Manufacturing of jute yarns: An overview

The main functions of jute spinning units are to convert jute fibres to yarns for different end uses. The types of jute yarn manufactured can be classified according to the application/use to which they are put ie, fine yarns, hessian yarns, carpet, sacking yarns, etc. These yarns can be further classified into warp and weft yarns, the warp yarns normally being superior to the weft yarns as they have to withstand the cycles of stress during weaving while the weft yarns act more as filler and undergo less strain during weaving process.

Jute yarns of various dimensions are plied together to make twines, ropes, cordages, etc as per requirement and use. These are used for the purpose of tying, knotting, binding, etc particularly agricultural commodities.

It is not possible to produce jute yarn finer than 138 tex (4 lb/spy) by conventional techniques. But, later on after development of apron draft ring spinning system it is easier to produce yarn as fine as 60 tex (1.75 lb/spy). This type of jute yarn has the prospect of being used in high quality jute textiles.

The range of yarns spun from jute is given in Table below:

<table>
<thead>
<tr>
<th>No</th>
<th>Yarn type</th>
<th>Linear density (Count)</th>
<th>Tex</th>
<th>lb/spy**</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fine jute yarns</td>
<td>60 - 103</td>
<td>1.75 - 3.0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Carpet yarns (CBC*)</td>
<td>120 - 205</td>
<td>3.5 - 6.0</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Hessian warp</td>
<td>240 - 310</td>
<td>7 - 9</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Hessian weft</td>
<td>240 - 410</td>
<td>7 - 12</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Sacking warp</td>
<td>275 - 350</td>
<td>8 - 10</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Sacking weft</td>
<td>700 - 1400</td>
<td>20 - 40</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Carpet yarns</td>
<td>480 - 820</td>
<td>14 - 24</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Jute blended yarns</td>
<td>50 - 275</td>
<td>1.5 - 8.0</td>
<td></td>
</tr>
</tbody>
</table>

*CBC - Carpet backing cloth, ** lb/sp = Weight of yarn in pound of length of 14400 yards.
The processing sequence in jute spinning is:

**Selection**

Raw jute reeds after retting and drying are packed in the form of bales of 150 kg or 180 kg for easy transportation to jute mills. The bales from the mills godown are taken to the selection section where all the jute bales are opened to find out any defect and to remove the defective portion from the morah by experienced workers. The bales are assorted according to end use like hessian weft, sacking wrap, sacking weft, etc. After selection, jute bales are carried to softening/batching section by workers.

**Softening section/Batching section**

The process of adding oil and water emulsion on jute batches is called as batching. The stack of fibre blends from different types of jute for a particular class of yarn is called a batch. The department where the jute is prepared for carding is called the batching house. In this section the fibres are conditioned by adding oil and water to it for easy processing in consequent processes. For making the jute fibre bundles suitable for next carding operation the morah prepared in selection are processed through softener or spreader machine. During its passage through these machines, oil in water emulsion is applied on jute for its moistening or lubrication.

**Jute batching emulsion**

Jute batching emulsion usually contains the mineral oil, water and an emulsifier. The commonly used mineral oil is Jute batching oil (JBO), a middle distillate produced by petroleum refineries. JBO lubricates the fibre and makes it pliable. Water provides sufficient dampness to the fibre and increases its extensibility. The emulsifier reduces the surface tension and stabilises the emulsion. The emulsion solution can be prepared by using 20 - 30% water, 2 - 5% JBO and 0.1 - 0.5% emulsifying agent on the weight of fibre depending upon the humidity condition. The processing of jute through spreader or softener machine with emulsion application and subsequent piling of about 24 - 48 hours weakens the joints of the meshy structure for easy longitudinal splitting in the carding operation. During piling oil and water migrates through the fibre mass and "Thermo fillic" action take place by bacterial fermentation which softens the hard portion of the root.
**Spreader**

In this machine the jute reeds are assembled into a continuous sliver. The reeds pass between a pair of fluted feed rollers and on to the pins of slow moving coarse pinned lattice known as slow chain; above the slow chain there are two or three lantern rollers to trace the jute firmly down on to the pins. Half way along the machine the material is transferred from slow chain to similar type fine pinned lattice fast chain. Because of the greater linear speed of the fast chain the jute is combed and drafted at the transfer point. After crossing over the fast chain, the jute passes between a pair of fluted drawing rollers and is guided down a conductor channel where the emulsion is added, either by a pressure tray or by a gravity – fed drip weir. The final action is to collect the sliver in compact roll form suitable for carding. Draft range lies between 10 - 11. Figure 1 shows the schematic diagram of a spreader machine.

**Softener**

Industrially softener machine is used for batching of sacking yarns, the raw materials of which are lower grade. It is a long machine comprising 64 - 72 pairs of cast iron fluted rollers. The lower of the pair is driven by side shaft and the upper is spring loaded one by contact with the lower of the pair.

Figure shows the schematic diagram of jute softener machine.

**Functions of softener:**

- The jute is flexed between two pair of rollers and is made softer, some of loose dust and dirt falls off and pieces of bark and stick broken making them easier to remove at later stage.
- The emulsion solution is dripped onto the jute through a simple gravity fed weir about one third of its way along the rollers.
- The sump beneath the rollers collect the excess amount of emulsion solution passed through the rollers and through the fibres and these excess solution is pumped back through various filters.
- After softening the longer jute (after cutting the heavy barky root end) is conditioned for 24 - 48 hours and is then ready for feeding to breaker card.

**Carding**

The primary objectives of jute carding are:

a) To split the jute reeds longitudinally and break it transversely.
b) To convert the reeds of jute into a uniform fibrous strand, sliver suitable for further processing.
c) To clean, orient and attenuate the fibre to some extent.
d) To randomise the fibres among themselves.
In jute processing generally two carding machines are used breaker and finisher and these are roller and clearer type.

**Breaker card**

The breaker cards are commonly down striking and half circular ie, the cylinder pins strike downward the fibre feed from the top and the fibres travel half way round the cylinder. It is a very important machine in jute processing system because it determines the average fibre length and fineness which affects yarn quality. It has two pairs of workers and strippers. Figure 3 shows the sketch of one such machine.

Normally 6 - 8 spreader roll slivers are fed onto the feed sheet from a creel at floor level and the material passes over up towards the 'shell' feed. The shell feed system consists of a pinned roller with backward facing pins and a cast iron shell which is shaped to follow the circumference of both feed roller and the main cylinder, through which the jute enters and travels towards the fast moving cylinder comb, split and convert the jute reeds into a fibrous mass. The fast moving pins of cylinder progressively. The clearance between the shell and the feed roller and cylinder and also the rate of fibre feeding have a considerable influence on the average fibre length in the card sliver.

After shell feed operation, the jute reeds come into the real carding action carried out by two pairs of workers and strippers. The essential features of this worker and stripper action are combing, teasing, spitting as the fibre is transferred from the cylinder to worker, then from the worker to stripper and finally from the stripper back to the cylinder. Since the pins of cylinder and worker are point to point arrangement and surface speed of cylinder is very higher than the worker, the top layered fibres are arrested by the 1st worker pins and the remaining fibres firmly held by the cylinder come into action of next worker stripper action.

Due to the two pairs of worker and stripper action the fibre networks are gradually split into fibrous mass and in addition there is some degree of mixing inside the card as some of the material is held back and deposited on top of fresh. Indeed, it is possible for a bunch of fibres to travel several times round the worker stripper pair before it passes on with the cylinder. The tin roller below the worker and stripper pair reduces the amount of fall-out of the fibrous mass below the card.

After leaving the 2nd worker stripper pair the jute meets the doffer whose function is to strip the jute off the cylinder and pass it to the nip of drawing rollers whose surface speed is about twice that of doffer. However, doffer removes a major portion of the fibre mass on the cylinder while the rest travels round with the cylinder. The fibre is caught as a thin and consistent web in the nip of the drawing roller and the doffer pins. The web emerges from the drawing nip and passes down a V or U shaped sheet metal condenser and a pair of heavily loaded delivery roller to compress the jute into a compact sliver.
**Typical parameters of breaker card:**

- Feed roller diameter: 10.6"
- Cylinder diameter: 48"
- Stripper and worker diameter: 10.6 inches
- Doffer diameter: 21.3"
- Cylinder Speed: 200 rpm
- No of doublings: 6 - 8 spreader rolls
- Draft: 10 - 25
- Sliver count: 18 - 26 lb/100yds (90 - 130 ktex)

**Finisher card**

Figure 4 shows the lay out of a finisher card suitable for hessian, carpet and sacking warp yarns.

The machine is designed as 4.5 pairs, full circular, double doffer and down striking. The roller and cylinder are pinned in the same manner as the breaker card but somewhat finer and closer together. The commonest type of feed arrangement is the pinned plain roller feed suitable for hessian and carpet quality and sacking warp cards. In the pinned plain feed the feed roller is clothed with pins but the roller immediately above it is not.

The action of more number of workers and strippers in the finisher is same as in the breaker and therefore the finisher continues the work of drafting, doubling, splitting the fibre networks and cleaning. For coarser variety of jute, one more carding passage called 'Inter card' is provided between breaker and finisher cards for better splitting and opening of jute.

In some of the finisher card, there may be a short of drawing head attachment comprising a pair of feed rollers, a short lattice of pin bars and a pair of delivery rollers. Whenever the sliver passes through it, the pinned lattice controls the fibre movement.

**Typical parameters of finisher card:**

- Feed roller diameter: 6.4"
- Feed stripper: 6.4"
- Cylinder diameter: 48"
- Stripper and worker diameter: 10.6 inches
- Doffer diameter: 21.3"
- Cylinder Speed: 200 rpm
- No of doublings: 8 - 12
- Draft: 10 - 20
- Sliver count: 13 - 18 lb/100yds (65 - 90 Ktex)
Draw frame

The primary objectives of jute draw frame are:

1. Drafting the finisher card slivers to count suitable for feeding the spinning frame.
2. Doubling the slivers to minimise the irregularities.
3. Straightening and paralleling of the fibres along the sliver axis.

Figure 5 shows the general outline of the drafting mechanism of a jute drawing frame. The slivers feed through two retaining rollers and a self weighted jockey roller and then pass through the gill pins. The gill pins are carried on a series of faller bars which move forward and follows a rotational path. As the slivers leave the nip of the back retaining roll, a faller bar with its sharp pins strike upwards into it and the slivers are carried forward to the front of the machine in a controlled manner like a continuous layer over the faller bars. When the faller bars are close to the drawing rollers they drop out of the sliver and travel back underneath the sliver in preparation for another strike upwards. The relative surface speed of the drawing roller and retaining roller determines the draft. The linear speed of the gill pinned fallers is 10 to 15% higher than that of retaining rollers to maintain the required tension and is known as lead%.

The distance between the centre of the front retaining roller to the nip of the drawing and pressing roller is called the reach of the drawing frame. It should be slightly longer than the longest fibre in the sliver. It generally lies between 14 to 16 inches. If reach is less, longer fibre will break, more waste will generate and irregular sliver will produce. If reach is higher, there will be no control on the loose and short fibres, so produce irregular sliver.

Doubling may be carried out by placing two or more slivers together at the feed end of the machine and entering them on to one set gill pins or by placing individual slivers on each set pins and uniting the slivers as they emerge from the nip of the drawing rollers. The former situation holds for the lighter slivers at the last drawing passage and in the later situation doubling takes place at front of the machine through the doubling plate.

The doubling plate is a cast iron plate having slots with rounded edges at an angle of 45° to the line of the frame through which the sliver can pass so as to change their direction. In this doublings one sliver comes straight and the other slivers are turned through 45° and pass along the back of the plate to another 45° slot. When they pass through the second slot they are laid down on top of one another and travel towards the delivery roller where they are consolidated into one sliver and leave the machine.
Jute drawing frames are divided into two types, depending on the mechanism of faller bars.

1. **Push bar type:**

In this type of draw frame, in between the retaining and drawing rollers there are two carrier wheel shafts which drive the faller bars. The bars move forward on the slide driven by the teeth of the carrier wheel. The fallers have specially designed crank ends which run in slides on the machine frame. The bars bear across the full width, the bar behind pushing the bar in front. The carrier wheel has half as many teeth as there are faller bars, alternate bars being driven from opposite side of the machine.

2. **Spiral or Screw gill type:**

In this type there are two spiral screws on each side, one set directly above the other. The ends of each faller bar are cut to fit into the grooves on the spirals so that as the screws rotate they drive the faller bars along. As each faller bar comes to the end of the top screw it is knocked down on the bottom one by a cam on the top screw, springs holding it steady as it falls into the grooves of the bottom screw. The bottom spiral is more coarsely pitched than the top one so that the faller bars are returned quickly to the back of the machine ready to be lifted by cams on the bottom screw up into the spirals of the top screw. By having a coarse spiral on the bottom fewer bars are needed to complete the gill sheet.

The common arrangement for hessian qualities is to have three drawing passages over a first pushbar, a second double thread spiral and a finisher triple thread spiral drawing. The double thread and triple thread are designed to increase the speed of the faller bars. The differences between the push bar type draw frame and spiral type draw frame are as shown in the Table below.

<table>
<thead>
<tr>
<th>Push bar type</th>
<th>Spiral (Screw gill type)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faller drops up to 850/min</td>
<td>In double screw faller drops up to 400/min In triple screw faller drops up to 650/min</td>
</tr>
<tr>
<td>Faller bar lead over retaining rollers 4 - 10%</td>
<td>Faller bar lead 1.5 - 4.5%</td>
</tr>
<tr>
<td>Less noise</td>
<td>More noise</td>
</tr>
<tr>
<td>Tends to clog with dirt</td>
<td>Self cleaning because of the jerk at each drop</td>
</tr>
<tr>
<td>Pinning good</td>
<td>Pinning excellent</td>
</tr>
<tr>
<td>Occasionally lapping occurs</td>
<td>Seldom lapping</td>
</tr>
</tbody>
</table>

As the sliver becomes finer in its passage through the drawing stages the coherence between the fibres gradually decreases. It is difficult to handle and also carry up the back of the spinning frame. To overcome this, the sliver is crimped by the crimping box attached to the
delivery of the draw frame to insert certain amount of cohesion to the strand. The sliver leaves the nip of the drafting roller and passes down the sliver plate into the nip of a pair of fluted delivery rollers, the upper one being spring loaded and positively driven through a wide pitch gear from the lower one.

The sliver is driven into the box where it meets a metal finger hanging down into the box. The finger blocks the motion of the sliver and fills the box quickly. When more slivers enters at the back the lid of the box is forced to open and the crimped sliver exits. These slivers are then collected in the cans which rest on can turning plates at the front of the machine and packed with the help of the up and down movement of the can tramping arms attached with the frames one for each delivery.

<table>
<thead>
<tr>
<th>Machine</th>
<th>Draft</th>
<th>Doubling</th>
<th>Sliver kts</th>
<th>Faller drops</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Drawing</td>
<td>3.5 - 5</td>
<td>2 or 4</td>
<td>40 - 80</td>
<td>Push bar type/700 - 850</td>
</tr>
<tr>
<td>2nd Drawing</td>
<td>5 - 7</td>
<td>2 or 3</td>
<td>23 - 28</td>
<td>Double spiral/250 - 400</td>
</tr>
<tr>
<td>3rd Drawing</td>
<td>8 - 10</td>
<td>1 or 2</td>
<td>4.5 - 6</td>
<td>Triple spiral/350 - 650</td>
</tr>
</tbody>
</table>

**Spinning**

The majority of jute yarns are spun from finisher drawing sliver and spinning from roving is confined chiefly to finer counts (173 tex or 5lb/sp less) of yarns. But now days mostly ring spinning is used for fine count yarns directly from slivers. Jute spinning frames (flyer spinning) are designated by the pitch (distance between adjacent spindles). The main objectives of spinning process are drafting, twisting and winding.

**Drafting**

All jute spinning frames have two sets of rollers along the length of the machine—the retaining roller and the drawing roller. In each set one roller is positively driven and the other roller is the pressing member to grip the fibres in between. Depending upon the draft control, jute spinning frames can be classified into following types.

1. **Slip draft system (Figure 6):** This draft system is used in 4¼ inch or in 4¾ inch pitch spinning frame. It consists of a semi-circular type breast plate having upward concave and a pair of deeply grooved intermediate rollers for control of short fibre movement in between retaining roller and drawing rollers. It's draft range lies between 10 - 22 and it can spin medium to coarse count yarns (8lb/sp to 28lb/sp) depending upon the pitch of the frame.
2. **Apron draft system (Figure 7):** This draft system is used in 4¼ inch pitch spinning frame. It consists of either two rubber aprons or bottom rubber apron with top metallic plate in between the retaining and drawing rollers for better short fibre control. Its draft range lies between 10 - 22 and it can spin fine count yarns (4 lb/sp to 8 lb/sp).

3. **V roller (groove) draft system** This draft system is used in 5½ inch pitch spinning frame. It consists of a series of intermediate rollers, each of which has a deep groove cut in its face. In between the retaining roller and drawing roller. Its draft range lies between 4.5 to 10.5 and suitable for coarser counts (18 lb/sp to 50 lb/sp).

**Twisting**

Jute spinning frame inserts the twist by means of overhung flyers, either two legged flyer or Baxter flyer, suspended above the bobbins. The flyers are carried on ball bearing wharves mounted on the front of the frame. The part of the wharf projecting above the mounting assembly is called the cap and the part below the assembly is called the crown, which is driven by cotton or nylon tape from the main cylinder of the machine. Here the flyer is positively driven and the bobbin is driven by the yarn pull.

The yarn passes from the nip of the drawing rollers to the wharf cap and continues through the wharf up to the flyer eye at the bottom of the leg and then winds on to the bobbin. The simplest relationship between flyer speed, delivery speed and twist is,

\[ \text{Twist per inch} = \frac{\text{Flyer speed (rpm)}}{\text{Front roller delivery (inches/min)}} \]

This equation can be modified depending upon twist take up (2 or 2½% in jute yarn) as follows

\[ \text{TPI} = \frac{\text{Spindle speed in rpm}}{\text{FR delivery in inches/minute}} \times \frac{100+T}{100} \]

Where \( T = \) Take up% = (Untwisted length-twisted length) x 100/Untwisted length.

Twist in yarn is generated by the rotation of the flyer and ascends from below into the upper portion of the yarn towards the drawing nip. The twist angle or the twist factor remains constant throughout the length of the yarn. The thinner parts of the yarn have more turns per unit length than that of thicker one.

\[ \text{Twist factor} = \text{Twist per inch} \times \sqrt{\text{Grist}} \]
Common twist factors:

<table>
<thead>
<tr>
<th>Yarn types</th>
<th>Twist factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sacking weft</td>
<td>13.5 - 14.0</td>
</tr>
<tr>
<td>Sacking warp</td>
<td>12.5 - 12.75</td>
</tr>
<tr>
<td>Hessian weft</td>
<td>12 - 12.25</td>
</tr>
<tr>
<td>Hessian warp</td>
<td>12 - 12.25</td>
</tr>
<tr>
<td>CBC warp</td>
<td>12.0 - 12.25</td>
</tr>
<tr>
<td>CBC* weft</td>
<td>11.75 - 12.0</td>
</tr>
</tbody>
</table>

* CBC - Carpet backing cloth.

Winding on

The bobbins rotate around central dead spindles which are set vertically in the builder. As the builder moves up and down the bobbins alternately rise into and withdraw from the flyers and this reciprocating movement, combined with the rotation of the flyers about the bobbins, winds the yarn on the bobbin in a continuous spiral. When the builder is at the top of its traverse the yarn is winding on at the bottom of the bobbin and vice versa.

The following equation corresponds the correct winding.

\[ n_{fly} - n_{bo} = \frac{L}{pd} \]

Where \( n_{fly} = \) flyer rpm, \( n_{bo} = \) bobbin rpm, \( L = \) delivery speed, \( d = \) bobbin diameter.

The implication of the relationship is that as the bobbin fills, \( d \) becomes greater and the difference between flyer speed and bobbin speed decrease. As the flyer speed remains constant, the bobbin speed must increase. It is attended automatically by the bobbins themselves as a result of the manner in which they are rotated by the yarn.