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POLYESTER FIBRE:

Fibre manufacturing process:

Today over 70 to 75% of polyester is produced by CP(continuous polymerisation) process using PTA(purified Terephthalic Acid) and MEG. The old process is called Batch process using DMT(Dimethy Terephthalate) and MEG(Mono Ethylene Glycol).

Catalysts like 5b3O3 (ANTIMONY TRIOXIDE) are used to start and control the reaction. TiO2 (Titanium di oxide) is added to make the polyester fibre / filament dull. Spin finishes are added at melt spinning and draw machine to provide static protection and have cohesion and certain frictional properties to enable fibre get processed through textile spinning machinery without any problem.

PTA which is a white powder is fed by a screw conveyor into hot MEG to dissolve it. Then catalysts and TiO 2 are added. After that Esterification takes place at high temperature. Then monomer is formed . Polymerisation is carried out at high temperature (290 to 300 degree centigrade) and in almost total vacuum. Monomer gets polymerised into the final product, PET (Poly ethylene Terephthalate).

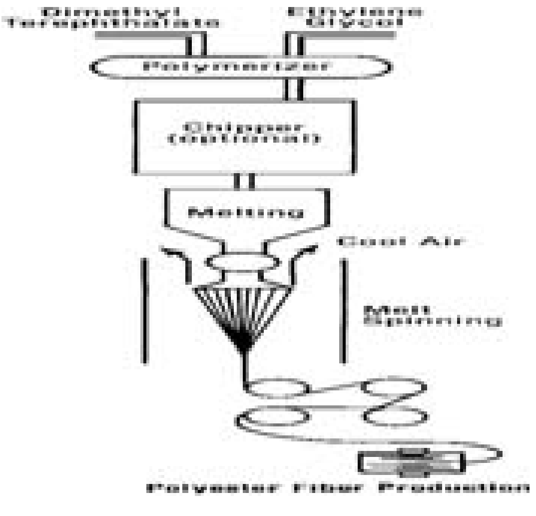
This is in the form of thick viscous liquid. This liquid is then pumped to melt spinning machines. These machines may be single sided or double sided and can have 36/48/64 spinning positions. At each position, the polymer is pumped by a metering pump-which discharges an accurate quantity of polymer per revolution (to control the denier of the fibre) through a pack which has sand or stainless steel particles as filter media and a spinneret which could be circular or rectangular and will have a specific number of holes depending on the technology used and the final denier being produced. Polymer comes out of each hole of the spinnerette and is instantly solidified by the flow of cool dry air. This process is called quenching. The filaments from each spinnerette are collected together to form a small ribbon, passed over a wheel which rotates in a bath of spin finish: and this ribbon is then mixed with ribbon coming from other spinning positions, this combined ribbon is a tow and is coiled in cans. The material is called undrawn TOW and has no textile properties.

At the next machine (the draw machine), undrawn tows from severl cans are collected in the form of a sheet and passed through a trough of hot water to raise the temperature of polymer to 70 degrees C which is the glass transition temperature of this polymer so that the polymer can be drawn. In the next two zones, the polymer is drawn approximately 4 times and the actual draw or the pull takes place either in a steam chamber or in a hot water trough. After the drawing is complete, each filament has the required denier, and has all its sub microscopic chains aligned parallel to the fibre axis, thereby improving the crystallinity of the fibre structure and imparting certain strength.

Next step is to set the strength by annealing the filaments by passing them under tension on several steam heated cylinders at temperatures 180 to 220 degrees C. Also the filaments may be shrunk on the first zone of annealer by over feeding and imparting higher strength by stretching 2% or so on the final zone of the annealer. Next the fibre is quenched in a hot water bath, then passed through a steam chest to again heat up the tow to 100 degree C so that the crimping process which takes place in the stuffer box proceeds smoothly and the crimps have a good stability. Textile spin finish is applied either before crimping by kiss roll technique or after crimping by a bank of hollow cone sprays mounted on both sides of the tow. The next step is to set the crimps and dry the tow fully which is carried out by laying the tow on a lattice which passes through a hot air chamber at 85degree C or so.

The two is guided to a cutter and the cut fibres are baled for despatch. The cutter is a reel having slots at intervals equal to the cut length desired <u>32 or 38 or 44 or 51mm</u>. Each slot has a sharp stainless steel or tungsten carbide blade placed in it. The tow is wound on a cutter reel, at one side of the reel is a presser wheel which presses the tow on to the blades and the tow is cut. The cut fibre falls down by gravity and is usually partially opened by several air jets and finally the fibre is baled. Some, balers have a preweighting arrangement which enables the baler to produce all bales of a pre determined weight.

The bale is transported to a ware house where it is "matured" for a minimum of 8/10 days before it is permitted to be despatched to the spinning mill.



<u>FIBRE SPECIFICATION:</u>

<u>DENIER:</u> Usually the actual denier is a little on the finer side i.e for 1.2 D, it will be 1.16 and for 1.4 , it could be 1.35. The tolerance normally is +- 0.05 and C.V% of denier should be 4 to 5%. Denier specifies the fineness of fibre and in a way controls the spinning limit. Theory tells us that in order to form yarn on ring

spinning (and also in air jet) there must be minimum of 60 to 62 fibres in the yarn cross section. Therefore the safe upper spinning limit with different denier is

DENIER	COUNT(Ne)
1.0	90
1.2	80
1.4	62
2.0	40
3.0	32

The limit is for 38 mm fibre. The limit rises for a longer fibre.

When spinning on open end system, the minimum no of fibres in the yarn cross section is 110. So all the fibre producers recommend finer denier fibres for OE spining . Here the safe upper spinning limit is

DENIER	COUNT(Ne)
1.0	50
1.2	40
1.4	30
2.0	24
3.0	16

However in actual practice , 30s is an upper limit with OE AND 1.2 Denier is being used, in USA and other countries, even for 10s count in OE.

Deniers finer than 1.0 are called micro-denier and commercially the finest polyester staple fibre that can be worked in a mill is 0.7 D.

CUT LENGTH: Cut lengths available are 32, 38, 44, 51 and 64mm for cotton type spinning and a blend of 76, 88 and 102 mm - average cut length of 88m for worsted spinning. The most common cut length is 38 mm.

For blending with other manmade fibres, spinners preferred 51mm to get higher productivity, because T.M. will be as low as 2.7 to 2.8 as against 3.4 to 3.5 for 38mm fibre. If the fibre legnth is more, the nepping tendency is also more, so a compromise cut length is 44 mm. With this cut length the T.M. will be around 2.9 to 3.0 and yarns with 35 to 40% lower imperfections can be achieved compared a to similar yarn with 51 mm fibre. In the future spinners will standardize for 38 mm fibre when the ring spinning speed reaches 25000 rpm for synthetic yarns.

For OE spinning , 32 mm fibre is preferred as it enables smaller dia rotor(of 38mm) to be used which can be run at 80000 to 100000 rpm.

Air jet system uses 38 mm fibre.

TENSILE PROPERTIES: Polyester fibres are available in 4 tenacity levels.

- Low pill fibres- usuall in 2.0 / 3.0 D for suiting enduse with tenacities of 3.0 to 3.5 gpd(grams per denier). These fibres are generally used on worsted system and 1.4D for knitting
- Medium Tenacity - 4.8 to 5.0 gpd
- High tenacity 6.0 to 6.4 gpd range and
- Super high tenacity 7.0 gpd and above

Both medium and high tenacity fibres are used for apparel end use. Currently most fibre producers offer only high tenacity fibres. Spinners prefer them since their use enables ring frames to run at high speeds, but then the dyeablity of these fibres is 20 to 25% poorer, also have lower yield on wet processing, have tendency to form pills and generally give harsher feel.

The super high tenacity fibres are used essentially for spinning 100% polyester sewing threads and other industrial yarns. The higher tenacities are obtained by using higher draw ratios and higher annealer temperatures up to 225 to 230 degree C and a slight additional pull of 2% or so at the last zone in annealing.

Elongation is inversely proportional to tenacity e.g

	TENACITY	ELONGATION AT BREAK	T10 VALUES
LOW PILL	3.0 - 3.5	45 - 55%	1.0 - 1.5
MEDIUM	4.8 - 5.0	25 - 30%	3.5 - 4.0
HIGH	6.0 - 6.4	16 - 20%	5.2 - 5.5
SUPER HIGH	7.0 plus	12 - 14%	6.0 plus

All the above values of single fibre. Testing polyester fiber on Stelometer @ 3mm gauge is not recommended.

The T10 or tenacity @ 10% elongation is important in blend spinning and is directly related to blend yarn strength. While spinning 100% polyester yarns it has no significance. Tenacity at break is the deciding factor.

CRIMP PROPERTIES:

Crimps are introduced to give cohesion to the fibre assembly and apart from crimps/cm. Crimp stability is more important criterion and this value should be above 80% to provide trouble free working. A simple check of crimp stability is crimps/inch in finisher drawing sliver. This value should be around 10 to 11, if lower, the fibre will give high fly leading to lappings and higher breaks at winding. Spin finish also gives cohesion, but cohesion due to crimp is far superior to the one obtained by finish. To give a concrete example, one fibre producer was having a serious problem of fly with mill dyed trilobal fibre. Trilobal fibre is difficult to crimp as such, so it was with great difficulty that the plant could put in crimps per inch of 10 to 11. Dyeing at 130 degrees C in HTHP dying machine reduced the cpi to 6 to 8. Mills oversprayed upto 0.8% did not help. Card loading took place yet fly was uncontrolled, ultimately the fibre producer added a steam chest to take the two temperature to 100degrees plus before crimping and then could put in normal cpcm and good crimp stability. Then the dyed fibre ran well with normal 0.15 to 0.18 % added spin finish.

SPIN FINISH:

Several types of spin finishes are available. There are only few spin finish manufacturers - Takemoto, Matsumoto, Kao from Japan, Henkel, Schill &Scheilacher, Zimmer & Schwarz and Hoechst from Germany and George A.Goulston from USA. It is only by a mill trial that the effectiveness of a spin finish can be established.

A spin finish is supposed to give high fibre to fibre friction of 0.4 to 0.45, so as to control fibre movement particularly at selvedges , low fibre-metal friction of 0.2 to 0.15 to enable lower tensions in ring spinning and provide adequate static protection at whatever speed the textile machine are running and provide enough cohesion to control fly and lapping tendencies and lubrication to enable smoother drafting.

Spin finish as used normally consists of 2 components - one that gives lubrication / cohesion and other that gives static protection. Each of these components have upto 18 different components to give desired properties plus anti fungus, antibacterial anti foaming and stabilisers.

Most fibre producers offer 2 levels of spin finishes. Lower level finish for cotton blends and 100% polyester processing and the higher level finish for viscose blend. The reason being that viscose has a tendecy to rob polyester of its finish. However in most of the mills even lower spin finish works better for low production levels and if the production level is high, high level spin finish is required if it is mixed with viscose.

For OE spinning where rotor speeds are around 55000 to 60000 rpm standard spin finish is ok, but if a mill has new OE spinning machines having rotors running @80000 rpm, then a totally different spin finish which has a significantly lower fibre - fibre and fibre - metal friction gave very good results. The need to clean rotors was extended from 8 hours to 24 hours and breaks dropped to 1/3rd.

In conclusion it must be stated that though the amount of spin finish on the fibre is only in the range 0.105 to 0.160, it decides the fate of the fibre as the runnability of the fibre is controlled by spin finish, so it is the most important component of the fibre.

Effectiveness of spin finish is not easy to measure in a fibre plant. Dupont uses an instrument to measure static behaviour and measures Log R which gives a good idea of static cover. Also, there is s Japanese instrument Honest Staticmeter, where a bundle of well conditioned fibre is rotated at high speed in a static field of 10000 volts. The instrument measures the charge picked up by the fibre sample, when the charge reaches its maximum value, same is recorded and machine switched off. Then the time required for the charge to leak to half of its maximum value is noted. In general with this instrument , for fibre to work well, maximum charge should be around 2000 volts and half life decay time less than 40 sec. If the maximum charge of 5000 and half life decay time of 3 min is used , it would be difficult to card the fibre , especially on a high production card.

DRY HEAT SHRINKAGE:

Normally measured at 180 degree C for 30 min. Values range from 5 to 8 %. With DHS around 5%, finished fabric realisation will be around 97% of grey fabric fed and with DHS around 8% this value goes down to 95%. Therefore it makes commercial sense to hold DHS around 5%.

L and B colour:

L colour for most fibres record values between 88 to 92. "b" colour is a measure of yellowness/blueness. b colour for semidull fibre fluctuates between 1 to 2.8 with different fibre producers. Lower the value, less is the chemicals degradation of the polymer. Optically brightened fibres give b colour values around 3 to 3.5. This with 180 ppm of optical brightner.

DYE TAKE UP:

Each fibre producer has limits of 100 +- 3 to 100+-8. Even with 100+-3 dye limits streaks do occur in knitted fabrics. The only remedy is to blend bales from different days in a despatch and insist on spinning mills taking bales from more than one truck load.

FUSED FIBRES:

The right way to measure is to card 10 kgs of fibre. Collect all the flat strips(95% of fused fibres get collected in flat strips). Spread it out on a dark plush, pick up fused and undrawn fibres and weigh them. The upper acceptable limit is 30mgm /10kgs. The ideal limit should be around 15mgm/10kgs. DUpont calls fused/undrawn fibres as DDD or Deep Dyeing Defect.

LUSTRE: Polyester fibres are available in

bright: 0.05 to 0.10 % TiO2

Semil dull : 0.2 to 0.3 % TiO2

dull : 0.5 % TiO2

extra dull : 0.7% TiO2 and

in optically brightened with normally 180 ppm of OB, OB is available in reddish , greenish and bluish shades. Semi dull is the most popular lustre followed by OB (100 % in USA) and bright.

PHYSICAL AND CHEMICAL PROPERTIES OF POLYESTER FIBRE:

1. DENIER: 0.5 - 15
2. TENACITY : dry 3.5 - 7.0 : wet 3.5 - 7.0
3. %ELONGATION at break : dry 15 - 45 : wet 15 45
4. %MOISTURE REGAIN: 0.4
5. SHRINKAGE IN BOILING WATER: 0 - 3
6. CRIMPS PER INCH: 12 -14
7. %DRY HEAT SHRINKAGE: 5 - 8 (at 180 C for 20 min)
8. SPECIFI GRAVITY: 1.36 - 1.41
9. % ELASTIC RECOVERY; @2% =98 : @5% = 65
10. GLASS TRANSITION TEMP: 80 degree C
11. Softening temp : 230 - 240 degree C
12. Melting point : 260 - 270 degree C
13. Effect of Sunlight : turns yellow, retains 70 - 80 % tenacity at long exposure
14. RESISTANCE TO WEATHERING: good
15. ROT RESISTENCE: high
16. ALKALI RESISTENCE: damaged by CON alkali
17. ACID RESISTENCE: excellent

18. ORGANIC CHEMICAL RESISTENCE: good

PROBLEMS WHICH OCCUR DURING MANUFACTURE OF POLYESTER STAPLE FIBRE:

The manufacture of polyester fibre consists of 4 stps:

- Polymerisation:Using PTA/DMT and MEG on either batch or continuous polymerisation (cp_ - forming final polymer
- Melt spinning :Here molten polymer is forced thorough spinnerette holes to form undrawn filaments, to which spin finish is applied and coiled in can
- Drawings: in which several million undrawn filaments are drawn or pulled approximately 4 times in 2 steps, annealed, quenched, crimped and crimp set and final textile spin finish applied and
- Cutting: in which the drawn crimped tow is cut to a desired 32/38/44/51 mm length and then baled to be transported to a blend spinning mill.

1.PROBLEMS FACED IN POLYMERISATION:

properties of Polymer: The polymer formed is tested mainly for intrinsic viscosity (i.v), DEG content, % oligeomers and L and b colours. Intrinsic viscosity is an indirect measure of degree of polymerisation and this value is around 0.63 for polymer meant for apparel fibres. DEG or Di Ethylene Glycol gets formed during polymerisation and varies from 1.2 to 1.8%. Oligomers are polymers of lower molecular weight and vary in quantity from 1.2 to 1.8 %. L and b are measures of colour. L colour signifies whiteness as a value of 100 for L is a perfect value. Most fibres have L colour values around 88 to 92. b colour denotes yellowness/blueness of polymer. the positive sign for b colour indicates yellowness whilst negative sign shows blueness, only polymer which contain optical brightener has b of 3 - 3.5 whilst all semil dull polymers show b values of 1.0 to 2.4. Higher values indicate more yellowness, which indirectly shows chemical degradation of the polymer.

Running a CP @ lower / higher throughput:

Every CP is designed for a certain throughput per day. Like say 180 tons/day or 240 tons/day. Sometimes due to commercial constraints like high buildup of fibre stocks etc. , the CP may have to be operated at lower capacityies. In that case the polymer that is produced has a higher "b" colour and a lower DEG content. Higher "b" colour of say 1.5 against normal value of 1.0 will show fibre to be yellowish and has a little more chemical degradation; which gives higher fluorescence under UV light. Most spinning mills have a practice of checking every cone wound under UV lamp to find out whether there has been any mixup.

However if a mill is consistently receiving fibre with a "b"colour of say 1.0 and then if one despatch comes of "b"colour of say 1.5 then in winding, ring bobbins of both "b" colours will be received, and when cones are wound and checked under UV lamp, then higher "b" colour material will give higher fluorescence compared to that of lower "b" colour materials, and will cause rings under UV lamp. Fortunately a minor difference in "b" colour of 0.4 to 0.5 does not give variation in dyeability.

What can spinning mills do to overcome this problem:

One way is to use a Uster Glow meter which measures the reflectance of fibre samples under UV light. We understand that these values lie between 80 and 120 for samples from different bales. so then divide bales with reflectance values of say 80 to 90 , another 91 to 100, third 101 to 110 and fourth 111 to 120. Then while issuing bales to blow room, issue first group say 80 to 90 then issue the enxt group and so on. Bales from different groups should not be mixed.

Second is to use bales from each truck separately.

Third is to mix up bales from 4/5 trucks to do a blending

Changes in DEG: The amount of DEG in fibre is directly proportional to dye pick up or dye ability of the fibre. Higher the DEG, higher is the dye ability, so much so that some filament producers add DEG, but then higher DEG will lower tensile properties. So this practice is not followed for fibre, where tensile properties are critical. So if the CP is run at lower throughout, DEG drops down, so the dyeablity of the fibre goes down. Since fibre production group is keen on maintaining merge, they resort to lowering of annealer temperatures to maintain dye ability but in the process tensile properties suffer, and mills will notice thread strength falling by 5-7% if annealer temperature is lowered from say 210 degree C to 180 Degree C. If fibre production group does not do this, then they will produce fibre with a different merge - which normally accumulates in the warehouse and so is not appreciated by both marketing and top management.

Also when CP is run at higher than rated, then higher temperatures have to be used to compensate lower residence time, here "b" colour actually improves

It must be emphasized that the "b"colour changes occur not only due to higher / lower thorugh put but there are several other factors such as air leakags in valves / polymer lines, failure of pumps to remove product from one reaction vessel to another etc.

There is yet one more problem in CP. It is a sudden increase in oligomer content. When the amount of oligomers increase, it manifests itself in excessive white powder formation on rings and ring rail.

Oligomers cause problems in spinning of dyed fibres. The surface oligomer content almost doubles on dying dark and extra dark shades. The only way to control oligomers is to use LEOMIN OR in 1 - 1.5 gms/litre in reduction clearing bath. All oligomers will go into suspension in reduction clearing liquor and get removed when the liquor is drained.

Higher annealer temperature also cause higher surface oligomers

2.PROBLEMS FACED IN MELT SPINNING:

Control of C.V% of Denier: A good international value of C.V.% of denier is 4 to 5. However some fibre manufacturers get value as high as 10 to 12.

Denier is controlled by having uniform flow of polymer through each spinnerette hole. However if a hole is dirty or has polymer sticking to it, its effective diameter is reduced; and the filament that comes out becomes finer. IF the spinneretters have been used for more than say 6 to 7 years , then some of the holes would be worn out more than others and filament emerging out would be coarser

Currently sophisticated instruments are available to check the cleanliness and actual hole diametrs of each and every hole automatically, but few producers have them.

Fused Fibres: These are caused mainly at melt spinning either due to breaks of individual filaments or breakages of all the filaments(ribbon break) and polymer and block temperatures are too high. Tying of broken position in the running thread line should be as near to the broken position as possible, failure to do this will result in trailing end leading to fused fibres. Other reasons could be impurities, choking of polymer filters and non-uniform quenching or cooling of filaments.

The only way to control is to ensure that breaks at melt spinning are held at the minimum.

3.PROBLEMS FACED AT DRAW LINE:

Draw line is the place where the fibre is born. All its major properties denier, tenacity , elongation at break , crimp properties, spin finish, shrinkage and dye ability are all imparted here. For obtaining excellent runnability of the fibre in a blend spinning mill, the two most important properties are - spin finish and crimp.

Spin finish: Finish is applied to the undrawn tow at melt spinning stage essentially to provide cohesion and static protection. On the draw line, a major portion of this finish is washed away, and a textile spin finish is put on the tow by either kiss roll or a spray station. This textile finish consists of two components, one that gives cohesion and lubrication and the other confers static protection, usually these 2 components are used in 70/30 ratio. These spin finishes are complex and each may contain some 18 chemicals to not only control inter fibre friction (should be high at 0.35 to 0.40), fibre metal friction (should be low at 0.15-0.20), anti bacterial components, anti foaming compund etc.

Finish is made in hot demineralise water and is sprayed on to tow after the crimper by a series of spray nozzles mounted on both sides of the tow. The finish is pumped to the spray unit by a motor driven metering pump, which is linked to the draw machine such that when the machine stops, the pump motor stops. The percentage of finish on the fibre is based on spin finish manufacturers recommendations and fine tuned by tech service. Once set, the finish and its percentages are normally not changed.

The percentage spin finish is decided by the end use of the fibre. Mills blending polyester with viscose need higher amount of spin finish and also mills running their equipment at high speeds. 60 to 65% of problems faced in mills are due to uneven % of spin finish on the fibre. IF a fibre producer desires to put say 0.120% spin finish on fibre, then ideally the %finish should be maintained @ 0.120 +- 0.005 i.e from 0.115 to 0.125 only; then the fibre will run smoothly.

If the finish is on the lower side, card web will show high static, web will lap around doffing rolls, sliver will not pass smoothly through coiler tube - causing coiler choking. Sliver could be bulky and will cause high fly generation during drafting. On the other hand if spin finish is on the higher side, fibres will become sticky and lap around the top rollers, slivers will become very compact and could cause undrafted. Thus it is extremely important to hold finish level absolutely constant. The reasons for non uniformity is concentration of spin finish varies; sprayer holes are choked ; the tow path has altered and so the spray does not reach it. Normally fibre producers check spin finish% on the fibre quite frequently- even then in actual practice considerable variations occur.

Crimp: It is the most important to spin finish for smooth running of fibre. There are 3 aspects of crimp.

- no of crimps per inch or per cm - usually 12 - 14 crimps per inch
- crimp stability - be 80% plus and
- crimp take up - be 27% on tow

crimps per inch can be measured by keeping a fibre in relaxed state next to a foot ruler and counting the no of crimps or arcs.

Crimp stability refers to % retention of crimps after subjecting fibre to oscillating straightening and relaxing. We can get an indication on how good crimp stability is in a spinning mill by measuring crimps per inch in fibre from finisher drawing sliver. The crimps per inch of drawing sliver should be atleast 10 to 11, if below this, then the crimps stability is poor , so to compensate may be a cohesive compound like Nopcostatt2151 P or Leomin CH be used in the overspary.

Fibres like trilobal and super h igh tenacity fibres are difficult to crimp. Trilobal because of its shape and super high tenacity due to very high annealer temperature (220 degree C) used which makes the fibre difficult to bend.

Also fibre dyeing particularly dark and extra dark shades reduces crimps per inch from 14 to 10 - 11 and in trilobal, as it is crimps per inch in fibre is 11 to 12, after dyeing it goes further down to 8 to 9. In dyed trilobal fibre, crimps per inch in fibre at finisher drawing may be around 6 to 7 so necessitating using almost 50% of cohesive compound in the overspray.

Crimp take up is % difference between relaxed length and straightened length of fibre in fibre stage. Normally this difference is around 18 to 20%. If the difference is much smaller, then it means the crimps are shallow and would have lower cohesion.

After the tow is crimped , the crimps are set by passing tow through a hot air chamber.

If crimp per inch is low, then that could be due to lower stuffer box pressure, but if crimp stability and/or crimp take up is low, it means the steam supply to crimper steam box is low.

Undrawn fibre: As the draw line, 1.6 to 3.0 million filaments are drawn or pulled, if a filament had a break at spinning and this is fed as a trailing end to the drawing, then that end cannot be drawn fully, and causes plasticises and fused fibres.

Undrawn fibres are generated if the draw point is not uniform i.e not in a straight line.

Plasticised fibre: When drawline is running and if some filaments breaks then these broken filaments wrap themselves around a rotating cylinder, since most of these cylinders are steam heated, the wrapped portion solidifes. The operator then cuts out the solid sheet and throws it away as waste but then usually picks up the plastic end and uses it to thread the material and so a small piece of plastic material goes into the cutter and falls into the baler.

Tenacity / Dye ability: Both these properties are controlled by acutal draw ratio and annealer temperature. Draw ratio does not change in running, but annealer temperature can fall due to problem of condensate water removal. Most drawlines have temperature indicators - but then some buttons have to be pressed to see the temperatures so if the annealer temperature falls, tenaciy will fall and dye ability will increase which could lead to a change in merge.

PROBLEMS FACED IN CUTTING / BALING:

Nail Head / Tip Fusion: In the cutting process, a highly tensioned tow is first laid over sharp blades and the pressed down by a Pressure Roll, resulting in filaments being cut. However if some blades become blunt, then the pressing of tow on to those blades creates high temperature and so tips of neighbouring fibres stick to each other and so separating this cluster becomes impossible. If it is not getting removed in Lickerin it will go into the yarn and cause a yarn fault. The tip fusion occurs when the blade is fully blunt. If the blade is not very sharp, it does not give a straight edge, there could be some rounding at the cut edge. Such fibres are called nail heads.

Tungsten carbide blades gives sharp cut

Opening of fibre cluster after opening: When fibres are cut, they fall down by gravity into the baler. Because of crimping clusters get formed; and so those need to be opened out; otherwise these can cause choking either in blowrrom pipes or in chute feed. This opening is obtained by having a ring of nozzles below the cutter through which high pressure air jets are pointed up; and these jets open up fibre clusters.

Over length / Multilength: Over length fibres are those whose length is greater than the cut length plus 10mm and are casued by broken filaments which being broken cannot be straightened by tensioning at the cutter. Multilength are fibre whose length is exactly 2 or 3 times the cut length and are caused by nicks in neighbouring blades.

SPECIALITY FIBRES IN POLYESTER:

- HIGH/LOW SHRINK FIBRES: The high shrink fibre shrinks upto 50% at 100 degree C while that of low shrinkage is 1%. The high shrink fibre enable fabrics with high density to be produced and is particularly used in artificaial leather and high density felt. Low shrinkage fibre is recommended for air filters used in hot air, furniture, shoes etc.
- MICRO DENIER: Available in 0.5/0.7/0.8 deniers in cutlengths 32/38 mm. Ideal for high class shirts, suitings, ladies dress material because of its exceptional soft feel. It is also available in siliconised finish for pillows. To get the best results, it is suggested that the blend be polyester rich and the reed/pick of the fabric be heavy.

- FLAME RETARDANT: Has to be used by law in furnishings / curtains, etc where a large number of people gather - like in cinema theatres, buses, cars etc in Europe and USA. It is recommended for curtains, seat covers, car mats, automotive interior, aircraft interiors etc.
- CATIONIC DYEABLE: Gives very brilliant shades with acid colours in dyeing / printing. Ideal for ladies wear
- EASY DYEABLE: Can be dyed with disperse Dyes @98 degrees C without the need for HTHP equipment. Ideal for village handicrafts etc.
- LOW PILL: In 2 and 3 deniers, for suiting end use and knitwear fibre with low tenacity of 3 to 3.5 gm/denier, so that pills which forms during use fall away easily.
- ANTIBACTERIAL:It is antibacterial throughout the wear life of the garment inspite repeated washing. Suggested uses are underwears, socks, sports, blankets and air conditioning filters
- SUPER HIGH TENACITY: It is above 7 g/denier and it is mainly used for sewing threads. Low dry heat shrinkage is also recommended for this purpose. Standard denier recommended is 1.2 and today 0.8 is also available.

- MODIFIED CROSS SECTION: In this there are TRILOBAL, TRIANGULAR, FLAT, DOG BONE and HOLLOW FIBRES with single and multiple hollows. Trilobal fibre gives good feel. Triangular fibre gives excellent lustre. Flat and dog bone fibres are recommended for furnishings, while hollow fibres are used as filling fibres in pillows, quilts, beddings and padding. For pillows silicoised fibres is required. Some fibre producers offer hollow fibre with built in perfumes.
- CONDUCTING FIBRE: This fibre has fine powder of stainless steel in it to make fibre conductive. Recommended as carpets for computer rooms.
- LOW MELT FIBRE: It is a bi-component fibre with a modified polyester on the surface which softens at low temperature like 110 degree C while the core is standard polyester polymer. This fibre is used for binding non woven webs

Step 1: Choose Project

There are lots of different ways to warp a loom. If you use another method, that's great! The objective is to find a method that is most comfortable and easy to use for you. I will describe a method that I use when warping from Front-to-Back.

Step 1 - Choose Your Project and Yarns

First, you will need to determine how wide and long you want your project to be and what type of yarn you will be using. For beginners, it is advisable to choose a pre-determined pattern so that some of the calculations will be done for you already. Some weaving patterns and projects are listed on our site. There are also many handweaving books and magazines on the market. Handwoven is a great source for ideas. Check with your local library, weaving guild or our on-line bookstore as well for project books.

Step 2. Determine the sett of your cloth, or how many threads per inch the fabric will be.

Step 3. Choose the correct Reed

Step 4. Calculate the Yarn requirements.

Step 5. Wind the Warp using a warping board or warping mill.

Step 6. Remove the warp chains and place them on the loom.

Step 7. Sley the Reed.

Step 8. Thread the heddles, following the draft plan.

Step 9. Wind the warp onto the back beam

Step 10. Tie the warp ends to the front beam.

Congratulations! Now you a ready to Weave!

Glossary of "Period" Costuming Terms

(Thanks to Jean for the list)

- Angel Sleeves
    - Very long full sleeves that are open at wrist; opening can vary in width, hanging to waist or to floor. (see Holkeboer, pg. 63, 71 & 77)
- Armscye
    - Armhole.
- Bell Sleeve
    - "Made narrow at the top, set into normal armhole, & flaring at lower edge like a bell…" (Calasibeta, pg. 521)
- Bliaut/Bliaud/Bliaunt
    - A later form of a t-tunic that is much more fitted to the body shape for both men & women by means of lacing either at back or sides. The woman's bliaut has a very distinctive shape in that it is heavily wrinkled or pleated through the torso from bust to hips. It was originally thought that a "corset" or belly band was what caused that look; but now most historical costumers are of the opinion that the look is the result of the torso of the dress being cut extremely long then gathered up (with the help of the lacing) to form the fine wrinkles or pleats. (see Holkeboer, pg. 74 through 78)
- Caftan
    - A full length coat-like garment "… consisting of a long full robe with slit neckline, decorated with embroidery & long, full, bell-shaped sleeves… Egyptian or Near Eastern… coatlike garment with long sleeves, worn by men with sash around waist." (Calasibeta, pg. 80)
- Cap Sleeve
    - "Small extension cut on the front & back of a blouse to cover the shoulder. Has a seam at the shoulder fastening front & back of garment together, but no armhole seam…" (Calasibeta, pg. 521)
- Chainse
    - An early relative of the chemise, a fine white linen under-gown worn by women with long tight sleeves, that sometimes showed beneath the over-tunic or bliaut. (see Holkeboer, pg. #82, referred to as chemise)
- Chemise/Camise/Smock/Shift
    - Various names for the same garment worn by both men & women. The original body garment &/or nightgown. It consisted of a straight, loose-fitting body & could be either sleeveless, have long tight sleeves, or long full sleeves gathered at the wrist. The neckline varied widely as well. Most Renaissance dress patterns have a good basic, full-sleeved chemise pattern.
- Chiton
    - Greek in origin. "Two large rectangles hung in folds from the shoulders, with back & front pinned together… The Doric chiton was bloused & belted in a variety of ways… The Ionic chiton was made of sheerer fabric, sewn together at the sides & sleeves were formed by pinning." (Calasibeta, pg. 109) (see Holkeboer, pg. 30 through 33)
- Corselet
    - Worn sometimes over the bliaut, this was a separate bodice or vest that was form fitting, sleeveless & laced up the back. It was also often quilted. (see Holkeboer, pg. 79 & 80, referred to as "corsage")
- Cote
    - An over-tunic that could be unfitted or fitted somewhat by lacing. Was also sometimes referred to as a tunic or (for women) a kirtle.

- Cotehardie
    - Worn by both men & women. The first outer garment that was actually tailored to closely fit the human body & the first to have set-in sleeves, rather than sleeves cut as part of the body. Originally, both men's & women's had boat-shaped necklines, men's later developed a standing collar. Men's was shorter (waist to hip lengths), women's was floor length or longer. Both had long tight sleeves & buttoned from neckline to hem; women's sometimes was laced. Full skirts for the women. (see Holkeboer, pg. 120 through 123. 130 & 131, referred to as courtepy)
- Cyclas
    - The early version of the sleeveless gown, again worn by both men & women. Long & fairly straight, the armhole could be just left open or cut longer & laced or buttoned up. (see Holkeboer, pg. 94 through 99)
- Doublet
    - Descended from the men's cotehardie. A close-fitting garment similar to a jacket. Mostly commonly seen in the Italian Renaissance. (see Holkeboer, pg. 160 through 163)
- Gambeson
    - A jacket made either from either leather or quilted fabric, that was usually worn under men's armor to protect the body. Could also be called a Gipon or Jupon.
    - How to make
- Houppelande
    - A long, full garment worn by both men & women. The early version had a high, funnel or stand-up collar; the later version developed into a v-neckline (the women's would have a modesty panel or "dickey" inserted). It was shaped by a wide belt worn under the bust. The sleeves varied from fairly tight-fitting, to "bagpipe" sleeves to extremely large angel sleeves that were frequently dagged (cut into fanciful designs on the edges). (see Holkeboer, pg. 128 & 129, 136 through 141)
- Jewel Neckline
    - a "high" round neckline, basically the base of the throat - where a string of pearls would rest.
- Kirtle/Robe
    - A later version of the t-tunic over-gown, also fitted mainly through lacing at sides or back. The body was smoother than a bliaut. Necklines varied. Sleeves tended to be long & fairly tight. (see Holkeboer, pg. 106, 107, 114, 115, 132, 133, 156 & 157)
- Sideless Surcoat (or Surcote)
    - The early version of what we now consider a jumper. A long loose outer-garment with the armhole cut deep, to waist or hip. The early version was simply cut away under the arm & was often seen to be laced up. The later version was cut very deep & wide, allowing the gown beneath (& the shape of the woman's body) to be easily seen. Usually had a rounded or boat-neckline. Skirt is extremely full, long & usually trained in the later version. (see Holkeboer, pg. 114 through 117)
- Surcoat
    - Worn by both men & women, it could be sleeved or sleeveless. An over-tunic with a variation of shapes & uses. The men's surcoat, was often worn over armor (to keep it cool) & could be slit in front & back for ease in riding a horse. Also sometimes called the Cyclas
- T-Tunic
    - This is the garment most people think of as being THE medieval garment. Derives its name from the shape, body & sleeves are cut in one piece in a basic "t" shape. Loose-fitting, usually shaped with a belt worn either at waist or hips. The sleeves were either

elbow- or full-length, straight, belled, or angel-type. They were frequently worn in pairs, with the over-tunic being shorter in both body & sleeve length. (see Holkeboer, pg. 56 through 71)

- Tabard
  - A long tunic that consisted of just a front & back panel with the side seams left open all the way to the hem. It was usually belted closed. The neckline was normally rounded.
- Trumpet Sleeve
  - "Sleeve fitted into natural armhole, falling straight to elbow where it flares in the shape of a trumpet." (Calasibeta, pg. 524)
- Tunic
  - see T-Tunic.

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Terms for Indian clothing

In the description of the costumes, we talk about Boromir and mention his sleeves are sari fabric. He is not technically wearing anything like a sari, he's wearing a silk kurta. The wire-wrapped thread embroidery on it I think is called Zardozi and typically incorporates semi-precious sparkly pieces or mirrors and stuff.

Here's a quick glossary of Indian clothing which you might be interested in. (Thanks to Jen for this section.)

- Sari
  - Is used for the unstitched length of cloth usually about 6 yards long that has a decorated edge called a Pallav. Sometimes these fabric lengths are cut apart for their trims.
  - When we refer to "sari fabric" we're often referring to the decorations on the edges.
  - Example, it Boromir's sleeves were not custom embroidered, then there is a very good chance that the sleeves were cut from the decorated side of a sari.
- Choli
  - Is the name of the blouse (usually a tight one that is any length from waist to just under the bust) worn with Saris or lenghas/ghaghras (skirts).
  - When you purchase a good length of sari cloth, you often get enough to form a standard size Choli, including edges embroidered for the sleeves. These are normally a bit less ornate than the edge of the Sari fabric, but still match.
- Lehnga or ghaghra

  - full skirt.
- Kurta
  - tunic worn by either men or women.
  - Technically Boromir could be wearing a silk kurta. However, we just call it a tunic because it is a more understandable term.
- Kameez (like a chemise!)
  - long tunic, I think it's really just a more feminine or fancy name for kurta.
- Salwar
  - Wide trousers often with a fancy border on the hem.
  - Technically, these could describe Gandalf's trousers, down to the embroidery on his grey version. However, in the books his are referred to as culottes.
- Churidar
  - Pants that are narrow and tight at the calves and ankles.
- Pajama
  - more trousers. (Plainer than Salwar? tends to be used to describe men's white wide-legged pants by my family), it might just be a generic term for pants.
- Chunni/Dupatta
  - veil, sash, scarf type piece.
- You tend to call outfits by their combinations: Salwar Kameez, Kurta Pajama, Lehnga Choli, etc.

Outlook for the World Cotton Market in the 1998/99 Crop Year

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The big story in the global economy last year was the Asian currency crisis. The Thai Baht depreciated sharply after it was moved to a floating exchange rate and soon the rest of the Southeast Asian currencies were involved. The only country not experiencing a depreciation in its currency was China, causing China's exports to become more expensive comparatively and therefore less competitive to its Asian neighbors. This has sparked some debate as to whether the Chinese government will depreciate the value of its currency in the near future. Thus far, the government of China has undertaken the task of eliminating unnecessary expenditures in its own budget in order to stay fiscally stable. Although the immediate effect of the Asian currency crisis was not as dramatic as some expected because of various forms of financial help from the IMF and the governments of the U.S., Japan and Australia, the aftershocks are likely to be felt for some time.

In the cotton market, both the 1996 and 1997 crop years were relatively stable fundamentally. Worldwide, and production dropped off by less than one percent and consumption remained steady at 88.6 million bales. Due to a number of factors, a regional shift in demand occurred: in Indonesia, a slowdown to about 30% capacity utilization in textile production after the Rupiah was pulled into the currency crisis and, in Brazil, a warm winter reduced the demand for value-added cotton products. In Japan, where structural change in the spinning industry has been occurring for some time and a recession threatens the economy, consumption dropped by 10.7% between 1996 and 1997. Offsetting the decrease was consumption in Mexico, which rose by 32.3% to reach 2.1 million bales. Because of these factors, world ending stocks rose slightly and the stocks-to-use ratio, excluding China, moved from 31.3% to 32.5%.

World trade in raw cotton has remained steady over the last seven years, with the U.S. and Uzbekistan accounting for 42% to 51% of exports. A falloff of imports into Japan and Indonesia, both major cotton consumers and importers, was offset by an increase in imports into Mexico, mostly from the United States. The USDA forecasts 1997/98 exports for the U.S. and Uzbekistan at 7.5 million bales and 4.3 million bales respectively.

The African Franc Zone and Australia also remained strong suppliers of exportable cotton this year. Australia, in an effort to compete for Asian business, offered in April to guarantee US$250 million worth of trade credit specifically for cotton going to Asia, with Indonesia as the main destination. Generally, over 90% of Australia's cotton production ends up on the export market with one third of that amount going to Indonesia and only 10% going to non-Asian destinations.

Appearing on the export market for the first time in three years was China, with two separate offers. In early April, 1.4 million bales of cotton, excluding any from the western province of Xinjiang, were offered. Most of that cotton was apparently sold to a U.S. merchant. At the end of May, a second tender offer was circulated; this time for 1.2 million bales of new crop cotton from the Xinjiang province, with delivery during the 1998/99 season.

China has a vast inventory of raw cotton, amounting to about 40% of total world cotton stock. When China previously held such a large amount of cotton in stock, it soon appeared as a major exporter of cotton. In 1985, for example, China exported 2.8 million bales and in 1986 exported 3.2 million bales. The USDA attaché is currently estimating that 1.1 million bales of cotton will be exported this year. This is 900,000 bales more than the USDA's latest official estimate and reflects cotton from the original tender offer.

So what does the 1998/99 crop year look like? First of all, world planted acreage is expected to be lower than this year by between 1% and 5%. Although a small percentage, the decreases are mostly seen in exporters and major producers such as the U.S., China, Argentina, India, the African Franc Zone and Brazil, likely affecting those dependent upon imported raw cotton.

China is the world's largest producer and consumer of cotton, but due to the Chinese government's lowering of the price paid to farmers for cotton, a shift in acreage away from cotton has been occurring and is likely going towards more vegetable production. Argentina experienced major problems with weather and therefore yield during this year's harvest, which may account for why forecasts are for lower planted acreage in 1998, but it is still very early to tell what is likely to happen. In Uzbekistan, the second largest exporter of cotton, planted acreage is expected to remain at about 3.7 million acres in 1998 according to the USDA. Pakistan's planted acreage is also expected to remain similar to last year. Mexico, which has emerged as a major consumer and importer of cotton over the last three years, is expected to plant more acres in cotton, but the increase is insignificant compared to their increased needs.

World planted acreage has remained fairly steady, averaging 82 million acres over the last twenty years. About half of the change in planted acreage can be explained by changes in the 'A' Index, a proxy for world price, during the harvest period of the previous crop year, while government programs, participation in the export market, and other factors each influence the level of planted acreage to a lesser extent. As planted acreage usually decreases as the 'A' Index falls, planted acreage is expected to decline slightly.

World cotton yields have leveled out over the last few years. The last significant technological change that affected yield was the introduction of pyrethroid chemistry in the late nineteen seventies. At first, the increase in yield was dramatic, but since 1984, world yield has averaged 500 pounds per acre. The last three years have seen minute increases of less than one percent, indicating that, unless new technology affects yield, it is likely to remain level. The ICAC forecasts world yield for 1998/99 as the same as this year, 512 pounds per acre. Yield problems in the major producing countries are responsible for the immobility of overall world yield. In China, weather and pest problems caused lower yields while leaf curl virus reduced yields in Pakistan. Yields in Uzbekistan may recover now that the disruption in input supply caused by the breakup of the Soviet Union is no longer an issue. It is also notable that world yield has tended to fall in the years following an El Niño event. The average yield during those periods is about 3% below years in which no El Niño occurred.

Given an expected drop in planted acreage and about 3% lower yield, world cotton production could fall to between 84 and 87 million bales in 1998. The ICAC is forecasting 1998/99 world cotton production at 87.1 million bales, a four percent decrease from this year. Until recent declines in world prices for cotton, the ICAC had been forecasting less than a one percent decrease in world production. The USDA is forecasting 86.5 million bales in cotton production, a 2.4% drop from this year.

Over the last twelve years, production has fallen to a low of 70.6 million bales in 1986/87 crop year and risen to a high of 95.7 million bales in 1991/92. The 1986 crop year had the lowest planted acreage in the past twenty years and the 1991/92 crop year had acreage similar to the last two years. Whether production ends up to the low side of the forecasts or to the high side, not much change is expected in world production as a whole, but as most of the drop is expected in regions with heavy participation in the export market, cotton available for export may fall.

World cotton consumption has remained steady over the past decade. The USDA is forecasting consumption of 90 million bales in the 1998/99 crop year. This compares to the ICAC forecast of 89.5 million bales. Both show that, although consumption in Asia may have slowed, cotton consumption worldwide is expected to remain strong. The decrease in raw cotton consumption in Asia has been offset somewhat by increased consumption in Mexico. Mexico is now a major consumer of raw cotton with consumption having risen by two and a half times the level attained in 1993. The U.S. is a driver for increased yarn, fabric and apparel production in Mexico as it provides a lucrative retail market at close proximity. It is likely that by late 1999, barring any further problems such as an extended recession in Japan, the world economy will have recovered somewhat from the currency crisis.

An important indicator to watch over the next few months is the level of value-added exports from Asian origins; Asian currency exchange rates have steadied. Textile exports from Indonesia, the most troubled of the Southeast Asian countries, were reported as 86% higher in January 1998 than one year earlier, but overall exports are lower. Exports of goods from Thailand, Malaysia, and Taiwan have fallen since last year, while exports from South Korea, the Philippines, and China have increased. Asia has been an important source of goods in the U.S. and worldwide, but individual companies' liquidity and ability to continue operations are of concern. This is perhaps what is causing exports from the troubled regions to fall despite the favorable exchange rate for buyers.

In the 1997/98 crop year, Mexico offset decreases in imports of raw cotton by Asian countries, importing 1.6 million bales, a 77.8% increase over last year. As new textile mills open and existing mills increase production in Mexico, the need for raw cotton imports should remain strong.

Indonesia, the second largest importer of raw cotton in 1997, has experienced problems because of the currency crisis. Export-oriented companies in Indonesia have had a comparative advantage as their products became relatively cheap due to the devalued Rupiah. Companies focusing on domestic consumption have encountered more difficulty in continuing their operations as unemployment rose and personal consumption expenditures slumped. Recently, energy prices were hiked by 60% in order to cover the higher cost of imported inputs only to be reduced later because of the violence that ensued. Indonesia has developed the production capacity to become a net exporter of polyester within the next year while raw cotton needs to be imported. The amount of cotton imported by Indonesia is expected to fall significantly during the 1998/99 crop year.

Until recently, China has been a major importer of cotton, but began to reverse in position several months ago. At first, an incentive program encouraging Chinese mills to use Chinese cotton was instituted. Then, China began to enforce an import quota policy that stopped state-owned mills from importing cotton. Lastly, China appeared as a cotton exporter when it offered a tender of 1.4 million bales in early April and one for 1.2 million bales in late May.

China's actions are particularly important as they have been determined to have an effect on world price. The ICAC proposes that a 100,000 bale change in China's net imports has a 2 cent per pound effect on the 'A' Index. China's participation on the import/export market may be responsible for as much as 44% of the change in the 'A' Index. As previously mentioned, changes in the 'A' Index likely account for half of the change in planted acreage. Therefore, if China's net imports fall in 1998 as expected, planted acreage in 1999 may be even lower than this year and, unless some technological change to boost yields occurs, the recent downward trend established in world cotton production is likely to continue.

Consensus forecasts of Gross Domestic Product (GDP) worldwide show a picture not as severe as some cast. Other than the recession seen in Indonesia, the slowest growth in GDP for 1998 is forecast for Japan, where growth is expected at less than one percent. This has important implications as Japan serves as a major export destination for Southeast Asia and is likely to be a crucial determinant of recovery in the area. The threat of recession in Japan has caused property values to drop and a decrease in consumer expenditures. It also appears that the government's debt situation may be more severe than previously reported, causing concern as to how far the government can go towards assisting in the economy's recovery. Brazil is also expected to see growth at under 2%, with some increase in 1999. The only countries for which higher growth in 1998 compared to 1997 is forecast are in Europe.

So where does this leave us in the 1998/99 crop year. First of all, production is forecast at 86.5 million bales by the USDA and consumption at 90 million bales. This will reduce ending stocks and cause the world stocks-to-use ratio, excluding China, to fall to about 27% compared to this years' 32.5%, indicating a tightening in the world cotton market. The outcome in the world cotton market next year hinges upon the ability of the Asian economies to recover. At this point, raw cotton consumption of 90 million bales may be optimistic. If consumption is lower the tightening in the market may not be as severe, but pressure on supply is still likely to be more intense than over the past four years.

Cotton Production Prospects for the Next Decade

Introduction

World Bank Technical Paper Number 231, "Cotton Production Prospects for the Decade to 2005, A Global Overview" (Eisa et al 1994), was prepared in 1991 to provide background in- formation for the nine country cotton study which is discussed in this document. It was updated in 1993 prior to publication in February 1994. Although it is a recent publication, rapid changes have occurred in policies on cotton production, particularly with regard to government interventions, input pricing, price support and cotton marketing. Cotton production has suffered setbacks in some countries, notably the impact of leaf curl virus disease in Pakistan and India and the development pyrethroid resistance in Helicoverpa populations in China, India and Pakistan.

The nine country study of Cotton Production Prospects for the Next Decade was initiated because projections on consumption indicate a steady increase as a result of population growth, increased per capita consumption in some countries, an increasing share of the fiber market as a result of new spinning technology and increased public awareness of the advantages of cotton, particularly in the USA and Europe. However, some projections over the same period suggest that there could be a decline in the area planted to cotton because of the need to produce more food. The increase in production, therefore, may have to come from higher yields and not from area expansion. The intention of this study was to use case studies of key cotton producing countries to determine where and how the increase in yield will be achieved in a sustainable agricultural system. Even if cotton/food crop price ratios rise, any significant expansion in cotton area seems unlikely. There has been none in the last forty years (Figures 1; Table 1.2).

Cotton is grown in over seventy countries and is one of the most important cash crops in the world. The fiber is used universally as a textile raw material while cottonseed is a major source of vegetable oil and cottonseed cake which is a source of high quality protein for stockfeed or, with careful processing, for human food. Cotton plays a vital multi-sectoral role in the economies of many developing countries in Asia, Africa and Latin America, earning foreign exchange and providing employment for millions of people in the agricultural and related processing and textile sub-sectors. Foreign exchange earnings may come from the direct export of raw cotton or from the export of value added cotton based textiles.

Over the past fifty years, cotton lint production has increased from an annual average of 5.24 million mt between 1946 and 1950 to a projected 19.12 million mt between 1991 and 1995 (Figure 1). Initially, the increase resulted from area expansion from an average of 26.27 million ha between 1946 and 1950 to 35.44 million between 1951 and 1955 (Figure 1). New areas came into production as a result of the work of the British Empire Cotton Growing Corporation (ECGC) and the French Institut de Recherches du Coton et des Textiles Exotiques (IRCT), mainly in Africa, expansion of irrigation in Central Asia and the impact of new pesticides which made it possible to move into areas which had previously been considered unsuitable for cotton because of the incidence of insect pests. Since the mid 1960s, however, the area planted to cot- ton has remained fairly constant at between 32 and 34 million ha and most of the increase in production has come from yield enhancement, resulting from improved varieties, agronomic practices and crop protection, going from a five-year average lint yield of 200 kg/ha between 1946 and 1950 to a projected 582 kg/ha between 1991 and 1995 (Figure 2).

A great deal of the increase in world production occurred in the former Soviet Union (predominantly Uzbekistan) and the Peoples' Republic of China. These two countries, together with the USA, produce about two thirds of the world's cotton. Spectacular increases in production also occurred in Pakistan, Australia and Southern Africa. Over the past twenty years, several countries, notably in South East Asia, have introduced programs to encourage cotton production in order to reduce reliance on imports to supply the needs of their rapidly expanding textile industries. While these countries are never likely to become major cotton producers, if they achieve even partial self sufficiency, it will influence world trade in raw cotton.

The governments of most cotton producing countries are heavily involved in cotton production and marketing because of its multi-sectoral role in the economy and its socio-economic and strategic importance. This was discussed in World Bank Technical Paper 231 (Ibid). In practically all cases this involves some form of price intervention or stabilization to bolster grower confidence, prevent wide fluctuations in production caused by price volatility, or to provide supplies of fiber to domestic textile industries at prices below the international level. This may be a fixed price for a specific grade of seed cotton, declared in advance of the season with premiums and discounts for grades above and below the standard grade or it maybe a minimum price which only comes into play if the international price for a standard grade falls below this level. The fixed price may be based on long term averages to stabilize the farmgate price or it may be related to the current lint equivalent price on the international market. Government intervention may also involve input subsidies and procurement which affect input price and supply and/or import/export taxes, quotas etc. which affect trade. The various types of policy are discussed in Chapter 3.

Government interventions influence domestic production, the domestic textile industry and the international cotton, yarn and textile markets. Arguments for their justification include economies of scale, quality control, logistical barriers and environmental concerns. Some of the arguments have economic/technical justification while others do not. However, while cottonseed is a valuable source of vegetable oil and protein, cotton is grown primarily to supply the raw material needs of the textile industry, an industry that relies on regularity of supply and quality. Thus studies of cotton production economics and policy should be complemented by an under- standing of their impact on the markets for cotton lint, yarn and textiles.

Initially, the study "Cotton Prospects for the Next Decade" was intended to be a study of technological innovations that could lead to the necessary yield increases. However, because the interdependence between production and the textile industry influences government policies and these policies influence yield through their impact on the application of new technology, the scope of the study was widened to encompass policies on input supply and pricing, the farmgate price for seed cotton/lint and marketing. The importance of the textile industry in several of the countries in the study necessitated consideration of government policies on these industries.

The study was conducted in Brazil, China, Egypt, India, Mali, Mexico, Pakistan, Tanzania and Uzbekistan. China, India, Pakistan and Uzbekistan were selected as four of the world's top five cotton producing countries. Egypt produces fully irrigated, speciality cotton which has the best quality of its type in the world. Until recently, Brazil was the sixth highest cotton producer in the world and also the sixth largest consumer. Mexico has been an important producer but production has declined, largely because of government policies on alternative crops. Finally Mali and Tanzania represent two countries which have environmental similarities but differ in the level of management of their cotton sub-sectors.

Local, multi-disciplinary teams of consultants were employed to conduct the country studies. The country report were reviewed in each country at a meeting attended by the study team and representatives of all sectors of the cotton industry. The World Bank employed inter- national consultants to review the draft documents and to assist in the preparation of a synthesized draft report, a draft document on Challenges and Recommendations and a draft document on Country Policies. These documents were discussed at the Ismailia International Workshop, Cotton Production Prospects for the Next Decade' which was organized by the Canada Egypt Mcgill Agricultural Response Program, in cooperation with the Egyptian Government from November 14 to 17, 1994. Representatives of each of the study teams and specialist consultants participated in this workshop to identify common conclusions of the case studies and to discuss the study follow-up.

This document is a synthesis of the reports of the target country study teams. Chapter 6 brings together their conclusions and recommendations which formed the basis of discussions at the Ismailia International Workshop, and provides a summary of the workshop discussions.

Cotton

Introduction

Is a vegetable fibre obtained from the mature capsule of the cotton plant, a shrub about 40 cm high, with leaves and flowers of a red or yellow colour. When the flower is fecundated it loses its petals and within 25 days a capsule surrounded by a leaf called bract grows. The capsule is sustained by a cup and has a drop shape rounded at the lower extremity. Inside the capsule there are from five to eight seeds on which the fibre developed. When the capsule is mature it opens into four parts showing the cotton ball. On the same plant the maturation of the capsules does not occur simultaneously, therefore more passages are required for the harvest of the cotton. The harvest is carried out a week after maturation. The first operation after harvesting is husking, which permits the removal of the fibres from the seeds. Then the cotton is carded and combed so as to eliminate all the impurities. 4000 fibers is the seed average. Staple length = 1/8" - 2.5" (0.32 - 6.35cm) - for manufacturing yarns, fabrics, 7/8" - 11/4" (2.22 - 3.18cm) is standard.

The requisites on the basis of which to judge the quality of the cotton are the grade, the colour, and the length of the fibres and the character.
The grade is given by the external appearance of the cotton and is determined on the basis of the major or minor brightness of the fibres, by its more or less white color, by the major or minor presence of particles of the leaf or other extraneous substances.

The color is another important element of evaluation of cotton.
In fact, from the major or minor whiteness of the cotton depends the facility of later workings and the possibility of obtaining good yarns. The colour of cotton fibre differs greatly: that of cultivated cotton is generally white, more or less candid or tending towards grey; but there are also reddish, tawny, chamois, etc. coloured varieties.

The length is the most important attribute of the fibre. In this regards, cotton is divided into two large categories: long fibre cottons (long staple), which measures more than 28 mms and amongst which Sea Island in the United States holds the record and the Egyptian Makò and Sakellaridis which arrive at and sometimes overreach 50 mms, and short fibre cotton (short staple), that do not reach the length of 18 mms and that derive from the Asian regions; there is also an intermediate category of cottons whose fibre length is included between 18 and 28 mms, such as those from the United States Uplands and which constitute the grand mass of the world production, 60% and more.
The character is the attribute determined with more difficulty. It is in part connected with the origin, variety and maturity, but at the end a cotton of good character is that whose fibres are the most strong and robust, so as to resist traction and breakage, homogenous and uniform, so as to produce few losses in working, and have a complete physical-chemical constitution, so as to give the cotton mass notable solidity and compactness, smoothness and silkiness. The biggest cultivations of cotton are to be found in America, India, China, Egypt, Pakistan, Sudan and Eastern Europe.

Properties

Cotton, as a natural cellulose fiber, has a lot of characteristics, such as:
Comfortable Soft hand
Good absorbency
Color retention
Prints well
Machine-washable
Dry-cleanable
Good strength
Drapes well
Easy to handle and sew

Specific gravity
1.54
Strength (Tenacity)
3.0 - 4.9 g/d
(cotton is 20% stronger when wet)
fiber elongation is almost linear to
the stress imposed
Elasticity
Relatively low
Absorbency and Moisture Regain
7-8% at standard conditions
Birefringence
0.046
Dielectric constant
3.9-7.5
Resistivity
Order of 109 ohm/cm3
Micronaire
2.0 - 6.5 (upland cotton)
Denier
0.7 - 2.3 (upland cotton)
Length
0.9 - 1.2 in (upland cotton)
Diameter

9.77 - 27.26
Coefficient of friction
0.25 (for raw dry cotton, otherwise strongly changes for treated and/or wet fiber)
Thermal Properties
Decomposes when exposed at the temperatures about 300oF

FIBER LENGTH
Fiber length is described as "the average length of the longer one-half of the fibers (upper half mean length)" This measure is taken by scanning a "beard " of parallel fibers through a sensing region. The beard is formed from the fibers taken from the sample, clasped in a holding clamp and combed to align the fibers.

LENGTH UNIFORMITY
Length uniformity or uniformity ratio is determined as " a ratio between the mean length and the upper half mean length of the fibers and is expressed as a percentage".

FIBER STRENGTH
Fiber strength is measured in grams per denier (g/d) or centi-newton per tex cN/tex. It is determined as the force necessary to break the beard of fibers, clamped in two sets of jaws, (1/8 inch apart). The breaking strength of cotton is about 3.0~4.9 g/denier, and the breaking elongation is about 8~10%.

MICRONAIRE
Micronaire measurements reflect fiber fineness and maturity. A constant mass (2.34 grams) of cotton fibers is compressed into a space of known volume and air permeability measurements of this compressed sample are taken. These, when converted to appropriate number, denote micronaire values.

COLOR
The color of cotton samples is determined from two parameters: degree of reflectance (Rd) and yellowness (+b). Degree of reflectance shows the brightness of the sample and yellowness depicts the degree of cotton pigmentation. The color of the fibers is affected by climatic conditions, impact of insects and fungi, type of soil, storage conditions etc. There are five recognized groups of color: white, gray, spotted, tinged, and yellow stained. As the color of cotton deteriorates, the processability of the fibers decreases.

TRASH
A trash measurement describes the amount of non-lint materials (such as parts of cotton plant) in the fiber. Trash content is assessed from scanning the cotton sample surface with a video-camera and calculating the percentage of the surface area occupied by trash particles. The values of trash content should be within the range from 0 to 1.6%. Trash content is highly correlated to leaf grade of the sample.

LEAF GRADE
Leaf grade is provided visually as the amount of cotton plant particles within the sample. There are seven leaf grades (#1-#7) and one below grade (#8).

PREPARATION
Preparation is the classer's interpretation of fiber processability in terms of degree of roughness or smoothness of ginned cotton.

EXTRANEOUS MATTER

Extraneous matter is all the material in the sample other than fiber and leaf. The degree of extraneous matter is determined by the classer either as "light " or "heavy".

NEPS

A nep is a small tangled fiber knot often caused by processing. Neps can be measured by a nep tester and reported as the total number of neps per 0.5 grams of the fiber and average size in millimeters. Nep formation reflects the mechanical processing stage, especially from the point of view of the quality and condition of the machinery used.

CHEMICAL PROPERTIES OF COTTON

Cotton swells in a high humidity environment, in water and in concentrated solutions of certain acids, salts and bases. The swelling effect is usually attributed to the sorption of highly hydrated ions. The moisture regain for cotton is about 7.1~8.5% and the moisture absorption is 7~8%.

Cotton is attacked by hot dilute or cold concentrated acid solutions. Acid hydrolysis of cellulose produces hydro-celluloses. It is not affected by cold weak acids. The fibers show excellent resistance to alkalis. There are a few other solvents that will dissolve cotton completely. One of them is a copper complex of cupramonium hydroxide and cupriethylene diamine

Cotton degradation is usually attributed to oxidation, hydrolysis or both. Oxidation of cellulose can lead to two types of so-called oxy-cellulose, depending on the environment, in which the oxidation takes place. Cotton can also degrade by exposure to visible and ultraviolet light, especially in the presence of high temperatures around 250~397° C and humidity. Cotton fibers are extremely susceptible to any biological degradation (microorganisms, fungi etc.)

OPTICAL PROPERTIES OF COTTON

Cotton fibers show double refraction when observed in polarized light. Even though various effects can be observed, second order yellow and second order blue are characteristic colors of cellulose fibers.

Applications

The major end-uses of cotton include:

Apparel - in a wide range of wearing apparel: blouses, shirts, dresses, children wear, active wear, separates, swimwear, suits, jackets, skirts, pants, sweaters, hosiery, neckwear.

Home Fashion - curtains, draperies, bedspreads, comforters, throws, sheets, towels, table cloths, table mats, napkins

Medical and cosmetic applications - bandages, wound plasters

Technical applications -

White cotton articles should be washed in the washing machine at 60° C, whilst colored cloths, especially if dark, should be washed at lower temperatures. Normally it should be ironed on the right side. Dark articles should be first ironed on the inside and then on the outside, with a cloth, to avoid that the heat of the iron shine the cloth. White articles can be starched to give more consistency to the cloth and avoid it creasing easily.

Grades

fibers

ground flock

tow/tops

spun yarns

Grading of cotton quality takes into account:

length
uniformity
diameter
strength
maturity
color
amount of foreign matte

American Upland
50% world crops major type grown in SE US – white , 13/16 - 1 1/4 inch (2.1 - 3.2 cm) length, diameter = 18 my
American Pima
longer than Upland 1 3/8 - 15/8 in (3.5 - 4.1 cm) - more costly grown mostly in SC, NM, and AZ
Egyptian
1 ½ - 1 ¾ in. (3.8 - 4.4 cm), yellow brown in color
Sea Island - SC, GA coast
longest of all cotton fibers 13/8 - 21/2 in. (3.5 - 6.4 cm), most expensive, yellow in color

Processability

Each cotton fiber is composed of concentric layers. The cuticle layer on the fiber itself is separable from the fiber and consists of wax and pectin materials. The primary wall, the most peripheral layer of the fiber, is composed of cellulose crystalline fibrils. The secondary wall of the fiber consists of three distinct layers. All three layers of the secondary wall include closely packed parallel fibrils with spiral winding of 25-35° and represent the majority of cellulose within the fiber. The innermost part of cotton fiber- the lumen- is composed of the remains of the cell contents. Before boll opening, the lumen is filled with liquid containing the cell nucleus and protoplasm. The twists and convolutions of the dried fiber are due to the removal of this liquid. The cross section of the fiber is bean-shaped, swelling almost round when moisture absorption takes place.

The overall contents are broken down into the following components.

80-90%	**cellulose**
6-8%	**water**
0.5 - 1%	**waxes and fats**
0 - 1.5%	**proteins**
4 - 6%	**hemicellulose and pectins**
1 - 1.8%	**ash**

During scouring (treatment of the fiber with caustic soda), natural waxes and fats in the fiber are saponified and pectins and other non-cellulosic materials are released, so that the impurities can be removed by just rinsing away. After scouring, a bleaching solution (consisting of a stabilized oxidizing agent) interacts with the fiber and the natural color is removed. Bleaching takes place at elevated temperature for a fixed period of time. Mercerization is another process of improving sorption properties of cotton. Cotton fiber is immersed into 18- 25% solution of sodium hydroxide often under tension. The fiber obtains better luster and sorption during mercerization.

After scouring and bleaching, the fiber is 99% cellulose. Cellulose is a polymer consisting of anhydroglucose units connected with 1,4 oxygen bridges in the beta position. The hydroxyl groups on the cellulose units enable hydrogen bonding between two adjacent polymer chains.

FIBER PROCESSING

About 30% of world cotton production is harvested by machines. Australia, Israel and USA are the only countries where all cottons are picked by machines. Fifteen percent of world cotton production is ginned on roller gins and almost all rest of cotton is saw ginned in most countries.

Historic info on cotton:

The earliest evidence of using cotton as a textile fiber is from India and the date assigned to this fabric is 3000 B.C. There were also excavations of cotton fabrics of comparable age in Southern America. Cotton cultivation first spread from India to Egypt, China and the South Pacific. Even though cotton fiber had been known already in Southern America, the large scale cotton cultivation in Northern America began in the 16th century with the arrival of colonists to southern parts of today's United States.

The largest rise in cotton production is connected with the invention of the saw-tooth cotton gin by Eli Whitney in 1793. With this new technology, it was possible to produce more cotton fiber, which resulted in big changes in the spinning and weaving industry, especially in England. Today, cotton is grown in more than 80 countries worldwide.

Exporting And Marketing

- The world's main cotton exporters are the United States (6.5 million bales), Uzbekistan (3.5 million bales) and Australia (3 million bales).
- Australia is only a small supplier in the world cotton market, accounting for about 12% of world exports, so variations in Australian production have a small influence on world prices.
- Around 200,000 bales of the cotton grown in Australia is spun by local spinning mills, the remaining 94% is exported, largely to Asia.
- Indonesia, Japan and Thailand are the main buyers of Australian cotton with other countries including South Korea, India, Taiwan, Italy, Bangladesh, the Philippines, Hong Kong, Turkey and Ireland.
- Despite cotton's fall in the share of the world fibre market, consumption of cotton is increasing overall due to increases in population growth.
- Land area sown to cotton has remained static since the mid 1980s, with production increases arising from increased yields.
- As the bulk of the Australian crop is harvested between February and May, Australia effectively has a window in which to trade its cotton on the world market when supplies from other major exporters are somewhat restricted.
- Australian marketers can aim to avoid the seasonal low in October-November when the US crop that dominates world supplies is harvested.
- Australian cotton growers forward-sell their crops, even before they are sown, and up to three years in advance. They mostly do this through a processor/marketing company.
- The largest processor/marketers in Australia are the Namoi Cotton Co-operative, Auscott and Queensland Cotton. Colly Farms and Dunavant are two other organisations. These companies are represented by the Australian Cotton Shippers Association.

How to grow a pair of jeans

Soil

- Healthy soil provides nutrients, water and stability for cotton plants. Growers are often members of Landcare groups and use crop rotations and no till farming to care for the soil.

Water

- About 80% of cotton is irrigated. Cotton, like any other plant, needs water to grow.

Seed

- There are over 10 varieties of cotton grown in Australia. Many have been developed especially to suit Australian conditions. Some even grows in colours!!

Pesticides

- More than 30 different pests attack cotton crops. They can damage crops and ruin the cotton's quality. Growers use a combination of different chemicals, farming methods and natural predators to control them.

People

- There are many different people involved in the cotton industry from the field to the shop. Agronomists, chippers, pilots, bug checkers, fashion designers and manufacturers work in the industry.

Preparing the land

- Before the cotton can be planted the seedbed needs to be prepared. This is done using a tractor and cultivation machinery.

Planting

- Cotton is planted in late September to mid November. A cotton plant will grow to about 1 metre in 180 days.

Watering

- Most farms are watered by furrow irrigation, which means running water down between rows of cotton. Irrigated cotton farms recycle the water they use to prevent waste. Dryland farms rely on rainfall.

Controlling the Pests

- Farmers use a combination of methods to control pests such as - attracting good insects, disturbing insect burrows, cotton varieties that need fewer chemicals and applying pesticides. Pesticides are carefully applied to the cotton crop in ideal weather conditions.

Weeding

- The crop is "chipped" to protect it from weeds. Teams of cotton chippers do this job by hand, using a hoe.

Picking

- Around March to May, depending on the region, cotton bolls mature and split open to reveal fluffy cotton. A machine is used to pluck the cotton and it's blown into a big basket on the back of a cotton picker.

Processing (ginning)

- The raw cotton is sent by truck to a cotton "gin". It is put through machines that separate the fluffy cotton from the cotton seed. It also removes trash like leaves and dirt.

Shipping

- Over 90% of Australia's cotton is packed in containers and sent overseas to be made into fabric and other products.

Spinning and Weaving

- At the mill the cotton is combed into long continuous ropes and then spun into yarn. Next it's knitted or woven into fabric, cut into lengths and made into cotton products like...

JEANS!

Where is Cotton Grown?

Australia

- In Australia, cotton is grown mainly in central and north-western NSW and central and southern Queensland.
- In the 1999/2000 season, 452,000 hectares were set aside for cotton growing. Of this, 307,000 hectares were in NSW with the remainder in Queensland.
-

Globally

- Cotton is grown in over 90 countries.
- The main cotton producing countries are China, the USA, India, Uzbekistan and Pakistan.

Facts and Figures

Number of Growers

There are approximately 1,500 growers in Australia. The vast majority of cotton farms are family-run and typically grow around 400 hectares of cotton each season.

Total Cotton Growing Area

The total cotton growing area for Australia for the 2000/01 season was 512,000 hectares. Of this, 334,000 hectares were in NSW and the remaining 178,000 were in Queensland.

The total world cotton growing area was 31.6 million hectares.

Production

The Australian cotton industry produced just over 3.4 million bales of cotton in the 2000/01. The gross value of this production was over $1.7 billion.

The world cotton industry produced in excess of 85 million bales. Of this, China produced 19.4 million bales and the United States produced 16.6 million bales. Other major producers include India, Pakistan and Uzbekistan.

Exports

Australia exports approximately 94% of its cotton crop. The value of these exports in 2000/01 was in excess of $1.5 billion.

The main buyers of Australian cotton are Indonesia, Japan and Thailand.

Yields

Australia has some of the highest yields for cotton grown in the world. For the season 2000/01, Australia cropped 1,528 kg per hectare or 2.59 times the world average.

For more in-depth facts and figures please go to the following:

Research and Technology

The cotton industry invests heavily in the fields of research and technology. The majority of research funds are invested in areas of crop protection, reducing dependence on chemicals, sustainable farming practices and the breeding of new cotton varieties.

Growers pay a compulsory research levy of $1.75 per bale to the Cotton Research and Development Corporation and these funds are matched by the Commonwealth Government up to 0.5 per cent of the gross value of production.

Other research organisations leading the way in the Australian cotton industry are the Australian Cotton Growers Research Association and the Australian Cotton Cooperative Research Centre.