soap. That is along with secreted materials from A. *niger* at convenient PH and temperature levels namely (3-5 PH / 40-50 °C), what could bring the bond of attachment to a value that save time and cost .

Introduction

Although cotton seed remains and hairs were recovered in Egypt from animal dung and dated back to 2600-2400 B.C., the Egyptians at the time did not realize the importance of cotton in textile inventions, instead it was celebrated as of value of nutrition (Chowhury and Buth, 1971). The ancient Nubin Kingdom was probably the first to spin and weave cotton fibers. It is not clear whether old spinners were aware of the differences in quality among cotton strains, but modern industrialists and growers are indeed. Of all cotton fibre properties, strength and points of breakage received much attention and already a number of studies or observations focused on the structural points of weakness, either those found in gross morphology (such as the constricted regions where shear forces are generated) or those in the fine structure (the reversals for example).

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However, the nature of fibre strength attachment was not realized until the 1930's, and this is really too late in comparison with the rise of concern in other quality elements. Thereafter, precisely after the second world war, more attention was given to the significance of fiber breakages, energy input, and more recently to reducing dust.

Fiber attachment: is well known that cotton fiber attached to the seeds have physical properties that are changed between the seed cotton on the plant and the bale, thus the fiber are subjects to several mechanical operations: mechanical harvesting, cleaning, ginning and possibly more cleaning. While Eweida and Wahba (1991) reported that no specific trend due to the effect of ginning units on fiber-to-seed attachment strength. Further studies of fiber attachment strength in relation to other character are recommended.

Mere strength of tenacity is by definition "a generic term for the ability of material to resist strain of rupture induced by external forces" (D-123 ASTM, 1984), but strength of attachment is an arbitrary measure which evaluates the actual forces needed to pull off raw cotton fibres from seed coats.

For certain, both types of strength do not correspond to have the same influence on cotton fibre. While tensile strength is important for all stages of cotton processing and use before and after the transformation of raw material into fabric; attachment strength is a matter of concern, only during the mechanical condition, especially ginning machines.

Fiber base formation and detachability:

The wall thickening of epidermal cell to form fibers starts before those neighboring cells. The latter then undergo a massive enlargement and thickening exerting a substantial pressure on the fibre base, results in the formation of the constricted spot (i.e. the shank). Only the lower end of the base spreads out broadly just below the epidermal level, forming the "foot" a characteristic feature of the cotton base; a narrow passage was raised as being an absorptive organelle (Fryxell, 1963). Immediately above seed surface Fryxell (1963) observed the formation of the elbow, which was thought to generate a shearing force while ginning and this was again considered to determine the ease of detachability. Differences in the degree of the elbow angle were absent after quiet several microscopic observations on wild and cultivated cottons (Fryxell, 1963-64). Then, any possible involvement in fibre detachment of naturally grown plant was eliminated. The possibility of morphological discontinuity in the cell near the elbow was also denied (Fryxell, 1963), and this view was placed in support for very young fibres (four days only in age – Waterkeyn, 1987 after Ryser, 1981), but thin pitted areas in the shank and foot walls were described, and strongly considered weak spots (Waterkeyn, 1985-87; Waterkeyn, 1987 after Ryser, 1985).

Although Fryxen did not isolated the presence of these cytoplasmic strands, he agreed with Waterkeyn in the admiration of the role of the structural pits in maintaining reasonable supplys of water, nutritive materials and enzymes necessary for cell turgor, and fibre growth. On line with this numbers and size were took important form both mechanical and botanical points of view.

Similarly, by the application of light microscope, Waterkeyn, (1985-87) obtained on evidence on the presence of crossed and bent reversals in the cellulosic secondary walls of the fibre base, which strongly suggest the availability of tension and / or weakness regions in fibre base. On other hand, Mauney (1984) after Berlin and wordworth (1983) observed a secondary thickening of basal walls that is restricted in the epidermis, but fuzz have well developed secondary thickening above seed surface, which would cause a breaking during ginning.

The fibres were found to be firmly attached to the seed coats during first 12 days of elongation but weaker attachment initiates between the fifteenth and the thirtieth day. Owing to the thickening of the epidermal cell walls, the attachment was firmer from the 30th. Day onwards, but it was never attained firm attachment as during the first 15 days (Hector, 1936). Anatomical studies of seed coat attributed the firmness of fibre attachment to:

(a) discontinuity in seed coat structure its, because of a chalazal aperture where the palisade layer ends abruptly leaving a small circular area of spongy cells (Iyengar, 1954; Christiansen and Moore, 1959). Thus, detached fibres with seed coat bits " pins heads, needles eyes, ect." reflect the strength of seed coat testa rather than fibre base tenacity.

(b) The differences in palisade cell and colourless layer hights, for each increase in their hights requires more force to elicit seed cracking (Medaniel, 1987). Varieties with physically shock absorbency, and stronger cells can withstand damage better during fibre detachment. A difference as little as 25 in palisade cell hight required an additional force as much as 16 N (16 kg.m/sec^2) to crack the seed coat (Medaniel, 1987).

(c) Or essentially to the presence of weak points in fibre seed base, and in fibre-seed interface, when fibres fail in the real life ginning.

This particular point is thought by some to have pectin in its chemical composition (Wade and Rowland, 1979). The effect of this hemicellulase was attributed to action on seed hull, which is consisted of polyurodine from one unit of D-glucuronic acid with 10-16 units of D-xylose. The wetting agent tergitol TMN decreased the bond owing to weakening the chemical bonds in seed coat, denaturing cell wall proteins in the foot, or motivating enzymes present naturally in seed coat. The activity of this enzyme is depressed by lowering PH of TMN solution to 3.0 or by raising temperature to 60 °C. thus, keeping PH at 4-5 and temperature at 40-50 °C is essential to activate the enzyme.

The point of fibre emergence is also active in moisture diffusion out and into seed. Consequently heat is expected to propagate changes (Friesen and veal, 1971) in the rate of moisture uptake and heat evolution alter the regain of the base and whole fibre, which has an influence on the actual fibre strength. Moisture at lower relative humidity diffuses, more frequently, from the seed to the fibres (Friesen and veal, 1971). Dry testa tress weakens the body of fibre, while weak points of the fibres themselves are strengthened (Razzouk, 2000).

Machinery and measurements:

Methods and measures were not resumed, since all are not standardized, nor agreed with each other in values pattern, but an idea on the development of measurement types and instrumentations were indicated (Table 1).

Table 1: Development of attachment strength estimation.

Author	Instrument	Unit	Experimental Specimens
W.E Chapman 1969, 1972	Modified Scott tester with 1/8 inch spacer	g /mg	Bundle of fibres
R.L. lyengar 1954	Lever connected with a spring and floating inside a cylinder	g per fibre	Bundle of fibres
W. S. Smith and L. pearson 1941	Pendulum instrument attached to a weel with graduated quardant	g per fibre	Single fibres
=	Pendulum type for single strands of yarns	g/200 fibres weight	Bundle of fibres
C. P Wade and S. P. Rawland 1979	Hand method, flat nosed tweezers for Pulling	5 categories	Butter flied seeds into quarters
Fransen, Vershraege And Kalisa 1984	Falling pendulum with an armed friction needle on a quadrant scale with Pressley clamps	CN. cm / mg	Bundle of fibres
S. Razzouk 1989	=	=	=
H.Y.Awad 1989	=	=	=
F.T.Wahba and M A. Ewieda, 1990	=	=	=

The most modern one is "The Fibre – to – Seed Attachment Tester", which is furnished and featured by the Shirley development limited in cooperation with the technical division of the International Institute For Cotton. The instrument estimates the kinetic energy of the falling pendulum at the lowest level, and the reading are assumed by a friction needle and quadrant arm (graded from 0- 90%). The amount of lost energy to shear bundle of fibres gripped titely with Pressley clamps without spacer. It is equivalent in some way to the work of rupture, and expressed E (the energy delivered by the pendulum) by the weight of fibre sample in milligrams. E values usually are calculated as follows:

$$m\,g\,h / 10 \text{ cN.cm}$$

Where: (g) is the acceleration of gravity which is variable with the place of measurement, and considered for practical reasons to equate 9.8066 m/sec^2, (m) is mass delivered by the pendulum, and (h) is the high that correspond to one division on the scale and calculated as follows:

$$h = h.\,(1 - s / 100) \text{ cm}$$

(h.) is assumed the hight at scale zero, where (s) is the scale reading.

For routine work, a short cut calculation formula is in application as below :

$E \text{ (cN. cm / mg) } = (s / w)\, q$

Where w: the weight of sheared fibres in mg.

q: constant represents the maximal force applied expressed. In percent energy units, and it has a value of (13.785) for the tester which is distributed by Shirley development Ltd.

A chart graph for the determination of E values was composed. Despite it, the designers of instrument reported highly reproducible results (Vershraege and kiekens, 1985 ; Fransen el al. , 1984) Experience, also indicated a coefficient of variation of 100%, and in some others it rose to 25-30% (Razzouk, 1986-89; Awad, 1989)

Results taken from biological experimentation, particularly those for the versatile nature of cotton fibres, are expected to be more variable. The big size of variation in values did not eliminate the significant differences between varieties, varieties x temperature interaction, or between regions of the seed surface (the blunt, pointed and middle zones of fully mature cotton seeds).

However, one can always introduce the use of high volume machinery " Instron" and likewise. This instrument is very adequate and accept amounts of single fibers and / or bundles, where tenacity of attachment can be taken directly by digital type, or through calculations from stress-strain curve. Nevertheless, such large and exact instrument would give CV percentages about 30 between varieties and replicates, but it does not exceed 0.5 % of indicated load. However, SE's values for both methods did not cross a limit of 5-10% of the overall means for Instron and pendulum machines (Table 2).

Table 2: Variation in quality elements

Quality Element	Instrument	Specimens	C.V.(%)	Author
tensile strength, expected	Pressley, no Spacer	Within bundles	3-7	Lord, 1961
=	=	Within samples	1-3	=
Tenacity Expected	=	5 samples, one operator	5-8	Anderson 1983
=	=	Between Laboratories	16-25	=
Strength of Attachment, Observed	Pendulum type	6 samples, one operator	16-53	Razzouk, 1989
Breaking load, Observed	Instron-1026	Single fibres*, one operator	32.03	Razzouk, 2000

* in instances, weak fibres produced branched curve, which was dropped out from final analysis to minimize variation.

Other practical methods were used less frequently in the 1940's and 70's, showed little coherence in results (Table 1).

Correlation between attachment strength and other elements of fibers quality:

Greater attachment strength and lower tensile strength resulted in a higher proportion of short fibers in the array diagrams. Fransen et al. (1984), showed that fiber mean length was decreased by roller ginning compared to hand procedure (from 24.77 to 19.24 mm respectively in Reba B- 50 for example). These results are in accordance with those of Abdel-Salam and Nomeir (1973), found that mechanical ginning resulted in an increase in short fiber, number of neps, and decrease in yarn appearance grade compared to hand ginning. However, (Table 3) exhibited inconsistent correlation, for the trends were erratic. Strength was significantly correlated with attachment strength in lyengar (1954), while in Chapman (1969–72) and Fransen et al. (1984) had low correlation.

The fuzziness of the seed had no direct intercourse with the attachment strength (lyengar, 1954), but in Chapman's (1969-72) was positive and significant at ($P > 0.001$). On the other hand Wahba and Eweida (1990), recorded that fuzz index had positive and high significant correlation with fiber-to-seed attachment strength ($r = 0.767$), confirming the results of Awad (1989).

Table 3: The correlation patterns and coefficients between Fibre attachment and other agro-quality elements

Correlation	Pattern of / and size of correlation	Experimental material	Reference
Verticillium wilt	n.s.*	Field, Acala 1517 D	Chapman, 1969
Fertilizers (N + P)	n.s	Field, Acala 1517	=
Relative humidity (70, 55, 30 %)	n.s.	4, upland	=
	+increased to 70, then decreased	3 species	Lyengar, 1954
Seed cotton storage (2years)	0.01, increased	4 strains, Pima and Upland	Chapman, 1969
Rate of ginning			Chapman, 1969-72
S* (Ib / h)	- 0.22 (0.01)	Upland	
1*	-0.61 (0.01)	Pima	
Turn out			=
S	- 0.18 (0.01)	Upland	
r	- 0.49 (0.01)	Pima	
	-0.816 (Very S.)	9 varieties	Wahba and Eweida, 1990
middle zone	+ 0.783	13, upland	Vershraege and Kiekens, 1985-1987
micopylar	+ 0.796		
both	+0.873		
Species	Mean values	10 strains, upland and pima	Chapman, 1969-1972
Barbadense	v. low	2 samples	Lyengar, 1954
Hirsutum	v. high	42 samples	=
Herbaceum	low	8 samples	=
Arboreum	high	10 samples	=
Barbadense & Upland	Si*	replicates	Amad, 1989
Verieties	n.s.	4, upland	Chapman,1969-1972
	n.s.	4, pima	=
	0.05	16, upland	Vershraege and kiekens, 1985
	Si at levels	6, upland	Razzouk, 1989
	Si	9 varieties	Wabba and Eweida, 1990
Strains	0.01,0.05	Groups	Chapman, 1969-1972
Seed index			
s	- 0.17 (0.01)	130, upland	=
r	+ 0.29 (0.01)	156, pima	=
	n.s.	9 varieties	Wahba and Eweida, 1990
Linters			
s	+0.55(0.01)	130, upland	=

r	+0.52(0.01) +0.767(very s.)	156, pima 9 varieties	= Wahba and Ewieda, 1990
notated	n.s	species and strains	Lyengar, 1954
Fibre length (inch) s r not stated	 +0.10 n.s. +0.07 n.s. - 0.64 (0.01)	 130, upland 156, pima not stated	Chapman, 1969-1972 Lyengar, 1954
	n.s.	9 varieties	Wahba and Ewieda, 1990
Fibre strength (gf/grex) s r not stated (gf) pressley index	 -0. 01 (n.s.) -0.01 (n.s.) +0.66 (0.01) n.s	 130, upland 156, pima 16 varieties 16, upland	Chapman, 1969-1972 = Lyengar, 1954 Fransen, Vershraege And kalisa, 1984
=	n.s	6, upland	Vershraege and Kiekens, 1985
=	n.s	9 varieties	Wahba and ewieda, 1990
Micronaire s r	 - o.25 (0.01) - 0.2.3 (0.01) n.s.	 130, upland 156, pima 9 varieties	Chapman,1969-1972 = Whaba and Ewieda, 1990
Naps(per 100 sq. inch) s r per g	 -0.19(0.05) +0.27(0.01) +0.510(si.)	 130, upland 156, pima 9 varieties	Chapman,1969-1972 = Whaba and Ewieda, 1990
Seed coat fragment (%by weight) s r Hand	 +0.04 n.s. -0.03 n.s. noted	 130, upland 156, pima 6, upland	Chapman,1969-1972 = Razzouk, 1989
Short fibres (<1/2 inch,%) s r	 +0.16(0.05) +0.32(0.01)	 130, upland 156, pima	Chapman,1969-1972 =
Regions Micropyle Other s as whole	 Higher Nearly same Si*	 11, varieties = 16, upland	 lyengar,1954 = vershraege and Kiekens, 1985
four sides left and right	0.01 0.01	4, upland =	Razzouk, 1989 Razzouk and Whittington, 1991

Energy consumption K. W/h	Positive	3 species	Lyengar, 1954
Fibre perimeter	n.s	3, varieties	Vershraege and Kiekens , 1987
Fibre maturity (%)	n.s	4,varieties	=
elongation	n.s	9 varieties	Whaba and Ewieda, 1990
Uniformity ratio	=	=	=
Anthesis date (3 dates)	Lowest at second for micropyle and middle	4, varieties	Vershraege and Kiekens, 1987
Bolls Lock	0.05 +from base to top	4, upland 7 locks , 1 variety	Razzouk, 1989 Fransen, Vershraege and Kiekens, 1984
Temperature Night Day	 0.001 0.001	 4, upland =	 Razzouk, 1989
Salinity	0.01	3, upland	Razzouk, 1989-Razzouk and Whittington,1991

* S saw gins, r roller gins, n.s. not significant, si significant, very s. very significant.

In conclusion, the increase in attachment strength decreased ginning out-turn and increased energy consumption, while the decrease in attachment strength increased gin stand capacity, this explains why some varieties gin faster than others. Whaba and Eweida (1990).

The fibers on the micro-Pyle are strongly adhered to the seed, and cottons of different genetic resource differed in the overall mean of fiber attachment [Razzouk, 1989, Awad, 1989 and Abdel-Salam 1999]. The differences were significant between varieties and between species [G. barbadense is less attached than G. hirsutum for example, Awad 1989].

Effects of environment on attachment strength:

Literature did not report any observation on this subject. Nonetheless, personal exercises based on strings of studies in limited conditions provided preliminary, painstaking verses on two major variables:

1. Temperature:

Temperature has no effect on attachment order of fibers belong to different regions of the seed, but it influences the actual observed value itself. High day temperature (accompanied by 23 °C at nigt, and 10 h day with constant light intensity of 70 W m^{-2}) decreased fibre attachment strength to lowest level ever recorded. On the contrary low temperature accompanied by reasonable night temperature (20 °C) and adequate level of natural radiance (500 W m $^{-2}$ at 12.00 h and 400 W m^{-2} at 6 PM h light intensity). The values are bound to fell, and the overall trend would be downwards rather than upwards as before (Fig. 1).

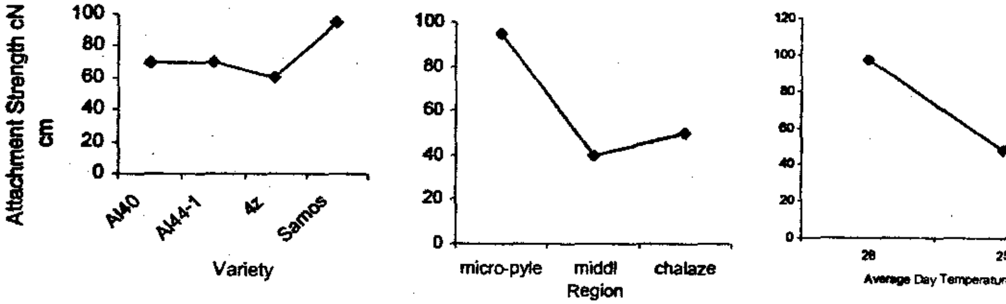

Figure 1-A: Effects of average day temperature (oC)
(Razzouk 2001)

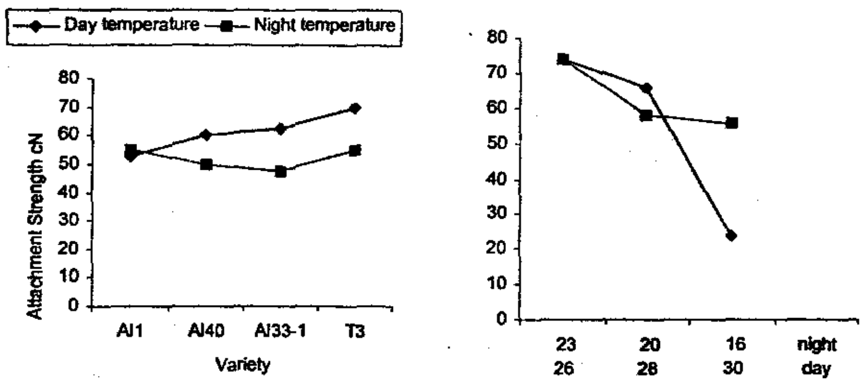

Figure 1-B: Effects of day and night temperature (oC)
(Razzouk 2001)

2. Salinity:

Salinity effect is totally absent from literature, except little shed light (Razzouk, 1989, Razzouk and Whittington, 1991) reported declines in attachment strength with every increase in Sodium chloride concentration (43 and 86 mol m^{-3}) for number of varieties (Fig. 2). In some instance certain varieties registered an increase for 43 mol m^{-3} treatment over the control. With the progress of other adverse environmental factors (i.e. toward the end of growth season). The effect of increasing salinity was by larger by 6.7% at 43 mol^{-3} salt compared with the control. Further increase in salinity and bad water reduced attachment by only 4.02 %, on the other hand, the interaction between cultivars and micronutrients exerted a significant influence on attachment strength in both seasons, Eweida et al (1992).

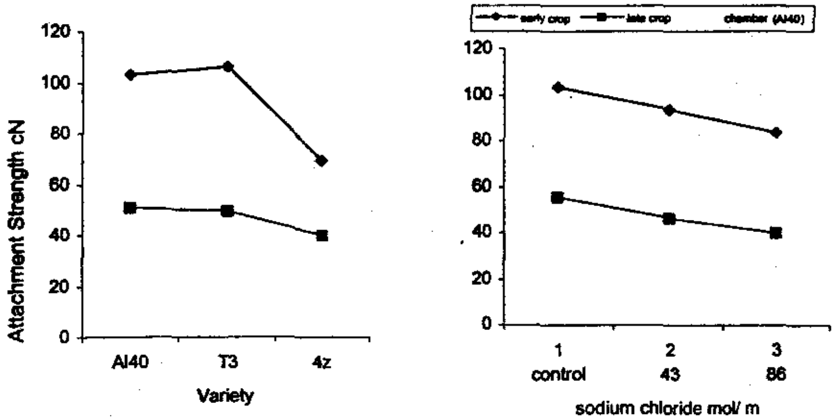

Figure 2: Effects of salinity (mol / m3)
(Razzouk 1989)

In every instance, the reduction in attachment strength was correlated positively with fuzz index which declined with every increase in salinity. Despite the latter is not directly concerned in the measurement of attachment strength, the point of clamping the lint is 3 mm above the seed surface and beyond the fuzz. Fuzziness, has been showed, to raise attachment strength merely through a mechanical effect during detachment, for example by an alteration in the nature of epidermal cells those in immediate vicinity to the base of fibers, or simply by changing the density of outgrowth on seed surface, and this in turn would alter the angle at which fibres initiate, then, rise over the seed surface.

<u>Atmospheric conditions of tests:</u>

Air moisture and temperature (in the normal range of the sinuous conditions) have little, if any, effect on cotton stress – strain curve. The attachment force is not an exception. Although, direct measurement are, yet, not existed, number of already established data are in our reach, where cotton is proved to be insensitive to conditioning atmosphere in terms of tenacity, breaking extension, work of rupture, while this was not so for initial modulus (Table 4). Combined temperature / humidity proved, in some reports, to be relevant to increments variation in strength of regenerated cellulosic fibres. Other reports did not, especially as far as attachment bond is concerned (Table 3), for not significant correlation were noted between the attachment strength and humidity, drying or cleaning.

Table 4: Humidity / temperature °C roles on quality elements (after Morton and Hearle, 1975)

Test status	Tenacity	Breaking extension	Work of rupture	Initial modulus
Ratio cotton (wet 95 °C/ wet 20 °C)	1.00	1.00	1.00	1.00
= ratio (wet / 65 r.h.)	1.11	1.11	0.92	0.33
Viscose rayon ratio (wet 95 °C/ wet 20 °C)	0.90	1.03	0.89	0.80
= ratio (wet / 65 r.h.)	0.50	1.58	0.69	0.03
Acetate ratio(wet, 95°C/ wet, 20 °C)	0.43	1.98	0.75	0.07
= ratio wet / 65 r.h.)	0.54	1.41	0.63	0.17

Fibre	Thermal conductivity m W m^{-1} K^{-1}	Retention of strength after 20 days 100 °C (%)	Coefficient of expansion (per °C)
Cotton	71	92	4 x 10^{-4}
Cellulose acetate	230	-	(0.8 – 1.6) 10^{-4}
Air	25	-	-
Viscose	-	90	-

However others stressed on relative importance of moisture gains in increasing cotton strength (Lord, 1961), but did not support their views with statistical events. Presumably, the combined and complex effect of air humidity / ambient temperature is more powerful on sides of quality concerned with air flow measurement, such as gravimetric fineness and alike. Strikingly enough to note that a heat buildup in seed cotton is associated with the deterioration of the lint and seed, rather attributed to ambient conditions per se.

According to Fick's equation (Razzouk, 2000) trend of liquor transient continuum is predicted from the formula :

$$dm = (D \{d^2 \ M \ / \ d \ x^2\}) \ dt$$

where M is moisture content, D is diffusion coefficient, x is distance from surface, t is time.

Size of the materials (thickness and other dimensions) are in every way assured, and it contributed in the original revelation of the very same formula which descended from the following from:

$$dm / dt = - DA \ (dm / dx)$$

where A is the area perpendicular to the concentration gradient .

This is regenerated in another form after moisture passed from side to next as follows:

$$[- \{D\, dm / dx + d /dx (D\, dM / dx)\, dx\}\, dt]\, dm / dt = d / dx (D\, dm / dx)$$

Possible fraction for ambient situation is absent from Fick's assuming it is consistent, but others believed that moisture diffusion does not obey this law, and argued for part that respiration plays in biological materials along with the expected changes in volumes during time thresholds (Friesen and Veal, 1971).

On line with this another calculation method was established empirically as follows:

$$dM1 /dt = dMo / dt + Co\, Mo - C1\, M1 + C2\, F(t)$$

Where M1 is average moisture content of sample, Mo is average partial moisture content of sample, C0 and C and C2 are constant, t is time, F (t) is forcing function which is in this case is RH and temperature of environment.

Assuming that environment effects are diminished or being negligible enough or standardized, both equations seem equal, and the question of modification is foundless. Notably, shear forces are intimidated by variables through passive and potent factors, the moisture transfer from seed to fibre contribute in creating them, and those are namely the heat evolved plus vapor pressure inside fibre base, the foot and the shank, not to forget possible changes in dimensions. More attention is due to attain clear view about this sector of attachment / detachment problem.

Conclusions

Attachment strength of cotton fibres to seed was delivered, throughout a prolonged lapse of time , enough affection. A practical consideration must be forced, then, to decrease the unit expense of energy needed to extract fibres in ginning. One could consider fitting nozzles of the same type fixed to pre-wet unit sizing system described by Rozelle (2001) or those fitted in the compartment of moisture preservation namely the humidifying chamber having the water-spray system as stated by Baker and Griffin (1984), that produce a prescribed mixture of enzymes and wetting agents enough to lower attachment bond with seed surface, but do not bring deterioration on whole fibre body tenacity to avoid breakages and high percentages of floating indices, in order to avoid more expenses served for larger twist factors or so. Attachment of fibres to seed still, then, need further justifications before pulling down curtain on the final scene.

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قوة التصاق ألياف القطن

(نظرة علي معناها وطرق قياسها)

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ملخص

إن قــوة ارتباط الألياف بسطوح البذور واحدة من العوامل المهمة التي تلعب دورا محددا وملموسا في تقدير كمية الطاقة المصروفة علي فصل الألياف عن بذورها من غير إيقاع خسائر في الصفات النوعية الأخري ، مثل المتانة ونسبة الألياف القصيرة والاستطالة المستعادة.

ولقــد حظيــت قــوة الارتباط بقدر قليل من الاهتمام وذلك علي امتداد فترة زمنية طويلة ، امتدت منذ بداية الحــرب العالمــية ، ولكن حديثا وتحديدا في الثمانينيات من القرن العشرين وحتي الآن ، نالت حظا أكبر من العــناية بسبب تصنيفها مع عنصر نوعي فاعل آخر هو عمل النقل القطاع (أو بمصطلحات محمد السيد عبد السلام القدرة علي امتصاص الجهد باعتبار انها تأخذ في الحسبان كمية الطاقة المبذولة لانجاز عمل ميكانيكي تــتم تأديته بفجاءة من الزمن) . ومن حينه تم تصميم جهاز لهذا الغرض ، وأصبح بوسعنا مقارنة هذه الصفة مــن ســواها في سبيل تحديد معناها وتقنينه تقنينا ذاتيا ، أو تعريفه وإزاحة الغموض عن دور العناصر التي تحرك اتجاه القيمة في المنحني المطلوب والمرغوب به.

وفــي النتــيجة ، تم التوصل إلي اقتراح حل يفرض علي قوة ارتباط الألياف هبوطا ملحوظا في مقدار القيمة يوازيه ، ثمة، إنحدار مماثل في المصاريف اللازمة لتغطيه ثمن الطاقة المبذولة في عمليات الحليج .

وذلــك ، علــي سبيل الافتراض ، يتم بإدخال رؤوس اقراص مخروطية تثبت في جزء حر ومتاح من آلات الحليج. وهذه الرؤوس تعمل بالتنبيه لدن الاحتكاك بين الطرفين المعنيين ، رؤوس المخاريط وسطوح البذور ، فتفرز المخاريط مزيجا محضرا من عناصر مرطبة (تيرجيتول) وإنزيمات (هميسيللولاز) في وسط مناسب تــم ضبطه مسبقا علي درجة حرارة ٤٠-٥٠م وحموضة ٤-٥، ويمكن أن يستعاض عن ذلك كله بمستخلص كحولــي من الفطريات التي تتبع جنس Sclerotinia الفطور ذوات الامشاج القاسية، أو ببساطة محلول من المواد المنظفة الفاعلة مع الصابون ، إلي جانب إنزيمات طبيعية ، الأمر الذي يساعد علي تخمير ثم أضعاف قوة الارتباط ومن ثم يخفض المدة الزمنية اللازمة للإنجاز ويوفر في كميات وأثمان الطاقة المستهلكة.

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