CHAPTER EIGHT

Roving

For hessian and sacking qualities the roving frame has been superseded by the finisher drawing frame with its crimped sliver, but it is still used to produce heavy count 'rove' yarns in the range 1–7 ktex (70 to 200 lb/sp) or to provide another drawing stage to reduce the sliver count to a level suitable for spinning fine yarns of 120–170 tex (3½–5 lb/sp).

The roving frame is essentially a drawing frame fitted with an attachment for inserting twist into the drafted strand and winding it up on to a bobbin. The amount of twist that is put in depends upon whether the rove is to be used as a rove yarn or as a pre-spinning rove. For rove yarn sufficient twist must be inserted to give strength to the structure, but for pre-spinning roves only enough twist is put in to hold the fibres together to allow the material to be handled and to give some inter-fibre friction as it is being drafted on the spinning frame (see Chapter 9). Figure 8.1 illustrates a jute roving frame, with its gill-pins, positively driven flyer, and bobbin. There are three principal motions on a roving frame.

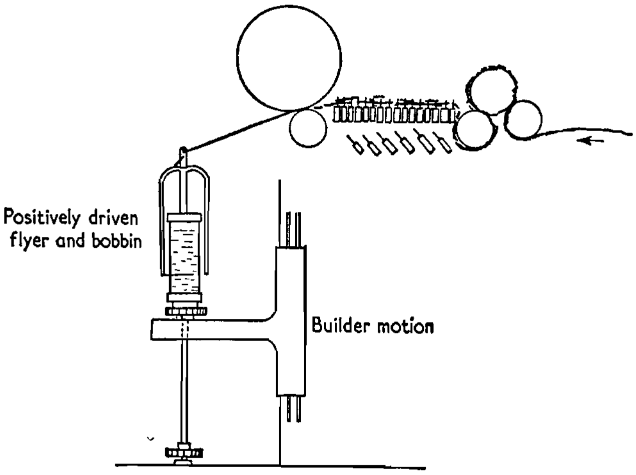

Figure 8.1. Essential features of the roving frame

(1) *Drafting.*

Drafting is carried out by the usual arrangement of retaining rollers and drawing rollers, with fibre control being exercised by gill-pins carried on faller-bars that are screw-driven. The factors governing the movement of the floating fibres that were discussed in the previous Chapter are also applicable here.

(2) *Twisting.*

The thin tenuous sliver emerges from the nip of the drafting rollers and passes down to the top of the flyer. It enters one of the hollow legs and travels down inside, to emerge near the foot and pass through the flyer 'eye'. As the flyer rotates, one end of the drafted strand is turned about the strand axis and the fibres become twisted into rove. The amount of twist which is inserted is changed when the count of the rove is altered (the reason for this will be dealt with later) and therefore some means must be found to do this. On the roving frame, the flyers are driven at a constant speed and so the only way to alter the amount of twist in the rove is to alter the speed of the delivery; if a low twist is desired then the material must issue from the drafting nip quickly, but if a high twist is wanted then the delivery speed must be reduced. For example, if the flyers rotate at 800 r.p.m. and 800 in. of rove are delivered each minute then there will be $800 \div 800 = 1$ turn of twist in each inch of rove, but if the delivery is reduced to 400 in./min then there will be $800 \div 400 = 2$ turns per inch. The relationship between flyer speed, twist, and delivery speed is,

$$t = \frac{n}{v}$$

where t is the twist per unit length, n is the speed of the flyers, and v is the delivery speed of the machine.

This is an important relationship since it means that the delivery speed of the machine is inversely proportional to the twist in the rove; thus a high twist automatically means a low delivery rate.

Since the flyers rotate at a constant speed they can be driven by a train of gear-wheels in the manner shown in Figure 8.2, the motion being derived from the main shaft. Because it is necessary at times to alter the twist by speeding-up or slowing-down the delivery rollers, the drive to these rollers is through a gear-train with a change pinion, the twist pinion, in it. When the twist pinion is changed the speed of the drawing rollers *and* the retaining rollers is altered but their relative speeds, i.e. the draft, remains unchanged.

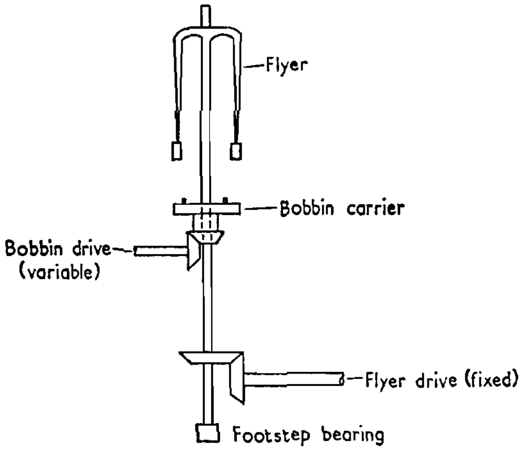

Figure 8.2. Flyer drive on a roving frame

(3) *Winding-on.*

At all times the delivery of rove from the drafting rollers must be wound up on to the bobbin. This is achieved by driving the bobbins slightly slower than the flyers, i.e. there is a flyer lead. (In other branches of the textile industry, bobbin lead may be found but as all jute frames are flyer lead only this type will be considered here.) The *winding-on revolutions are equal to the difference between the flyer* and bobbin revolutions, e.g. if the flyers rotate 700 times in a minute and the bobbins 600 times in a minute then there are 100 winding-on revolutions in a minute and the net effect is the same as if the bobbin has been stationary and the flyer has rotated round it 100 times.

On the roving frame, if v is delivery speed, d is bobbin diameter, n is winding-on revolutions, f is flyer revolutions, and b is bobbin revolutions, then,

$$n = (f-b)$$
$$v = \pi n d$$
$$v = \pi d(f-b)$$

As the delivery speed is fixed by the twist pinion on the frame and the flyer r.p.m. is fixed by the gearing, it follows from the above equation that as the diameter of the bobbin increases the winding-on r.p.m. must fall and, to accomplish this, the bobbin r.p.m. must *increase* as the bobbin fills.

In order to put as much rove on the bobbin as possible and to build a uniform package the coils of rove on the bobbin should lie neatly one above the other in a close-fitting spiral formation. This is achieved by mounting the bobbins on a movable carriage which can rise and fall and in so doing lift the bobbin into and drop it out of the flyers. This carriage is called the builder, and in the time taken to lay one coil of rove around the bobbin core it must move vertically a distance equal to the diameter of the rove if the rove is to fit snugly beside its fellow. At the start of the bobbin the circumference is small and one coil is put around quickly and therefore the builder must move equally quickly, but when the bobbin is nearly full then it takes longer to lay on a coil of rove and the builder must slow down to accommodate the increased laying time if the coils are to be laid contiguously.

The requirements of the winding-on motion can be summarized:

(1) It must increase the speed of the bobbins as they fill up.
(2) It must slow the builder down as the bobbins fill.

To accomplish this, a selection of mechanical devices may be used, such as expansion pulleys, friction plates, etc., but only one will be dealt with in detail here. This is the Holdsworth differential gear on the cone roving frame. The differential consists of a fixed bevel keyed to the main driving shaft, two free bevels carried in a straight spur gear wheel called the crown wheel, and a fourth bevel called the socket bevel which is attached to a free-running shaft *over* the main shaft. Figure 8.3 illustrates the device, with the socket bevel shaded. The crown wheel is positively driven in the *same* direction as the main

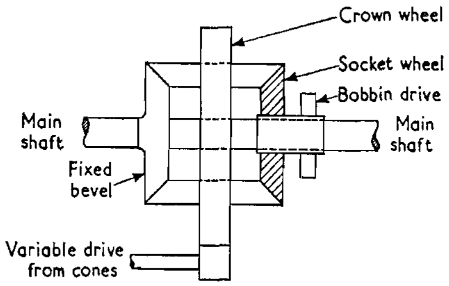

Figure 8.3. Differential motion on a roving frame

shaft. The socket bevel provides the drive to the bobbins and therefore if the speed of the bobbins is to be changed then the speed of the socket bevel must be varied first of all. Consider first the case where the crown wheel does not revolve; the fixed bevel runs at the main shaft speed, say 300 r.p.m., and through the bevels on the crown wheel acting as intermediates the socket bevel will be driven at the same speed, 300 r.p.m., but in the opposite direction as the fixed bevel. If the crown wheel is driven, each revolution makes the socket bevel rotate twice, i.e. if the crown wheel makes 30 r.p.m. the socket bevel will make 60 r.p.m. and so on. The only point still to be considered is the direction of rotation of the crown wheel. On jute flyer lead frames, the crown wheel always rotates in the same direction as the main shaft and each revolution of the crown wheel decreases the speed of the socket bevel by two revolutions. If the main shaft is running at 300 r.p.m. in a clockwise direction then, through the free bevels on the crown wheel, the socket bevel will run at 300 r.p.m. anticlockwise but, in addition, the crown wheel may be running at, say 30 r.p.m., in a clockwise direction like the main shaft. This clockwise motion drives the socket bevel at 60 r.p.m. also in a clockwise direction. The sum of the socket bevel r.p.m. then is 300 anticlockwise and 60 clockwise = 240 anticlockwise. The general form is

$$\text{main-shaft r.p.m.} - (\text{crown wheel r.p.m.} \times 2) = \text{socket bevel r.p.m.}$$

Here, then, is a means of changing the speed of the bobbins during the time taken to fill one bobbin with rove; all that must be done is to *decrease* the r.p.m. of the crown wheel and the speed of the socket drive to the bobbins will automatically *increase.*

The general lay-out of the gearing of the cone roving frame is shown in Figure 8.4. The differential has been discussed already and it is the variable drive to the crown wheel which will now be dealt with. On this type of roving there are two cones—a top cone and a bottom cone—whose outlines follow a particular kind of curve called a hyperbola. The two cones are shaped in this way so that their combined diameters at any point is constant and the special speed considerations for the bobbin drive and the builder drive may be obtained. The top cone is driven through spur wheels from the main shaft at a constant speed and it, in turn, drives the bottom cone through a leather belt. Because of the shape of the cones the speed of the bottom one will vary depending on the position of the belt. For example, when the belt is at the extreme left-hand end of the cones where the top cone diameter

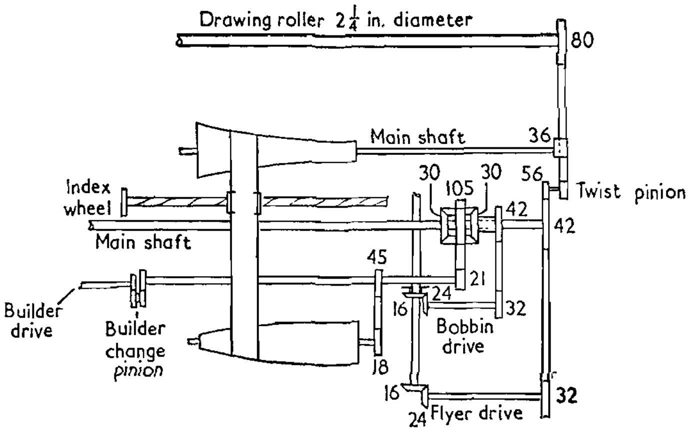

Figure 8.4. Cone roving gear

is 7 in. and the bottom cone diameter 3 in. then if the top cone is running at 240 r.p.m. the bottom cone will run at

$$240 \times \frac{7}{3} = 560 \text{ r.p.m.}$$

At the middle of the cones, the top diameter might be 5 in. and the bottom one 5 in., in which case the bottom cone would rotate at 240 r.p.m., but when the belt is at the right-hand end of the cones where the top cone diameter might be 4 in. and the bottom one 6 in. then the speed of the bottom cone would be 160 r.p.m. Therefore, by moving the belt along the cones the bottom one of the pair can be made to alter its speed. This speed variation is transmitted to the crown wheel of the differential through a train of gears. In this way the necessary alterations in speed of the bobbin drive take place.

Besides the change in bobbin speed to bring about the necessary winding-on, *the builder speed requires to change to accommodate* the different times taken to wind on one coil of rove on an empty bobbin and a full one. As can be seen from Figure 8.4, the builder is driven from the bottom cone through a train of gears and, therefore, as the speed of the bottom cone falls the builder slows down and allows more time for each coil of rove to be laid on the bobbin. There is a pinion in the gear train driving the builder called the traverse pinion which may be changed to give a general increase or decrease in the builder speed to suit different counts of rove.

It is now necessary to examine the way in which the belt is moved along the cones to effect the speed changes. Because the diameter of the bobbin increases by an amount equal to the rove diameter × 2 as each layer of rove is laid on, the speed of the bobbins (and the builder) should be changed at the end of each builder traverse. In other words, the speed of the bottom cones should not alter continuously but in a step-wise manner. This can be done by making the belt move along in regular steps at the end of each traverse of the builder. A simple mechanism, worked from the builder itself, is responsible for this.

As the builder comes to the top or bottom of its traverse it trips a small lever which allows a coarsely pitched pinion, called the index wheel, to move half a tooth. The index wheel is attached to a shaft which has a spiral groove cut into it along which runs the fork for moving the leather belt between the cones. At the start of each bobbin the belt is at the left-hand end of the cones and as the frame is started and the builder makes one traverse the index wheel is moved round half a tooth; this makes the shaft it is fixed to rotate slightly and the belt fork is moved along by the spiral. As time goes by, the belt is moved along the cones and the necessary speed changes are effected. When the bobbin is full the frame is stopped and the belt is pulled back by a hand-wheel ready for the start of the next bobbin. The rate at which the belt moves along the cones depends on the number of teeth in the index wheel. The index wheel must be changed to suit different sizes of rove.

ROVE TWIST

So far, only the mechanics of the roving frame have been examined, but it is now necessary to discuss rove twist in greater detail. When the fine ribbon of fibres is twisted together the fibres take up a spiral formation and the rove becomes more or less circular in section. The degree of twist can be expressed in two ways; in terms of the number of complete turns in a given length, or in terms of the angle at which the fibres are inclined to the axis. Figure 8.5(a) shows two roves, one much thicker than the other, having the same twist angle; if, however, these are examined from the point of view of the turns in a given length it will be found that they do not have the same number of turns. Twist angle and turns per unit length are related; in Figure 8.5 (b) the rove has been cut along its axis and opened out in one plane. It will be seen that a triangle is formed whose base equals the circumference

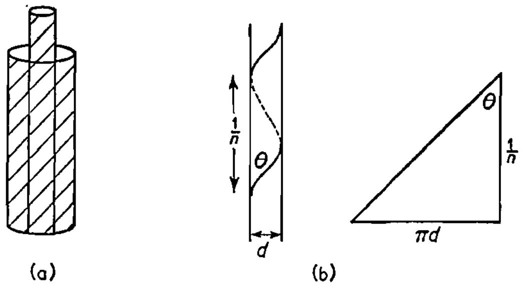

Figure 8.5. Twist and twist angle. n = turns per unit length, d = rove diameter, θ = twist angle

of the rove and whose height depends on the turns per unit length, or rather its reciprocal, the length of one turn. From the triangle,

$$\tan\theta = \pi dn$$

For practical reasons, it is easier to measure the turns per inch (or per centimetre) so twist is always referred to in these terms, but in fact it is the twist angle which is the important factor in deciding how the rove will behave. In a twisted structure, be it rove or yarn, if a tensile force is applied along the axis, the fibres, because of their angle, exert an inward-directed force which has the effect of increasing inter-fibre friction and making it more difficult for the tensile force to rupture the structure. If one has twistless rove, there is no inter-fibre cohesion at all and the fibres slip past each other as soon as a tensile force is applied, but if twist is inserted and steadily increased the strength of the rove gradually rises as more and more inter-fibre friction is induced by the inward-directed force resulting from the spirality of the fibres. After a certain point, however, any increase in the twist angle cannot compact the yarn any further and the fibres are now in a state of strain and the strength of the rove begins to decrease. Thus, if the strength of the rove is plotted against the twist angle, as in Figure 8.6, one sees a steady increase over the part (a), a flat maximum over (b), and a fall in strength over (c). In (a) the rove breaks by the fibres slipping past one another, in (b) there is a mixture of fibre-slip and fibre-breakage, and in (c) the predominant cause of failure is fibre-breakage because the inward force is sufficiently strong to stop fibre-slip. The use to which the rove is to be put, therefore, determines how much twist will be inserted. If it is to be used as a pre-spinning rove, where the fibres must be able to slip past

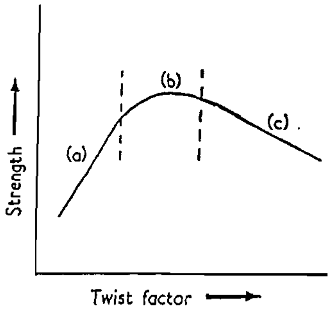

Figure 8.6. Twist/strength relationships

one another during drafting on the spinning frame then, obviously, one must work on the (a) part of the curve, but if the rove is to be used as a heavy count yarn where strength is required then the twist must be selected which would give a strength in the (b) part of the curve.

If one has roves of different count and wishes these roves to have the same *relative* degree of strength, then one must arrange for the twist angle to be the same in each case, so that the inward-directed forces will be equal. The twist angle is related to n, the turns per unit length, and d, the rove diameter, but d is proportional to $\sqrt{(\text{count})}$, therefore, θ is related to $\sqrt{(\text{count})}$.

$$\tan\theta = \pi d n$$

$$d \propto \sqrt{(\text{count})}$$

$$\tan\theta \propto n\sqrt{(\text{count})}$$

$$\theta \propto n\sqrt{(\text{count})}$$

i.e. if θ is to be constant for all weights of rove

$$n\sqrt{(\text{count})} = K$$

where K is a constant, known as the twist factor. By means of this twist factor it is a simple matter to calculate the turns per unit length for any count of rove. In jute units the twist factor for pre-spinning rove is normally about 7 and for rove yarns about 10.

$$\text{turns per inch} = \frac{7}{\sqrt{(\text{lb/sp})}} \quad \text{for pre-spinning rove}$$

$$\text{turns per inch} = \frac{10}{\sqrt{(\text{lb/sp})}} \quad \text{for rove yarns}$$

In the tex system,

$$\text{turns per centimetre} = \frac{16}{\sqrt{(\text{tex})}} \quad \text{for pre-spinning rove}$$

$$\text{turns per centimetre} = \frac{23}{\sqrt{(\text{tex})}} \quad \text{for rove yarns}$$

PINION CHANGES NECESSARY WHEN CHANGING COUNT

(1) *Draft.* This pinion is arrived at in the usual way,

$$\begin{aligned}\text{draft pinion} &= \frac{\text{draft constant}}{\text{draft}}\\ &= \frac{\text{draft constant} \times \text{rove count}}{\text{sliver count}}\end{aligned}$$

(2) *Twist.* The required pinion can be found from a gearing constant called the twist constant which is analogous to the draft constant. It is found by assuming that the drawing roller is driving the flyers and calculating the number of flyer revolutions made in the time taken for one revolution of the drawing roller. This number of turns of the flyers is then inserted into the length of rove delivered by one revolution of the drawing roller, i.e. one circumference. The pinion is found from

$$\text{twist pinion} = \frac{\text{twist constant}}{\text{turns per unit length}}$$

(3) *Index.* The speed of the bobbins (depending on the bottom cone speed and the crown wheel speed) must be changed in proportion to the diameter of the rove since the bobbin diameter is increased by twice the rove diameter as each layer is put on. It is more convenient to work in terms of count than diameter as the latter is directly proportional to the square root of the count. The index wheel chosen is not rigidly fixed like the draft and twist pinions as individual preference may decide just how tight the rove is to be wound on the bobbin, but it is common practice to work with an index constant of 135, i.e.

$$\text{index wheel} = \frac{\text{index constant}}{\sqrt{(\text{count})}}$$

(4) *Builder.* Similarly to the index wheel, the builder pinion is not absolutely fixed by the rove specifications but the pinion should be such that the builder is driven up and down at a speed that will lay the

coils of rove side by side. In this way as much rove as possible will be packed on to the bobbin. Again, a builder constant may be used, 280 being a common one

$$\text{builder pinion} = \frac{\text{builder constant}}{\sqrt{(\text{count})}}$$

Table 8.1 summarizes these changes.

TABLE 8.1

Pinion	*Heavy rove*	*Light rove*	*Pinion Proportional to*
Draft	More teeth	Fewer teeth	Count
Twist	More teeth	Fewer teeth	$\sqrt{(\text{Count})}$
Index	Fewer teeth	More teeth	$\sqrt{(\text{Count})}$
Builder	More teeth	Fewer teeth	$\sqrt{(\text{Count})}$

PRODUCTION ASPECTS OF THE ROVING FRAME

The common sizes of roving frame range from 56 to 80 spindles with a production capacity of 300–400 lb/hr. The efficiency (running time ÷ total time) of roving frames is usually around 70–80 per cent, much of the lost time being due to doffing. To doff the full bobbins of rove each flyer must be given a half-turn and lifted off its spindle, the bobbin of rove removed and an empty one substituted, and then the flyer replaced. This, as may be imagined, takes some little time.

The rove bobbins in common use are 10 in. long by 5 in. or 6 in. in diameter and work with a packing density of about 26 lb/ft^3. The following example is typical of those met.

A rove bobbin holds 2·9 lb of material. A 64 lb/sp pre-spinning rove is being produced at a flyer speed of 600 r.p.m. If doffing takes 3 min, what is the machine efficiency, allowing 10 per cent for unavoidable stoppages due to mechanical troubles, etc.?

$$\text{The bobbin holds} = \frac{2{\cdot}9 \times 14400}{64}$$

$$= 645 \text{ yd of rove}$$

$$\text{Twist in rove} = \frac{7}{\sqrt{64}}$$

$$= 0{\cdot}88 \text{ t.p.i.}$$

Delivery speed of frame $= \dfrac{600}{0{\cdot}88 \times 36}$
$= 19$ yd/min

Time to fill the bobbin $= \dfrac{645}{19}$
$= 33$ min

Total cycle time (including doffing) $= 36$ min

Machine efficiency $= \dfrac{33}{36} \times 100 - 10$ per cent
$= 82$ per cent