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CENTRAL TESTING LABORATORIES
FOR JUTE GOODS

DP/BGD/79/030

BANGLADESH

A manual of process quality control in jute manufacture*

Prepared for the Government of the People's Republic of Bangladesh
by the United Nations Industrial Development Organization
acting as executing agency for
the United Nations Development Programme

Based on the work of P. E. Atkinson, quality control adviser

United Nations Industrial Development Organization
Vienna

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PREFACE

This Manual was prepared under the United Nations Industrial Organisation's Project DP/BGD/79/030, Central Jute Testing Laboratories. This Project was conducted for the Ministry of Jute and Textiles of the People's Republic of Bangladesh between 1982 and 1985.

It is hoped that in producing a simple, practical guide to control methods in jute manufacture some assistance will be given to those not only directly employed in quality control in the Bangladesh jute industry but also to line supervision and management.

R.R. Atkinson

August 1985.

CHAPTER ONE

Organising for Quality Control

The word 'quality' is often used in the sense of 'excellence' and in many cases we talk of the quality being good or bad, high or low. For quality control this concept will not do. We can only define quality in terms of some characteristic which we can measure. A product therefore is of satisfactory quality when it conforms to a preconceived specification. Thus, a cheap sacking weft yarn and an expensive carpet yarn can be of equal 'quality' if each conforms to its own specification in regards to strength, count, twist and so forth.

We see already that before we can begin to control quality we need to have a set of specifications for our yarns, cloths and bags and for all the processing stages of manufacture. We must know quite clearly what quality parameters we must meet and how to check that our processes and products conform to them.

If no standards exist the first task is to set about establishing them. To do this, we can use existing test records; we can speak with the supervisors involved; we can make observations on the machines; we can consult other standards and specifications. Whatever method is used, the standard we draw up should reflect the capabilities of the mill. We may hope to improve the quality in the future at which time it may be possible to re-write the whole, or parts of, the specification with higher levels or tighter tolerances.

On the question of tolerances each specification must have some plus or minus variation shown for each parameter. For example, there is no sense in saying each bag in a lot shall weigh 800 g because we know perfectly well that the bags will vary, perhaps from 750 g to 850 g. A realistic tolerance must therefore be included in the standard if it is to have a meaningful part to play in our control scheme.

In all industrial processes the cost of manufacture includes the cost of raw materials, their conversion into the finished product and the many administrative functions required to run the enterprise. Hidden within these we find extra costs which are related to quality. These include such things as the cost of excessive waste, returns from customers, repair or reprocessing, down-grading and not forgetting the intangible cost of complaints from customers and the loss of a good name. The chief executive may delegate the quality function to specialists but he cannot abdicate his responsibility for the over-all quality policy of the mill.

The Quality Control (QC) department's duty is to assist line management in its pursuit of good quality by testing and evaluating the manufacturing processes and the finished products. The department provides a service to production by supplying information about the process and the product so that line supervision can take quick, effective action to correct any deficiencies. Most of the QC effort should be spent on the mill-floor and not in the laboratory. Quality is neither created or controlled in a laboratory; it is 'built in' by the raw materials, the processing machinery and the workers who use that machinery. Among the many factors which influence quality we must consider:

(a) The grade of fibre selected. The standard of yarn or cloth which we make is affected by the fineness, the strength, the cleanliness, etc., of the kinds of fibre we blend together in our batch.

(b) The grade of our other inputs such as the quality of the jute batching oil (JBO), dressing mixtures, spool and cloth roll centres, etc.

(c) The processing system and the state of the machinery. We must select a system which will provide us with the necessary quality of finished product at the lowest price. Poorly maintained machinery can never produce good work and the amount of money which the mill can afford to spend on maintenance has a great bearing upon quality.

(d) The standard of labour which is available. The level of technology in jute manufacture is not high and we are quite likely to find that operator error is a significant source of poor quality. If this is so then a careful assessment of training needs may be required.

(e) The testing and evaluation techniques we have installed in our mill. The control scheme must be able to provide production management with meaningful information which can be acted upon quickly.

In the past, many people have come to associate quality control with "statistical quality control". In some cases, the use of statistics has over-awed people. This has, to an extent, lowered the value of simple, direct methods of control based upon sound technical knowledge. Statistics, do have a part to play in quality control but certainly for jute manufacture the best schemes are those which are practical and direct, using only basic statistical methods. In most circumstances, the simpler and the more easily-understood the scheme is, the better it will be.

Conformance with standards

We judge the success or failure of our control of quality by comparing our test results against pre-set standards. These may be in-house standards, national standards or customer's specifications. Such standards should be realistic (and achievable) keeping in mind the constraints of costs, raw material, machinery and worker skill.

To maintain a satisfactory level of quality we must therefore establish a sound control scheme which gives due consideration to:

(a) Providing adequate inspection and test equipment

(b) Ensuring a trained QC staff

(c) Up-dating of inspection methods and testing techniques

(d) Instituting a planned calibration timetable for the testing equipment

(e) Avoiding unnecessary paper-work and superfluous tests which do not add positively to control

(f) Providing standards with which to assess the quality of our products, be they in-process or finished

(g) Having an awareness of the true capabilities of our raw inputs, machinery and workers

With the passage of time, our quality control scheme may not be fulfilling its original promise and the results may be disappointing to say the least. We must face the fact that the scheme may have been over-ambitious in the first place. A modest scheme can always be expanded whereas a grandiose one may over-extend the capabilities of the QC staff and their facilities. Another cause of failure may be a lack of support from senior management who are not committed wholeheartedly to the scheme. We also recognise that in some cases there may be mistrust and jealousy between the QC department and production staff. In a situation like this the QC officer must try to break down barriers by listening sympathetically and constructively to any points put to him. Another cause of failure may lie with management having pre-conceived ideas about the quality in the mill. The author has found that it is not unknown for results to be falsified in order to agree with a supervisor's opinions.

QC Personnel

The head of the department should be fully acquainted with all facets of jute manufacture and be familiar with standard quality control methods. It is usually easier to train a candidate from within the mill staff by giving him an appreciation of control methods than to take a new entrant to the mill who may be very competent in the general field of quality control but who has no experience of jute processing.

The inspectors and QC Assistants need a good working knowledge of jute spinning and/or weaving and laboratory work. The department head should train his staff to be on the look-out for faults in the machinery and, if they see a fault, not to assume that someone else will report it. They should be vigilant, without developing an over-critical attitude. It is easy to find faults; to put them right is more difficult but the hardest part of all is to prevent the fault happening again.

The Test Laboratory

Although quality is built-in on the mill-floor, and not by testing, a good laboratory is an essential part of the quality control department. Its floor-area will vary with the needs of the mill but even a small unit will require at least 18 - 20 m^2 of floor space. Lighting should be of a high standard since many of the tests need good illumination if they are to be done accurately. Water and drainage must be in adequate supply. Electric power is best supplied by a ring main from which spurs can be tapped off at various places in the room.

In a jute mill laboratory, controlled conditions of humidity and temperature are not strictly necessary. Fortunately, the tensile and other properties of jute are relatively unaffected by the ambient conditions in the test room. Count and cloth weight, of course, are highly susceptibile to humidity but modern electronic moisture meters allow an accurate enough estimate of the moisture regain for standardisation of weight testing without traditional conditioning in a controlled atmosphere. However, in cases of dispute, or for special tests, recourse must be made to a laboratory where the atmosphere is controlled to 65% rh at 20°C or 27°C. The regional laboratory of the Directorate of Inspection for Jute Goods qualifies in this respect.

Figure (1) shows an example of badly laid out laboratory with poor utilisation of space and cramped work-stations.

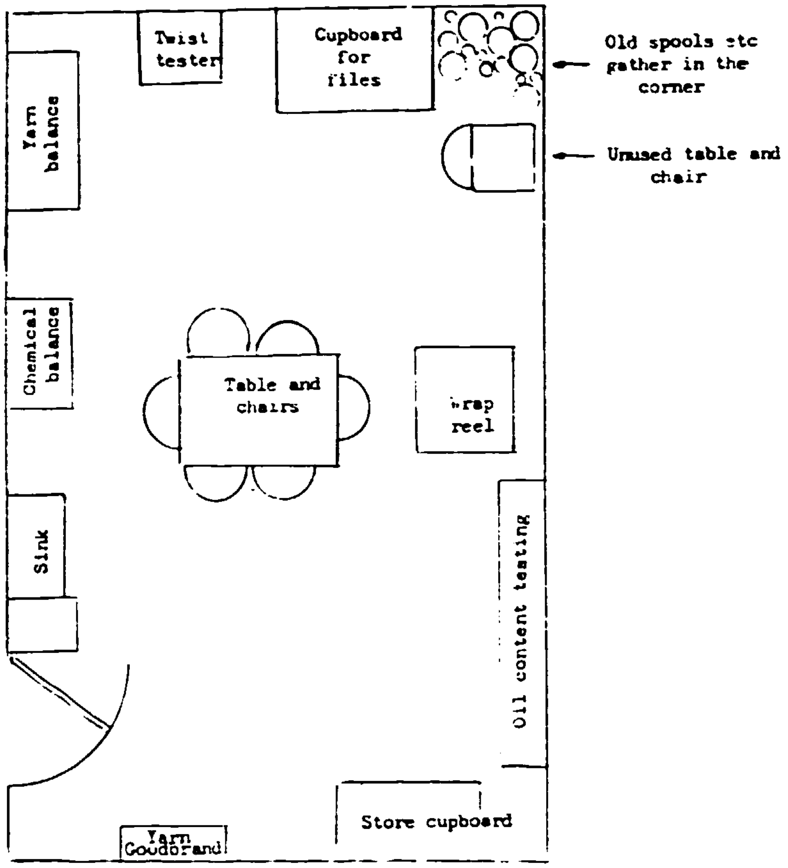


Fig (1)

Poor layout showing haphazard placing of equipment, cramped and awkward work stations

Figure (2) shows how the same floor-space has been used to better advantage with potential for greater output and efficiency. Laboratory staff, like mill staff, work better in neat, well-designed premises.

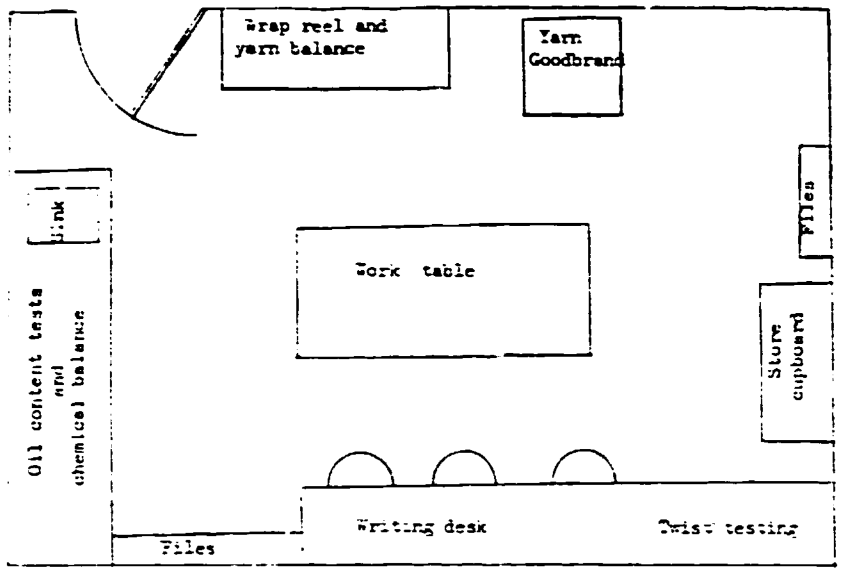


Fig (2)

Logically planned layout giving better working space

Once a good laboratory plan has been formulated and executed the room must be kept clean and tidy. It is sad to see, as the author has in many mills, test-rooms being allowed to fall into poor shape through lack of good house-keeping. It is the QC Officer's duty to see that his test-room is an example to the rest of the mill.

Equipment

Although the mill laboratory may not have a controlled conditioned atmosphere it is good practice to measure the temperature and humidity in the test rooms at regular intervals during the week. A recording thermohygrometer is the ideal choice but much useful data can be collected by using a simple whirling hygrometer. The ordinary wet and dry bulb type of hygrometer seen so often hanging on the wall of the test room is often next to useless because it measures the atmosphere conditions only of the air immediately surrounding itself and gives no information about the rest of the work-area.

Because much of the routine work of the department will be concerned with measuring moisture, a reliable moisture meter is essential. Common types are the Mahlo and Aquaboy meters which will be discussed later in this Manual. Moisture drying-ovens for routine moisture testing have largely been superceded by such meters although they are still seen from time to time in mill test-rooms.

The laboratory must have a range of accurate balances. These will include analytical balances for chemical work, direct-reading types for yarn count measurement and the weight per unit area of cloth and bags, plus one or two others to give a good range of capacities. For calibration of these balances, a special box of weights from 1 mg upwards should be kept under lock and key.

Tensile testing, both for yarn and cloth, can be catered for by simple constant-rate-of-traverse pendulum testers. Although the CRT method of testing has fallen from favour in other spheres it is still very satisfactory for jute. Twist testing is carried out on the standard type of twist tester. Oil content checks can be accommodated on the traditional Soxhlet apparatus or the WIRA Rapid Oil Tester.

The lists which follow give the equipment which is required for good control and the addresses of some suppliers.

Textile testing equipment is not cheap and for this reason alone it should be well looked after. Proper cleaning, maintenace and calibration checks must be carried out at intervals of not less than six months. The QC Officer should keep a log book which shows when servicing is carried out. Only if the test equipment is kept in good order can reliable results be obtained from it.

Laboratory Equipment List

Item of Equipment	Essential	Desirable
1. Spinning Mills		
Whirling Hygrometer	X	
Moisture Meter	X	
Tachometer	X	
Stop Watch	X	
Yarn Balance	X	
Analytical Balance	X	
Soxhlet/WIRA Oil Apparatus	X	
Sliver Yardage Count	X	
Wrap Reel	X	
Yarn Examining Boards		X
Twist Tester	X	
Single Thread Tester	X	
J.B.O. Viscometer		X
Conditioning Cabinet		X
Centrifuge		X
2. Weaving Mills (in addition to above items)		
Piece Glass	X	
Bench Magnifier		X

Cloth Strength Tester	X	
Crimp Tester		X
Bursting Tester		X
Brightness Tester		X
Starch Viscometer		X

Additionally,a good supply of glassware and general laboratory equipment should be provided.

Suppliers of General Laboratory Equipment

Casella & Co Ltd
Regent House
Brittania Walk
London N1 7ND

Gallenkamp Ltd
Belton Rd W.W.
Loughborough LE11 OTR
U.K.

Stutz et Cie
47 Rue Wastin
F 59120
Loos-en-Lille
France

Karl Kolb GMBH
Postfach 100
Dreieich
W. Germany

Tekmatex Marubeni
Box 595
4 - 2 Ohtemachi
1 - Chome
Chiyoda - Ku
Tokyo 100 - 91

Delmhorst Instrument Co
117 Cedar Street
Boontown
New Jersey 07005
U.S.A.

VWR Scientific Inc
P.O.Box 3200
San Francisco
U.S.A.

Suppliers of Specialised Textile Testing Equipment

James Heal & Co Ltd
Richmond Works
Halifax
Yorkshire
U.K.

Goodbrand-Jeffries Ltd
Elm Works
Mere Lane
Rochdale
Lancs
U.K.

Shirley Developments Ltd
P.O. Box 6
856 Wilmslow Road
Manchester
U.K.

K P Mundinger
D-7253
Renningen/Wurtt
Postfach 1260
West Germany

Tekmatex Marubeni
P.O. Box 595
4 - 2 Ohtenmachi
1 - Chome
Chiyoda-Ku
Tokyo 100 - 91

Branca Idealair S.A.S.
Via Milano 7
I - 21020 Mercallo Dei Sassi
Italy

Hans Schmidt & Co KG
Schichstrasse 16
D-8264 Waldkraiburg
Federal Republic of Germany

Mahlo KG
D - 8424
Saal/Donau
Federal Republic of Germany

These lists are not exhaustive, neither does UNIDO endorse any manufacturer.

Direct Costs of the QC Department

The bulk of the cost of running a quality control department is related to staff salaries. 85 - 90% of the total costs will be accounted for in this way, and the remainder being spent on accommodation expenses, electricity, chemicals and the like.

Although the QC labour loading will vary from mill to mill a figure of about 3 man-hours/ton is enough for hessian and sacking mills. Small mills will tend to exceed this figure but they should not need more than 3.5 man-hours/ton for a good level of control. Productivity in the QC department is every bit as important as in any other department in the mill.

Some idea of reasonable laboratory work-rates (including time for preparing specimens and calculations) are:

Yarn:	
Count and regain	60 hanks/hour
Strength	100 breaks/hour
Twist	50 specimens/hour
Cloth:	
Strip test	20 breaks/hour
Grab test	30 breaks/hour
Seam test	15 specimens/hour

Oil content (single unit Soxhlet) 0.75 samples/hour

CHAPTER TWO

Quality in Batching and Carding

In jute spinning, the cost of fibre represents rather more than half of the total yarn price. For this reason, if no other, careful choice of fibre and its suitability for the market is vital. It is in the careful monitoring of the price of the batch relative to its quality that much of the financial success of the mill lies.

Jute, the major bast fibre in commerce, varies in quality depending upon such factors as:

Type of seed and its viability
Soil characteristics
Climatic conditions
Use of fertiliser
Method of sowing
Time of harvest
Availability of retting water
Incidence of flooding

Even fibre which is grown in the same district will vary from crop to crop. Experienced graders are required to assess the quality of the fibre used in the mill. Grading is done on the basis of 'hand-and-eye' methods. Scientific tests do exist which will make a good estimate of the quality of yarn which can be spun from a particular grade of fibre but they are time-consuming and unsuited to routine QC mill work. Careful supervision in the assorting shed is therefore essential.

The important fibre features which have a bearing on the quality of the yarn which we can spin from a particular grade may be summarised:

Fineness	Fine fibres give yarns which are generally superior
Strength	Yarn strength is determined to a great extent by this property (coupled with fineness)
Flexibility	Good flexing properties help in spinning - this feature is again related to fineness
Stick, bark	Small pieces of plant tissue, often black in colour, on the fibre can form the nuclei of slubs. They detract from the appearance of the yarn
Root	If the fibre is heavy-rooted, up to 30% of the reed may have to be cut off and downgraded at a loss of fibre value
Lustre	Generally, lustrous fibre is fine and of good strength
Croppiness	Harsh, wiry fibre at the crop-end which does not card well
Runners	Long ribbons of bark resulting from poor retting. The fibre will not have good spinning properties
Knots	Small hard sections of fibre caused by insect damage in the growing crop. May cause slubs if excessive

Heart damage	Found in baled fibre which has excessive moisture. Micro-biological growth weakens the fibre and, in extreme cases, reduces it to dust
Dazed fibre	Dull, lifeless fibre; caused by excess moisture, very often coupled with mildew

Batch Selection

With jute yarns, the range of qualities and counts which are produced is very large. We may have fine, clean, regular yarns for decorative fabrics with counts as low as 5 lb/sp on the one hand and heavy, coarse, low-grade yarns of 200 lb/sp for the cable trade on the other.

No hard and fast rules can be followed universally for batch selection since price and fibre quality vary month by month and year by year. We can only look at some common fibre blends as examples of these which are used for specific markets.

High quality yarns which are to be bleached or dyed are made from clean, top quality white jute, free from defects such as stick, bark etc. In this type of yarn, strength is not the main requirement since the yarn will be judged mainly upon its appearance.

The range of batches used for carpet yarns is wide. For high quality closely woven carpets the weft yarns may be fine (very often 2-ply with singles counts as low as 6 lb). For this product, strength and uniformity are essential and so the upper grades of tossa are most suitable. For medium carpet yarns, in the 10 to 20 lb range blends of the upper and medium grades of tossa will be used; in less demanding markets a proportion of white jute may be blended as a price-reducer. In heavy carpet yarns for cheaper types of carpet, counts as high as 36 lb single or 24/2 lb are made from medium grade white/tossa jute perhaps with some mestha.

Coming to yarns which will be used to make secondary backing for tufted carpets, blends of medium/low grades of white with some tossa may be selected along with the injection of waste from higher batches.

Hessian batches comprise lower grade white jute with a proportion of cuttings or mestha and other lower grade materials. Some tossa may be included to help spinning.

Sacking yarns have mainly cuttings, low grade jute and mill wastes as their principle ingredients. For heavy cable yarns such as 96 lb up to 200 lb the batch will be mainly composed of cuttings with some low grade mestha.

Considerable skill and experience is required in selecting the type of fibre which will give the necessary yarn properties at an acceptable price. Typical examples of some common yarns are:-

Type of yarn	Count	Minimum quality ratio
Wall covering yarn	7 lb	110 %
Fine carpet yarn	8	110
Medium weight carpet yarn	14	120
Heavy carpet yarn	36	100
Hessian warp (good)	8	100
Hessian warp (low)	8	80
Carpet backing warp	8	95
Sacking warp	10	75
Cable yarn	96	65

The batch which is finally selected takes into account the market, the availability of fibre and the price which can be realised for the product. The batches which follow are illustrative only.

8 lb Hessian warp :

White C	40%
White X	40%

8½ lb Hessian weft :

White C	20%
White X	50

32 lb sacking weft :

Tossa X	20%
Ropes etc	20%
Cuttings	60%

10 lb sacking warp :

White X	40
Tossa X	30
Cuttings	30

8 lb CBC warp :

White B	40%
White C	60%

14 lb Carpet weft :

Tossa B	60%
Tossa C	40%

32 lb Carpet weft :

White C	50%
Tossa C	25%
White X	25%

7 lb wall-covering warp :

White B	80%
White C	20%

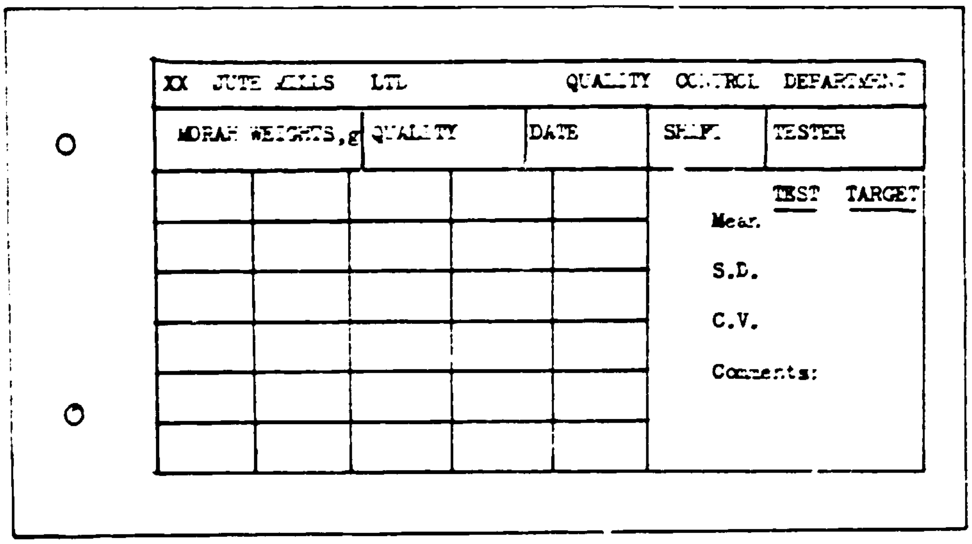
Morah Weight

In all jute processing, the quality of the material from one machine depends to a large extent upon the quality of the material fed to it. We must therfore pay particular attention towards quality in the batching department because it is here that we set the general pattern for quality for the mill. If the performance of the batching department is not in conformity with the standards laid down by management the rest of the mill will suffer.

The first control point is the size of the morahs. A good weight will be around 1000 g. This allows regular feeding at the softener, spreader and the breaker card. Regular checks are necessary and, to give a reasonable degree of accuracy we should weight at least 25 morahs using a balance which can be read to 5 g. With typical CV's of morah weight, this gives an accuracy of around ± 5%, which is adequate for most purposes.

Under mill conditions a CV of 10% for individual weights can be considered satisfactory when using the better grades of long jute. Some specialist mills do achieve very low figures of CV but only at extra expense. The cost of their refinement and the benefit which is derived from it must be carefully balanced. When short, uneven jute is being processed the CV can increase to around 20% under normal conditions.

Figure(3)shows a suitable form which can be used to collect the control information. Off-standard performance may result from poor supervision, carelessness or inexperienced workers or irregular jute.



XX JUTE MILLS LTD QUALITY CONTROL DEPARTMENT

MORAH WEIGHTS, g	QUALITY	DATE	SHIFT	TESTER

TEST TARGET

Mean

S.D.

C.V.

Comments:

Fig (3)

Morah weight test form

Fibre Feed Control

As we have said previously, the regularity of the output of one machine is partly determined by the regularity of its input so good control over fibre feeding is an essential part of process control in the batching department. This is particularly so with the spreader. All spreaders work with a machine-driven pointer, indicating the rate at which jute should be fed, and which must be followed by the weighbridge pointer exactly. Figure (4) shows a typical feed arrangement with the drive taken off the spreader itself with the gear train to the driven pointer to show the worker the speed at which he should feed his machine.

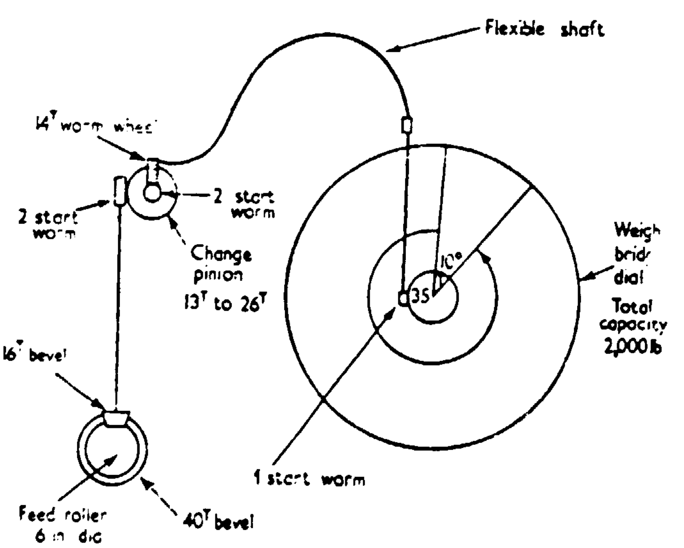


Fig (4)

Drive to spreader feed control

mechanism

This type of feed arrangement controls the rate of feed well if the worker is conscientious. With good morahs and a smooth-running slave pointer gear very good work is possible.

There is sometimes discussion about the respective merits of hand-fed breaker cards versus the jute spreader from the viewpoint of quality. The truth is that, given skilled and conscientious workers both systems give satisfactory results. The spreader is cheaper in labour costs but dearer in capital cost and maintenance. The spreader does however allow closer control over the application of emulsion.

Jute Batching Oil (JBO)

It is not customary to test batching oil regularly and indeed few mills are equipped to do this. Nevertheless, it is advisable to make random checks from time to time by using external services wuch as those of the laboratories of the Directorate of Inspection for Jute Goods.

The most frequently specified properties of batching oil are:

Colour	Indicates the degree of refinement of the oil
Flash point	Measures the ignition temperature of the oil

Saponification value	Shows the quantity of fats, waxes etc., in the oil
Carbon residue and distillation	Indicate the refinement and purity of the oil
Viscosity and pour point	Measures the "thickness" of the oil
Specific gravity	Signifies the density of the oil

An example of a batching oil specification is:

S.G. at 20°C (ASTM D1298)	0.85 min.
Smell	Free from kerosene
Colour (ASTM D1500)	7 max.
Flash point (ASTM D93)	180°C
Viscosity, Redwood sec.at 40°C	50 min.
Pour point (ASTM D97)	25°C max.
Carbon residue (ASTM D189)	0.3 max.
Distillation (ASTM D86)	50% recovery at 370°C max.
	40% recovery at 410°C max.

The function of JBO in spinning is to reduce fibre-fibre and fibre-steel friction, consolidate slivers and produce regular yarns.

The amount of JBO added depends on the kind of yarn we want to spin.

The following are common figures for oil content.

1 - 2% Yarns for certain food-stuffs, fabrics for bleaching or dyeing special "stainless" carpet yarns

4 - 5% Hessian yarns, carpet yarns

6 - 7% Sacking yarns

Spinning low oil content material is more difficult than spinning standard oil content yarns because the slivers are loftier and fibre friction is greater. Strangely enough, the strength of jute yarns is at its maximum when the oil content is about 1%. The results of research on this subject show this. These tests were carried out at the Scottish Textile Research Association's laboratories.

Oil Content of yarn	Quality Ratio %
0	93
0.5	105
1.0	110
2.5	206
5.0	104
9.0	96

Part of the fall-off in strength of course arises from the fact that oil is replacing jute and so there are fewer load-bearing fibres in the yarn, but, even allowing for this, there is still a maximum at about

1%. Despite this, it is a practical fact that low oil yarns do not spin so well because of other factors such as hairiness, lofty slivers, irregularities etc.

We might think the viscosity of the JBO would influence the strength of the yarn and the spinning performance. The answer is that over the common range of 150 - 250 Redwood seconds at 20°C there is no real effect. We must go to very high viscosities (800 or more) before we see a fall off in strength and spinnability.

The Role of Moisture

When we add moisture to the jute our aims are:

1) To increase the extensibility and flexibility of the fibre so that it can be carded without excessive fibre breakage.
2) To give good conditions for maturing the jute.
3) To allow for the inevitable moisture losses during processing.
4) To spin an even yarn of good strength and appearance.
5) To keep dust and waste to a minimum.

Jute Batching Emulsions

JBO and water are, as we all know, added in the form of an oil-in-water emulsion. The emulsifiers commonly in use can be grouped into two types:

Anionic	: Soaps (little used nowadays)
Nonionic	: Hydrophilic compounds, often ethers or esters.

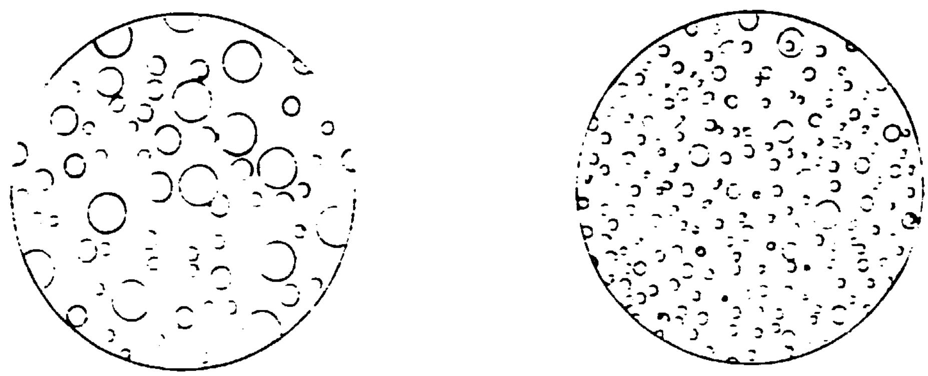
Anionic emulsifier can give problems with emulsification, especially if the water is hard or has a high salinity. In these conditions lime-soaps may build up which actually increase fibre friction - the opposite to the effect we want. The nonionic emulsifiers are very much better in all respects and even in hard water or saline areas they can give good stable emulsions if they are used properly. They are much to be recommended in the light of their better wetting power and general reliability.

As we shall see later, one of the desirable features during the batching process is that the fibre should heat up during maturing. Heating is due to bacterial action and it is possible to obtain emulsifiers which have an organic accelerator added to them which stimulate the growth of the bacteria. These accelerators are very often based upon urea compounds. As an alternative the accerlerator may be added to the emulsion separately in powder or liquid form. Proprietory emulsifiers containing accelerators are Amoa Elsol JN, Seljute, Whitcol SJ etc.

Defects in Emulsions

The most glaring defect in an emulsion is for it to have the wrong proportions of oil and water. This is so obviously due to carelessness in preparation that no more will be said about it. Apart from this obvious fault, two defects may arise.

1) Creaming. When an emulsion is prepared it is impossible to make all the drops exactly the same size, some will be much smaller than others and there will be a few quite large drops. In general, the smaller the drops and the less scatter there is in their diameters the better is the emulsion. Figure 6 illustrates a 'good' and a 'bad' distribution of droplet sizes. If there are a number of comparitively large drops of oil they will slowly rise to the top of the emulsion because of their lower specific gravity until a layer of them forms at the surface of the emulsion. In emulsion technology this is known as 'creaming'. As would be expected those emulsions with big drops cream more quickly than those with small drops. Figures 5 and 6 show the appearance good and bad emulsions would have under the microscope and their distributions of droplet size.



Poor emulsion	Good emulsion
Large droplets of oil	Small droplets of oil
Irregular size of drops	More uniform drop sizes
Low number of drops	Large number of drops
Creamy colour	Milk-white colour

Fig (5)

Appearance of a good and bad emulsion under the microscope

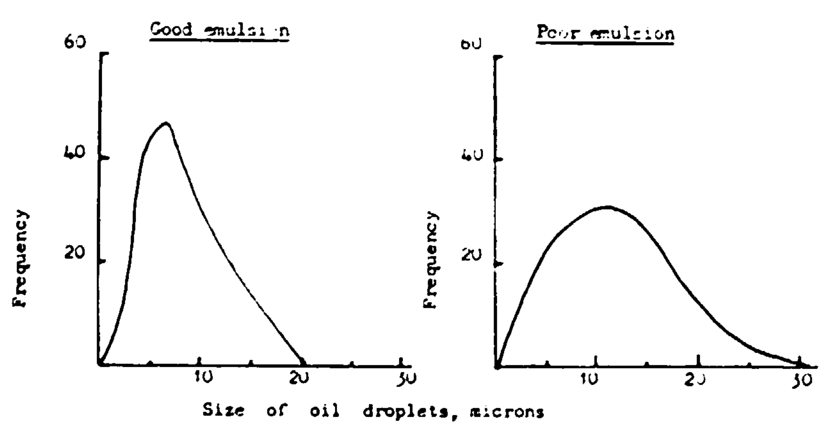


Fig (6)

Oil droplet size distribution in good and bad emulsions

While creaming is a defect it is not a serious one. Rather, rapid creaming should be taken as a sign of a poor emulsion and attempts should be made to decrease the droplet size. The danger with a creamed emulsion is that supplies of emulsion for the spreaders may be drawn off the top layers which have become loaded with the oil. When this happens the oil content of the jute will be high, but when the emulsion level has dropped and it is now being taken from the oil-deficient layers then the oil content will be low. This trouble is overcome by arranging a slow-running paddle to keep the contents of all emulsion storage tanks in gentle motion as creaming will only occur in a standing emulsion.

2) Breaking. Breaking can be regarded as the opposite of emulsification where the droplets of the internal oil phase unite to form large drops which float to the surface of the emulsion. It is a sign of complete instability in the emulsion and once begun cannot be arrested. No amount of re-agitation will split these drops once they have formed and a broken emulsion is useless. The process may be quick or it may take several days, but in jute batching emulsions the presence of drops of free oil on the surface should lead one to suspect a poor emulsion on the point of breaking. Apart from the fact that if this kind of emulsion is put on to the jute the oil droplets will be large and will not spread evenly along the fibres, there will be parts of the emulsion which are deficient in oil and so the oil content of the jute will vary over a period of time.

Emulsion Recipes

A good emulsion should be stable and have the correct proportions of oil and water. As a rule, the whiter an emulsion is the better. No free oil drops should be seen on the top of a sample even after 24 hours. As a general rule, with nonionic emulsifiers one should use an emulsifier/oil ratio of around 1/30 – 1/40, selecting the lower ratio if better wetting power is needed e.g. with mestha.

Typical examples:

1. For long jute (25% applied, 5% oil)

Emulsifier (Nonidet P 40, Lissapol NX etc)	0.5%
Oil	20.0
Water	79.5

2. For mestha (35% applied, 6% oil)

Emulsifier (Nonidet P 40, etc)	0.4%
Oil	14.3
Water	85.3

3. Low oil batch for carpet backing (25% applied, 1% oil)

Emulsifier (Nonidet P 40, etc)	0.1%
Oil	4.0
Water	95.9

When we calculate the oil/water addition to the jute we should remember that there is one, and only one application, which will give the proper additions of oil and water. Figure 7 shows how the three factors are inexorably linked.

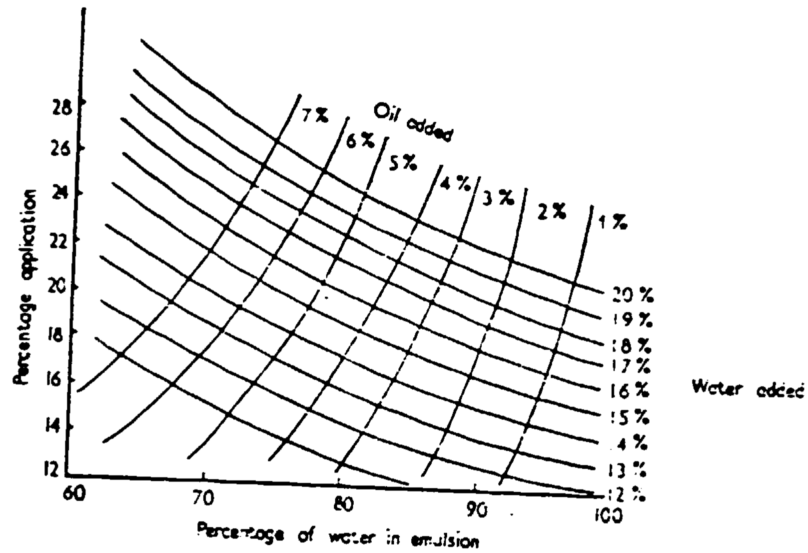


Fig (7)

Relationships of oil and water added to emulsion application and recipe

The simplest method of checking that the emulsion is being made correctly is to 'crack' a sample, i.e. deliberately break the emulsion so that it separates into two phases which can then be measured.

Method 1 - suitable for all types of oil-in-water emulsions. In this test a definite volume of emulsion is cracked with acidified sodium sulphite and the separated oil is measured. A sample of emulsion is drawn off, preferably from the sprays or the weir, some 110 ml being a suitable sample size for routine purposes. The sample bottle is shaken well and 100 ml measured from it into a measuring cylinder and then transferred to a beaker and heated to 90 - 95°C. 10 ml of 10 per cent sulphuric acid and 5 g of anhydrous sodium sulphite are added to the measuring cylinder and the hot emulsion poured back into it. The contents of the cylinder are stirred well with a glass rod and the oil allowed to separate into an upper layer and its volume measured; if there are v ml of oil in the top layer then the emulsion contains v per cent oil and (100 - v) per cent water. After the hot emulsion has been put back into the cylinder never shake or invert the contents since the rapid evolution of gas may force some of the hot acidic solution out of the vessel.

Method 2 - suitable for emulsions prepared with ionic or soap-type emulsifiers only. From a well shaken sample of about 110 ml, 100 ml are measured off into a measuring cylinder and 10 g of common salt (or 10 ml of 10 per cent sulphuric acid) is added and the contents shaken and allowed to settle. Again the oil forms an upper layer the volume of which is read off and the oil content calculated in the same way as Method 1. It may help the emulsion to break if the sample is warmed slightly.

Application of Emulsion

We have two ways of adding emulsion to the jute, by sprays or by weir dripping. From the quality aspect, there is little to chose between the two systems provided they apply the emulsion evenly. Pressure sprays can become clogged with dirt which prevents the full amount of emulsion being applied; the weir is free from this defect. The great thing is to add the emulsion uniformly.

There is a custom in some mills of dipping the root end of the jute into a tank of emulsion at the feed of the softener then, 1/3 of the way up the softener adding a little – or even no – emulsion. This is to enable the mill to use unct, i.e. cheaper, jute. By dipping, the root end receives a large amount of emulsion and there is no doubt that in the maturing bins the root is softened most effectively. The disadvantage is that the middle and crop end get very little transfer of emulsion in the bins. As a consequence some of the jute from the middle and crop end is fed into the breaker card in a dry, brittle state giving rise to lower quality.

Basically the application levels are fixed by the type of yarn that we are processing and by the moisture losses throughout the process. If there is too much moisture in the slivers then lapping will be a problem while, at the other extreme, too little moisture will cause irregular yarn and excessive waste. If the oil component is too high then eventually the pins of cards and drawings will become dirty, black specks may also appear on the heated bowl of the calender. These can transfer to the cloth and mar its appearance.

The usual levels of application are:

	Emulsion Applied
Good quality long jute	20%
Lower grade long jute	25%
Good quality mestha	20% - 25%
Lower grade mestha	25% - 30%
Ropes, cuttings, habijabi	30% - 35%

Once we have established that the correct ratio of oil : water is present in the emulsion we must ensure that the correct quantity is applied to the fibre. This is done either by direct measurement at the spray or weir of the spreader or softener using a simple apparatus such as is shown in Figure 8.

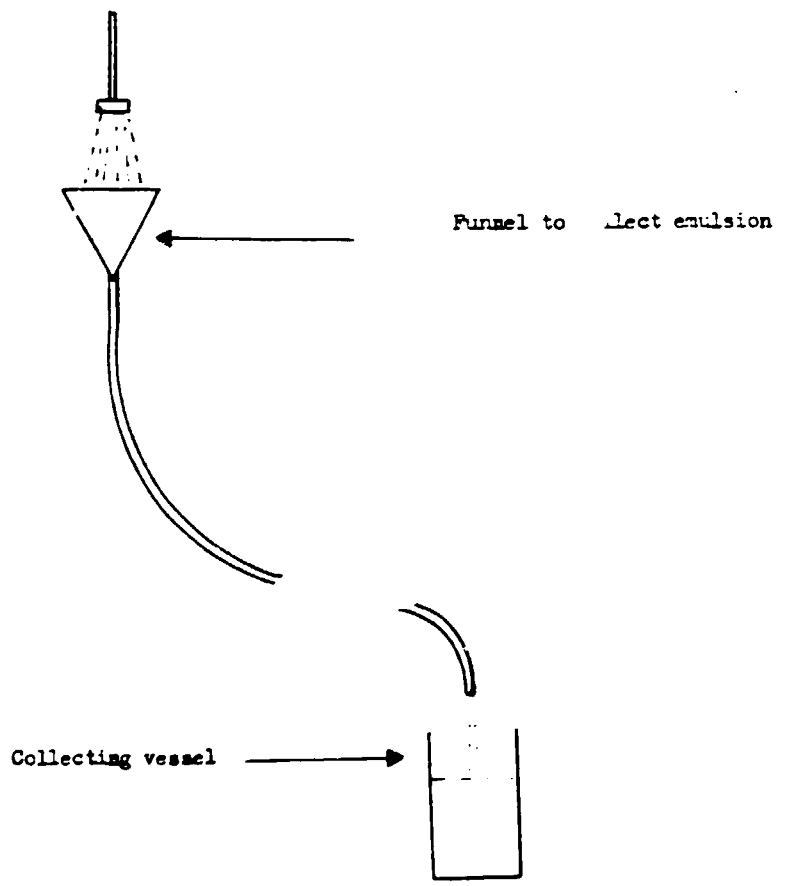


Fig (8)

Simple emulsion-collecting funnel and tank

A given volume of emulsion is collected in the container and the time to fill the container to a certain level is recorded. From there it is a matter of simple arithmetic to find the rate of flow of the emulsion e.g.

Volume in container	5.00 litres
Time to fill container	4.30 minutes
Rate of flow	$\frac{5.00 \times 60}{4.30}$ litre/hr.
	= 69.8 litre/hr.
S.G. of emulsion 0.97	
Emulsion flow	= 69.8 x 0.97 = 67.7 kg/hr.

An example of the calculation of control limits for the flow tests will now be given.

30 flow tests are made over 10 days, taking one test per shift.

<u>Flow rate, lb of emulsion/minute</u>

5.30	5.45	5.15	5.30	4.92	5.47
5.41	4.85	5.35	4.83	5.28	5.29
5.27	5.35	4.95	5.30	5.43	5.56
5.25	5.55	5.15	4.99	5.01	5.35
4.90	4.80	5.40	4.87	5.38	5.40

Mean = 5.22

S.D. = 0.23

CV = 4.4%

We can, if we wish, construct a control chart for these results but it is easier and usually sufficient to use limits based on 2 x S.D. on which we will take action without recourse to charts. In the example these would be

$$5.22 \pm 2 \times 0.23$$

i.e. 4.76 and 5.68 lb/minute

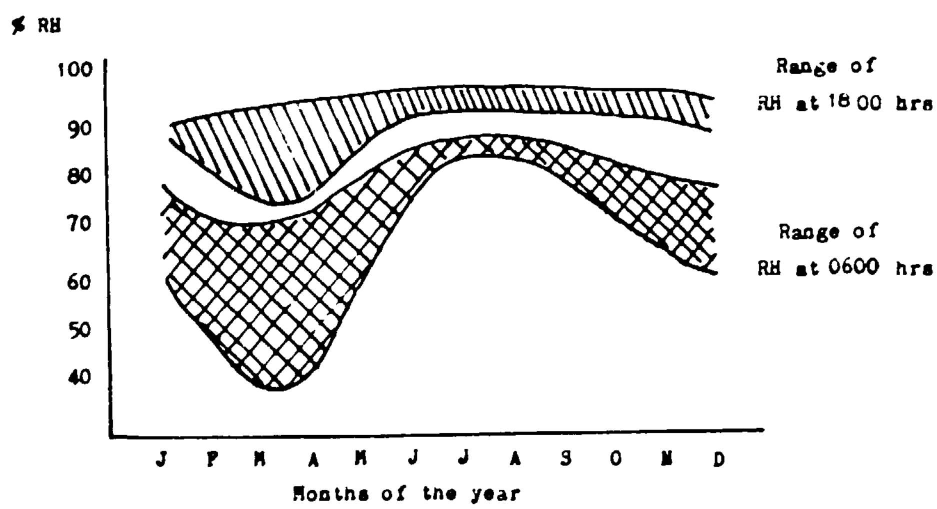
As long as we maintain our target flow of 5.22 lb/minute over a week's tests and keep daily tests within 4.76 and 5.68 lb/minute we can be sure that all is well and no remedial action is needed.

The alternative method for check application rates - and one which is more usually employed at softeners - is the simple 'add-on' test in which a convenient quantity of fibre is passed through the machine, being weighed 'before' and 'after' to give the quantity of emulsion which has actually gone on to the jute. For example:-

Weight of dry jute fed		252 kg
Weight of batched jute		317 kg
Emulsion applied	$\frac{317 - 252}{252} \times 100$ =	26 %

Whichever method is adopted, and one may opt to use both, it is essential that the amount of oil and water going on to the jute by way of the emulsion is controlled at the required level. In carpet yarn and CBC mills the flow-rate should be checked every shift but in mills producing hessian or sacking a daily test is sufficient, provided each shift is covered on a rotating basis.

In tropical countries it will usually suffice to have two levels of emulsion application - one for the wet season and one for the dry season. It is sometimes thought that some allowance can be made for short-term variations in humidity. A moment's reflection will show that this is impossible because of the maturing time and the time-lag between the application of the emulsion and the subsequent processing of the jute. An alternative to two emulsion levels is the use of humectants such as magnesium chloride to retain the moisture in the jute during dry spells. Figure 9 shows how the humidity varies throughout the year in Bangladesh and is based upon data from the Meteorological Office of Bangladesh.



Monthly relative humidity in Bangladesh

Fig (9)

Typical daily variations in humidity in Bangladesh

As we would expect, the regain of the yarn is related to the quality of emulsion which is added at the start of the process. The regain, of course, is affected greatly by the humidity in the mill as we shall discuss in a later Chapter, but the data below shows how application rates and regain are interconnected when the humidity is held constant. These results were obtained in tests made in a climatically-controlled mill in the U.K.

% application of 70 : 30 water - oil emulsion	% regain of yarn at spinning
15	15
20	18
25	19
30	23

Emulsion Stability

Testing the emulsion for stability i.e. measuring the length of time taken for an emulsion sample to separate out into two layers - an upper oil-rich one and a lower oil-deficient one is standard practice. From this we can judge the efficiency of the preparation of the emulsion. Emulsions with large droplets of oil are undesirable and these will separate out (or "cream") more quickly than a good emulsion which has tiny oil droplets. To do the test we measure out exactly 100 ml of emulsion then set it aside for 24 hours. At the end of that period the measure the depth of upper layer and record the volume of oil which has creamed. Ideally, a good emulsion should be stable for 24 hours and should exhibit a very small cream layer at the top - a matter of 5 or 6 ml. Good emulsions, too, are milky-white. One should never see oil drops on the top of the sample. If oil drops are present then either the recipe is wrong or the emulsion-plant is not working in the proper manner. Very often one finds that the cause of free oil on the top of the sample has been too little emulsifier in the recipe. It is false economy to try to economise in the use of the emulsifying agent.

In carpet yarn and CBC mills the stability should be checked on each shift but in hessian and sacking mills daily tests suffice.

Maturing of Jute

After the emulsion has been added to the fibre it is essential that the jute is laid aside for a period of time to condition and mature. During this process considerable heat will be generated and the temperature can reach 65°C within a matter of days.

Two main factors affect the heating of jute in the maturing stages; firstly, the method of stacking and secondly the amount of emulsion which is applied and its temperature. Because the heating of maturing jute is a result of bacterial action the temperature and the amount of water present has a direct bearing on the phenomenon. Each type of bacteria and fungi has an optimum temperature at which it multiplies most rapidly and easily.

During maturing the bacteria soften and split the reeds of jute and help to loosen dirt and speck and to convert rooty material into spinnable fibre. It is almost as though retting was being continued inside the mill.

As the temperature in the jute increases succeeding 'waves' of micro-organisms push the temperature higher and higher and under good conditions temperatures of 60 to 70°C can be achieved. If heated emulsion is used the growth of these bacteria is begun earlier and the stack reaches a good maturing temperature more quickly. For instance when the temperature of the emulsion was 20°C it took, in one test, 10 days for the jute to reach 50°C but when the emulsion was added at 35°C the jute reached 50°C in only 3 days.

Similarly, we find that the growth of micro-organisms accelerates rapidly when the moisture regain is over about 30% and we must ensure that enough moisture is applied to create these conditions.

A certain amount of ventilation is desirable to hasten maturing and it is customary to raise the stack on some form of stillage to let air in, while covers of heavy jute cloth or tarpaulin are used to retain the heat in the pile. Pile densities of 8 lb/ft^3 for long jute and 12 lb/ft^3 for cuttings and short fibre will be found to give satisfactory maturing.

Besides these benefits, maturing helps the JBO to lubricate the fibres. When the emulsion is sprayed on the fibre the oil forms a "skin" on the fibre surface. After a time some of the oil penetrates the fibre and lubricates the fibre and softens it internally. This happens in about 18 hours if we have fine fibre but takes as long as 6 days with coarse hard fibre. During oiling, moisture becomes more evenly distributed throughout the jute making carding easier.

A factor of supreme importance in process control in the batching department is that sufficient time is allowed to elapse before the fibre is put into work. A guide to the length of time which different qualities of jute require is:

Long jute (good grade)	..	2 days
Long jute (medium grade)	..	2 - 3
Long jute (low grade)	..	3 - 4
Cuttings	..	4 - 8
Mestha (good grade)	..	5 - 6
Mestha (medium/low grade)	..	6 - 9

When the pile is being taken down for feeding to the breaker cards there is some advantage to be gained from doing this as quickly as possible since there are indications that hot, or at least warm, jute fibre can stand the forces of carding at the shell/feed roller area of the breaker card better. This, in turn, gives a longer fibre length in the sliver - a beneficial state of affairs.

While it may seem to be a simple matter to keep a sufficient quantity of jute in the maturing stage the truth is that sometimes jute is fed into the process before it is ready.

If a mill spins from two batches and has the following production:

Batch A	White C	50%	12,000 lb/day
	White D	50%	
Batch B	White C	50%	18,000 lb/day
	Tossa D	25%	
	Cuttings	25%	

The daily jute requirement is as follows:

White C	6000 + 9000 =	15000 lb
White D		6000 lb
Tossa D		4500 lb
Cuttings		4500 lb
		30,000 lb

If the spreader rolls weigh 300 lb then the stocks maturing must not be less than -

White C : $\frac{15000}{300} \times 2$ days = 100 rolls

White D :	$\frac{6000}{300}$ x 2 days	=	40 rolls
Tossa D :	$\frac{4500}{300}$ x 2 days	=	30 rolls
Cuttings :	4500 x 6 days	=	27,000 lb in bins

At no time should a QC check show less than these stocks and, for safety, some 10% extra should be allowed for break-downs, power failures and so on. If the stocks of maturing jute are allowed to fall below the minimum levels the quality of the yarn will deteriorate. If it means working overtime or on days when the mill is normally closed, so be it. The stocks must be got up as quickly as possible to recover lost ground.

Carding Processes

In jute yarn manufacture, a good length of fibre is always beneficial. Short fibre, by itself, would not be a disadvantage if the distribution of fibre length was fairly even. The difficulty with jute is the great disparity of fibre lengths we find. Many fibres are less than 25 mm long while a few are as long as 500 mm. This is an intrinsic feature of the fibre and no carding system exists at present which can improve on this type of fibre length distribution with any degree of success.

About half of all the physical work done in the converting of reeds of jute into workable fibre takes place at the breaker card and, of this proportion, 80% occurs at the feed. Although many tests have been made on carding and carding theories abound, in practice there is little to be gained by departing from the machine maker's reccommended drafts, speeds and settings. Experience has shown that these give satisfactory quality over a wide range of types of fibre.

As generalities, we can summarise the important factors for the breaker card :

Pin density	Research has shown that extremes of pin density on either side of the norm have little or no effect upon the quality of sliver which is produced.
Cylinder speed	As speed is increased fibres get shorter and finer but the effect is small.
Breaker draft	High drafts give shorter fibre and lower quality ratios.
Shell/feed cylinder settings	Close settings give short fibre and low yarn quality ratios.
Loading	High loadings cause irregular yarn.

The finisher card continues the work of splitting the fibre network begun by the breaker card. In addition, it is a valuable doubling machine for reducing sliver irregularities. If the jute is dirty the finisher card will remove much of the bark and speck from the fibre and clean up the entrant sliver.

Once more there is little to commend altering the maker's recommendations but the following points may be noted.

Settings	Close settings <u>may</u> improve quality but only at the cost of more chokes in the card.
Worker speed	No effect between 30 and 90 ft/min.
Loading	Like the breaker, high loadings mean poor quality.

Carding Control

Checking for count at the finisher card should be the key control point. Here much of the earlier process irregularities have gone and we do not have the added statistical complications which these induce. A sliver length measuring roller, a balance reading to 1 g and a moisture meter are required. Five yards from each of five rolls are measured off and weighed and, at the same time, the moisture regain is found. An average weight is calculated then standardised to a pre-selected regain to eliminate the effects on the count of changes in the material's moisture regain. The choice of the standard regain is not important as long as all the tests are converted to this regain.

It is possible to check the finisher card sliver count by making measurement over the whole roll. The length of sliver is found from the knowledge of the final delivery speed and the time it takes to form each roll. The roll is weighed and by using the calculated length, the lb/100 yd can be calculated by proportion. Again the count would be standardised to a certain regain. The snag about this method of test is that it is necessary to have a very accurate indication of the delivery speed of the roll-former and also it is difficult to start and stop a watch exactly at the start and finish of a roll. Errors of 5% can easily be introduced in this test and the method is not so simple as it would seem.

Over a large number of 5 yd lengths a CV of 10% is satisfactory but each mill must evaluate its own performance and compile limits for control.

An example of this is given below :

The mill makes 500 measurements of the weight in lb/100 yd over 5 yd lengths by accumulating results from all the finisher cards on each quality over a period of 30 days. In this way we acknowledge differences between machines and between days over a reasonable period of time. The CV of the 500 tests is calculated and control limits determined in the usual manner using 2 SD's and 3 SD's as the limits.

Grand average of 500 tests	=	14.2 lb/100 yd
S.D.	=	1.16 lb/100 yd
CV	=	8.2%

A control chart may drawn up with the limits set :-

Upper action	17.7 lb/100 yd
Upper warning	16.5
Lower warning	11.9
Lower action	10.7

(Note Three significant figures is quite enough, do not calculate, for instance, the mean to 14.198 lb/100 yd).

An example of a suitable form for routine tests is seen in Figure 10.

XX JUTE MILLS LTD — QUALITY CONTROL DEPARTMENT

FINISHER CARD SLIVER TEST

DATE SHIFT TESTER QUALITY MACHINE NO.

Test mean, lb/100yd ________

Test range, lb/100yd ________

Test MR, % ________

lb/100yd @ STD MR ________

Spec. @ STD MR:

Mean lb/100yd

Range lb/100yd

MR

Wt of sample, g	Moisture regain of roll
Av. =	Av. =

Fig (10)

Example of test form for finisher card sliver tests

A control chart here is useful <u>if</u> the QC department has the ability to sustain it (of which more will be said later) but often, in practical mill conditions, a chart is not needed and a single limit of 2½ SD used for simplicity the picture then is :-

Target mean	14.2 lb/100 yd
Lower limit	17.1
Upper limit	11.3

Naturally, if we work without a chart we would expect there to be the extremes and we would want to see most (80%) of the results within 12.8 - 15.7 (± 1.25 SD's).

Great emphasis should be paid as far as possible given the constraints of the fibre grade, to reducing the finisher card sliver CV. A low CV is of great help in controlling the count of yarn over long lengths and controlling cut - to - out variations in cloth weight.

As well as controlling the average count of the sliver from each machine it is very important that each card should be operating under the identical conditions and producing material of the correct weight per unit length. It is not unknown for pinions to be changed during overhauls and the fact not reported to management with the result that perhaps one card in the line is non-standard. Inevitably this introduces extra variability in the total product line which cannot be corrected and will progress forward to the yarn and the cloth.

It should be regular practice for the QC staff to patrol the carding department observing the appearance of the carded fleece. A cloudy, patchy fleece indicates dirty or damaged rollers in the machine. Excessive numbers of chokes can give an indication that all is not well with the settings and a check requires to be carried out immediately. The importance of the QC and production staffs keeping alert surveillance on the cards cannot be over-emphasised.

CHAPTER THREE

Process Control in Drawing

The basis of good yarn quality is regularity of count and strength. The foundation of this is laid down in the early stages of manufacture. We may summarise broadly the effects of each process stage on the final regularity of the yarn :

Machine	Cause of irregularity	Effects in yarn
Spreader/ breaker feed	Human error Variable fibre feed Variable emulsion flow	Long drifts in count Makes most of the bobbin - to - bobbin variation
Cards	Variable feed Gulping Missing doublings Missing pins, blunt pins Dirt	Some bobbin - to - bobbin variation in count Neps and yarn uneveness
Drawings	Variable feed sliver Missing doublings Missing pins Bad splicing	1st DF responsible for variations in count of adjacent 100 yd lengths, 2nd DF for adjacent 5yd. lengths

	Dirt	3rd DF sets pattern for "thicks and thins"
Spinning frames	Variable feed sliver Bad splicing Dirt Poor draft control Bad rollers	Final "thick and thin" variation and slubs

The drawing stages of the process as we see play an important part in setting the degree of variation over lengths of yarn 100 m or less. In this regard, the number of doublings is a very important factor; the more doublings we have in the drawing stages the lower will our CV of hank weight become. As a general rule, the variation in weight varies with the square root of the number of doublings; for example a certain input variability, V, would be reduced in the output by $\frac{1}{n}$ where n is the number of doublings. Unfortunately, in practice, drafting brings in other irregularities until we get the final situation.

$$V_o = \frac{Vi \times d}{\sqrt{n}}$$

where V_o = variability in the output

V_i = variability in the input

d = draft

n = number of doublings

As quality specialists, we can do little about the fundamental design of the process in regard to doublings but there are some practical points which we can influence in our scheme of control.

The first of these is the proper use of doubling plates. At first sight these may seem to be simple devices to change the direction of the slivers so that they can be brought to a common delivery. This certainly is the one main function but they have more subtle action as well.

To understand this we must look back to the faller-bars. When a faller-bar reaches the end of the top slides and drops down to begin its return journey on the bottom slide, a group of short fibres is uncontrolled and is drafted as a thick place in th sliver. So, in all slivers we have a succession of thick places - faller-bar slubs - at regular intervals. In fact they are a distance apart which is found from

Faller-bar pitch x draft on the machine

As the slivers emerge from the drawing rollers all the thick places are, as it were, "in-step". An analogy may be seen in the army. When a platoon of soldiers is marching in step their feet meet the ground in a series of crashes. Our faller-bar slubs come out from the drawing rollers like this. When the platoon comes to a frail bridge the soldiers are told to break step because the rythmical beat of their feet may damage the bridge if they stay in step. When they move across, out of step, the bridge survives because the load on it is made more uniform. Our faller slubs are made "out of step" by the doubling plate and so give a more uniform delivered sliver.

The machinery maker has designed the plate, in terms of size and thickness, specially to achieve a more uniform delivered sliver and it is very bad practice not to use the doubling plate in the correct manner. One often sees slivers bypassing the 45°slots; the emerging sliver will, without doubt, be more irregular if this is done. Here is one control which must be imposed if quality is not to suffer.

It goes almost without saying that missing or damaged pins must never be tolerated if good control over drafting is to be achieved. The most heinous crime of all is to run with a faller bar missing.

Process control in the drawing really is fairly simple and comprises careful observation and supervision. Specific points to look out for are :-

1. Back guides should be correctly placed to lead the sliver centrally on to the gill-pins. Their width should be correct and on no account should fibres be seen outside the gill-pin bed.

2. All pins and bars should be in place.

3. Where picking bars are fitted, these should be at the correct height.

4. Loading on the pins should not be excessive. Sliver riding over the pins is to be deplored – it is a sign of heavy sliver, poor pins or wrong leads of the bars over the retaining rollers. Push-bar machines are more difficult to control in this respect as are low oil-content slivers.

5. No rags which can snag fibres should be seen on the front conductors.

6. Rubber-covered pressing rollers must not be damaged or have flats on them.

7. Drawing pressing roller springs should be correctly tensioned.

8. Crimp should be clean and related to sliver count.

9. Cans should be free from rough edges and should move properly on the coiler plate.

10. Can-tramper heads should be free from rough or sharp edges and their traverse should not trap sliver against the side of the can.

11. Stop-motions should always be operable. Too often one sees stop-motions held up by plugs of fibre; this is a sign of bad maintenance. This is another example of how good maintenance

and good quality are inexorably linked.

12. Cleanliness is imperative if dust-slubs are to be kept out of the sliver. All bars should be picked and cleaned on a regular schedule.

Sliver Faults

With the best intentions in the world it is impossible to avoid all faults in slivers. Some of these are :-

1. Neps. Small (less than $\frac{1}{8}$ inch in diameter) entanglements of fibre seen in card sliver. They are caused by worn or hooked pins. They do not fall from the sliver and can be the cause of the yarn slubs.

2. Dust slubs. Accumulations of dirty short fibre usually seen in the later drawing stages. As the name implies they result from dirty machines.

3. Slubs. Pieces of sliver 3 or 4 times as thick as the normal sliver. May be caused by slow chokes which should have been removed from the can but were not. They may be several yards long.

4. Low count. Sometimes long sections of sliver are found to be under-count. This may arise from one sliver "stealing"

fibre from its neighbour when entering the machine. It will always be accompanied by the same length of heavy sliver in some other sliver.

It may also result from a lap at the delivery and failure to remove the faulty piece from the roll or from the can. If a doubling has been lost at the feed low count sliver must result.

5. Dirt. Usually oil from careless lubrication causes this.

6. Splitting. A phenomenon seen at roll feeds where drawing sliver which has been doubled at a delivery splits at the feed of the next machine. This will cause intermittent thick places in the delivered sliver.

Sliver weight control

The key control point for sliver weight control in the drawing stages is the finisher drawing frame. Many mills spend a lot of time testing each sliver weight at each drawing stage but, really, there is little merit in this. Draft pinions are seldom, if ever, changed at any of the drawing stages and so testing each stage is largely of academic interest. It is much more fruitful to spend this testing time in checking that each of the finisher drawings are working under identical conditions and are producing sliver all of the same count.

The recommended procedure is to measure out five 25 yd lengths from each finisher drawing in the line, weigh them, check the sliver moisture regain and then calculate the sliver count at the pre-selected regain. Sliver count checking at the finisher drawing can be regarded in the light of assuring that none of the earlier processing stages have gone out of control and also of giving 'early warning' that some draft changes may become necessary in the spinning department in the next few hours.

The control may be applied by means of the conventional control charts for mean and range.

Autolevelling

We should also mention process control for autolevelling drawings of the Mackie Draft-o-matic type which are used to produce higher quality yarns. These are sophisticated machines and they need good maintenance. If they cannot be given this their value is doubtful.

We can summarise their effect on yarn quality in this way :-

1. Short-term irregularities of yarn are not improved by autolevelling
2. Long-term count variation is improved
3. An autoleveller is equivalent to about 25 doublings at fixed draft

Quality control checks which can be made on-line for the autoleveller are important. As well as visual examination of the position of the cone belt at the rear of the machine, one may make "full can" tests to check the long-term stability of the machine and also "short-length" tests of 10 yd or so to check how well the measuring rollers and the mechanism are reacting to input variations. A Mackie Draft-o-matic, in good order, can correct long-term variations up to ± 20% in the feed slivers and can reduce the CV of yarn count by about 50% . Fixed-draft second drawing sliver has a CV of 1 yd lengths of around 6% under average mill conditions. With a well-maintained Draft-o-matic drawing this can be reduced to 2 - 3%. Carrying this forward to yarn count variations, the CV can fall from 6% to 3% when an autoleveller drawing is used. Some improvement in spinning efficiency may be expected but the effect is small because (a) the autoleveller does not improve the short-term yarn regularity and (b) the major influence on spinning breaks is the condition of the frame itself.

Drawing systems

The drawing system used to produce sliver of various grades takes account of the type of fibre and its quality requirements. The following are examples drawn from practice and which will give satisfactory quality:-

	CBC grade (A/D)	Hessian and sacking warp (PB & SD)	Sacking weft
1st drawing			
Draft	3.7	3.7	4.0
Doublings	2	2	2
Del.speed,ft/min	123	120	112
lb/100 yd del	9	9	7
Faller drops/min	860	900	675
Intermediate drawing			
Draft	6.4	6.0	-
Doublings	8 (DOM)	4	-
Del.speed ft/min	192	90	-
lb/100 yd del.	11.2	3.9	-
Faller drops/min	760	380	-
Finisher drawing			
Draft	9.3	9.0	8.4
Doublings	1	2	120
Del.speed ft/min	115	130	340
lb/100 yd del	1.2	0.9	1.7
Faller drops/min	400	450	620

To summarise, we can say that the aim in drawing is to present as even a sliver as possible to the spinning frames. The sliver must be on count and have a regain at the target level. Modern thought in textiles is to control, as closely as possible, slivers early in the process to achieve long-term count stability. In jute manufacture this means careful measurement at the finisher card sliver primarily and, as a secondary control, at the finishing drawing frame. The main work of control in the drawings is vigilance to prevent miss-use of the machines and bad working habits.

CHAPTER FOUR

Process control in spinning

Users of jute yarn place most emphasis on regularity, mean count and mean strength when judging the quality of a yarn. But before we can assess a yarn, even in those simple terms, we should try to understand something of the factors involved in yarn quality, to know which are important and which can be controlled successfully.

Short-term Irregularity

Much of the short-term irregularity in weight arises from machinery effects late in the process and unless draft control is good, especially at the finisher drawing and spinning frame, the yarn will have greater irregularity than the fibre grade would lead us to expect.

The importance of good short-term regularity shows up particularly in relation to yarn strength. Under practical conditions the performance of a yarn is decided, not by its average strength so much as by the strength of its thinnest places. One may have two yarns with the same mean strength but if one is more irregular than the other then it will break more often in winding and weaving. An example showing this effect follows.

	Yarn 1	Yarn 2
Mean strength	4.0 kg	4.0 kg
CV of strength	14%	18%
SD of strength	0.56 kg	0.72 kg
Calculated minimum strength ($\bar{x}$ - 3SD)	2.32 kg	1.84 kg

The wide divergence of fibre length found in jute makes draft control difficult. When the long fibres are caught in the nip of the drafting rollers and move forward they drag short fibre along with them in an uncontrolled manner. This gives rise to thick places followed by thin places in the slivers or yarn. There is no way to avoid this completely but to minimise it we must maintain the machine's draft control system in as good condition as we can. At an apron draft spinning frame, for example, if the apron's movement is jerky then irregular drafting will occur and slubs will inevitably appear in the yarn.

Although thin places in the yarn are undesirable the other end of the irregularity spectrum is a problem too. Thick places and, in their extreme form,slubs cause problems in subsequent processing when they stick in guides, reeds, etc., and cause breaks at weaving. This is a particularly bad defect with yarns which are to be used for Axminster carpet weaving where smashes caused by slubs are very expensive to repair. Pile distortion in carpets may be seen as a result of extra-thick places in the jute.

Undue emphasis however must not be put on the 'normal' variations in diameter of yarns. It is when we enter the field of gross defects that really serious quality problems arise.

Gross Yarn Defects

The difficulty which arises here in quality control is that although such faults are extremely serious they are sometimes difficult to isolate in view of their comparitively infrequent occurence. Gross defects include very large and heavy slubs (particularly from apron-draft spinning frames) "run-ins", dust slubs, bad piecings, slack twist, blow-ins, etc. These may happen only once in every two or three bobbins i.e. in every 4000 or 5000 metres and so it is very difficult to pick up such faults in routine testing. Often the best place to find them is in the winding department (especially if one is using yarn clearers)

Examples of defects include :

Slubs up to 200 mm long and three times the usual yarn diameter	Often seen on apron-draft yarn caused by a mechanical fault (very often associated with the apron)
Dust slubs	Twisted-in lumps of dust often coming from dirty drawing frames

Blow-ins	Loosely attached fibre from an adjacent end which has not stopped delivering fibre because of a faulty stop motion
Bad piecings	Poor technique by the spinners
Slack twist	Twist too low due to an incorrectly tensioned list on the flyers

Long-term Variation

Although this aspect of yarn irregularity is of less importance than the short-term, it still requires attention and control. The factor above all else which determines the long term irregularity is the number of drawing doublings - the higher this number, the better will be the regularity between 50 to 100 m length.

TABLE 2

Effect of drawing doublings on hank CV of good/medium grades of jute

No. of drawing doublings	CV of 100 m lengths
24	4
12	6
6	8

approximately -

$$CV = \frac{20}{\sqrt{\text{No. doublings}}}$$

The values for hank CV will vary about these figures but the general level is set in the drawing passages. It should be noted that these data refer to individual 100 m hanks taken one from each of 100 bobbins. (The CV of hank weight depends cricially upon how one samples the yarn as we will see later). The question is often asked, 'what is a good CV of jute yarn?' In reference to 100 m hanks taken one per bobbin the following values can be taken as typical :

Regular	Less than 3.5%
Medium	3.5 - 5.0%
Irregular	5.0 - 7.0%
Very irregular	over 7.0%

TABLE 3

Sources of Yarn Weight Irregularity

Machine	Cause of irregularities	Effect in yarn
Spreader or softener	Human error at feed	Long term drifts in count
	Variations in morah weight	Responsible for 75% of bobbin-to-bobbin variation
	Drafting waves	
	Variations in emulsion flow	Bobbin-to-bobbin variations in count in small samples
	Variations in feed slivers	Responsible for 25% of between-bobbin count fluctuations
	Gulping	
Drawings	Variations in feed slivers	1st responsible for variation in count of adjacent 100 yd lengths
	Missing doublings	
	Faller-bar slubs	2nd for adjacent 20 yd lengths and sets pattern for 'thick and thins'
	Bad splices	
	Faulty stop motions	

Spinning frames	Variations in feed sliver	Sets final degree of short-term irregularity
	bad splices in sliver and yarn	
	Incomplete draft control	
	Faulty aprons	

Yarn Strength

For all normal quality control purposes this is one of the main criteria used for assessing the quality of yarn. As we said earlier, it is not the average strength which is so important in practice but the minimum strength, because the yarn will always break at its weakest point when a load is applied to it.

Statistically, yarn strength follows the normal, or Gaussian, distribution and it is the breaks in the lower 'tail' of the distribution which really reflect how the yarn will behave in spinning, winding and weaving.

The strength of yarn is influenced by many inherent variables such as the following :

Fibre fineness and length	Generally, fine jute gives better strength than coarse fibre; long fibre is to be desired

Twist	If the twist is too low then some of the fibres will slip passed one another when a load is applied and the yarn will be weak. On the other hand too high a twist causes internal strains in the yarn and again we get low strength results. For each yarn there is an optimum twist for maximum strength. For carpet yarns higher twist factors may be used to give better abrasion resistance and a rounder thread with less surface hair. Again, lower grades of fibre require higher factors to bind in their short fibre.
Evenness	An irregular yarn will always have a lower breaking load than a more regular one because of the increased number of thin spots which it will have. The unevenness may arise from the raw material or faulty processing.
Fibre defects	Root, bark and stick in the yarn will all increase the variability of breaking load and produce a weaker yarn.

Frame Type and Yarn Quality

The question is often asked, does the apron-draft frame make a better yarn than the slip-draft ? Like so many questions in jute technology, the answer is "yes and no". Yes, if the AD frame is well-looked after. No, if maintenance and cleanliness are poor.

TABLE 4

Yarn quality from SD and AD frames

	QR		CV Breaking load	
	SD	AD	SD	AD
1. Hessian batch				
8 lb		102%	19%	21%
10	96	108	16	15
12	99	116	15	11
14	105	113	14	12
16	104	114	12	12
2. Good carpet yarn batch				
6 lb	103%	114%	18%	14%
8	120	127	16	11
10	127	139	14	12

Table 4 shows the results of a test in which a set of finisher drawing cans were fed to an AD frame then to SD frame then back to the AD and so on until the sliver was finished. This ensured that the material being fed to both frames was homogeneous. If a difference was found between the yarns it could be ascribed to the machine and not to variations in the sliver.

Clearly, AD spinning gives superior yarn but, paradoxically, it gives worse yarn if it is not maintained well. The AD frame will produce slubs of size and length never seen in SD-spun yarn if the maintenance is not first class. This is yet another example of how good quality and good maintenance are inter-related. A well-maintained mill is a quality mill.

On the AD frame the following points must be attended to diligantly if good control is to be achieved.

1. Builders must be level, no over - or under - built bobbins to be seen.
2. Builder locking pins and rack teeth to be cleaned away from the builders and slides each shift - an air jet is useful for this.
3. Old oil should be drained, spindles cleaned and new oil put in the resevoirs every 1000 hours.
4. Inspect bobbin carrier drag pads and clean with wire brush soaked with kerosene every 1000 hours. Add a drop of oil to each pad when the carrier is replaced.

5. Check regularly that the oil is at the correct level in the reservoir at least every 75 hours.
6. Remove the apron assembly and clean thoroughly every 450 hours.
7. Trim the apron when necessary to prevent it bearing on the side stands - a 3 mm clearance at each side is essential if slubs are to be avoided.
8. Wear on the rubber-covered delivery pressing roller should not exceed 0.2 mm. No damaged rollers should be tolerated.
9. The yarn conductor must be in place at all times.

Yarn Count Control

When yarn is being checked for c nt some practical points should be remembered

- Ensure that one of the QC staff take the samples or at least are present when they are taken to avoid sampling bias. Any supervisor worth his salt can choose bobbins of light or heavy yarn to suit his needs at the time.
- Test the count as quickly as possible and report back immediately
- For counts up to about 20 lb take off 100 yd hanks, one from each of five bobbins. Make sure that the balance used is of suitable capacity (an accuracy of 0.1 g is ideal).
- Do not use a reel of less than 1.5 yd circumference and see that it has an efficient traversing mechanism. Under no circumstances should yarn pile on top of pervious layers on the reel. For yarn over about 24 lb it will help if the hank

length is reduced to 50 yd.

- Measure the regain as quickly as possible and then standardise the count at regains of 20% for sacking, 16% for hessian and 14% for CBC and sale yarn.

An example of a type of count control test form and a control chart used to check the mean and range in count can be seen in Figures 11 & 12. It is useful to have space on the control chart to show the weekly mean count, mean range, regain and CV of hank weight.

The CV should be only calculated weekly using the thirty or more results accumulated during the week of 6 days.

There is no need to take samples for count testing more than once per shift in a well-run mill. It is however important that we take samples from the first two doffs after a draft pinion change to make absolutely sure that we have "started right". Thereafter it is a question of testing periodically to make sure to "keep right".

Whether count is checked during every shift or once per day depends upon the grade of yarn being spun, the size of the mill, personnel availability and so on. As a rule of thumb guide, if a sample is taken from every 2000 lb of each quality of yarn which is spun then adequate control will be achieved. In smaller mills this may be increased to one sample per 1500 lb spun.

One man can comfortably handle 40 5 - bobbin tests in an 8 - hour shift along with other duties. In larger mills blocks of frames on the same count and quality can be treated as one and samples drawn accordingly. If off-standard yarn is found in a block of frames the others in the block should be checked to see how widespread the off-limit material is.

As a general rule we can say that it is always better to take samples from as wide a population as possible. For instance, it is better to take 100 yd from each of 25 bobbins than to take 500 yd from each of five bobbins. Although we finish with 2500 yd in each case by casting our net over 25 bobbins we improve our chances of detecting light or heavy yarn.

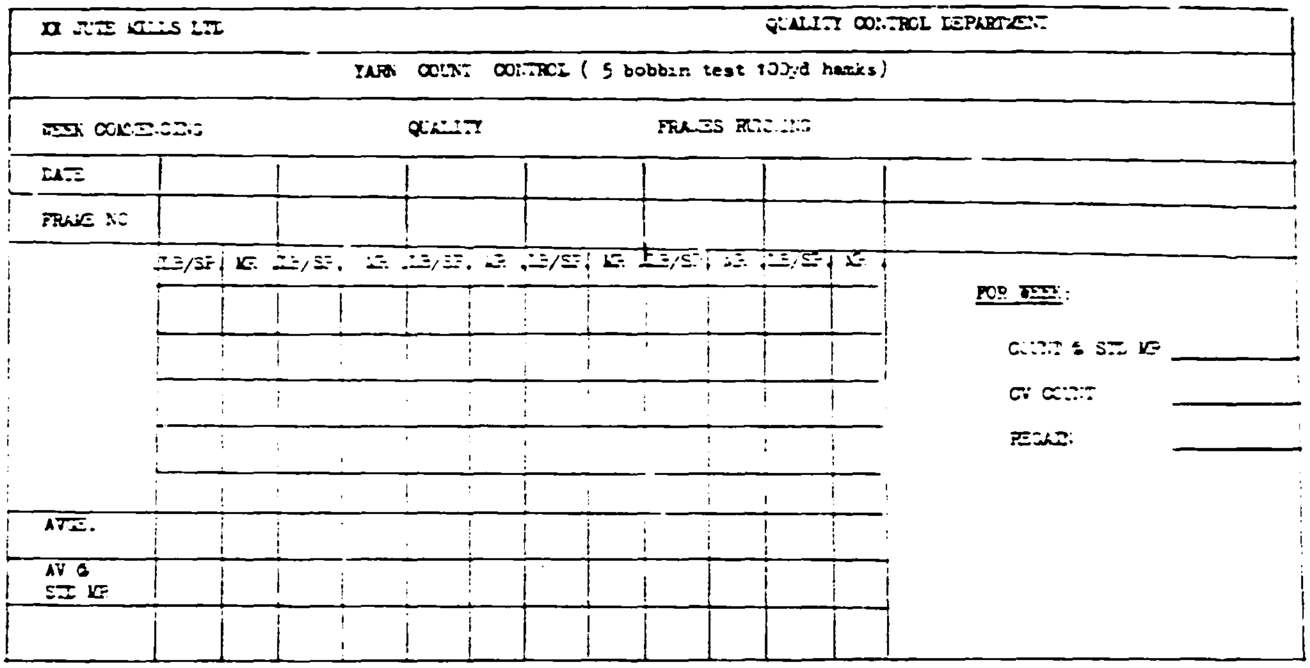


Fig (11)

Count testing form

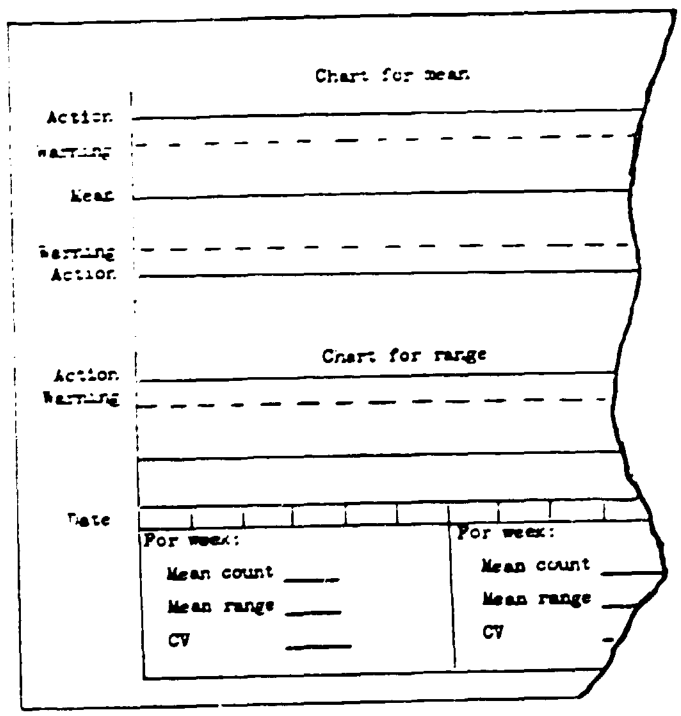
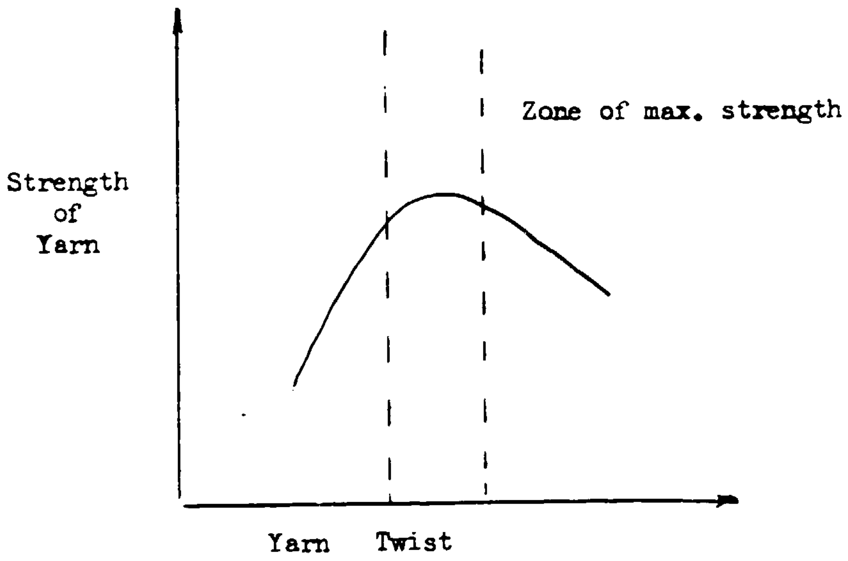


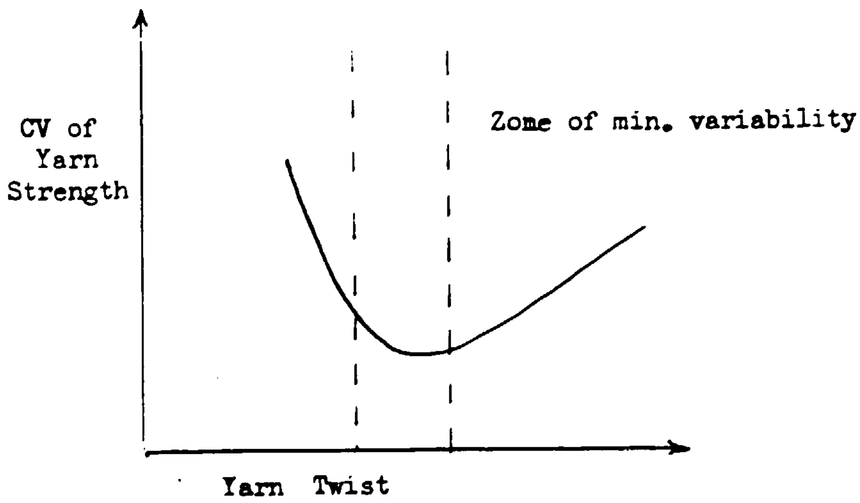
Fig (12)

Control chart for yarn

Twist and Yarn Quality

It is well-known that the strength of yarn varies with the amount of twist in it. Figures 13 and 14 illustrate how strength and CV of breaking load change as the twist is steadily increased in jute yarns.





Figs. 13 and 14. Effect of twist on yarn properties

The zone of the greatest strength and lowest CV is not defined exactly but it is somewhere between twist factors of 11 and 12 for long jute and about 13 for yarn made from cuttings, ropes etc. Twist factor ofcourse being –

$$\text{Twist factor} = \text{t.p.i.} \times \sqrt{\text{lb per sp}}$$

Sometimes, in order to get special effects we use a twist factor somewhat higher than 11 – 12 e.g. in yarn for carpet weaving a rounder, less hairy yarn is wanted and a twist factor of about 13 is selected for this purpose.

Common twist factors in use are :

Hessian weft	11.0 – 11.5
Hessian warp	11.5 – 12.0
Carpet yarns	12.5 – 13.5
Sacking warp	13.0 – 14.0
Sacking weft	12.0 – 15.0

We can summarise the effect of twist :

Higher twists give

- less hairy yarn
- rounder, leaner threads
- slightly more extensible yarn
- yarn with better abrasion resistance
- less production/hour

Twist is measured on the conventional twist tester. Many Standard Test Methods stipulate a 10 inch test length but for jute a 4 inch test length makes the test easier and quicker to carry out. The shorter test length increases the variation slightly in the results but the practical advantages gained far outweigh this. The four inch test length is now standard in Bangladesh mills.

Twist testing is only required once or twice a week as a routine check. As a rule, twist gives few problems in process control. However, there is one feature we should be on guard about and it is slack twist. Slack twist is twist which is very much below the correct value and is usually isolated to one bobbin in the set. It is caused by slow flyer rotation due to excessive slip at the wharf. On the frame itself, this may be seen by looking long the machine to see whether any of the flyers is rotating in a different manner from the rest. It is seen as a stroboscopic effect.

Process control and Ends down

All other things being equal, a low quality yarn always breaks more often than a better quality one during spinning. On $4\frac{1}{4}$ inch frames for example the spinning tension is, on average about 600 g but there are pulses of tension of very short duration which can be as high as 4500 g. When one of these tension peaks coincides with a weak place in the yarn, the end breaks. We might think therefore that if we were to count the number of times a yarn breaks in a given time on the spinning frame, we would have a very good estimate of its quality. The idea is tempting in its simplicity but in practice many other factors come into operation. The least of these is the difficulty of measuring the ends down rate (EDR) with any great accuracy. It can be done only when conditions are good. If the spin is bad it is next to impossible to record the number of spinning breaks in a certain time especially if there is more than one spinner working on the frame. An observer can cope with an EDR of up to about 120/100 spindles per hour but above this his accuracy falls dramatically.

With good quality yarn and well-maintained frames the EDR can be as low as 10/100 sp/hr on apron-draft frames and 25/100 sp/hr on slip draft frames. At the other extreme, heavy sacking weft yarns have EDR's which are so high it is impossible to record them accurately.

The other way of dealing with ends down observations is to use the random snap-observation technique where a "snap-shot" of the frame is made instantaneously by an observer and the number of spindles which are idle due to end breaks is recorded. If anything, this method seems easier than the one mentioned previously but, again, there are practical difficulties to be faced. First, it is essential that the snap observations are really made instantaneously and at random. This is more difficult than people realise. Second, workers can (and do) deliberately influence the number of idle spindles on their frame when they see an observer approaching. Third, statistical variations in this test are extremely large as we shall see later in this book.

Both tests – the EDR and the snap-observation – are best kept as investigative tests. Experience shows that they are of little merit as routine quality control tests and yield little, if any, control information. If some process change has been made or perhaps a new cleaning schedule set up or some other major alteration introduced in the mill then this is the time to use end break tests.

We started this section by saying that end breaks are related to yarn quality 'all other things being equal'. In spinning they seldom are. The of factors influencing the end breakage rate which follows could be added to many, many times :

Frame factors

1. Dirty drag-pads which give rise to high spinning tensions.
2. Drag-pads in the wrong position. In the inner position they give least strain on the yarn and vice versa.
3. Eccentric spindles cause high sudden tension peaks in the yarn resulting in more breaks.
4. Flyers which are grooved or have sharp edges will cut the yarn.
5. Flyer r.p.m. must be suited to yarn quality. As a general guide front roller speed should be

4.25"	SD frame	850–950 in/min
4.25	AD	1000–1150
4.75	SD	800–900
4.74	AD	950–1050
5.50	SD	750–850

6. The tops of bobbins should be smooth and free from snags. Over-building at the top or bottom of the bobbin must be avoided otherwise high, irregular tension will develop at the end of each builder traverse.
7. Stop motions must all be in good order.
8. List joints must be correctly made to avoid tension jerks.

Yarn factors

1. Grade of fibre
2. Dirt, foreign matter, root, bark all cause problems in spinning.
3. Low regain yarn does not spin as well as properly conditioned material.
4. Weak, damaged fibre.
5. Wrong twist pinion on the frame.
6. Wrong draft pinion on the frame.
7. Count of yarn not related to frame size. The following can be used as a guide.

SD frames	
4.25 inch	6 - 10 lb
4.75	10 - 18
5.50	18 - 36
6.00	38 - 64
AD frames	
4.25 inch	5 - 12 lb
4.75	8 - 18
5.50	14 - 36

Environmental factors

1. Spinner's skill and diligence
2. Standard of cleanliness
3. Temperature and humidity

In the light of this list of it is not hard to see the inherent dangers of trying to use end-breakage tests as a means of routine quality control.

Before leaving this section we should note the importance of spring compensators fitted on Mackie apron-draft frames (with the exception of their $4\frac{1}{4}$" frame) see Figure 15.

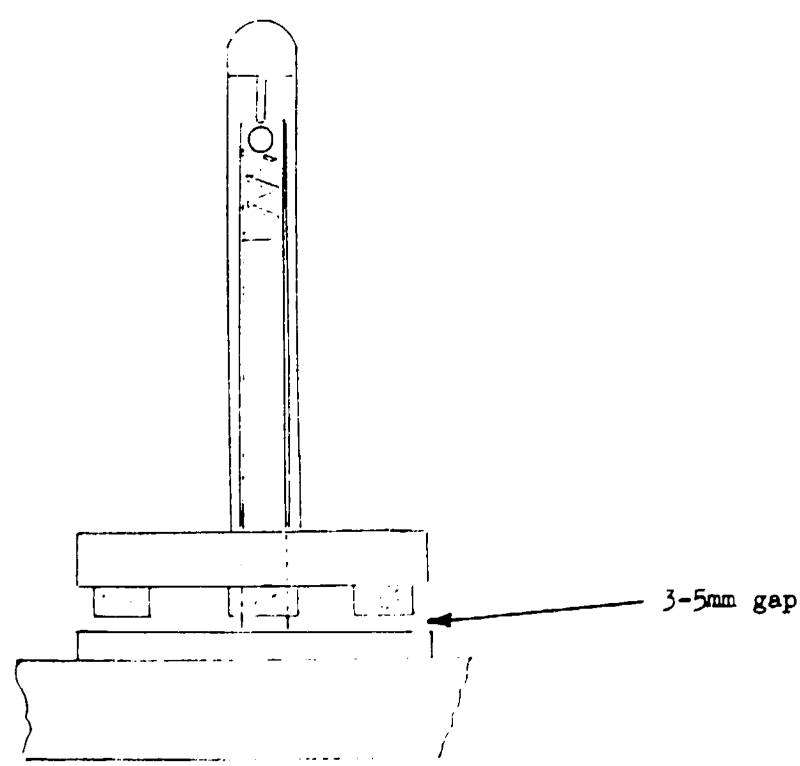


Fig (15)

Spring compensator in AD frame

The principle is that when spinning starts the compensator supports the carrier and bobbin reducing the pressure of the drag-pads on the bobbin-plate. As the bobbin fills and its weight grows the compensator spring compresses and the carrier bears more firmly on the plate. By correct use of the compensator it is possible to arrive at more even tensions while spinning and as a result have fewer end breaks. This is of benefit to quality since each end break is a potential yarn defect. The compensator spring is correct when the empty carrier floats about 3 - 5 mm above the plate. Sadly this is seldom seen in poorly -maintained mills and their usefulness is lost. The figures below illustrate the effect of the correct use of the compensator on spinning tension in tests made at S.T.R.A.

	Average spinning tension	
Yards on bobbin	Without correct spring compensator	With correct spring compensator
10	207 g	97 g
150	130	98
300	117	100
450	95	96
600	75	93
750	97	88
870	105	91

The number of end breaks fell as a result from 101 to 35 in one test and 66 to 34 in another. Regrettably, it is more common not to see the compensators in use than to see them in use.

CHAPTER FIVE

Control in Winding and Beaming

Even if we have spun good quality yarn we lose much of the benefit if we do not wind it well. Many of the problems associated with pre-beaming and dressing can be traced back to poor spools. A particularly important feature is found in winding precision spools for sale to carpet manufacturers; these must be presented with the highest standard if very serious trouble is to be avoided at the carpet loom.

When we sell yarn on precision-wound spools the quality aspects to be controlled are :-

1. Hardness. The rule is that no precision-wound spool can be too hard. If the spool is struck firmly with the knuckles it should emit a sharp clear note if it has been wound firmly enough. A dull note indicates softness - a very bad defect. Another simple test is to push strongly with the thumbs on the ends of the spool. If an indentation can be made, the spool is too soft and it should immediately be sent back for re-winding.
2. Lay. There is no excuse for incorrect lay. The adjustment is so simple that each spool should be correct. A danger to be avoided at all costs is too close a lay at the beginning

of the spool - this will cause cut or damaged yarn at the cross-overs.

3. Position on the spool. The yarn should be central on the centre.
4. Tag-ends. If the order calls for them, there should be 100% tag-ends present. Any departure from this indicates slack supervision.

Daily checks must be made in the winding department and it will be found useful to have a check-list against which the various parameters can be compared. This not only gives objective evidence that the check has been carried out but gives line management information so that precision winding is given in Figure 16.

XX JUTE MILLS LTD			QUALITY CONTROL DEPARTMENT
PRECISION SPOOL CHECK-LIST			
DATE	SHIFT	QUALITY	COUNT
NUMBER OF SPOOLS EXAMINED ______			
DEFECTS:		NO. OF DEFECTS FOUND	
Bad position on centre			
Poor lay			
Softness			
No tag-end			
Cobwebs			
Visible yarn faults			
Dimensions		______	
TOTAL NUMBER OF DEFECTS		______	

Fig (16)

Precision spool fault check-list

As far as cops are concerned, a particularly important feature is the nose angle. If the angle is less than 62^{o} there is a danger of the cop throwing off coils of yarn on every second pick when the shuttle is brought to rest in the box. These coils will appear in the cloth as 'snarls', see Figure 17.

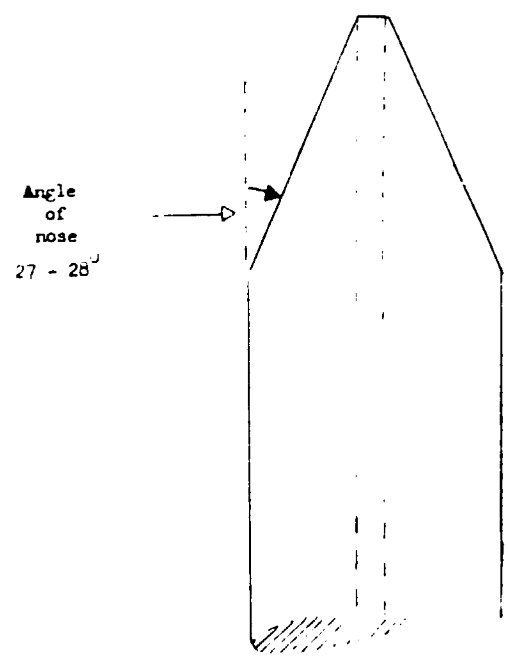


Fig (17)

Correct cop nose angle

The angle can be checked with a simple angle-gauge or by measuring the length of the nose; it should be at least 3 mm greater than the diameter of the cop. The other dimensions, viz. length and diameter are important too since the cop must fit closely, but not tightly, into the cavity of the shuttle. To aid control of this property a go-no-go gauge can be used to good effect, as is shown in Figure 18.

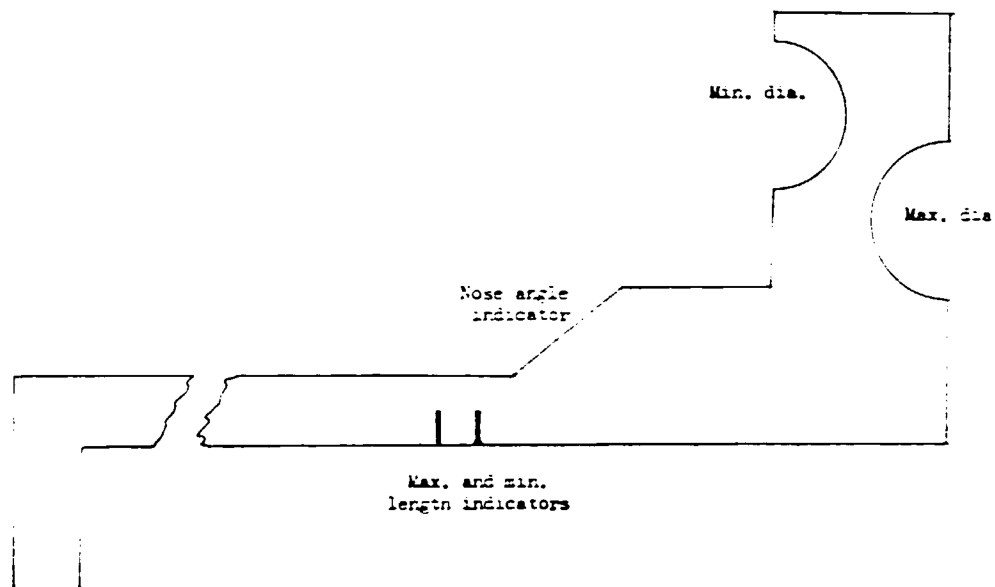


Fig (18)

Cop dimension gauge

Measurements of moisture regain should be made in the winding department on spools which are to be sold. For spools which are to be used for weaving within the mill this is not so important. However, for in-house weaving a check should be made upon the moisture regain of cops because this has an effect upon cloth width - the higher the regain, the narrower is the fabric. Variable cop moisture is one of the factors which cause variable cloth widths. Since it is relatively easy to measure and control it is worth doing so.

If the mill is producing yarn for sale it is essential for the spools and cops to be wrapped in polythene film then packed correctly and neatly in appropriate bags which are correctly labelled. It is good practice to insert a small label in each spool showing the count and quality of the yarn and such details as the winder's work's number, shift number and date of winding. Where several counts and qualities are in production simultaneously in the mill great care is needed to ensure that no mixing of yarn takes place in the packing department.

Yarn Clearing

As a general rule, each successive stage in jute manufacture is more expensive in all respects than its predecessor e.g. drawing is more expensive than carding, spinning is more expensive than drawing and so on, until ultimately the most expensive operation of all, weaving, is reached. For this reason as well as for quality we should eliminate, as far as practicable, machine stoppages at the more expensive stages. In a sense we want to remove at winding, as far as we can, weak places and thick parts of yarn. A stoppage at a winding spindle is much cheaper to repair than a stoppage at weaving. High winding tensions will remove most, although not all, weak points in the yarn.

To remove thick slubs and other defects the yarn may be passed through clearers (also known as slub-catchers or yarn scanners). These devices may comprise a simple case-hardened slot through which the yarn can pass if it is 'normal' diameter but in which a thick slub will be caught. The offending element is then removed, the yarn knotted and the spool restarted. Other more sophisticated clearers operate through moveable blades or by photo-electric or capacitance-measuring devices which trigger a cutting blade when a thick piece of yarn comes along. Whichever system is selected the principle is similar. The measuring device is set to a gap related to the yarn count. The yarn will pass through if it is within a pre-set tolerance for diameter but is stopped if it is outside the tolerance. In selecting the gap-width for the clearer there is no standard for each count of yarn and each mill must make its own standards. The choice lies between removing the most troublesome defects in the yarn while at the same time not having so many stoppages that the winding production is seriously hampered and the yarn is full of knots. We must therefore compromise between 100% clearing with very low production and a lower level of clearing but a more reasonable production. In the practical case, clearing can be relied upon to remove only 75% of the thick places in the yarn.

The gap setting will vary with count as may be expected and clearers will be much easier to use when the yarn count has been carefully controlled.

Clearing is particularly important when we sell carpet yarn. Table 5 gives an idea of the faults in with yarns and with good clearing. We hope to elimate most of the class 3 and 4 faults.

TABLE 5

Slubs and faults in carpet yarns

Size of slub	Up to 1 in.	1 to 3 in.	3 in. or more
6 x yarn dia.	3	3	4
4 x yarn dia.	2	3	4
2 x yarn dia.	1	2	3

1 = acceptable

2 = annoying but acceptable

3 = cause for complaint

4 = very serious defect

As a starting point, the gap should be set to 2.5 x yarn diameter and small adjustments made from there to accommodate different grades of yarn and clearing levels. If 8 lb yarn is passed through at 1.7 mm gap there will be of the order of 1 slub stoppage per 1000 yd for a good grade of yarn.

Knots

In the normal course of winding we cannot avoid yarn breakages and bobbin changes at each end of which we must tie a knot. In addition, if the yarn is cleared there are extra knots at each place where a slub has been taken out. Each knot should be neatly tied using a weaver's knot as this is the one knot which will move comparatively easily through the dents of the reed in the loom. It has been shown that roughly 25% of all warp breakages in the weaving of good-quality hessian cloth are caused by knots. The importance of neat knots cannot be overestimated and regular checks should be made in the winding department to see that the quality standard is being kept up. The tails of the knot should be trimmed to 3 mm or so. If they are cut too close to the knot the ends will pull apart under tension in weaving. Long tails, of course, entangle with adjacent yarns and cause breaks as well as being unsightly.

Yarn Clearing used for Quality Control Assessments

Since the yarn clearer is set a level which will take out many of the yarn faults, useful information can be derived if all the yarn which is cleared is collected and analysed at the end of the shift.

After we have collected the cleared faults over the duration of a shift the quantity can be measured easily by weighing the yarn taken out and relating this weight to the amount of yarn which has been wound. By eye we can also assort the faults into varying lengths and diameters to try to isolate the reason for irregularities.

Control in Warp Preparation

Just as winding can affect the quality and efficiency of pre-beaming and dressing, so too does the standard of warp preparation have a direct bearing not only on how well the warp will weave but on the quality of the cloth which will come from the loom. Each weaving stoppage is a potential quality defect. Missing ends, crossed ends, big knots, slack and tight ends all have a detrimental effect on the quality of the cloth and great care is needed when warps are being make. All guides, reeds, pre-beams and weaver's beams require regular checking for signs of wear and damage.

In pre-beaming, the use of an oscillating reed will help to make a more uniform beam with more even tensions between the ends. If the surface of the beam is allowed to develop grooves and hollows there is a danger that some threads will become trapped or overlaid. When they come to dressing they cannot unwind correctly and they are broken by the high tensions which develop. The pre-beamer provides a good point at which the regularity of the yarn can be seen. If we find that the number of breaks in the yarn at the pre-beamer is going up this can be a useful indicator that all is not well and trouble may be expected in the looms when we put these warps into work.

Dressing

The main object in dressing jute yarns is to lay the surface hair so as to make the passage of the yarn through the loom easier and to provide a clean shed through which the shuttle can pass. Other beneficial side-effects accrue viz. improved abrasion resistance, some increase in yarn strength and a somewhat better cloth appearance. Some data on the difference between starched and unstarched yarn is given in Table 6.

TABLE 6

Properties of 8 lb yarn before and after sizing

	Unsized	Sized
Count, lb/sp	8.1	8.4
Mean strength lb	7.1	8.0
Extension at break, %	1.7	1.5
Abrasion resistance (unsized = 100)	100	137
Ballistic strength, in.lb	20	25

In jute yarns, the ideal is to pad the starch paste into the yarn to a depth equal to 25% of the yarn radius. More than this and we find that the yarn becomes too stiff and the little elasticity it has will be lost.

For good dressing the amount of starch paste which is picked up as the yarn moves through the starch box should be equal to about its own weight i.e. a starch pick-up of 100%. The temperature or viscosity of the starch paste is not critical over the normal range we meet within practice but nevertheless, when we have specified processing conditions, periodic checks should be made to ensure that no unwanted variations have crept in.

The viscosity of the paste will depend upon :

1. The type of dressing agent used e.g. farina, sago, tamarind kernel powder.
2. The concentration of starch. For any type of starch the greater the weight of dry starch relative to the quantity of water, the more viscous will be the paste.
3. Temperature. In general, the higher the temperature the lower will be the paste viscosity. In the preparation and use of starch pastes for dressing an important factor is the speed at which the thin cell-wall of the starch granule ruptures; this is affected by temperature and time. Finally, all starch pastes gel when cooled; once this has occurred the paste can never again be transformed into a satisfactory dressing agent.

4. Agitation. This will cause permanent loss of viscosity and so all movement in pumps, supply lines and starch boxes should be gentle.
5. Storage. The viscosity will fall if the paste is kept for any length of time even when it is not mechanically agitated. The loss is permanent.

The other ingredients of dressing mixtures, e.g. tallow, metallic chlorides, gycerol, soap, salicylic acid etc., have little or no practical bearing on the starch paste viscosity.

The quality factors which require some examination and control during dressing are mainly concerned with the level of moisture which is left in the yarn after it has been dried. If the yarn is over-dried either by running the dressing machine too slowly or by letting the yarn stand on the hot cylinders for too long a time, it will be weak and brittle and lead to more weaving breaks than we would expect from the inherent properties of the yarn itself. It has been established quite clearly that dry warps give more breaks, more caddis and lower weaving efficiencies. On the other hand, if the yarn has not been sufficiently well dried there is a danger of mildew developing in the beam if it is in the loom for any length of time, at a holiday-period for example. For good weaving conditions the aim should be to maintain the moisture regain at 20 $\pm$ 3% on the beam and we should make daily checks to see that this is so. When beams are being checked for moisture particularly beams 4 or 5 m wide, it is necessary to take several measurements across the width of the beam since very often the regain will be found to rise towards the middle of the beam, as in Figure 19.

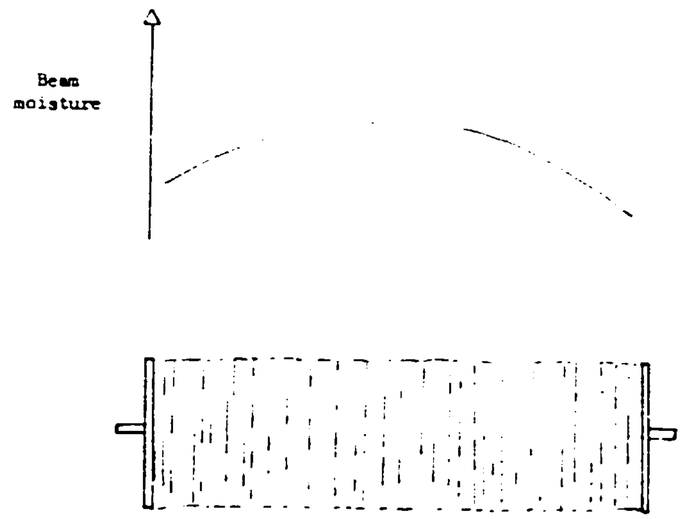


Fig (19)

Uneven beam regain due to bowing of the pressing roller in the dressing machine

The regain on the beam depends upon the pick-up of the dressing mixture and the efficiency of drying. The drying capacity of cylinder dressing machines varies with thread spacing etc. but as a rough rule a machine in good order can evaporate 350-450 lb of water per hour per cylinder on warps 2.5 - 3.5 m wide. The commonest cause of low evaporative capacity is low cylinder surface temperatures caused by accumulation of condensate in the cylinder when the vents and steam traps are not working efficiently. Under the best conditions 1 lb steam will evaporate 1.5 - 2.0 lb water but steam consumption figures as high as 6 lb steam/lb water evaporated can be found in badly maintained mills.

Of all the variables concerned with the pick-up of the dressing paste, such as temperature, viscosity of the paste, throughout speed, depth of immersion in the box, the only one which has any significant practical bearing is the pressure at the nip of the starching rollers. At higher pressures the starch penetration is somewhat greater but, more importantly, less paste is picked up on the yarn. The result is that the drying section of the machine has less water to evaporate and so savings in steam can accrue. In energy costs this can be significant. Table 7 shows how the pressure at the nip affects the pick-up of the paste.

TABLE 7

Squeeze pressure and pick-up

(cloth covered squeeze roll)

Squeeze pressure	Starch pick-up
5 lb/in^2	125
10	118
15	104
20	98
25	92
30	85
35	80

Starch Recipes

Experience shows that the composition of the dressing mixture has little effect on weaving efficiency provided the dressing mixture lays the hairs in a satisfactory manner.

A suitable standard mix is :

TKP	2.5%
Adhesive	0.1
Antiseptic	0.05
Water	97.35
	100.00

The choice of antiseptic or adhesive is not critical, some mills add wax for lubrication but this is of doubtful value.

CHAPTER SIX

Control in Weaving

The controls in jute weaving are geared towards manufacturing a cloth to a given specification at maximum loom efficiencies and with as little waste of yarn as practicable.

As we have seen previously the preparatory processes play a great part in the quality (and quantity) of the cloth which we can produce and there should be no compromise in demanding good packages and beams from the winding and dressing areas of the mill. So often we find that fabric defects and yarn breaks arise from faulty warp preparation and poor cops. Of course, there are a number of features on the loom itself which have a bearing on the quality of the fabric. For example, poor shedding, damaged healds and reeds, excessive warp tension, incorrect timing, poor condition of the shuttle all play their part.

We can examine the QC system in two parts. The first concerns itself with conformity to specification and the second with fabric defects.

Conformity with Specification

The usual cloth features which are specified are ends, picks, width and weight. The first three should be subject of routine checks on the loom and a daily round of inspection is required to ensure that all the looms have been set correctly.

This is especially the case for checks on picks but it is usually sufficient to make a check on the number of ends at the start of each new beam. Indeed, where the custom is to tie-in most of the warps on the loom itself the frequency of end-checking can be greatly reduced. There is no need to carry out 100% inspection daily and a sample of 25% of the looms in the shed will suffice each day for such checks. We should remember that the responsibility for producing the correct fabric lies with the supervisory staff - the quality control officer is simply making a random check to ensure that all is well. The cloth weight can only be measured after it is out of the loom and has had its exact length measured at a roll-up machine or at a lapping machine. When the weight is being checked it is essential to measure the moisture regain so that the cloth weight at a pre-selected regain can be calculated. The standard regains are 20% for sacking and 10% for hessian and CBC.

Fabric Defects

This aspect of quality control is, in some ways, the more important aspect of quality control in jute weaving since an otherwise perfect cloth in terms of construction can be marred by gross defects which, if they are bad enough, will render the cloth unfit for use. Such defects may arise from poor yarn, poor preparation or poor loom performance.

1. Poor Yarn

Cloth faults arise from yarn unevenness due to the nature of the fibres; yarn imperfections arising from extraneous bark, root; faulty machinery; bad work-practices. If a high quality fabric is being woven, for example one to be used for wall-covering, then the presence of excessive quantities of root, stick etc., will certainly lead to rejection of the cloth by the customer because such yarn defects are aesthetically undesirable.

It is in the category of gross yarn defects that serious quality difficulties can arise. In addition to the problems associated with high quality fabrics for decorative purposes, cloth which will be used for industrial purposes such as tufted carpet backings, substrates for bitumen or PVC and so on can be marred by large slubs and splices, hard inclusions, dust slubs etc.

Moreover, there is another important factor connected with poor yarn and it is frequent warp breaks. These may arise from thin places in the yarn or simply a general overall weakness in the yarn.

2. Poor warp and weft prepartion

We have looked at this earlier but we reiterate that without good warp and weft prepartion it is impossible to weave good quality cloth.

Many defects in the weft of the cloth are the result of movement of the cop within the shuttle cavity. The shuttle on a 43 inch RS loom enters the box at about 34 ft/sec. and ideally it should be brought to rest as gently as may be to prevent movement of the cop within it. In practice this is often not achieved and the shuttle enters the box with such force that coils of yarn are thrown off the shuttle which, on the next pick, are laid into the cloth as 'snarls'. A further cause of this defect is short-nosed cops (see Chapter Five). If snarls are frequent the questions we should ask are:-

a) are the cop diameter and nose-length correct ?

b) is the shuttle and the box clean and in good condition ?

c) is the swell worn or are there other misalignments causing the problem ?

d) is the shuttle picking too hard and are both sides of the loom picking in the same manner ?

e) is the warp protection finger too far away from the back of the swell ?

3. <u>Poor loom performance</u>

Unless the timing of the loom is correct badly-made fabric will result. In jute weaving the usual timings are shown in Table 6.

TABLE 6

Loom Timings

Reed space inches	Picks/min	Picking strap taut	Shuttle enters shed	Shuttle speed ft/sec	Shuttle leaves shed	Bang off
46	150	80°	110°	33	250°	272°
60	136	79	107	36	252	274
84	120	78	103	39	256	277
100	110	76	101	40	259	279
125	97	74	97	42	263	283
135	92	73	95	42	264	284
168	78	71	91	42	267	289
174	80	70	89	43	268	290
210	65	68	84	39	270	295
216	61	67	83	36	271	296

A summary of cloth faults is now given.

Bar	A band in the weft direction where the picks are crammed, giving a solid appearance to the cloth. Usually about half an inch in width, starting abruptly then fading away into the normal cloth. Caused by pulling the cloth back too far after a warp or weft break repair or a missed shuttle change.
Bow	Curvature in the weft
Cockle	A wrinkled appearance when the cloth lies flat on a table. Often associated with uneven warp tension.
Crease	An unintentional fold in the cloth
Double pick	Two weft yarns running as one
Double end	Two warp yarns running as one
Drag-in	Distorted selvedge caused by tight picks
Float	Localised incorrect weave where one or more threads are not interlaced properly. May be caused by broken ends, large knots or poor shedding.

Gaw	A weftway gap arising from insufficient picks at that point. Made by bad pulling back and starting.
Mixed yarn	Warp or weft of the wrong quality or colour.
Missing pick	One pick ommitted from the cloth extending full-width.
Pin marking	Small holes in the cloth caused by bad pins on the loom roller.
Skew	Weft yarns running at an angle to the warp.
Snarl	Short length of weft looped on itself. It may or may not protrude from the cloth. Caused by bad cops, hard picking or poor checking of the shuttle.
Smash	An area where many warp and weft threads are broken. Often caused by trapping the shuttle in the shed.
Reed marks	Warp threads running in pairs with a gap between them. May extend over whole width or more commonly, near the selvedges. Caused by low back rest and lease rods too close to cambs, defective reed.

Tight end — A warp thread tighter than its fellows and causing a warp-way line in the cloth.

Warp stripe — Band of warp yarns different in some way, often in colour, from their fellows. It will often run down the whole of the cloth woven from that beam.

To give an idea of the relative importance of these faults we can classify them as minor and major

<u>Minor defects</u>

Bars

Pin marking

Creases

Double picks or ends (up to 12 inches long)

Floats (up to 3 inches long)

Snarls (infrequent)

Tight end

Warp stripe

Reed marks (in less than 10% of width)

Missing ends or picks (up to 12 inches long)

<u>Major defects</u>

Gaws

Reed marks (extensive, more than 10% of width)

Bad selvedges

Smashes

Missing ends or picks (more than 12 inches long)

Double ends or picks (more than 12 inches long)

Floats (more than 3 inches long)

Snarls (frequent)

Weft distortion in CBC

Bow and bias are common defects in wide hessian used for secondary backing for tufted carpets. As cloth weights have become lighter the problem has become more acute and now at 5.5 oz/yd^2 it is seen too frequently.

Although it is not easy to eradicate completely the following generalities apply :-

1. Distortion is greater with wider cloths.
2. It is usually worst near the start of the roll.
3. Most cloth in Bangladesh is inspected on inspection machines then taken to the final roll-up. This means that the cloth on the roll is wound in the same direction as it is woven. With this system there is danger of increasing weft bow and bias.
4. At each stage of manufacture - from pre-beaming to final roll-up <u>all</u> rollers <u>must</u> be perfectly aligned and parallel to each other.
5. All warp tensions should be as even as possible.
6. All the rails on the loom, back rail, breast rail, take-ups must be aligned correctly.

7. At the start of each roll on the loom and final roll-up great care is needed to attach the cloth to the core evenly. Wooden loom pins with a groove into which a slicket of wood can be inserted to trap the cloth at the start of a roll are preferable to a pinned roller. The cloth should be attached to the roller by gummed tape at the final roll-up.

Warp Breaks in Weaving

Most loom down-time in jute weaving is caused by breaks in warp yarns. From the viewpoint of quality control, the warp breaks have a direct bearing on cloth quality when bad examples have to be corrected at cloth inspection. There is a danger, too, that a weft bar or a gaw will result if the loom is not restarted properly after the warp yarn has been repaired by the weaver. While there is no doubt that weak yarn, or at least weak spots in the yarn will result in high break frequencies other yarn parameters play a part. Table 7 shows the results of some tests made on hessian weaving in which the cause of the warp stoppage breakage was broken down into five categories.

TABLE 7

Causes of warp breaks

Cause	% of breaks
Thin places in yarn	32
Slubs	18
Knots	25
Root	15
Other unclassified causes	10
	100

Ways of reducing the number of weaving breaks which occur include close attention to avoid worn or rough lease rods, shuttles, healds and reeds, races ; excessive warp tensions ; incorrect timing and shedding ; missing and crossed ends on the beam ; low moisture regain of the beam and the low atmospheric humidity ; inferior dressing.

Quality control studies on warp break rates can be of two types - continuous and intermittent, just as we had for spinning. In the continuous method the observer records, usually on two adjacent looms, the number of breaks which occur within a given time, often quoting the result of the study in terms of breaks/1000 ends/10000 picks. The other method uses the snap-observation technique. For example, the loom is either running or it is stopped when the observer passes it. If it is stopped then he notes the reason for the stoppage e.g. shuttle-changing warp breaks, weft break etc. After the study the stoppages are totalled and the reason for each type of stoppage is expressed as a percentage of the total number of observations. This technique allows a wider number of looms to be studied in a given time but we should be aware that it is subject to quite large statistical variations. Neither of these tests should be built into the quality control scheme as a daily routine test but they are very useful if they are regarded as tools for special investigations in weaving.

As a broad gneralisation, there is a relationship between weaving efficiency and yarn quality but so many other factors come into play that it is almost impossible to pick out any one yarn parameter which is the key to good weaving performanee. Breaking load, variability, abrasion resistance, elasticity, stiffness all play a part. Practical experience and careful attention to detail will in the end lead to good cloth quality and good weaving efficiencies.

Table 8 gives the best loom timings for various reed-spaces of loom.

Inspection procedures

Although in-process control requirements vary from mill to mill the following minimum inspection level forms the basis for a satisfactory control scheme.

Carpet backing cloth (5½ oz secondary backing)

Each shift measure

Width on the front rail on 50% of looms	
End and pick in loom	25%
Length	1 roll/day
Cloth faults	1 roll/day
Cloth weight	1 roll/day
Cloth width	1 roll/day
Bow / skew	1 roll/day
Moisture regain	1 roll/day

Hessian cloth (7 - 11 oz/40")

On each shift measure

Width on front rail	on 25 looms
Ends and picks in loom	on 5 looms
Length of cut	on 15 cuts
Weight of cut	on 15 cuts
Moisture regain	on 15 cuts 2 readings per cut

CHAPTER SEVEN

Process Control in Finishing and Bag Manufacture

The finishing sequence for jute is simple and should present no untoward quality problem.

Inspection

Usually 100% inspection is carried out and at the same time minor defects are repaired. If there are major defects the cloth should be laid aside for special attention. Despite 100% inspection we will not detect all the faults and we will still dispatch some cloth with weaving faults in it. It is common experience that a good inspector will only find about 75% of all the faults present in the cloth.

Damping and Calendering

Calendering has the effect of closing up the cloth under the influences of pressure and, usually heat. For good finishing damping should precede calendering in order to 'pasticise' the yarn and the starch film. This allows the calender pressure to flatten and smooth the cloth, improving its appearance and its cover. Cloth which has been damped should be allowed to lie for three hours at least so that the moisture can become more uniformly spread throughout the piece. Unless this is done the full benefit of damping will not be realised. For good results, 2 - 3% moisture is added at the damper. Calendering with a hot bowl is done at a speed of about 20 m/min and pressures of about 300 to 450 lb/in^2. Under these conditions the cloth thickness in hessian is reduced by approximately 25% and the cover is increased by roughly 30%.

Quality problems associated with these simple finishing processes are usually limited to cloth creases with, in extreme cases, cuts in the cloth under the high pressures of the calender. These latter may result from damaged rollers or from slubs and bad knots in the yarn. At the calender we have a convenient point at which we can make a general assessment of cloth quality as we watch the cloth leaving the machine.

During calendering the cloth width is decreased and the ends/inch increase as a consequence. The length increases and the picks/inch become fewer. The exact amount of these changes depends upon how much calender rail has been given but changes of the order of 1 or 2% are common.

Measuring

Each piece requires its length measured accurately before it is weighed. From time to time weighbridges and length recorders must be verified. The simplest way to check the length recorder is to tape a piece of paper tightly around the measuring roller then sever it with a sharp blade. The length of the paper is taken as the circumference of of the roller. A hand-held length measurer may also be used where some slip is suspected between the measuring roller and the fabric. During manufacture it is inevitable that some short pieces occur and these may be baled in accordance with BDS 813 : 1975 (Part 1) for hessian. A medium cut is defined as one between 37 and 82 m in length and a short cut between 18 and 37 m. Three medium cuts or two medium and one short cuts may be baled along with the remainder of full cuts.

On rolls of carpet backing cloth the true length should be within $\pm$ 1% of that marked on the pack-sheet.

Sacks and bags

A general formula for the carrying volume of a bag can be found from

$$v = \left(\frac{1}{\frac{1.16}{l} + \frac{0.67}{b}} \right)^3$$

where v = volume when packed

l = flat length

b = flat width

In this formula due allowance must be paid to the loss in length during closing - 2.5 cm for machine closing and 10 cm for bunching or hand sewing.

Bag defects are :-

Major	-	gaps in the seam
		bad gaws
		under shotting
		holes
Minor	-	weft bars
		reed - marking
		stains

A good bag is one in which the cloth and the seam are robust enough to stand all the strains during filling, transportation and stacking. In addition the bag must give sufficient protection to its contents and prevent all leakage or sifting.

A major fault is for a bag to be of the wrong size i.e. usually slightly underwidth (note that the width of a bag is the internal measurement for seam to seam or seam to fold).

Seam Strength

In heavy sacks such as B Twill, Heavy Cee, etc., overhead or herakles stitching at 2.25 to 2.75 stitches per inch is standard. The twine often used is two strands of 3 - ply 11 lb. To meet most specifications seam strength should be no lower than 72 kg. on average. Woolpacks use the same stitch but in this case the twine is a 4 - ply 11 lb. This should give an average seam strength of at least 120 kg. for good quality packs. Hessian bags made from 10 oz/40 cloth sewn with 2.25 - 2.75 stitches/inch overhead or herakles 3 - ply 8 lb. need to have an average seam strength around 40 kg., while bags from 7 oz/40 using the same seam should have average seam strength of about 28 kg. Sandbags made from 8 oz/40 cloth overhead stitched with 3 - ply 8 lb need to have a seam strength around 25 kg., to be of sound quality.

In assessing the quality of the bags which we manufacture we come up against the common problem found in process control of mass production i.e. that of taking minute samples from the bulk and trying to judge the quality of the whole from it. To illustrate this, let us consider a 250 loom unit making B Twill bags. The production will be about 325,000 bags a week. Suppose we have a specification to meet which demands a minimum bag weight of 900 g and we know from our previous records that our CV of bag weight is 5%. This means that about 3000 bags per week will be below specification. This is only about 1% of the output and the chancesof routine QC check ding them and rejecting them are slim. In these circumstances we decid risk selling these bags and we hope that the customer will, if he finds any, be reasonable. However, if the CV drifts up to 6% because of, perhaps, poor supervision, then the mill will make, not 3000 light bags, but 8000. The chance of complaints from customers becomes a reality.

CHAPTER EIGHT

Control of Moisture

We have seen that moisture plays a very important role in jute manufacturing as well as having vital economic implications. In this Chapter we shall try to get an overview of the ways in which we can control this facet of our technology.

Jute and humidity

Table 9 gives the absorption and desorption moisture regains of jute at various relative humidities, showing the hysteresis effect which depends upon the prior moisture history of the fibre. Many research workers have measured the effects of humidity on regain and found minor differences in their results, but Table 9 gives average figures which can be used for all practical purposes.

TABLE 9

Moisture regain of jute

RH %	Absorption regain %	Desorption regain %
45	9.2	10.3
50	10.0	11.3
55	10.8	12.3
60	11.8	13.3
65	12.8	14.6
70	14.0	15.9
75	15.3	17.4
80	16.8	19.3
85	18.6	21.8
90	21.2	24.8
95	25.2	29.0
100	34.4	34.4

The figures in Table 9 refer to jute tested at 20°C, but at other temperatures the differences found are small as we can see from Table 10.

TABLE 10

Effect of temperature on regain

Desorption regain %

RH %	15°C	20°C	25°C
50	11.5	11.3	11.1
60	13.6	13.3	13.0
70	16.2	15.9	15.6
80	19.6	19.3	19.0

Moisture in raw jute

It is essential that we measure and control the quantity of moisture in our raw material since a few percent more water in the jute can play havoc with the economics of manufacture. Invariably we shall find a moisture cycle in raw jute throughout the year with higher regains at the start of the new crop and lower ones as the year progresses.

A close watch needs to be kept on the regain of the jute entering the mill. Regains of 16 - 20% are normal but if they rise to 20% action needs to be taken. The method for measuring regain is to use an electronic moisture meter, taking checks on a daily basis. There is much to commend an experienced hand to detect damp jute and the QC staff should be encouraged to handle raw jute as often as possible so that they can acquire this experience.

Moisture in processing

As we might expect, the quantity of water we add at the softener or at the spreader has a direct bearing upon the final moisture in the goods we produce. This can be seen from Table 11 where the results of a series of special tests were made in a mill whose humidity was carefully controlled at 75% RH. Although it is true that different humidites in the mill change the general results a little, the general relationship stays the same.

TABLE 11

Effect of emulsion application on regain

% emulsion added	Moisture regain		
	Finisher card	Finisher drawing	Yarn
16	20	19	15
21	21	22	18
24	24	26	20
31	27	29	24

It is interesting to look at the effect of the ambient relative humidity at the spinning stage. Table 12 gives the results of some tests which were made a number of years ago in the experimental mill of the British Jute Trade Research Association. In the common range of humidities a drop of 10% in the RH leads to a fall i the yarn regain of some 2%.

TABLE 12

Moisture loss at spinning

(8 lb yarn, finisher drawing sliver 22% MR)

Spinning r.h. %	Yarn regain %
40	14
50	16
60	17
70	19
80	21

It has been found from practical experience that if the moisture regains shown in Table 13 can be maintained, processing will be satisfactory and good quality material made. There may be variations of one or two percentage points from these figures depending upon local circumstances and the QC Officer should be analysing his own results week by week so that any departure from the norms of the mill can be corrected. In day-to-day control it will be found that the regains drift somewhat and it is better to consider either weekly averages or moving averages of three or four days to get a better picture of what is happening in the mill.

TABLE 13

Moisture levels during processing

	Carpet yarn and CBC	Hessian	Sacking
Finisher card	27	27	30
Finisher drawing	25	26	28
Yarn on spool/cop	18	18	20
Beam	18	18	22
Finished product	14	16	20

Testing moisture regain

We begin with two well-known definitions.

$$\text{Moisture regain} = \frac{\text{Wt of moisture} \times 100}{\text{Wt of dry, oil-free jute}} \%$$

$$\text{Moisture content} = \frac{\text{Wt of moisture} \times 100}{\text{Wt of fibre + oil + moisture}} \%$$

Example :

A jute yarn has -

92 g of dry fibre
20 g of moisture
6 g of oil
118 g in total

$$\text{Moisture regain (MR)} = \frac{20 \times 100}{92} = 21.7\,\%$$

$$\text{Moisture content (MC)} = \frac{20 \times 100}{118} = 16.9\,\%$$

To convert MC to MR we must bring in the oil content (O.C.) and the formula is

$$MR = \frac{MC}{100 - MC - OC}$$

In routine quality control work we can assume two levels of oil content when making this conversion. One from 1 to 3% and the other from 3 to 8%. If we do this we can compile a conversion chart, as we see in Table 14. There is some error introduced in this assumption but it is so small that we can ignore it for practical purposes. Note that only whole numbers are used; moisture testing is not an exact science. If we use decimal places of regain we are claiming greater accuracy than the testing methods can provide.

For process tests of moisture there is really only one practical test method to use - electronic moisture meters. Examples are the Mahlo DBM Textometer, the Heal Deltamoist, the Aquaboy JFM 1, the Kett and others. These all adopt the same measuring principle. The electrical resistance of the jute is measured between two electrodes (usually pins) which are placed in intimate contact with the jute. At low regains the electrical resistance is high while at high regains it is low. By measuring the resistance with the meter we can arrive at the exact amount of moisture in the jute between the electrodes. The meters look simple to use but some precautions are necessary:-

1. Never use an electrode with bent or broken pins.
2. Never shorten the cable between the electrode and the meter. The internal cable resistance is taken into account in the design of the meter and if the cable is shortened the reading on the meter will be wrong.
3. Always push the electrode into the jute with enough pressure to give a steady reading on the scale on the instrument.

4. Do not use the meters on dyed material without first making a new calibration chart. The presence of dyestuffs alters the resistance and hence the meter's reading.

5. Wait until beams, bobbins or cops are at room temperature before testing them.

Some of these meters are calibrated by the makers in terms of moisture content but most are calibrated in regain. The Mahlo Textometer and the Aquaboy for instance measure regain. If there is any doubt, the manufacturer of the instrument should be approached for guidance.

The other ways of testing moisture are the ventilated drying oven and the Dean and Stark method. The drying oven test has the drawback that when the jute is heated to 105°C some of the JBO volatilises and weight loss of the sample is over-stated, consequently the indicated regain is a little on the high side. Secondly, even at 105°C there is still some residual humidity in the air in the oven and all the moisture is not dried out the yarn even when the sample is at a constant weight. Many Standards use this method, but on the other hand, ASTM Method D 2654 - 76 does not permit ovens to be used for jute and insists on the other method for testing moisture, the Dean and Stark method. When one tests samples by both methods one will find that the oven method will give regains of 0.5 to 1.0% lower than those from the Dean and Stark solvent extraction test.

TABLE 14

Moisture Regain	Moisture Content (Jute with 1 - 3% oil)	Moisture Content (Jute with 3 - 8% oil)
30%	22%	23%
29	22	22
28	21	22
27	20	21
26	20	20
25	19	20
24	19	19
23	18	18
22	17	18
21	17	17
20	16	16
19	15	16
18	15	15
17	14	14
16	13	14
15	13	13
14	12	12
13	11	11
12	10	11

Ambient humidity

It is a matter of common experience in Bangladesh that the relative humidity varies, not only throughout the year, but during the day as well. This is one of the reasons why it is essential to standardise all count and weight tests to pre-selected standard regains. In this way we will avoid spurious weight results which come not from a true variation in mass but from variations in regain.

Table 15 shows the maximum and minimum humidities at three points in Bangladesh during the year as reported by the Bangladesh Meteorological Department.

TABLE 15

Normal daily humidities in Bangladesh

	DHAKA			CHITTAGONG			KHULNA		
	Max.	Min.	Avge.	Max.	Min.	Avge.	Max.	Min.	Avge.
January	93	61	77	93	78	86	90	73	82
February	90	48	69	92	69	81	91	55	73
March	88	44	66	91	73	82	91	53	72
April	91	54	73	91	76	84	93	65	79
May	93	75	84	93	77	85	93	74	84
June	95	81	88	93	83	88	94	82	88
July	95	82	89	94	84	89	96	84	90
August	94	83	89	95	86	91	95	84	90
September	95	83	89	95	83	89	95	83	89
October	95	78	87	96	82	89	94	78	86
November	94	71	83	95	76	86	91	69	80
December	95	70	83	95	73	84	91	67	79

Naturally, these are average figures and there are departures from them from time to time but, nevertheless, they show that it is impossible to make even monthly alterations to the emulsion application to compensate for such wide fluctuations in humidity.

Each mill should make a practice of measuring the relative humidity at several locations in the mill on each shift. The best way to do this is by a whirling hygrometer. The main precaution to take when using this instrument is to keep the wick clean at all times. If the wick does get dirty it can be cleaned by boiling in soapy water. More sophisticated recording hygrometers are available but, for mill w..., they are too expensive and a cheap whirling hygrometer will give years of service if it is looked after. We often see wet and dry bulb hygrometers fixed to wall or pillars. These are next to useless (even when the.. are clean) because they do not give information about the humidity or temperature of the air where it really matters - out amc.g the machines.

CHAPTER NINE

Assessing product quality

This Manual is not the place for a full examination of testing methods for jute goods and in the following pages only the more general aspects of testing are discussed.

The success of our process control schemes is judged on how closely our finished products conform to their specifications and the needs of our customers. In the laboratory assessment of the quality of jute goods it is usually sufficient to measure count, twist, regain, oil content, strength, cloth and bag constructions. Other tests are called for from time to time but these just mentioned cover 95% of all needs.

The tests themselves are quite straightforward but, nevertheless, they must be carried out with attention and accuracy. Training in these tests must be comprehensive and the Quality Control Officer should be ever-watchful to prevent malpractices creeping into his laboratory.

Count

100 yd hanks are reeled, usually on a 2.5 yd reel but certainly never on one smaller than 1 yd in girth. The reel must be fitted with an efficient yarn traversing mechanism to prevent one layer of yarn piling on top of the previous one. The hanks must be weighed accurately.

A 1 or 2 kg balance, accurate to 0.1 g is ideal. Occasionally one sees hanks being weighed on analytical balances - this is very bad practice. When the count is checked, the regain must be measured and then the count standardised to the following regains :

Carpet and CBC yarn	14%
Hessian	16%
Sacking	20%

Jute yarn, as we know is measured on the direct system of lb/sp but we shall meet other count systems from time to time such as :

Tex	g/1000 m
Lea	Number of 300 yd hanks/lb
Metric number (Nm)	Kg/1000 m
Denier	g/9000 m

Table 16 gives the common conversions for these systems.

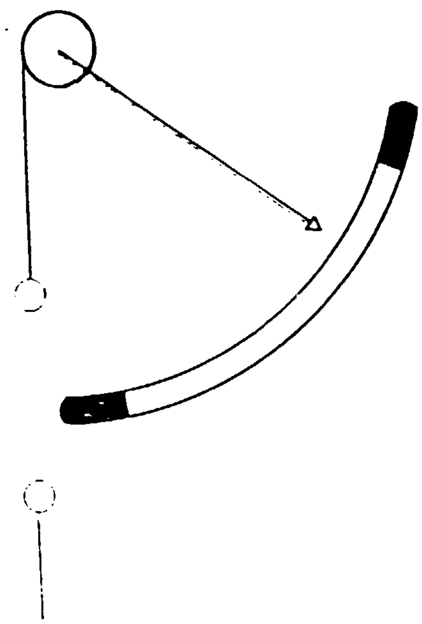
TABLE 16

Count Conversions

lb/sp	tex	lea	metric number	denier
5	172	9.6	5.8	1550
6	207	8.0	4.8	1860
7	241	6.9	4.1	2170
8	276	6.0	3.6	2480
9	310	5.3	3.2	2790
10	344	4.8	2.9	3100
12	413	4.0	2.4	3720
14	482	3.4	2.1	4340
15	517	3.2	1.9	4651
16	551	3.0	1.8	4961
18	620	2.7	1.6	5581
20	689	2.4	1.5	6201
24	827	2.0	1.2	7441
28	965	1.7	1.0	8681
32	1102	1.5	0.9	9921
40	1378	1.2	0.7	12402

Tensile tests

The bulk of tensile testing for jute yarns and cloth is carried out on CRT machines. These are simple and robust b t nevertheless they have certain features which must be given due attetion. The chief one of these is the capacity of the machine, be it for testing yarn or cloth. Because of the design of such machines their scales are not very accurate at the low and top ends. This is not a fault in the design but an inherent feature of their operation resulting from the inertia in the system, overthrow of the pendulum arm and other factors. Because of this it is essential that one does not use the bottom or top 10% of the scale if one can possible avoid it. One may be carrying out a test and find that one or two results fall into one of these two zones. This cannot be helped but under no circomstances should the majority of the results fall in these areas. In practice this means that the capacity of the machine must always be related to the average strength of the yarn or the cloth. Figure 20 illustrates the forbidden zones of the yarn testing machine.



shaded areas show parts of the scale not to be used

Fig (20)
Yarn tensile testing range

To illustrate this, we may have a yarn testing machine with two ranges, 0 – 10 lb and 0 – 100 lb. We wish to test 8 lb hessian warp and 14 lb carpet yarn on the machine. The 0 – 10 lb range is really only for use between 1 lb and 9 lb and the 0 – 100 lb range between 10 lb and 90 lb (deducting 10% from the bottom and top in each instance). The 14 lb yarn must be tested on the 0 – 100 lb range but we cannot test the 8 lb yarn on the same range because all the results will fall in the forbidden zone of 0 – 10 lb. Therefore we must change the pendulum weight for this test. If it means that we change the weight several times a day, so be it.

For yarn testing 500 mm is the standard test length and 300 mm/min is the standard rate of draw. We should however be aware of the effects of different test lengths and testing speeds on the results of tensile tests :

The greater the test length the lower is the breaking load result but the lower is the CV of strength. The following test results on 8 lb hessian yarn show this :

Test Length	Quality Ratio	CV
200 mm	92%	21%
300 mm	90%	20%
600 mm	84%	19%
900 mm	80%	18%

The faster the rate of draw the higher is the strength and the lower is the CV :

Rate of draw	Quality Ratio	CV
300 mm/min	92%	19%
200	84	20
100	81	21

In all textile testing it is common to relate strength to the count and in jute testing we use the concept of quality ratio

$$\text{i.e.} \quad \frac{\text{Strength, lb}}{\text{Count, lb/sp}} \times 100\%$$

Other systems we may meet in specifications are :

1. Tenacity measured in mN/tex (milli-Newton per tex)
2. Tenacity measured in g/denier
3. RKM (reisse kilometer) measured in Km

A conversion between the systems in shown in Table 17.

TABLE 17

Equivalent count/strength factors

Quality Ratio %	Tenacity mN/tex	Tenacity g/denier	R.K.M.
75	98	1.10	9.8
80	104	1.17	10.5
85	111	1.24	11.2
90	117	1.32	11.8
100	130	1.46	13.1
105	137	1.54	13.8
110	143	1.61	14.4
115	150	1.68	15.1
120	156	1.76	15.7
125	163	1.83	16.4
130	169	1.90	17.1

Fabric strength tests are of two types; the fringed strip, and the grab test.

There is no "best" way to test cloth and in fact all the tests use dimensions and speeds which have been selected arbitrarily and which have come to be incorporated in official Standards simply through use and wont. The grab test has the advantage of speed in the preparation of the sample but in this test breaks can be a problem.

Table 18 gives some examples of the various test methods specified in various standards.

TABLE 18

Concordance of Common Testing Methods

(All dimension in mm)

	IS 2818	BDS 813	ASTM D1682	BS 2576
1. Cloth strength ravelled strip				
Width of ravelled strip	100	100	50	50
Test length	200	200	75	200
Rate of traverse per min.	460	460	300	115
No. of specimens –				
warp	5	5	5 (see note 1)	5
weft	5	5	8	5
2. Cloth strength grab test	125 x 180	125 x 180	125 x 180	–
Jaw faces	25 x 25	25 x 25	25 x 25 or 50	–
Test length	75	75	75	–
Rate of traverse per min.	300	300	300	–
No. of specimens –				
warp	5	5	5[1]	
weft	5	5	8[1]	
	BS 1932	ASTM D541	PS 595	
3. Yarn strength				
Test length	500	250	610	
Rate of traverse per min.	See Note 2	300	300	
No. of specimens	50	See Note 1	50	
	BS 2085	ASTM 1422	PS 271	
4. Yarn twist				
Test length	100 or 250	250	100	
No. of specimens	50	See Note 1		

Note 1. $n = 0.11\ v^2$, where v = CV from known past records and n = no. of tests
If v is unknown then take at least 8 tests in each direction.

Jaw Breaks

A jaw break is defined as a break within 5 mm of the grips of the testing machine at a result substantially less than the normal range of results. The test result must be recorded but marked Jaw Break (JB) and a fresh specimen used as a replacement. Jaw breaks arise from random weak spots in the yran or cloth from the specimen being damaged by excessive pressure in the jaws or rough, sharp edges in the jaws.

It is essential that the jaw break results are recorded. The testing assistant must never be allowed to discard a test result by saying to himself, "that was very low - it was a jaw break". If frequent jaw breaks are found with jute it is a sign of poor testing technique.

Occasionally, when heavy strong cloth is being tested the specimen slips in the jaws of the tensile tester. This can usually be overcome by lining the jaws with jute or rubber. In extreme cases the specimen may be clamped in the manner shown in Figure 21.

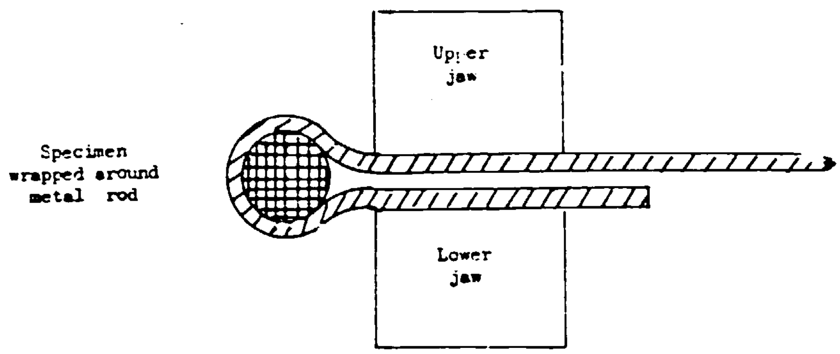


Fig (21)

Clamping method to
avoid jaw slippage

Twist

Turns per inch (or per metre) are measured by untwisting a (100 mm 4 in) length of yarn and recording the number of turns in that length. Many specifications call for test to be made on 250 mm (10 in) lengths. It will be found that the test is much easier with jute on a 100 mm test length and operative error is reduced. Normally two tests are made on each package in the sample.

Twist is conveniently related to the count by the twist factor -

$$\text{Twist factor} = \text{lb/sp} \times \text{t.p.i.}$$

$$\text{or Twist factor} = \frac{\text{tex} \times \text{t/m}}{100}$$

It is often said that twist runs into the thin places of the yarn and heavier sections of yarn have less twist. This is quite true but we should note that the <u>twist factor</u> is the same irrespective of whether that section of the yarn is heavy or light.

Table 19 gives the common twists used.

TABLE 19

YARN TURNS PER INCH

LB/SP	TWIST FACTOR				
	11.0	12.0	12.0	12.5	13.0
6	4.49	4.69	4.99	5.10	5.30
7	4.16	4.35	4.54	4.73	4.91
8	3.89	4.07	4.25	4.43	4.60
9	3.67	3.83	4.00	4.17	4.33
10	3.48	3.64	3.79	3.95	4.11
12	3.17	3.32	3.46	3.61	3.75
14	2.94	3.07	3.21	3.34	3.47
16	2.75	2.88	3.00	3.13	3.25
18	2.59	2.71	2.82	2.94	3.06
20	2.46	2.57	2.68	2.80	2.91
22	2.35	2.45	2.56	2.67	2.77
24	2.25	2.35	2.45	2.55	2.65
28	2.08	2.17	2.26	2.36	2.45
32	1.94	2.03	2.12	2.21	2.30

Moisture

Jute samples gain or lose moisture to the atmosphere more quickly than is often supposed. A sample left exposed to the atmosphere immediately begins to condition to its natural regain. Even 20 - 30 minutes is long enough to cause a change of a few percentage points, so when sampling and testing for moisture it pays to have a good supply of polythene bags for transporting specimens to the test room.

Oil Content

To measure the oil content of jute goods the most satisfactory method is the Soxhlet test. Other methods include a modified Dean and Stark technique or the W.I.R.A. Rapid Oil Test. No matter which method is selected the solvent which is used extracts some of the natural oils and waxes in the fibre as well as the JBO. The amounts vary as the following figures show.

Solvent	Natural oils and waxes removed
Petroleum spirit	0.12 %
Toluene	0.30 %
Dichloromethene	0.35 %

If two test methods are used in the same laboratory due regard must be paid for these differences.

A selection of miscellaneous information on product assessment follows in the next pages.

Moisture contents

at different oil contents (on dry fibre basis)

MR	Oil Contents 0%	1%	2%	3%	4%	5%	6%	7%
10	9.1	9.0	8.9	8.8	8.8	8.7	8.6	8.5
11	9.9	9.8	9.7	9.6	9.6	9.5	9.5	9.4
12	10.7	10.6	10.6	10.4	10.3	10.3	10.2	10.1
13	11.5	11.4	11.3	11.2	11.1	11.0	10.9	10.8
14	12.3	12.2	12.1	12.0	11.9	11.8	11.7	11.6
15	13.0	12.9	12.8	12.7	12.6	12.5	12.4	12.3
16	13.8	13.7	13.6	13.4	13.3	13.2	13.1	13.0
17	14.5	14.4	14.3	14.2	14.0	13.9	13.8	13.7
18	15.3	15.1	15.0	14.9	14.8	14.6	14.5	14.4
19	16.0	15.8	15.7	15.6	15.4	15.3	15.2	15.1
20	16.7	16.5	16.4	16.3	16.1	16.0	15.8	15.7
21	17.4	17.2	17.1	16.9	16.8	16.7	16.5	16.4
22	18.0	17.9	17.7	17.6	17.5	17.3	17.2	17.1
23	18.7	18.5	18.4	18.3	18.1	18.0	17.8	17.7
24	19.4	19.2	19.0	18.9	18.8	18.6	18.5	18.3
25	20.0	19.8	19.7	19.5	19.4	19.2	19.1	18.9
26	20.6	20.5	20.3	20.2	20.0	19.8	19.7	19.5
27	21.2	21.1	20.9	10.8	20.6	20.4	20.3	20.1
28	21.8	21.7	21.5	21.3	21.2	21.1	20.9	20.7
29	22.5	22.3	22.1	22.0	21.8	21.6	21.5	21.3
30	23.1	22.9	22.7	22.6	22.4	22.2	22.1	21.9

Typical yarn strength properties

	QR	CV
Good carpet yarns		
6 – 10 lb	115 – 125	14 – 18
10 – 24 lb	125 – 130	10 – 14
Medium carpet yarns		
10 – 24 lb	105 – 110	15 – 19
24 – 32 lb	100 – 110	10 – 14
CBC, good hessian		
8 – 10 lb	90 – 100	16 – 20
Medium hessian		
8 – 9 lb	80 – 90	16 – 22
Sacking warp		
10 – 12 lb	70 – 80	18 – 24
Sacking weft		
30 – 40 lb	65 – 75	18 – 26

THREAD CONVERSION TABLE - HESSIAN

Threads/ 10 cm	Threads/ inch	Porter (Hessian)	Threads/ 10 cm	Threads/ inch	Porter (Hessian)	Threads/ 10 cm	Threads/ inch	Porter (Hessian)
20.0	5.1	4.7	34.5	8.8	8.1	49.5	12.5	11.5
20.5	5.2	4.8	35.0	8.9	8.2	50.0	12.6	11.6
21.0	5.3	4.9	35.5	9.1	8.3	50.5	12.7	11.8
21.5	5.5	5.1	36.0	9.2	8.5	51.0	12.9	11.9
22.0	5.6	5.2	36.5	9.3	8.6	51.5	13.0	12.0
22.5	5.7	5.3	37.0	9.4	8.7	52.0	13.1	12.1
23.0	5.8	5.4	37.5	9.6	8.8	52.5	13.2	12.2
23.5	6.0	5.5	38.0	9.7	8.9	53.0	13.4	12.3
24.0	6.1	5.6	38.5	9.8	9.1	53.5	13.5	12.5
24.5	6.2	5.8	39.0	10.0	9.2	54.0	13.6	12.6
25.0	6.4	5.9	39.5	10.1	9.3	54.5	13.8	12.7
25.5	6.5	6.0	40.0	10.2	9.4	55.0	13.9	12.8
26.0	6.6	6.1	40.5	10.3	9.5	55.5	14.0	12.9
26.5	6.	6.2	41.0	10.5	9.6	56.0	14.1	13.1
27.0	6.9	6.3	41.5	10.6	9.8	56.6	14.3	13.2
27.5	7.0	6.5	42.0	10.7	9.9	57.0	14.4	13.3

THREAD CONVERSION TABLE - SACKING (CONTINUED)

75	9.5	5.9	104	13.2	8.1	133	16.9	10.4
76	9.7	6.0	105	13.3	8.2	134	17.0	10.5
77	9.8	6.0	106	13.5	8.3	135	17.1	10.6
78	9.9	6.1	107	13.6	8.4	136	17.3	10.7
79	10.0	6.2	108	13.7	8.5	137	17.4	10.7
80	10.2	6.3	109	13.8	8.5	138	17.5	10.8
81	10.3	6.3	110	14.0	8.6	139	17.7	10.9
82	10.4	6.4	111	14.1	8.7	140	17.8	11.0
83	10.5	6.5	112	14.2	8.8	141	17.9	11.0
84	10.7	6.6	113	14.4	8.8	142	18.0	11.1
85	10.8	6.7	114	14.5	8.9	143	18.2	11.2
86	10.9	6.7	115	14.6	9.0	144	18.3	11.3
87	11.0	6.8	116	14.7	9.1	145	18.4	11.4
88	11.2	6.9	117	14.9	9.2			

Typical fabric strength results

	Strip Test		Grab Test	
	Warp	Weft	Warp	Weft
7 oz/40, 8 x 9	100 kg	75 kg	35 kg	25 kg
7½ oz/40, 9 x 9	100	90	35	30
9 oz/40, 11 x 12	120	110	40	35
10 oz/40, 11 x 12	125	130	54	40
B Twill, 6 x 8	210	190	70	65
Heavy Cee	190	200	65	70
DW Flour, 8 x 8	185	165	70	60

CONVERSION FACTORS

From Imperial Units

The following selection of conversion factors is given in alphabetical order:

1 denier	= 1.111 decitex
1 dent/in	= 0.3937 dent/mm
1 end/in	= 0.3937 end/cm
1 ft	= 0.3048 m
1 ft/min	= 0.3048 m/min
1 ft^2	= 929.030 cm^2
1 ft^3	= 28.32 dm^3
1 ft^3/lb	= 0.0624 m^3/kg
1 gallon (UK)	= 4.54 litres
1 hp	= 745.7 watts
1 in	= 2.54 cm
1 in^2	= 645.16 mm^2
1 in^3	= 16.387 cm^3
1 lb	= 453.59 g
1 lb/ft^2	= 4.882 kg/m^2
1 lb/ft^3	= 16.01 kg/m^3
1 lb/sp	= 34.4 tex
1 oz	= 28.35 g
1 oz/yd^2	= 33.9 g/m^2
1 oz/40"	= 37.67 g/m^2
1 pick/in	= 0.3937 pick/cm
1 thou	= 0.0254 mm
1 thread/in	= 0.3937 thread/cm
1 turn/in	= 39.37 turns/m
1 yard	= 0.9144 m
1 yd/lb	= 2.0159 m/kg
1 yd/min	= 91.44 cm/min
1 yd^2	= 0.8361 m^2

CHAPTER TEN

Statistics and Process Control

It is unfortunate that, in many people's minds, the term 'quality control' is synonomous with 'statistical quality control' with its emphasis on rather obscure terms which are often ill-understood. In jute manufacture only the simplest of statistical calculations are required. We must be realistic in our approach, and wherever possible, we will manage with the minimum of statistics. Nevertheless we cannot avoid using some statistical methods at certain places in our technology. In this book we must assume a certain basic knowledge of mean, standard deviation etc. If the reader is new to the subject some useful books are listed at the end of this Chapter.

Histograms

We can sometimes get quite a lot of useful information if we plot histograms of the results of our tests. These present pictorially, for example mixed counts of yarn, drift in average and even (not that it would happen in our mill) suppression of "bad" results.

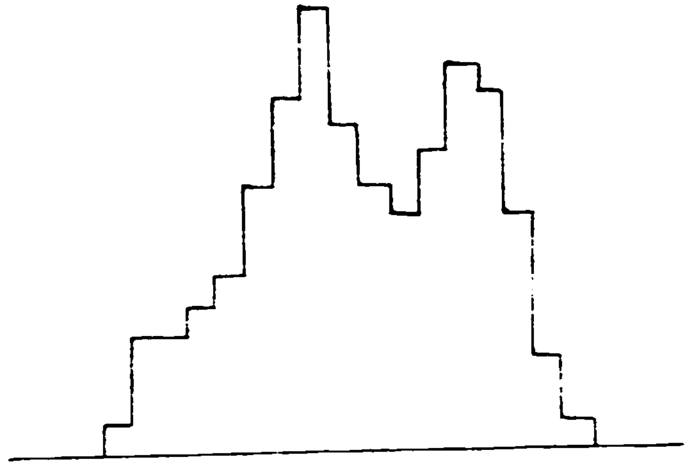


Fig 22. Two-peaked distribution

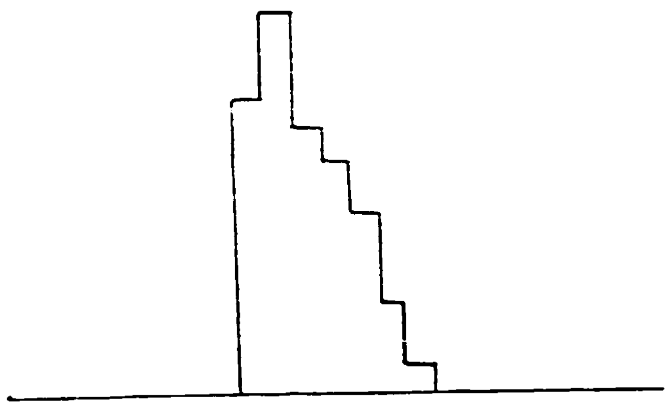


Fig 23. Abnormal Gaussian distribution

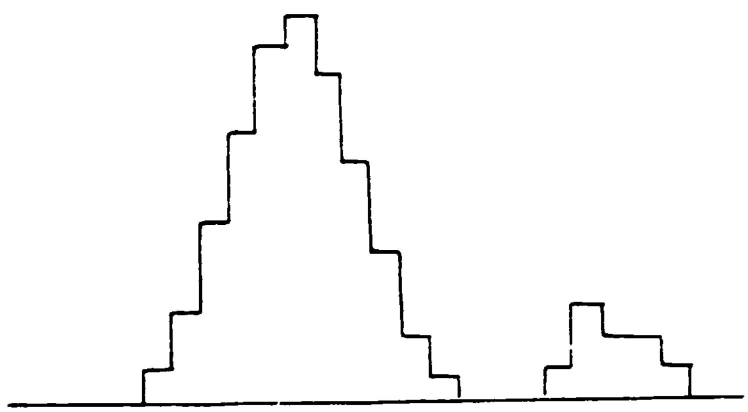


Fig 24. Some results do not belong to the main distribution

Figure 22 is an example of a distribution with two peaks. This is typical of the type which may be seen if two machines which are supposed to be identical have a difference in, say, draft, picks, moisture etc.

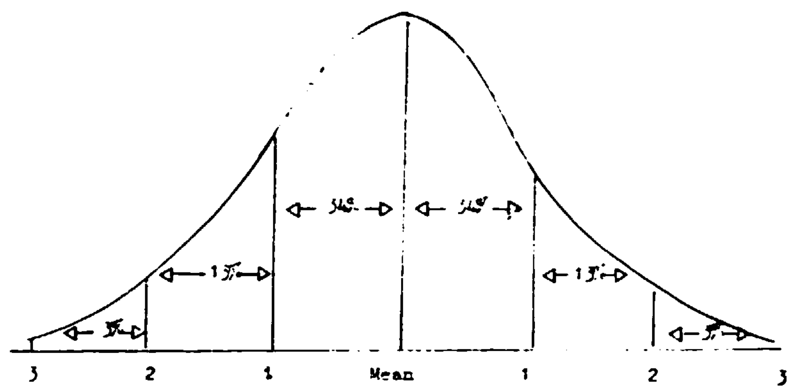
Figure 23 represent the results from a test where "poor" results have been deliberately suppressed (perhaps to escape the wrath of a superior). We see a typical cliff-like end to the distribution instead of the gradual decline in the normal case.

In Figure 24 we can see, at the right-hand end of the distribution results which are 'rogues'. Are they errors of measurement? Is there something far wrong with our process?

By looking at histograms we can see quite clearly if something is wrong. They will not tell us what but they will start us looking.

The normal distribution

If we take enough tests, and have a bit of luck, our histograms will become more and more symmetrical until it resembles the typical bell-shaped curve of the Normal Distribution curve. This is the type of distribution we have for many of our test results, e.g. count, bag weight, strength, teist, regain etc. The curve has an important feature. The spread from the lowest result to the highest can be measured by the standard deviation (SD) and we can take it, for all practical purposes, that the lowest result will be 3 x SD below the mean and the highest result will be 3 x SD above the mean. Further, theory tells us that the percentage of our results that we will find between each standard deviation will be as shown in Figure 25.



Approximate proportions of results at 1,2 and 3 standard deviations away from the mean

Fig (25)

Gaussian distribution

Poisson Distribution

The other distribution we need some knowledge of is called the Poisson distribution. This covers events which happen randomly and fairly infrequently in time. Such things as spinning and weaving breaks, the numbers of defects in cloth, the numbers of faulty bags and the like all come under the Poisson distribution. The Poisson distribution also has its standard deviation; this has the property of being equal to the mean. We will meet this later when we deal with methods for recording defects in our process or products.

Control Charts

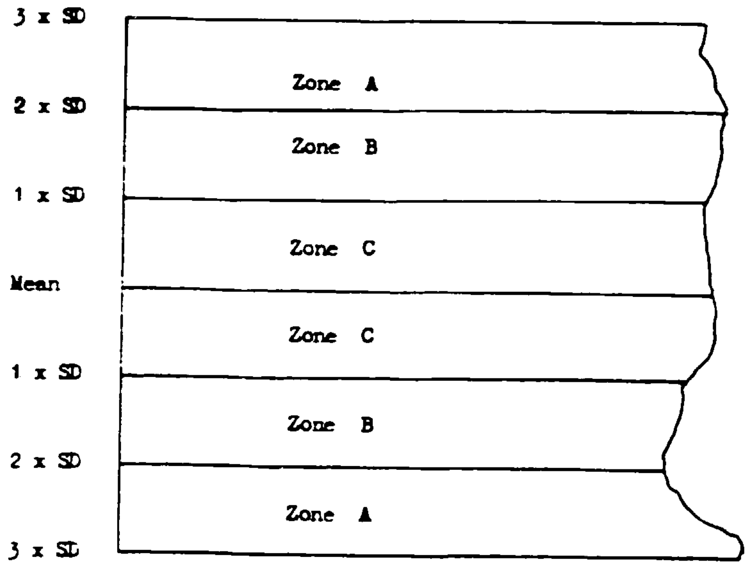
The first thing to be said is that no chart controls anything. Charts are only effective if they are used in the right place at the right time and when sensible corrective action can be taken when they show that something is amiss. Many mills control their quality quite successfully without any charts. But all the same, a chart does give a permanent visual record of how well we are controlling the mill; in this respect it is beneficial. Regrettably, it is easier to learn how to set up charts than it is to know exactly what to do when the process goes off-standard.

Where will we get most benefit from control charts? Obviously we only set them up at key control points. The commonest place to see charts in use is at spinning for controlling yarn count, however once a set of heavy or light cans is in at the back of a frame we cannot do much about it when we find that the count is drifting. It is prudent therefore to put charts at the finisher card sliver stage to get as much early-warning as possible when off-count material is in the process.

It may sometimes be enough to set up control charts at some stage in the process for a short time until we confirm that that stage is under control. We can then turn our attention elsewhere, relying on random checks to ensure that control is being continued and our process norms are being met.

Charts may be used to investigate machine-to-machine variations. These must be eliminated to the best of our ability. Minor variations between machines may still exist despite all our efforts and it may be impossible to remove these faults in our process within the constraints of time and expense. But, as a rule, an attack on machine defects and variations of speed, draft, picks, etc., will always improve yarn and cloth quality.

A good rule of thumb for interpreting charts to detect a drift in the average is to imagine that the chart is split into three zones at one standard deviation intervals, Figure 26.



Zones of Action for Control Charts for the Mean

Fig (26)

Decision zones for a control chart

We then assume that a genuine change has occurred if :

One result falls outside zones A

Two out of three successive results falls in sones A, or beyond.

Four out of five successive results falls in zone B, or beyond.

Eight successive results fall in zone C, or beyond.

Range charts

In most cases a range chart is of limited use for daily control. It is not easy to find the cause of high range figure or to do much about it at short notice It will be found in practice that we can assess the variability sufficiently well by special studies taken from time to time or by taking out weekly CV's.

Fraction defective charts

For recording the number of defects in a product e.g. bars/1000 yd in CBC, seam gap in bags, soft spools in 1000 sampled etc., we can use a fraction defective chart. The fraction defective being simply the number of faulty items which have been found divided by the total number under examination. For example, if we examine 100 bags and find 6 defective then the fraction defective is 0.06. Fraction defective chart limits are calculated thus :-

Warning limits $$p \pm 2\sqrt{\frac{p\,(1 - p)}{n}}$$

Action limits $$p \pm 3\sqrt{\frac{p\,(1 - p)}{n}}$$

Where p = fraction defective

Example :

We inspect cuts in batches of 120 and find, on average that we have 29 faults in them. Our chart limits would be -

$$\text{Fraction defective} = \frac{29}{120} = 0.24$$

$$\text{Warning limits } 0.24 \pm 2 \times \sqrt{\frac{0.24\,(1-0.24)}{120}} = 0.24 \pm 2 \times 0.039$$

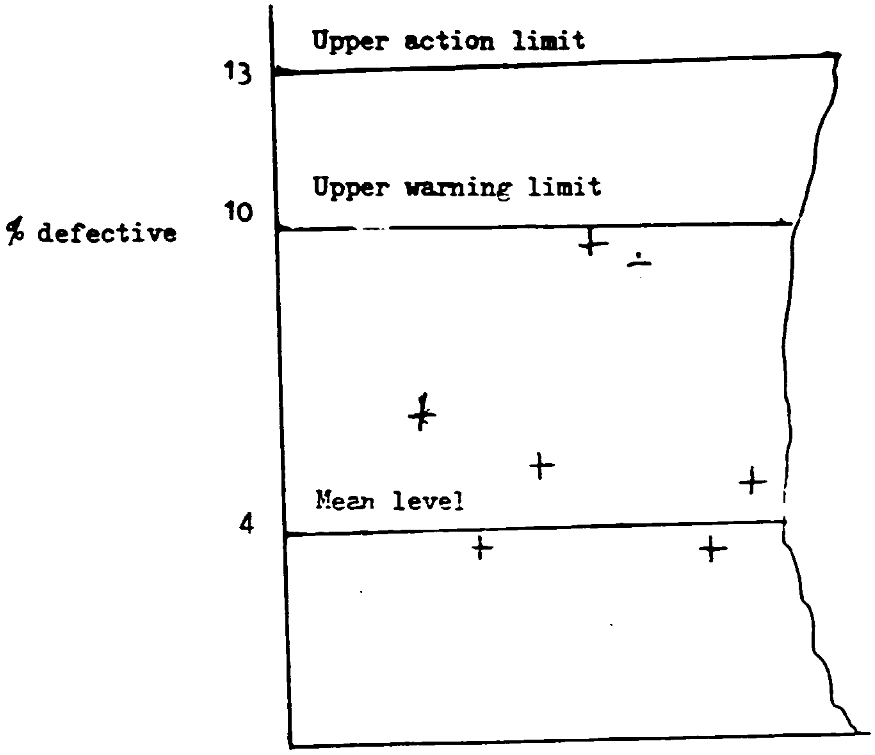
i.e. the limits are 0.16 and 0.32

$$\text{Action limits } 0.24 \pm 3 \times \sqrt{\frac{0.24\,(1-0.24)}{120}} = 0.24 \pm 3 \times 0.039$$

i.e. the limits are 0.12 and 0.48

We must note that these limits refer only to samples of 120 and if we move away from this size of sample we should recalculate the limits. In practice however, if the sample size varied between 100 and 140 we could still keep these same limits without great error.

Although the lower/warning and action limits have been shown in the calcuation they would not be put on the chart because it is only the upper limits in which we are really interested. Figure 27 is an example of a fraction defective chart for faults in B Twill bags.



Fraction defective, B Twill bags, sample size 120, all defects

Fig (27)

Fraction defective chart

End break tests

If we do decide to include end breakage tests and idle spindle surveys in our control scheme we have to take cognisamce of their variability. A control chart can be made using limits calculated from :

Warning limit	$c \pm 2\sqrt{c}$
Action limit	$c \pm 3\sqrt{c}$

Where c = mean number of breaks or idle spindles. Again on the chart we would only use the upper warning and action limits.

Accuracy of small samples

By taking small samples of in-process material and finished goods we hope to be able to assess the properties of our whole production with reasonable certainty. Statistics can help us to find how large a sample we should take in order get a specific degree of accuracy.

For most industrial applications, a satisfactory level of certainty is taken as 95%. That is to say, 95 times out of 100 of our estimate of the accuracy from a small sample will be correct.

For properties which follow the normal distribution (count, weight, regain and so on) the accuracy at the 95% level can be found from -

$$n = \frac{3.84 \times V^2}{E^2}$$

Where n = number of test

V = Coefficient of Variation

E = Accuracy level

Example

The breaking load CV of a yarn is 15% and we make 100 tests, what is the accuracy of our results?

$$E = \sqrt{\frac{3.84 \times 15^2}{100}} = 2.9\%$$

This tells us that the mean we find from these tests is (95 times out of 100) within $\pm$ 2.9% of the true average of all our production.

Looked at another way, if we want to be reasonably sure (i.e. at the 95% level) that the mean breaking load we find from a number of tests is within plus or minus 1% of the bulk, how many tests do we require?

$$n = \frac{3.84 \times V^2}{E^2} = \frac{3.84 \times 15^2}{1^2} = 864$$

Despite this large number of tests, we could still be unlucky and be wrong 5 times out of 100 (100% - 95%). We can, if we wish, improve our chances by going to a higher level of certainty. At 99%, the constant in the above formula (3.84) goes up to 6.64 and repeating the calculation we find that for this improved certainty we must carry out the colossal number of 1494 tests.

Table 20 gives the accuracy level (at the 95% confidence limit) relating to various numbers of tests and the CV of any particular property.

TABLE 20

Accuracy of test results for means

CV of property	Number of tests 5	10	15	20	25	50	100
3	± 2.6%	± 1.9%	± 1.5%	± 1.3%	± 1.2%	± 0.8%	± 0.6%
4	3.5	2.5	2.0	1.8	1.6	1.1	0.8
5	4.4	3.1	2.5	2.2	2.0	1.4	1.0
6	5.3	3.7	3.0	2.6	2.4	1.7	1.2
7	6.1	4.3	3.5	3.1	2.7	1.9	1.4
8	7.0	5.0	4.0	3.5	3.1	2.2	1.6
9	7.9	5.6	4.6	3.9	3.5	2.5	1.8
10	8.8	6.2	5.1	4.4	3.9	2.7	2.0
12	10.5	7.4	6.1	5.3	4.7	3.3	2.2
14	12.3	8.7	7.1	6.1	5.5	3.9	2.7
16	14.0	9.9	8.1	7.0	6.3	4.4	3.1
18	15.8	11.1	9.1	7.9	7.1	5.0	3.5
20	17.5	12.4	10.1	8.8	7.8	5.5	3.9
22	19.3	13.6	11.1	9.6	8.6	6.1	4.3
24	21.0	14.9	12.1	10.5	9.4	6.7	4.7

To use the Table, enter the row at the CV of the property in question and the column at the number of tests. The figure at the junction of the row and the column shows the accuracy we can expect.

Examples:

Yarn hank weight CV in a mill is 5% what is the accuracy of a 5-bobbin test? We can expect that the bulk average will be within $\pm$ 4.4 of the sample average.

Bag weight CV in a mill is 4%, how many bags should be weighed to get an accuracy of $\pm$ 2% ? 15 bags need to be weighed.

Just as the mean has its degree of accuracy, so too does the standard deviation. The accuracy (at the 95% level) of the standard deviation is found from

$$n = \frac{19208}{E^2}$$

where n = number of tests and E = accuracy level%

Example:

How many tests do we need to carry out to find the standard deviation of our production correct to $\pm$ 5%

$$n = \frac{19208}{5 \times 5}$$

$$= 768$$

Table 21 gives the accuracy level to be expected in standard deviation for different numbers of tests.

TABLE 21

Accuracy of Standard Deviation

Number of Tests	Accuracy
10	44 %
20	31
40	22
80	15
160	11
320	8
640	5
1280	4

We see at once that to get a good idea of the true standard deviation requires a very considerable volume of testing. This is why in day-to-day QC work we can get quite large fluctuations in the SD (and hence the CV) from small numbers of tests. It is easier to get an accurate estimate of the average of a set of samples than it is to get the same accuracy in the standard deviation. From Table 21 we can see the low level of accuracy we get in our estimate of S.D. even from 50 or so tests.

The foregoing paragraphs were concerned with results falling into the normal distribution. Now we can consider those which are governed by the Poisson distribution. For the same 95% level of confidence the formula for the relationship between the number of tests, n, and the accuracy is:

$$n = \left(\frac{196}{E} \right)^2$$

Example :

It is necessary to know the true warp breakage rate in a certain cloth to an accuracy of ± 15% (quite good enough for most purposes), how many yarn breaks must be observed?

$$n = \left(\frac{196}{15} \right)^2$$

$$= 171$$

If the time to accumulate 171 breaks is, say, 12 hours then the estimated hourly rate is $\frac{171}{12}$ = 14.3 warp breaks per hour and we can, with reasonable certainty, state that the true warp break rate is not more than 16.3 or less than 12.1 (14.3 ± 15%).

An idle spindle survey is planned and an accuracy of 5% is needed, how many observations are required?

$$n = \left(\frac{196}{5} \right)^2$$

$$= 1537$$

Since each time we observe the frame we are, in effect, making 100 observations (on a 100 spindle frame) we must visit the frame 15.37 i.e. 16 times, to get this accuracy.

Standard Errors

By the use of the Standard Error (SE) we can arrive in another way at some idea of the properties of the bulk form which a small sample is drawn. The SE of the mean of a normally distributed property is found from :

$$\text{Mean} \pm \frac{\text{S.D.}}{\sqrt{n}}$$

where n = number of tests

Again at the 95% confidence level, we find that the true mean of the bulk from which we have drawn our small sample will lie within :

Mean 2 x S.E.

Example:

The mean strength of a cloth is found to be 70 kg when 10 tests have been performed on it. From the mill records we know that the standard deviation is around 5.6 kg. With 95% confidence we can say that the true mean of all the cloth being woven at that time is :

$$70 \pm 2 \times \frac{5.6}{\sqrt{10}}$$

i.e. between 66.5 and 73.5 kg.

In the same way, the standard deviation has <u>its</u> standard error, but this time it is found from:

$$\text{S.E. of S.D.} = \frac{\text{S.D.}}{\sqrt{2n}}$$

<u>Example</u> :

10 strength tests are made on the previous cloth and we wish to know how accurate the CV is :

$$\text{S.E. of S.D.} = \frac{5.6}{\sqrt{20}} = 1.3$$

This is to say the true S.D. could be anywhere between:

4.3 and 6.9 kg

giving a CV of between 6% and 10%

We repeat, it is very difficult to estimate the S.D. and CV with any great degree of accuracy from a small number of tests. We would do well to ignore CV altogether unless we have 25 results or more to work with.

Dealing with Specifications

Sooner or later our sales department will ask us if one of our products can meet a specification laid down by a customer. The specification may be based on a national standard or it may be determined by the customer himself. In either case the steps to take are:

1. Examine the specification carefully.
   Are we familiar with all the terms used?
   Do we have all the necessary test equipment in our laboratory - if not, can we send our product to be tested by an independent organisation.
   Do we have experienced personnel to do the tests?
   Can we use our existing QC records to help us to decide if we can meet the specification?

2. Take sufficient samples from current production to make a good judgement. The sampling scheme will usually (but not always) be laid down in the specification. If it is, then follow it <u>exactly</u>. If it is not then state clearly how you have drawn the samples.

3. Assess the samples.
   Again, the test methods will usually (but not always) be laid down. If they are follow them <u>exactly</u>. If you cannot do this state clearly exactly how you have done the tests.

4. Compare the results with the specification.

5. Set up the necessary sampling and testing procedures if they are outside the normal QC system being operated.

Process Capability

To judge whether our process can meet a specification we use a concept called the Relative Process Capability. This is found by dividing the total tolerance in the specification by the standard deviation of that particular property.

Our process will be in one of the three categories:

1. Low relative capability -
   if $\frac{T}{SD}$ is less than 6. — The process is certain to have failures

2. Medium relative capability -
   if $\frac{T}{SD}$ is between 6 and 8 — The process is borderline. Some failures are inevitable

3. High relative capability -
   if $\frac{T}{SD}$ is greater than 8 — The process can produce goods which will pass the specification easily

Figure 27 shows three cases where our variability will (a) just pass a specification (b) fail and (c) pass easily

Let us look at two examples of the use of relative process capability (RPC)

1. We have been asked to supply a 12 lb yarn to the following specification.

Mean of 25 x 100 yd hanks	11.85 - 12.15 lb/sp
Quality ratio (50 breaks)	110%
Lowest individual break	9 lb

We must examine each aspect of the specification in turn

(a) Count

Our mill records indicate our hank weight on means of 25 x 100 yd is 2%. Our QR for g od Tossa yarn is 120% and the CV of strength is usually around 12%

$$\text{SD hank wt.} = 12 \times \frac{2}{100} = 0.24 \text{ lb/sp}$$

The tolerance allowed is 0.3 lb/sp, (12.15 - 11.85)

$$\text{R.P.C.} = \frac{0.3}{0.24} = 1.25$$

This is much less than 6 and so we will have no chance of passing the count requirement.

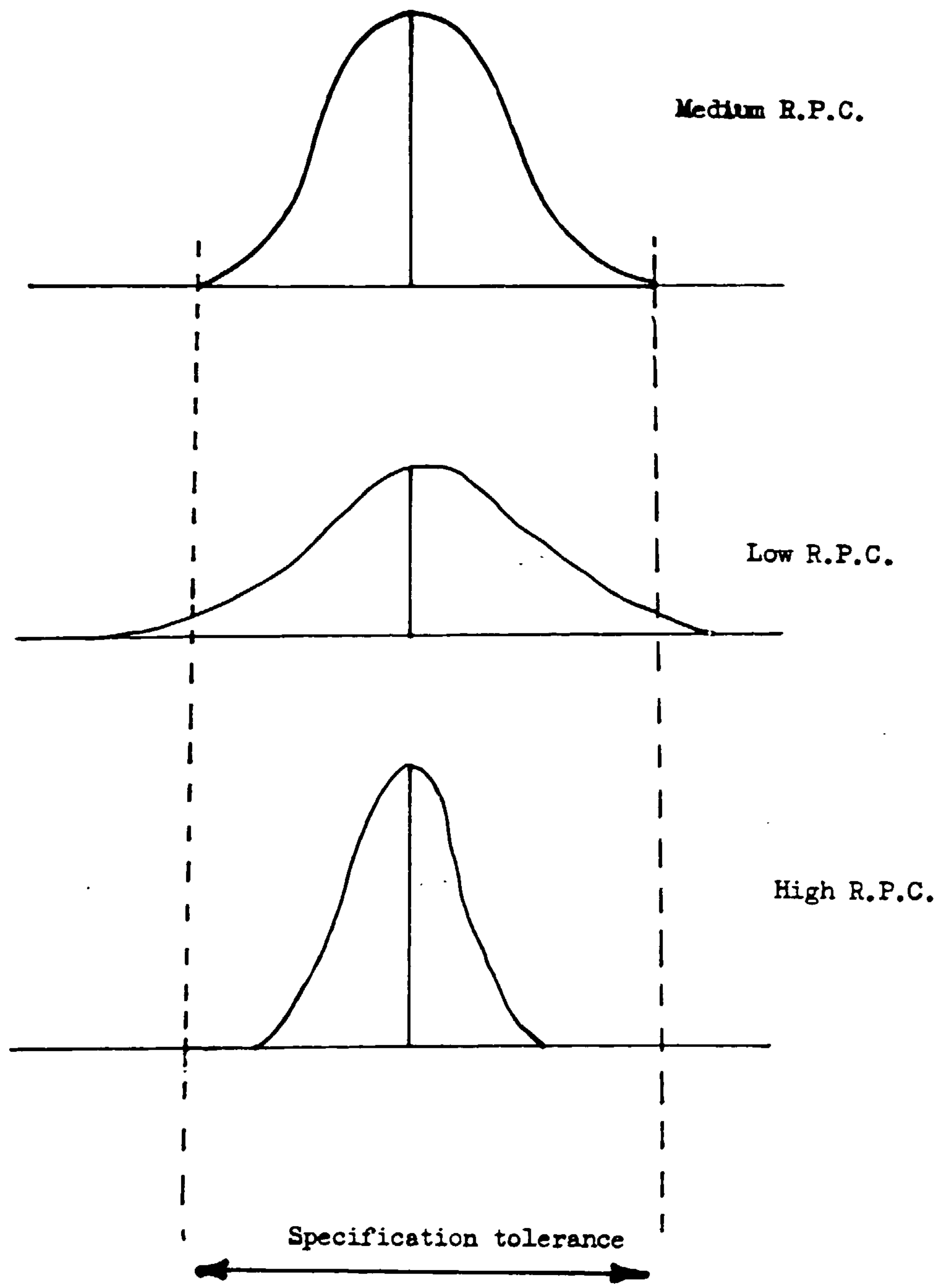


Fig (28)
Illustration of relative
process capability

(b) Strength

The usual average strength of our 12 lb yarn is 14.4 lb (120% QR) and our SD of strength is 1.73 lb

If we supply our normal yarn whose average strength is 14.4 lb then we would expect our minimum strength to be 9.21 lb (14.4 - 3 x SD). Therefore we would expect to meet this aspect of the specifiaation.

(c) Conclusion

We know from our experience that a hank weight CV of 2% is very good and we are unlikely to be able to improve it. The specification as it stands, is impossible to fulfill and the specification would have to be discussed with the customer and a modification to it agreed.

2. The second example concerns the weight of B twill bags. We are are told in a specification that all the bags must lie between 945 g and 1120 g. What is the maximum CV of bag weight we may have in order to pass the specification?

To pass comfortably we want an R.P.C. of 8 or more

$$\text{i.e. } \frac{T}{SD} = 8$$

$$\frac{1120 - 945}{SD} = 8$$

Therefore SD = 22 g

The mean bag weight is to be 1020 g and therefore the maximum CV we can allow is $\frac{22 \times 100}{1020} = 2.2\%$

One final word on process capability. Some customers demand levels of performance which can never be achieved with jute fibre and jute processing machinery. Equally, some mill managers indulge in wishful thinking in relation to the tolerances they can achieve. There is no possibility of controlling a mill without realistic and truthful recognition of the variables in the process. One hears of managers who lay down impossible standards and blame the production and laboratory staff when they are not met. This is not to say that quality standards can be slack. For the long-term future of the mill, quality standards must be high but attainable.

Sampling

In-process checking and product assessment by drawing small samples for the purpose of detecting non-standard occurences cannot be relied upon to be completely accurate and trustworthy. No sampling scheme can find <u>all</u> defective processes and products. 100% inspection might be expected to do this (barring inspector fatigue) but it is clear that this is impossible to achieve.

When we compare sampling, in the sense of examining carefully small samples, which we assume to be representitive of the bulk, with 100% inspection we find :

- fewer QC staff are needed
- the monotony of 100% inspection with its attendant errors is avoided
- it is a cheaper system to operate
- in destructive testing on slivers, yarns and fabrics it is the only workable solution
- "bad" quality or processing conditions may be missed when a "good" sample is drawn
- "bad" samples may be selected from processes which are in fact operating at standard
- more planning and organisation are required

All the sampling plans which are published are based upon random sampling i.e. all samples which have been drawn have equal chances of being selected from the bulk. In jute manufacture, as in many other industrial processes, we cannot achieve this exactly. We can only take samples, for instance, from the outside of bobbins or spools; we can only take cloth samples from the end of roll, and so on. So, in our case we have, as it were, several streams of our product flowing through the mill. From these we can only sample at specific intervals. This introduces us to "between" and "within" variation and its sampling difficulties.

As an example, we might have 10 bobbins on which we wished to carry out an accuracte count test, so we decide to take 10 hanks from each bobbin weighing each individually so that we finish with 100 test hanks.

Bobbin No.	Hank No. 1	2	3	4	5	6	7	8	9	10	Mean	CV
1	7.8	8.2	8.1	8.0	8.3	7.7	8.1	8.0	7.9	8.1	8.0	2.3
2	8.0	8.1	7.5	7.9	8.1	8.4	8.1	7.9	7.9	8.2	8.0	3.0
3	7.2	7.6	7.8	8.0	8.1	7.4	7.6	7.6	7.9	8.0	7.7	3.7
4	8.4	8.2	8.6	8.7	8.1	8.5	8.0	7.9	8.8	8.2	8.3	3.7
5	6.9	7.2	7.4	7.0	8.1	8.0	7.5	7.6	7.4	7.5	7.5	5.1
6	8.1	8.2	8.4	7.6	7.4	7.8	7.9	7.9	8.0	8.1	7.9	3.7
7	8.6	8.4	8.6	8.5	8.1	8.0	8.4	8.1	8.4	8.4	8.4	2.5
8	6.8	7.0	7.2	7.4	7.6	7.0	7.2	8.0	7.5	7.5	7.3	4.8
9	8.0	8.1	8.1	8.1	7.8	7.7	7.9	8.2	8.1	8.0	8.0	2.0
10	8.5	8.7	8.6	8.4	7.9	8.2	8.1	8.6	8.9	8.0	8.4	3.9
Mean	7.8	8.0	8.0	8.0	8.0	7.9	7.9	8.0	8.9	8.0		
CV	8.3	6.7	6.6	6.5	3.5	5.8	4.5	3.6	6.2	3.6		

If we calculate the CV for each bobbin then take the grand average CV (i.e. calculating the vertical columns) we are finding the variation in count within bobbins. This value is 3.6 %. Using the same data but this time calculating the CV between bobbins (i.e. calculating horizontally) we find a CV of 5.7 %. Which is "correct"? In fact they are both quite correct and we have found slightly different answers because we are really measuring two sorts of variation – the within-bobbin and the between-bobbin. If we treat all the results as one and repeat the calculation of CV we get a value of 4 %. This figure encompasses the within and between variability. Theoretically the total variability is compounded from the other two elements in this way –

$$\text{Total CV} = \sqrt{\text{CV within}^2 + \text{CV between}^2}$$

We must always remember that the CV figures which we use every day depend upon the number of tests we do, how many samples we take and from where we take them. It is therefore meaningless to say "we have a count CV of 2%" without explaining exactly how we take our samples and do our calculations.

It may help to put sampling into perspective if we look at Bangladesh Standard 813 for 7½ oz hessian in the light of the sizes of the samples which we must take when we are testing against this Standard. Let us suppose that we have a consignment of 95 bales to examine. The Standard requires us to take the samples in the following manner :–

1. From the 95 bales take 10 bales and weight to find	GROSS MASS
2. From these 10 bales, take 3 bales and check them for	TARE LENGTH MEDIUM AND SHORT CUTS

3. From these 3 bales take 15 cuts and measure	REGAIN
	G/M^2
	ENDS, PICKS
	WIDTH
4. From these 15 cuts take 3 m of cloth and check	BREAKING LOAD
	OIL CONTENT

Now, the 95 bales in our consignment weigh 40565 kg and our sample sizes are :

1. Gross weight	4057 kg	i.e. 10% of the consignment
2. Tare, etc.	1281 kg	3.2 "
3. Regain, etc.	285 kg	0.7 "
4. Strength	0.7 kg	0.002 "
5. Oil content	0.06 kg	0.00015 "

Equally, when we test yarn count once per shift we are examining an extremely small fraction of the bulk. For instance, we might have four $4\frac{1}{4}$ inch frames spinning 8 lb yarn at 3800 rpm with 4.2 tpi. If the control scheme is set to take one set of five bobbins from the block of frames once per shift then during this time we will have produced 4,000,000 yards of yarn. The test sample is 500 yards long and is only 0.01% of the bulk. It is from these extremely small samples that we must glean information about our process and products. We must therefore be rather cautious when making judgements from them and we must not jump to conclusions without double-checking. Before we can compare one mill with another it is absolutely imperative that we ensure that the sampling plans <u>and</u> the methods of calculation are identical in all respects.

Introductory books on Statistics.

1. Facts from Figures, Moroney, Pelican Books.

2. Statistical methods for Textile Technologists, Norris and Tippet, Textile Institute.

3. Simple Statistics, Pitman.

4. Quality Control, Juran, McGraw-Hill.

CHAPTER ELEVEN

The Process Control Scheme

We must repeat that there is no single scheme which is suited to all mills, and it is management's task to plan the size of the scheme in the light of :

- Product value and market
- Capital available
- Number and ability of staff
- Information feed back and action

It takes a degree of determination to reduce quality control costs but unless the scheme is playing a positive role most of the expense incurred is wasted. There is no merit whatsoever in filling note-books with data on which little or no action is taken. It is far better to carry out a small number of essential tests well than to test too many factors in a sketchy fashion.

In the following pages, examples of control schemes are given which are realistic in terms of cost and, at the same time, give sufficient information to line management in the task of the controlling quality in the mill.

Hessian unit

Scheme 1 represents the minimum level for a hessian unit laid out as follows:

250 looms @ 9 lb/hour = 18000 lb/shift (approx.200 cuts)
Average fabric weight 8.75 oz/40 constructed from 47% warp and 53% weft in weight

warp required = 8460 lb/shift
weft required = 9540 lb/shift

$4\frac{1}{4}$" SD frames producing 65 lb/hour of warp and 75 lb/hour of weft i.e. 16 warp frames on one count and 16 weft frames on two counts

50% sold as cloth - 100 cuts/shift
50% sold as bags - approx. 10000/shift

Sacking unit

In example II we consider a sacking unit producing mainly B Twill bags.

250 looms @ 18 lb/hour = 36000 lb/8 hour shift

This is equivalent to about 18000 bags. The product specification levels are not high. This would be reflected in quality control expenditure to an extent but the short, low-grade fibre which is used increases the difficulties of control.

CBC unit

Example III is a scheme for a 50 - loom mill weaving secondary carpet backing from good/medium long jute.

50 looms @ 14 lb/hour = 5600 lb/8 hour shift

If the cloth is 3.6 m wide and weighs 167 g/m^2 the mill will produce about 4 rolls per shift. This cloth has a higher unit value than either of these in I or II and a good quality standard must be kept up. Process control is increased accordingly.

Yarn unit

Finally, example IV is a scheme in an export-oriented yarn mill. The quality standards are very high and good process control is essential.

10 $4\frac{3}{4}$" A/D frames @ 110 lb/hour = 8800 lb/shift

This is equivalent to about 550 precision spools per shift.

Tests per shift

Control point	Control parameters	Mill examples I	II	III	IV
Morah weight	mean, CV and MR	1	1	1	1
Emulsion added/ flow rate	quantity	-	-	1	1
Emulsion composition	proportions	1	1	1	1
Emulsion stability	stability	-	-	1	1
Fin.card sliver	m/c to m/c variations in count, MR	1	1	2	2
Fin.drwg.sliver	m/c to m/c variations in count, MR	1	1	2	2
Yarn count	mean,record CV weekly, MR	4	4	2	6
Beam moisture	mean	1	1	1	-
Cloth	width on front rail	25	25	25	-
	ends x picks in loom	5	5	5	-
	faults (cuts/rolls)	10	5	1	-
	Wt + MR (cuts/rolls)	5	3	1	-
Spools	faults + MR	-	-	-	25
Bags	Wt + MR	25	25	-	-
	size	25	25	-	-
	faults	25	25	-	-
RH at selected sites		1	1	1	1

Tests per day (in addition to shift tests)

Control point	Mill examples I	II	III	IV
Emulsion added	1	1	-	-
Emulsion composition/stability	1	1	-	-
Standard of packing	1	1	1	1
Drawing frame inspection	1	1	1	-
Spinning frame inspection	1	1	-	-

As a guide, the following figures give the quality levels which can be reached in a well-run mill.

1. **Morahs**

Overall mean	1000 g
Individuals	750 g - 1250 g
Means of 25	950 g - 1050 g
Regain	22% max. for individuals
	18% max. for means

2. **Emulsion applications**

Emulsion applications	High R.H. Period	Low R.H. Period
Good quality long jute	22 $\pm$ 2%	24 $\pm$ 2%

Emulsion applications	High R.H. Period	Low R.H. Period
Medium quality long jute	22 ± 2%	25 ± 2%
Mestha	25 ± 2%	28 ± 2%
Cuttings, good	28 ± 2%	32 ± 2%
Cuttings, low	34 ± 2%	38 ± 2%

3. Emulsion composition

	% oil in emulsion for target oil contents of		
	2%	4%	6%
20% application	10 - 12	20 - 24	-
22%	9 - 11	18 - 22	-
25%	8 - 10	16 - 20	24 - 28
28%	-	14 - 18	22 - 26
32%	-	-	19 - 23
35%	-	-	18 - 22
38%	-	-	16 - 20

4. Maturing times

High quality long jute	2 days
Medium long jute	3 days
Mestha	5 days
Good cuttings	5 days
Low cuttings	8 days

5. Finisher card regularity — CV (5 yd tests)

Carpet yarn	8% maximum
CBC yarn	8%
Hessian	9%
Sacking warp	10%
Sacking weft	14%

6. Finisher drawing regularity — CV (25 yd tests)

Carpet yarn	8% maximum
CBC yarn	8%
Hessian	9%
Sacking warp	10%
Sacking weft	14%

7. Count CV %

Good carpet yarn	4.5% maximum (100 yd tests)
Medium carpet yarn	5.5%
Hessian	6.0%
Sacking warp	7.0%
Sacking weft	8.5%

8. Beam moisture regain

CBC	14 - 18%
Hessian	16 - 20%
Sacking	20 - 24%

9. Cloth width on front rail

40" Hessian	41 - 41.5 inches

10. Ends and picks in loom

Hessian	± 4%
Sacking	± 5%

11. Bags	Hessian	Sacking
Width	+ 1 in	+ 1.5 in
	- 0	- 0
Length	+ 1 in	+ 1 in
	- 0	- 0
Weight	+8%	+ 10%

CHAPTER TWELVE

Waste Control

Control of waste is an important, but often neglected, aspect of process control. Let us first look at some of the factors which create waste.

1. Low grades of jute. Short, coarse fibre will always make more waste due to greater quantities of machine droppings, more sliver and thread waste because of the more frequent machine stoppages, chokes, laps etc.

2. Moisture regain. If the regain is low we can expect to have more caddis. As an example the figures given below show the results obtained in one trial on hessian weaving.

3. Low oil content. When spinning is carried out with low (1 - 2%) oil contents we may expect to find more caddis, air-borne dust machine droppings etc.

4. Poor maintenance of the machinery. Card settings, poor drawings, frequent spinning and weaving breaks, poor loom tuning etc all play their part.

5. Poor operational techniques. Over-loading the machinery, excessive speeds, inefficient batching all add to waste considerably.

6. Low skill-levels and poor supervision. This, as much as anything else, can be a prime cause of excessive waste in the mill. If, for example, workers are allowed to make long splices or discard large amounts of sliver when they have a choke or a lap; throw away large cop-ends; ignore tag-ending; discard bobbins at winding which have only one or two layers of yarn on them after a break at winding; all these and many more add to the waste burden of the mill.

Waste can be classified as

- reworkable, e.g. sliver, thread waste, cloth cuttings, shaken dust or
- unrecoverable waste. Stick, fine dust, oily machine

droppings and other debris come into this category

Reworkable waste should be used only in lower batches if quality is not to suffer. Top quality yarns cannot be made successfully if waste is injected into them.

Waste measurement

Periodically, the quantities of waste should be related to inputs to give a means of measuring the degree of control which is being excercised in the mill. There are a number of ways of doing this but we should be aware of two important factors. The first is that we have "invisible" waste arising from moisture losses and volatilisation of the JBO. The second is that we have "visible" waste i.e. the sliver, thread and cloth wastes which we can see. This latter comprises recoverable waste, the mill dust sweepings, etc., which cannot be used again and which are either dumped or burnt.

Waste calculations are often wildly inaccurate and it is safer to take out figures over a fairly long period to reduce errors (especially of the work-in-progress stocks). A three-monthly waste balance is more reliable than a weekly one.

As an example of a waste balance, a mill might have:-

Inputs:

Raw jute	239.5 tonnes
JBO	12.1
Emulsifier	0.3
Dressing materials	2.1
	254.0 tonnes
Opening w.i.p. stock	73.2
	327.2 tonnes

Outputs:

Cloth	247.0 tonnes
Packsheet	2.5
Mill dust (to boiler)	8.9
	258.4
Closing w.i.p. stock	62.0
	320.4 tonnes

This mill had an invisible loss during the period of 6.8 tonnes (327.2 - 320.4) and a visible loss of 8.9 tonnes (mill dust)

Expressed as percentages of the total inputs these are :-

Visible waste $$\frac{8.9 \times 100}{327.2} = 2.7\ \%$$

Invisible waste $$\frac{6.8 \times 100}{327.2} = 2.1\ \%$$

Productive yield $$\frac{(320.4 - 8.9 - 6.8) \times 100}{327.4} = 93.1\ \%$$

There are other ways of calculating the waste percentages. Some are called "jute to jute", "cloth to cloth" and so on, which differ in the base which is used to calculate the percentage. The exact arithmetical method is not too important <u>provided</u> comparisons are made <u>only</u> between mills which use <u>exactly</u> the same methods for recording waste and use the same basis for their calculations.

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