CHAPTER (2)

REVIEW OF THE LITERATURE

1. Introduction

Continuing high prices of raw materials, fibre shortages resulting from natural disasters and fluctuations in demand, caused by economic recessions, make the reclamation and reprocessing of waste fibers of increasing importance in the world today.

The advantages of waste as a raw material are of course obvious, almost unlimited quantities are availab1e, levels of supply consistent and prices relatively stable. Almost the ideal raw material, it could be argued, and the only issue which can come into question is the economic viability of collecting waste. This is. However, dependent on social and other factors and these are outside the scope of this paper.

Wastes of interest are those which are either in, or can be broken down into fibrous form, for re-processing into yarn. That is:

1- Those wastes produced during the preparation and processing of fibers from the bale right through to the fabric stage; in the blow-room during carding drawing combing and then during the yarn and fabric producing stages, and of course also during spinning, winding, warping, weaving and knitting.
2- Fabric produced by cutting during garment make-up; that is: knit clips and fabric strips.
3- And finally, the worn out and disposed of garments and fabrics which can be-processed in rag form.

Wastes have been collected, sorted and graded for a very long time for conversion into yarns wadding, cotton-wool, non-woven paper, felts etc. but from this diverse range of products it is my intention to deal with only one the production for yarns from waste.

Traditionally, this has been carried out by condenser spinning in the condenser spinning process material is passed though a card with workers and strippers, and condenser bobbins produced containing slubbings. These are then ring spun on to large tubes using a low draft and yarn subsequently rewound on to bobbins. It is usual to add between 3-8% oil or soap to ensure sufficient inter fibre cohesion for drafting and to produce yarns in the range 60-200 Tex (Ne 3-10) at a production speed of 13-15 m/min.

It is not surprising therefore that waste spinners were quick to realize the potential of rotor spinning with its capability of handling fibres having a wide range of micronaire values and lengths at production rates 6-8 times higher than could be achieved with condenser spinning.

2. User classification and their fiber requirements

But who spins waste?
It is our experience that there are three main categories of user:-

1- The waste spinner, who buys different wastes in bale form, possibly cleans them and then spins them into yarn.

2- The conventional spinner who has a requirement for yarn whose parameters are not particularly stringent and who can therefore include a proportion of waste in his blend to reduce raw material costs.
3- A large spinning mill, possibly vertical in structure, operating also looms or knitting machines, so producing waste which must be disposed of as waste, or processed further into yarn capable of being used to make a saleable end product.

While the waste requirements of spinners in the above categories can to a degrees overlap, the fibers actually used will in each case be dictated by different circumstances.

For instance, long gone are the days when the waste spinner spun only noil rich blends. Increasing demand for noil and therefore their cost has been responsible for that. Instead, today he will use a wide range of fibres, the quantity of each in his blend being determined by price availability and final end product requirements. The waste spinner therefore probably has the greatest flexibility in his choice, particularly as possibility generally may not be of paramount importance. In any case, end breaks occurring per kilo of yarn produced will probably be far lower when rotor spinning, even under poor conditions, than was ever possible with condenser spinning.

This is in contrast to the requirements of the conventional spinner who, if including a percentage of waste fibres, must ensure that he does not over degrade his stock in two respects: trash content, which will increase the end breakage rate, and secondly mean fibre strength, which will be directly reflected in the strength of the rotor yarn produced. And lastly, there is the vertical organization equipped with a rotor spinning section to process waste, created by main stream processes. While certainly additional waste can be bought in to increase the size of the waste spinning operation or its flexibility, blend composition will usually be established by waste availability.

Typical quantities of waste liberated by a combed mill are shown in table (2-2). This means that to ensure the most effective utilization of the waste produced the following blend be spun are shown in table (2-1).

Table (2-1) represents the blend be spun from the waste produced

Flat strip	20%
Under card waste	10%
Noil	60%
Pneumafil waste	10%

And this is typical of the type of blend processed, though with rising price of noil, it is increasingly being replaced by other recovered fibres, and the noil sold separately.

3. Waste classification

Basically, cotton based wastes can be placed in four categories, each of which requires a different approach to its preparation, that is: the processes involved in-opening the fibres sufficiently for further processing and where necessary removing included foreign matter (trash, dust etc.) later the wastes will be blended and possibly man-made fibre (such as viscose) or virgin cotton added, though it must be appreciated that some man-made fibers may be introduced into the blend through being already in one of the constituents (such as polyester fibres in pneumatic waste from a polyester/cotton plant),The four categories are:-

3.1 Dirty soft wastes

a- Gin motes – having high trash content and containing a high percentage of immature fibres, as well as much dust.
b- Blow- room droppings – Again, having a high trash dust and short fibre content.
c- Suctcher waste – as (b) above.
d- Under card waste – also as (b) above.
e- Filter waste – with an extremely high dust and short fibre content.
f- Flat strip from low quality cottons – some good fibre but having a high dust and trash content.
g- Floor sweepings – generally contaminated with mineral impurities and possible hard waste. There may also be some man-made fibres.

Table (2-2) Re-workable Materials and Wastes Produced By a Combed Cotton Ring Mill

Process	Re-workable Materials	Reprocessable Waste
Blow room		Droppings 1.2% Filter 0.2%
Carding	Sliver 0.9 %	Flat Strip 0.2% Undercard 1.4% Sweepings 0.4%
Drawing	Slivers 1.3 % (Per machine)	
Lap preparation	Sliver and laps 0.3 %	
Comber	Sliver 1.6 %	Noil 15%
Roving	Sliver 0.3 % Rovings 0.2%	
Ring Spinning		Pneumafil 1% Hard waste 1%

3.2 Clean fibre wastes

a- Comber noils usually with a high nep content.
b- Flat strip from good medium cottons with up to 10% trash
c- Pneumatic waste
d- Draw frame sliver or card web wastes clearly having good fibre length and high cleanliness.

3.3 Soft twist waste

(a) Roving waste: clean and containing good length fibres.

3.4 Hard twist waste

(a) Cop ends and winding waste.
(b) Knitted and woven fabric clips.
(c) Selected rags (colour and fibre type being the main criteria to which sorting must be carried out).

4. Preparation

4.1 Requirements:

Bearing in mind that the fibres are to be prepared for rotor spinning, with blending being followed by a further passage of opening (optional), carding and possibly one stage of drawing, the following requirements must be met:-

(1) Fibre length: the maximum fibre length of the blend to be spun must not exceed a predetermined figure set by parameters of the rotor spinning machine. This is usually the rotor diameter which means a maximum of 40 or 60mm, with a corresponding free length between the nip of the feed roller and associated feed pedal and the point where the fibres come into contact with the opening roller clothing (pins, or wire tooth points).
Normally, there is no requirements to specify limits to minimum fibre length because a high short fibre content is frequently beneficial in rotor spinning, particularly when spinning coarse count yarns (coarser than 200 tex / 3Ne) Certainly the presence of short fibres does not reduce spinnability of the blend, measured in terms of and breaks per 1000 rotor hours, though a short mean effective fibre length will result in a lower overall yearn strength.

(2) Trash content: while many rotor spinning machines today are fitted with a very effective trash removal devices, capable of removing 50% more of the trash in the sliver spun, if a high end breakage rate is to be avoided during spinning, this trash removal device should not be considered a cleaning point in the process line.
Adequate cleaning of the stock to be spun should, and must be carried out before the material is fed to the rotor spinner. That is, the sliver should not contain more than 1.5% solid trash, as measured by the Shirley Analyzer.
It is however equally important that wastes are not over worked, as otherwise this will result in "stringing" to indicate a level it is usual to carry out sufficient leaning to ensure that the trash content of the card lap does not exceed 3% which in turn should ensure that the level of trash in the card sliver is not more than 1% which is below the specified maximum.

(3) Additives : while it is customary in the conventional spinning route – involving the roller clearer card and condenser spinning to add oils or water to reduce carding waste, increase fibre cohesion in the low twisted strands on the condensers bobbins , and to generally lubricate the fibres passing through the travelers and guides on the ring frame, additives in general cannot be tolerated for rotor spinning residual levels of oil or other additives to the fibres, whatever their origin will be deposited within the spinning head, on which entrained or liberated micro-dust and short fibres will build up, to ultimately stop the spinning operation. This effect is particularly detrimental within the rotor spinning groove.
Where an extremely heavy deposit will rapidly build – up due to the high centrifugal forces acting as a result of the rotation of the rotor. The degree of cleaning required to remove such deposits can be extremely tedious as is well known by those who have had to undertake this operation, or clean up after an abortive attempt has been made to spin cotton heavily contaminated with honey-dew.

Additives are normally only added to man-made fibre wastes at very low levels and they must then be applied evenly with metered dosing equipment made for the purpose.

4.2 Blow Room processing

To ensure that processed wastes meet laid-down specifications, in terms of maximum fibre length and trash content it is evident that each of the stated waste group will require a different processing ling.

Dirty waste will obviously need more severe cleaning than clean waste which in turn will only require opening or may even be blended in without prior treatment. Hard twisted waste, in the form of thread or fabric requires reducing to a fibrous state without further cleaning, with particular care being taken to ensure that hard threads are kept to an absolute minimum and preferably eliminated.

This means that there are three basic options:-

(1) To treat each element of waste according to its composition and then to blend the various components this can be carried out as a continuous process or in separate pretreatment lines for the twisted and dirty wastes, followed by pressing the treated wastes into bales, with all the wastes finally being fed through a short blow-room line.
(2) To blend the components and then process the mix according to its overall trash content, as if it ware a standard cotton mix. This approach applies of course only to constituents which can be readily mixed and not to hard on fabric wastes which must be treated separately.
(3) A combination of (1) & (2) above, involving the pretreatment of certain elements, such as particularly dirty materials.

If one takes option (1) then a line capable of dealing with all types of waste and if producing any required blend would take the from shown on fig.(2-1).

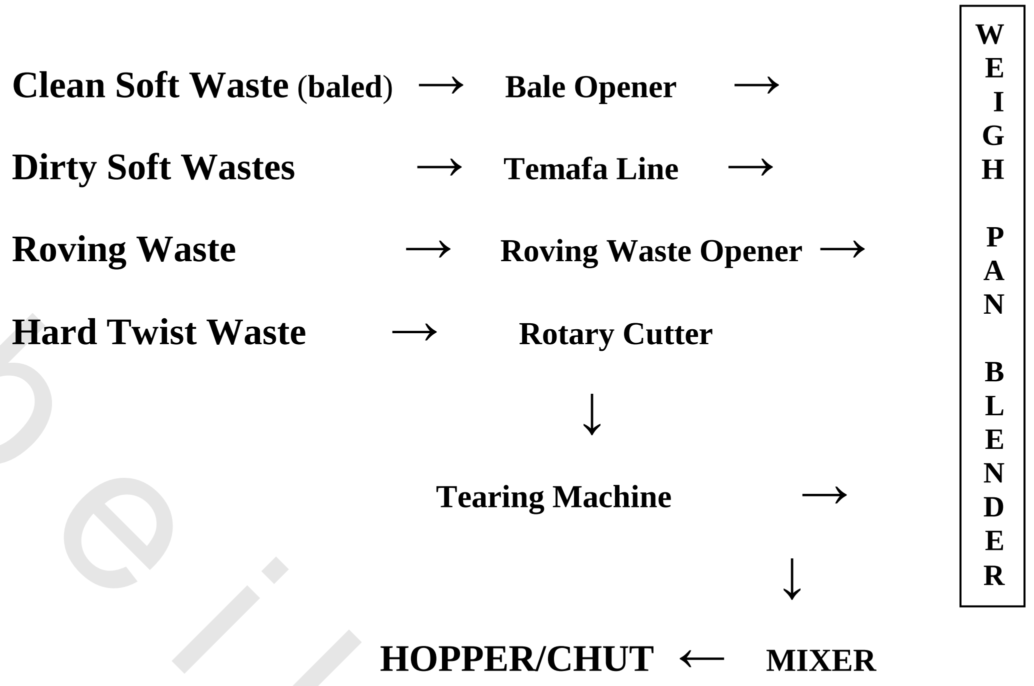

Fig. (2-1) All purpose cottone waste blowroom line

Provision can also be included for adding a carrier fibre, such as polyester ,viscose, which might be necessary in certain circumstances, though it is not universally recommended in view of the fact that a passage of drawing may have to be included in later preparation stages, which would otherwise be avoided.

Such a line would be more suitable for a large vertical organization requiring processing all types of waste.

The following process routes would be employed:-

(a) Clean soft waste (baled): Bale opener – weigh pan blender.
(b) Dirty soft wastes (baled): Bale opener – willow (one or two machines) weigh pan blender,
(c) Roving waste: Roving waste opener – weigh pan blender.
(d) Hard twisted waste: Guillotine or rotary cutter, multi cylinder opener or pulling machine – weigh pan blender.

It will be noted that the initial stage of mixing is carried out by a weigh pan blending system, which is recommended to ensure that constituents are mixed together in constant proportions. This is essential for successful spinning as is the inter position of some kind of stack mixer to even out short term variation. These, if not removed will be directly reflected in yarn properties such as yarn strength, variations in strength and yearn regularity, as well as in the evenness of dye up-take by the yarn in the finished end product.

It may even be advantageous to further open the fibres leaving the stack mixer before carding. A less sophisticated variation of this line is shown in fig.(2-2).

Here each component is pre-processed where necessary, and put into bale form, and then Blended using hopper bale openers. Any one of the pre-processing lines can of course be deleted if the mill does not intend to process a specific type of waste.

Experience has shown that some types of waste do not mix together easily, especially where one constituent is supplied as a dense hard pressed bale and others are lightly pressed or in loose form. In such cases it is essential to include a mixer in the line, particularly when the throughput volume is low.

Under the second option involving no pre-processing it is the trash content which determines the processing line, if an all clean waste blend is to be used, then only a hopper/bale opener and scutcher would be required and the line would be increased in cleaning power according to the trash content of the blend. See fig. (2-3).

If this total trash content of the blend exceeds 10% then the dirty components would have to be pre-cleaned in accordance with the third option to reduce the overall trash content contained by any constituent element.

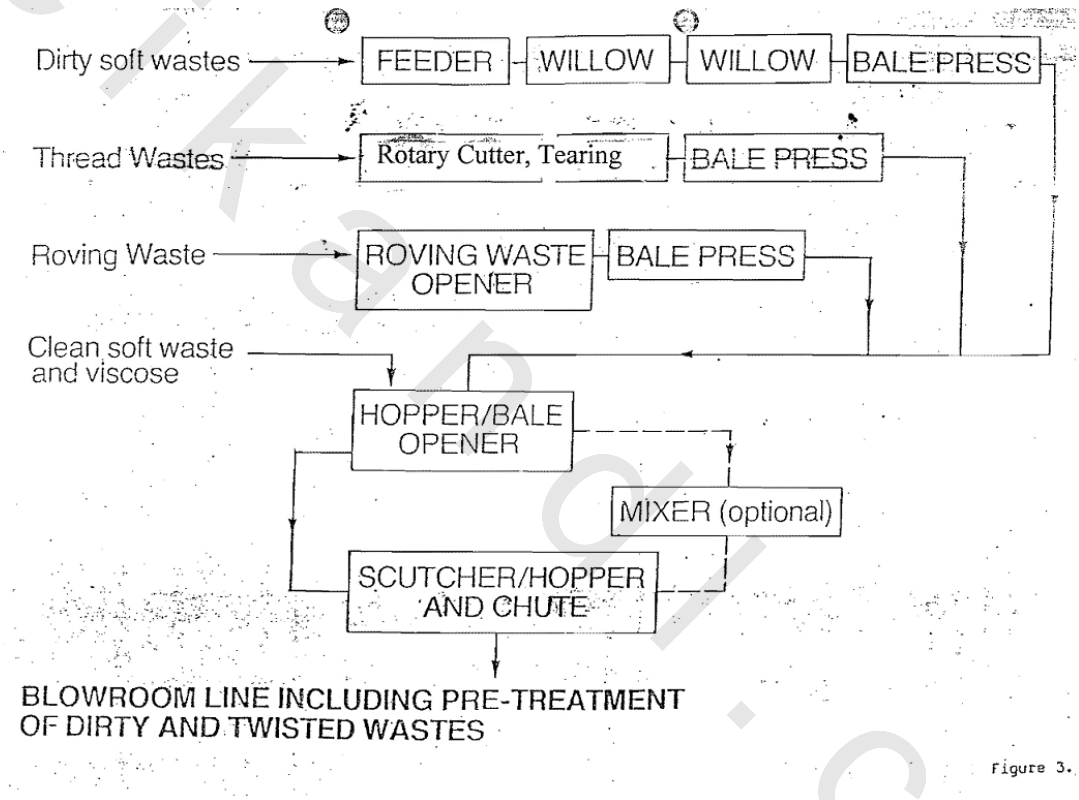

Fig. (2-2) Blow room line including pre-treatment of dirty and twisted wastes

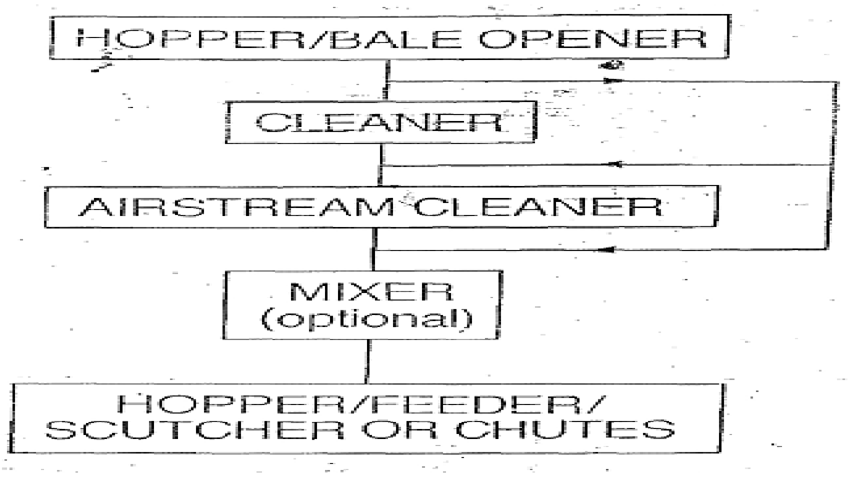

Fig. (2-3) Blow room line without pre-treatment

While a beater section could be added after the ultra cleaner, a second ultra cleaner, as used with dirty cottons would not normally be recommended because of the previously mentioned risk of stringing. Attention should also be paid to dust removal through the use of dust hoods and condensers.

If a lap former is employed, provision should be made to include in the lap former a means of feeding roving as binders into the lap to prevent their licking at the card.

4.3 Carding and drawing

Waste mixes will process quite satisfactorily on conventional high production cards, having either fixed or moving flats, the latter having an advantage in that no flat strip is removed – a rather pointless operation of flat strip is a constituent part of the blend. Card production rates would vary but lie normally within the range 20-30 kg/hr.

A further question of ten asked is whether single or tandem cards are better for processing waste. While it can be argued that for a given set of circumstances, a tandem card will remove more trash and dust, of importance is the quantity of fibrous waste also extracted by the card – which can be a tangible part of the mix being processed. In fact it is often said that the more of the processed stock the waste spinner can get into his yarn the richer he will become, perhaps this is an over statement of the fact, not taking into consideration the effect that too dirty a material will have on the subsequent spinning operation, but it does highlight the fact that there are causes however, where yearn is more important than, its quality, particularly if the yarns are for conversion into an end product with a short life expectancy.

On the other hand many waste spinners do have to supply yarns for use in high quality end products, (flannelette sheets, and upholstery fabrics) in which yarn variations have an extremely detrimental effect on quality.

Standards, in such cases the incorporation of an autolevelling system at the card can have a distinct advantage on the regularity of the yarn produced and on spinning performance.

A combined short and long term system would be recommended, the long term system being used to overcome short- comings in the card feed such as variations in lap thickness or irregularities caused by an improperly setup, or operating chute feed system.

Alternatively, an auto leveler can be incorporated at the draw frame, but this is of course only possible if a draw frame is employed in the preparation sequence. There can and should be no hard and fast rules about this.

Blends containing very high short fibre content may be difficult or quite impossible to pass through a draw frame in which case there is no alternative but to feed card sliver to the rotor spinner.

Omission of the draw frame however, on purely economic grounds can be a false economy and trials should always be undertaken to establish the effect of drawing on the process and the yarns produced. The difference can be quite startling both on the spinning performance and the quality of the yarn produced – and it can hardly be argued that a passage of drawing can have a critical effect on the economics of the process, because drawing is a low cost operation.

4.4 Rotor spinning

Evidence obtained from practical experience gained over a period of years indicates that no special features are required on a rotor spinner to be used for processing waste, as long as fibre preparation has been carried out in accordance with the requirements outlined. The very nature of the fibres handled implies a lower quality of feed stock, with a higher trash and dust content than would be present under normal cotton spinning conditions. In terms of overall concept the rotor spinner must have been designed to handle such raw materials. An effective trash removal device is essential, as a last stage of protection for the rotor. Further, to assure a satisfactory spinning performance close attention must have been given to design of the spinning head to minimize dust and trash accumulation in the rotor, through control of airflows through the spinning head and the choice of rotor having a groove suitable for waste.

Such a groove must allow an unimpeded transfer of twist to the fibres in the fibre ring as well as take up by twist of contaminants in the groove. Yet, the groove must not be so large that yarn strength is lost because fibers are no longer completely under control. Conversely, the groove must not be too small, in an attempt to maximize yarn strength, as then a severe cut-off will occur in the coarsest count that can be spun.

Rotor speed has not been found to be a critical factor. In fact, more and more evidence is becoming available to confirm that subject to any limitation imposed by maximum yarn delivery speed considerations, when producing very coarse yarns with a low twist, a rotor speed of 55000 rpm. Will frequently produce a stronger yarn than one spun at 45000 rpm.

While most waste blends will produce yarns over quite a wide count range when rotor spun, there is usually quite a sharp cut-off within the range 50-60 Tex (Ne 10-12) which is relatively independent of blend composition.

This has been confirmed by carrying out limit spins on different waste blends submitted by customers to us for test spinning, over a period of time.

Sometimes however, surprising results can be obtained, as for instance with a 50/50% blend of comber noils from Sudan and Egyptian cottons, having a pressley fibre strength of 96800 ibs/sq.ins., a micronaire value of 3.2 and other parameters as shown. It was possible to spin this material to 37 Tex (Ne 16) at a rotor speed of 55000 rpm. Using a 5.0 T.F. Test results show a very high yarn strength compatible with the high strength of the fibres spun, which is nevertheless unusual in view of the fine count, which must be very near to the limit for the material (see figures (2-4)&(2-5) .

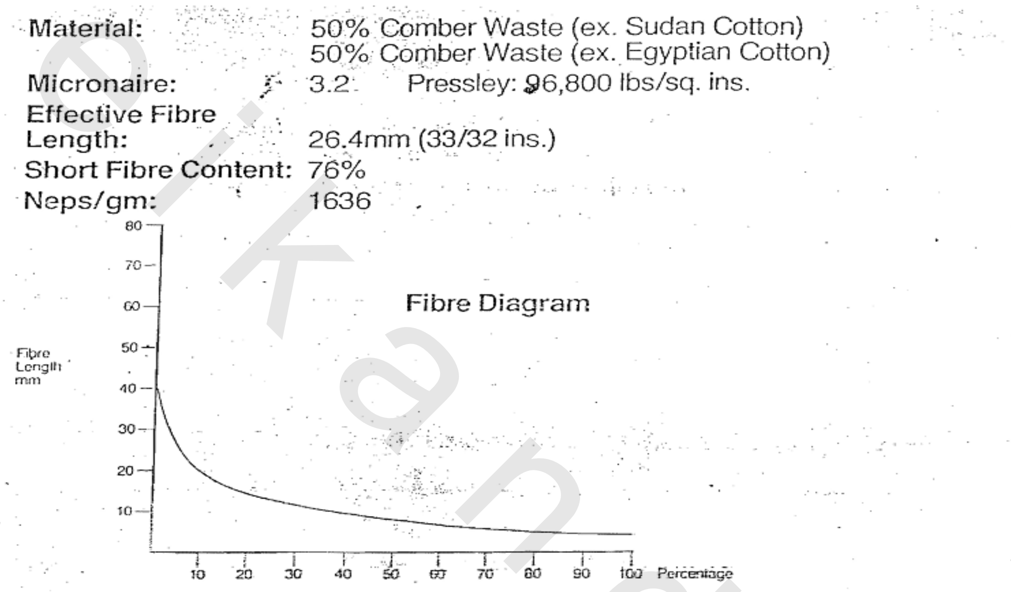

Fig. (2-4) Parameters of comber waste blend

Yarn Count:	**37.6 Tex (Ne 15.8)**		
Cont rang:	**1.2 %**		
Lea Strength:	**121.6 lbs**	**LSCP:**	**1921**
Single Thread Tests:	**Breaking Load**		**417.5 gm**
	Breaking Load C.V.		**11.9 %**
	Tenacity gm/tex (RKM)		**11.1**
	Extension		**6.1 %**
Regularity:	**Sliver**		
	(1st passage A/L)		**6.4 % U**
	Yarn		**12.9 % U**
Uster Imperfections (per 1000 meters)	**Thin places:**		**20**
	Thick places:		**38**
	Neps:		**952**

Fig. (2-5) yarn test results-comber waste

5. Further results

To show the varying type of results achieved when spinning different blends of waste, four mixes have been selected, all of which are spun commercially by spinners in different world markets:

These are:-

Blend "A" – 80% Bleached devilled cuttings.
_ 20% Viscose (matt) 40 mm x 1.7 d/tex

Blend "B" – 30% Devilled Egyptian thread waste.
- 20% Devilled Egyptian thread waste.
- 20% Devilled knit clips
- 15% cotton ravings
- 15% cord flat strip

Blend "c"– 100% comber waste (from American, Egyptian, Brazilian cottons).

Blend "D"– 85% comber waste (Blend 'c')
-15% devilled thread waste.

Blends 'A' & 'B' were spun at a rotor speed of 55000 rpm. With a 4.5 T.F to a nominal yarn count of 66 Tex (Ne 9). While the corresponding parameters for Blends 'c' and 'D' were: rotor speed 45000 rpm, twist factor 4.25 T.F and nominal count 84 Tex (Ne 7).

Comparative yarn regularity and strength (single end measured in gm/tex) are shown in (fig.2-6). A relatively low strength is evident which could well have resulted from the customers' requirement for low twists. Yarn strengths are however directly related to parameters of the fibres spun and can therefore be varied by feed stock changes. As in ring spinning the higher the blend's fibre strength the higher the strength of the yarn produced. This is borne out by comparing the strength of the 100% noil blend, 8 gm/tex with that of the previous 100% noil blend in which a single end strength of 11.1 gm/tex was achieved.

Looking at fig. (2-7) a similar increase in L.S.C.P. values occurs, 1486 as compared with 1921 – as a result of the fibre change.

Fig. (2-7**)** also shows uster imperfection values, in terms of thin, thick places and nap per 1000 meters. Uster statistics (as abstracted from Bulletin no.23 Aug.1975) indicates that for 75 tex (Ne 8) yarn imperfection levels on the 50% line for a pure cotton yarn would be 5, 35,110 respectively, that is: a total of 150 imperfections.

The yarn test figures compare favorably bearing in mind that the 50% line has been used and the yarns were spun from waste. The figures also substantiate the good visual assessments given to all the yarn.

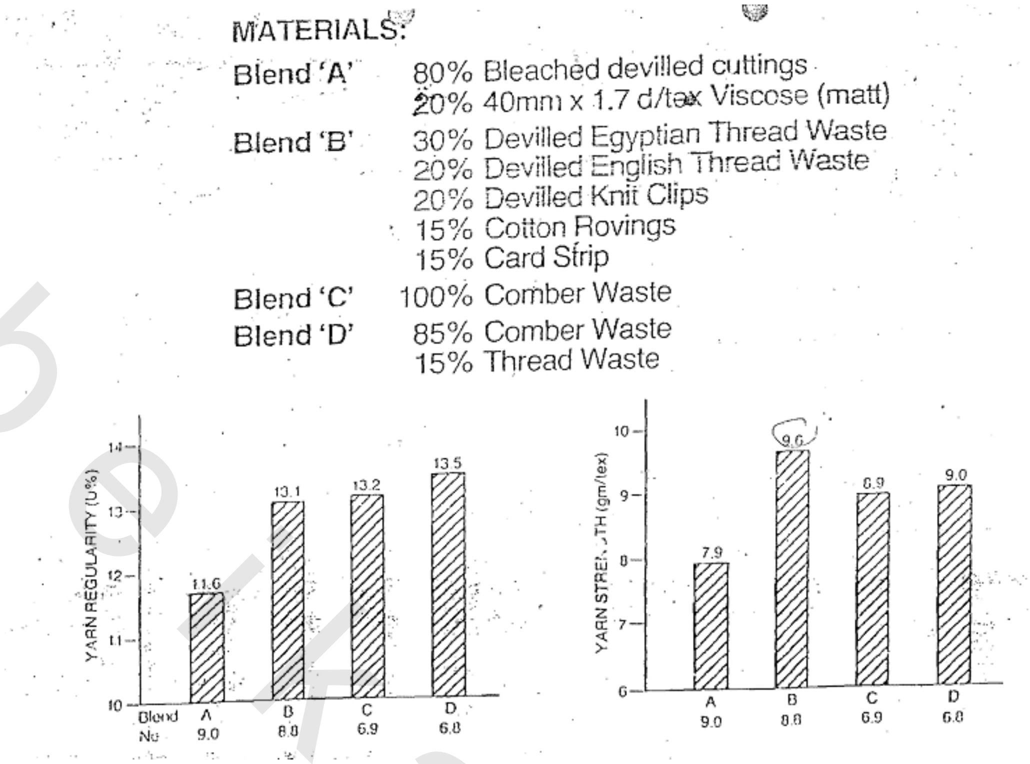

Fig. (2-6) Comparative yarn regularity and strength

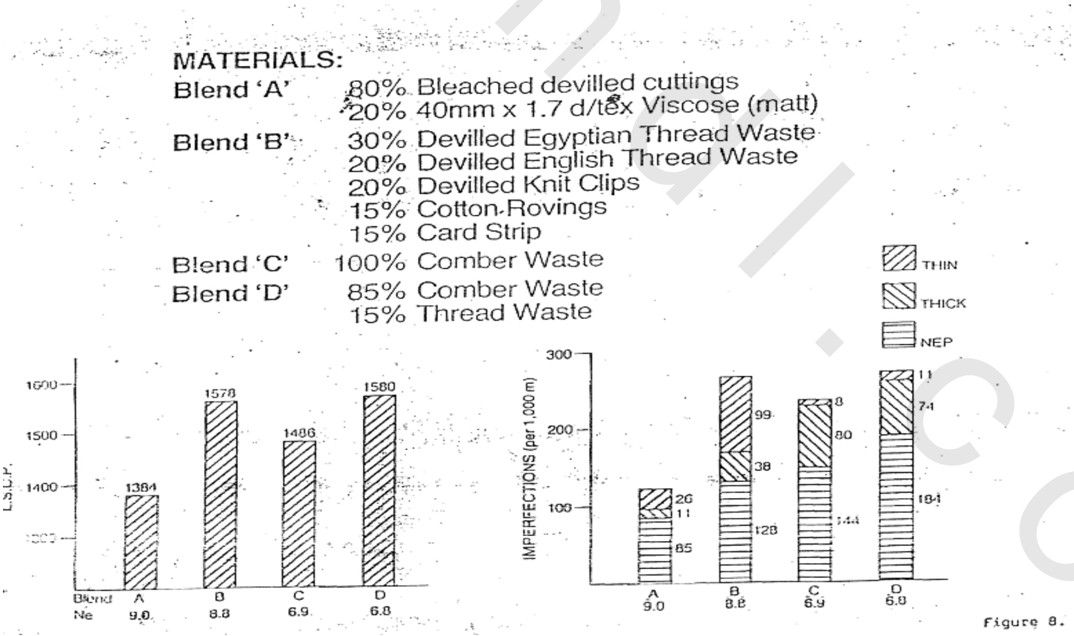

Fig. (2-7) uster imperfection values

6. Conclusions

While waste fibres cannot have a universal application they may be used successfully in a wide range of end products, in 100% waste from or mixed with varying percentages of natural or man-made fibres. Certainly no single set of recommendations can be laid down for handing wastes. The technique used must vary with the type, even though in each case the purpose of the preparation system is the same: to produce fibres in a clean and opened state for spinning.

7. Blends employed frequently in O.E rotor spinning

Often the recovered fibers are blended automatically with weighing feeders in the proper proportions for further processing. Table (2-3) shows some of the Blends employed frequently in O.E rotor spinning. Dipl.-lng. Ferdinand Leifeld, Trutzschler GmbH & Co, KG, Monchengladbach (D), "Cotton Waste Reclamation: a Money-Spinning Process", International Textile Bulletin, Yarn and Fabric Forming, 3/96, PP.57-60.

8. Using the Opened Garment Waste as Furniture Padding Materials, Quilting and Mattresses

El-Hawary, I.A. in Alex. Eng. J., Alex. Univ., Volume 28 No.2, pp 781-797 (1989).

Show that the compression characteristics of opened garment waste mainly depends upon the original fibre characteristics (length and fineness), fabric structure and degree of opening.

a- The shorter the fiber length in the extracted waste, the better the compression properties.

b- The high degree of opening improves the compression recovery behavior. Also at the degree of opening affects on the fibre length and the micronaire value, which indicates the degree of opening.

9. Study of Fibre Mass Compressibility Behavior Obtained From Opened Garment Waste

Sheta, A. M., El-Hawary, I.A. and Behery, H. M. in Alexandria Engineering Journal in July 1989 show that the method presented for measuring the different compression characteristics of fiber mass is found to be effective.

The apparatus for the cycling test could be readily adopted and can useful as a quality control tool for evaluating the fibers used in padding materials for furniture, mattresses, and quilts . The opened garment waste compression characteristics mainly depend on the original fiber properties, length and the degree of opening. The shorter the fiber length the better the compression characteristics. Also the high degree of opening improves.

Table (2-3) shows some of the Blends employed frequently in O.E rotor spinning.

TEXTILE WASTE Fibre Usage	**MIXING COMPONENTS FOR OE-YARNS** **Examples**																
Cleaned or opened virgin or secondary raw material	Tex Nm Ne	125 8 5		100 10 6		77 12 7		71 14 8		63 16 9		56 18 10		50 20 12		45 22 13	42 24 14
1. Fibre waste from cotton cleaning plants		10	40	20	30		30		40								
2. Card licker-in and grid waste		10	10		5				10								
3. Fibre waste from ginning plants	%			20		30	20						40		55		
4. Card flat stripes and suction waste		20	10		5	20			10		40						
5. Low grade cotton			20	20				20			20						
6. Cotton comber waste				10		20		30		55		70	10	85		100*	100*
7. Waste from men-made fibres production		35		10	50	15		10		10			50		15		
8. Suction waste			20		10				20		20	15		15			
9. Yarn waste		25		20		15	20	30		25	20	15			30		
10.Cutting from woven and knitted fabrics							30	10	20	10							
Table (2-3)	comber waste from long and extra long staple cotton*																