CHAPTER TEN

The System

IN THIS chapter, the factors which must be considered when assembling the various stages of the process into a complete plant will be dealt with. If an entirely new range of machinery is bought from one maker then he will ensure that the machines work smoothly as a whole and that each stage is operating under the best conditions for the grade of raw material envisaged. It is more likely, however, that one stage in an existing plant is to be replaced, or production requirements have changed in some way since the plant was installed. Under these conditions it is vital to have a knowledge of the fundamental factors governing the manner in which the separate stages may be integrated to form an efficient unit. Only then can the full potentialities of the machinery be realized.

A certain amount of the material in this chapter has been discussed earlier, but it is felt that for the sake of completeness, a reappraisal at this stage of some of the salient facts would not come amiss.

PRODUCTION ASPECTS OF THE SYSTEM

The term 'system' in the production sense refers to the integrated sets of machines fed from one breaker card, but in this chapter the term has been carried one stage back to the spreader or softener so that the inter-relationships of the complete set of machines may be studied.

If the system is to work satisfactorily it must conform to several conditions

(1) It must be able to produce the correct count of yarn.
(2) At no stage must the sliver be excessively heavy or light for the range of machinery in use.
(3) It must be capable of high production rates and operate with as low a labour force as possible.
(4) Each stage in the system must be able to produce enough material to satisfy the succeeding one; similarly, it must be able to consume all the material put out by the preceding one, i.e. the system must be 'balanced'.

By successive drafting the sliver count must be reduced to a level suitable for the spinning frames to work on. Since the spinning frames can only operate within a certain draft range the count of the finisher drawing sliver must be such that all the desired range of counts can be spun from it. The figures in Table 10.1 represent the normal range of sliver counts for hessian yarns.

TABLE 10.1

Sliver	*ktex*	*lb/100 yd*
Spreader	220–320	45–65
Breaker card	85–105	17–21
Finisher card	65–90	13–18
1st drawing	40–80	8–16
2nd drawing	23–28	4·5–5·5
Finisher drawing	4·5–6	0·9–1·2

For heavy yarns where there are only two drawings in the system the card slivers may be some 10 per cent heavier. The sliver from the first drawing is usually in the range 35–45 ktex and that from the finisher drawing 8–10 ktex.

These sliver weights are obtained from a variety of draft and doublings combinations but the figures in Table 10.2 represent typical arrangements for the production of hessian yarns.

TABLE 10.2

Machine	*Draft*	*Doublings*
Spreader	8–12	2 leaders (optional)
Breaker card	15–20	6–8
Finisher card	10–14	10–12
1st drawing	$3\frac{1}{2}$–5	2 or 4
2nd drawing	5–7	2 or 3
Finisher drawing	8–10	1 or 2

To achieve the maximum output from a given set of machines it is necessary to work with as high delivery speeds as possible. There is however a limit to the speed at which machines can be driven; above this level the machine will not function in the proper manner and the product is unacceptable or stoppages due to mechanical troubles become too frequent or both these defects arise simultaneously.

In addition, the count of the material must not overload the machine for which it was intended otherwise the necessary operations of splitting, opening, cleaning, parallelizing the fibres, and producing a regular sliver and yarn will not be carried out effectively, and the quality will suffer. On the other hand, if the sliver is too light for the range of machinery it is likely that short fibre control during drafting will be ineffective as the pins, rollers, aprons, etc., will be underloaded. There is, moreover, another important feature which determines the lower level of sliver count and that is the ability of the material to unwind from a roll or withdraw from a can. Nowadays, all spreader sliver and most card sliver is handled in roll-form and it has been found that difficulty is experienced in unwinding if the count of the sliver is low. This applies particularly at the spreader where the count of the lightest parts of sliver may only be about one-third of that of the average. Similarly sliver in card rolls must be strong enough to withstand the slight tension that must be applied between the take-off gear and the feed rollers to stop the slivers sagging. At the later stages there must be sufficient sliver bulk to give strength and cohesion for the sliver to be withdrawn from its cans without parting. It will be seen, therefore, that the lower limit of sliver count is intimately bound up with packaging, and since large packages are an essential economic

Speeds of Jute Machinery (ft/min)

Spreader delivery	
Cards:	180–225
Breaker, cylinder	2,400–2,700
Breaker, delivery	150–200
Finisher, cylinder	2,400–2,800
Finisher, delivery	150–210
Drawing frames, faller drops:	
1st, push-bar	700–850
2nd, spiral (double)	250–400
Finisher, spiral (triple)	350–650
Spinning, flyer r.p.m.:	
7–12 lb/sp	3,750–4,250
13–24 lb/sp	2,800–3,600

feature of jute spinning (especially in high labour cost countries) it is one which assumes considerable importance.

The speed and loading at which the machines may be run are dependent upon the design of the machine, the density of pinning, etc., but the following figures represent average values for hessian yarns and the like.

Average Machine Loadings, lb/100 yd

Spreader	500–700 on the gill-pins
Breaker card	350–400 on the feed sheet
Finisher card	170–240 on the feed sheet
1st drawing	14–18 on the gill-pins
2nd drawing	8–10 on the gill-pins
Finisher drawing	8–10 on the gill-pins

It will be appreciated that these conditions impose certain restrictions on the method of operating an integrated set of machines but, besides this, there is another important factor which must be carefully considered—the flow of material from one stage to the next.

Before this is discussed, however, it is necessary to consider machine efficiency. 'Efficiency' is a term which can cause confusion since it can mean different things to different people. Efficiency is commonly related to performance in the following way

$$\text{efficiency} = \frac{\text{machine running time}}{\text{machine running time} + \text{stopped time}} \times 100 \text{ per cent}$$

The confusion arises from the definition of stopped time. Stopped time may be taken as that time during which the machine is stopped for doffing but it may also refer to all the lost time during working hours and include maintenance time and time lost when the machine is waiting for material to work on. Taken over short periods the doffing time may be all that is allowed for and a high figure for efficiency will be obtained, but this is not a measure of the real operating performance of the machine when it is integrated in a system. Then, its efficiency is governed by doffing *and* the availability of raw material. For instance if machine A is producing material at a rate of 20 yd/hr for machine B and the latter can consume it at 30 yd/hr, then B can only work for

$$\frac{20}{30} \times 100 \text{ per cent}$$

of the time, since A has only 20 yd of material available in an hour. The efficiency at which B will operate is therefore closely bound up with A's performance. In this way in the jute processing system the efficiency of each machine is governed by the performance of the machine immediately before and after it in the processing sequence.

Again, the pursuit of high *efficiency* alone is not always justifiable since under certain circumstances a higher *output* can be realized by running the machine at a faster speed, even if this is accompanied by a lower efficiency, and *vice versa* (Table 10.3).

TABLE 10.3

Delivery speed	*Efficiency*	*Output*
10 *yd/min*	90 per cent	9 *yd/min*
12	88	10·6
14	85	11·9
16	80	12·8
18	70	12·6
20	50	10·0

The manner in which the separate machines in the jute processing system combine to form an integrated whole is of interest and has important practical implications since an examination of the inter-relationships between the various stages shows that a departure from the balance planned by the machinery-maker may lead to uneconomic operation. The prime factor to be considered in any system is the flow of material from one stage to the next, for it is this which governs the efficiency, the speed, and the number of machines required at each of the several stages.

Consider the finisher cards and the 1st drawings of a certain system; if the cards can produce more sliver than the 1st drawing frames can consume then, inevitably, there will be a build-up of material. To prevent this growing continually, the cards must be stopped for a time to let the drawing frames work away the accumulation of sliver. On the other hand if the drawing frames consume sliver faster than the cards can produce it then *they* must be stopped to allow the cards to work up a stock of sliver to supply the drawing frames. Ideally, the cards' delivery should be exactly equal to the drawing frames' feed. This situation can rarely be achieved because of the different speed capabilities, doffing requirements, and maintenance times between two successive stages. Under the practical conditions the stages automatically adjust their efficiencies so that the total net output at one stage equals the total net input at the next. This must happen in all systems otherwise there would be an accumulation of material somewhere in the process.

In a system there may be three finisher cards, each with a delivery speed of 200 ft/min and 20 drawing frame feed slivers running at 25 ft/min

$$
\begin{aligned}
\text{Total card output} &= 3 \times 200 \\
&= 600 \text{ ft/min} \\
\text{Total drawing frame input} &= 20 \times 25 \\
&= 500 \text{ ft/min}
\end{aligned}
$$

If all the machines worked continuously then there would be a card sliver gain of 100 ft/min over the drawing feed. But if the cards worked for only 5/6 of their time they would produce the necessary 500 ft/min of sliver for the drawing frames. In practice, however, the drawing frames cannot run non-stop and their efficiency will only be perhaps 80 per cent, i.e. their feed requirements are no longer 500 ft/min but 400 ft/min (80 per cent of 500). The finisher cards need only work long enough to provide this quantity of sliver and if they operate for 66·7 per cent of the time they will do this; in other words, their efficiency need only be 66·7 per cent to satisfy even flow conditions. If, for any reason, the drawing frame efficiency alters, then the card efficiency must alter too in order that no build-up or deficiency of material will arise.

At each transfer in the process from one set of machines to another the output and input are linked in this manner and the machine efficiencies are mutually interdependent. The general equations for transfer are

$$
\begin{aligned}
p_o &= v_o n_o \eta_o \\
p_i &= v_i n_i \eta_i
\end{aligned}
$$

where p is the production, v the machine speed, n the number of slivers at each stage, and η the machine efficiency, and the subscripts o and i refer, respectively, to the output at one stage and the input at the next stage. For even flow $p_o = p_i$ and the equations become

$$v_o n_o \eta_o = v_i n_i \eta_i$$

By means of these equations it is possible to calculate the efficiency at each stage in the process if the delivery speeds, drafts, and doublings are known. Once the operating conditions of draft, speed, etc., have been chosen then the machine efficiencies are predictable and will only be departed from over short periods of time as the flow of material oscillates between overproduction and underproduction.

The operating data for a system producing 600 kg/hr of 276 tex yarn are given in Table 10.4.

TABLE 10.4

	Number of deliveries	*Draft*	*Doublings*	*Delivery speed (m/min)*
Spreader	1	10·0	—	48
Breaker cards	2	17·4	6	61
Finisher cards	3	12·0	10	50
1st drawings	4	4·0	4	46
2nd drawings	24	6·5	2	24
Finisher drawings	60	9·0	2	47
Spinning frames	1600	18·0	—	25

The first step in setting up a list of efficiencies is to calculate the 100 per cent delivery and feed at each stage. One stage is then selected as the key stage from which the other efficiencies will stem. The key stage may be at the start of the process or at the end or even in the middle, the choice being made from some prior experience. In general, spinning frames operate with an efficiency of 85–90 per cent, drawings at 70–80 per cent, cards at 80–90 per cent, and spreaders at 70–80 per cent. The arithmetic of the calculation will only be shown for one transfer, all others being carried out in the same manner.

Consider the transfer from the spreader to the breaker cards, then from the flow equations

$$v_o n_o \eta_o = v_i n_i \eta_i$$

$$48 \times 1 \times \eta_o = \frac{61}{17 \cdot 4} \times 2 \times 6 \times \eta_i$$

$$\eta_o = \frac{61 \times 12 \times \eta_i}{48 \times 17 \cdot 4}$$

$$\eta_o = 0 \cdot 88 \eta_i$$

If now several hypothetical spreader efficiencies are assumed then the corresponding breaker card efficiency can be calculated from this relationship, e.g.

Spreader efficiency	*Breaker card efficiency*
70	80
75	85
80	91

The complete analysis of the *system* efficiency for several different *spinning* efficiencies is shown in Table 10.5.

TABLE 10.5

Spinning frames	88	90	92	94
Finisher drawings	69	71	73	76
2nd drawings	74	76	77	79
1st drawings	72	74	75	77
Finisher cards	88	90	92	94
Breaker cards	91	93	95	98
Spreader	80	81	84	86

It will be noted that when the spinning efficiency rises above 92 per cent the early machines must operate at very high efficiencies and it is doubtful if such performance could be maintained for long.

The importance of knowing the system flow characteristics cannot be overestimated for without such knowledge the full potentialities of the system cannot be appreciated. It is a simple matter to measure all the surface speeds in the mill and count the number of slivers at the feed and delivery of each stage; this is all the information necessary for such an analysis. By means of such calculations it is possible to find the effect of working overtime in one department or the effect of changing the speed or draft of any machine. Finally, one practical point about such calculations—it is always preferable to work in terms of the length delivered and consumed at each stage. It is possible to use the weight of sliver produced but, for accuracy, this requires that allowances be made for waste and moisture losses and if the length method is used then such complications are avoided.

An illustration of how a system may be analysed will be given to show the general method adopted. It should be noted that in an analysis of this type there is not one solution but a number, each of which is equally suitable provided they fulfil the conditions of speed, loading, and attainable efficiency at each stage. The analysis will be carried out on a hypothetical system which has become unbalanced, the object being to improve the system as much as possible.

TABLE 10.6

Stage	*Sliver Count (lb/100 yd)*	*Delivery speed (ft/min)*	*Draft*	*Doublings*	*Number of deliveries*
Spreader	65·0	171	10·0	—	1
Breaker cards	23·0	186	19·8	7	2
Finisher cards	20·9	156	11·0	10	3
1st drawings (push-bar)	12·0	180	3·5	2	6
2nd drawings (spiral)	5·7	99	6·3	3	20
Finisher drawings (spiral)	1·14	114	10·0	2	72
Spinning	0·056	78	20·4	—	1,800

First, the existing system is examined and the stage efficiencies calculated by means of the basic flow equations. Next, the sliver counts are studied and the loadings on the feed sheets and gill-pins at each stage found. Then the machine speeds are examined, with particular reference to the faller drops per minute at the drawing frames. In the system above, a general reduction in the sliver count early in the process would be likely to improve the yarn quality since the machinery is either working at its maximum loading or just over it.

TABLE 10.7

Stage	*Efficiency (per cent)*	*Faller drops*
Spreader	53	—
Breakers	69	—
Finishers	71	—
1st drawings	55	1,330
2nd drawings	63	400
Finisher drawings	70	375
Spinning	90	—

The 1st drawing frames are operating with too high a rate of faller drops, while the rate of the finisher drawing could be substantially increased. If the speed of the first drawing is reduced this will bring the faller drops to a reasonable level; this should be possible since there is scope for running the machines with a much higher efficiency than 55 per cent. Similarly, if the finisher drawing frames are speeded up it should be possible to reduce the number of deliveries, thus effecting savings in running costs.

The arithmetic of each step will not be shown since it only involves the basic flow equations and the calculation of the number of faller drops per minute dealt with in an earlier chapter. It will usually be found that several sets of calculations must be made, the final solution being obtained by selecting suitable data from each set of results. One method of revising the system is shown in Table 10.8.

TABLE 10.8

	Speed (ft/min)		*Sliver count (lb/100 yd)*		*Number of deliveries*		*Efficiency (per cent)*	
	E	*R*	*E*	*R*	*E*	*R*	*E*	*R*
Spreader	171	171	65·0	51·0	1	1	53	80
Finisher cards	186	186	23·0	21·0	2	2	69	91
Breaker cards	156	150	20·9	17·5	3	3	71	90
1st draw.	180	120	12·0	10·0	6	6	55	86
2nd draw.	99	99	5·7	5·5	20	16	63	82
Fin. Draw.	114	156	1·14	1·10	72	48	70	85
Spinning	78	78	0·056	0·056	1,800	1,800	90	90

E: existing system *R*: revised system

WASTE IN THE SYSTEM

At each stage in the production line a certain amount of waste is inevitable. This waste may be divided into three sorts: (1) Clean re-usable waste such as sliver ends, thread ends, and bale ropes; (2) dirty waste containing a certain amount of re-usable fibre, this type of waste is found under machines and in floor-sweepings and is passed through the dust shaker to recover the short fibre which can then be put into a sacking weft batch or equivalent; (3) true waste, i.e. mill dust, stick, and other fibre trash which is of no use in the mill.

When the bales are opened at the start of the production line some 4–5 lb of bale ropes represent the first loss, followed by about 1 per cent of dust and stick as the bales pass through the opener. At the softener or spreader roughly ½ per cent of the weight fed falls beneath the machine. At the cards the droppings usually amount to 1½ per cent at the breaker and ¾ per cent at the finisher. Besides the card droppings, there will be in the region of 2 per cent clean sliver waste. Little is lost over the drawing frames—over the complete drawing system about 1 per cent will be lost, while at spinning about another 1 per cent is the normal figure. Drawings and spinning will usually lead to about 1 per cent of clean sliver waste. Much of the waste is re-usable in lower grade batches and even the droppings from the mill will yield about 60 per cent of re-usable fibre from the dust shaker.

The factors which influence the quantities of waste in the mill are:

(1) Good housekeeping. A tidy mill with good cleaning schedules, both for the machinery and the buildings themselves will generally have less waste than a slovenly kept mill.

(2) Fibre quality. At all times a lower grade of fibre will produce more dust and waste than a good grade.

(3) Machine loading. Heavily loaded machines produce more waste than properly loaded ones, particularly in the quantities of sliver waste they produce as a result of choking and lapping.

(4) Oil content. Material processed with low oil contents, such as 'stainless' jute, has a higher waste figure than jute with the higher oil contents. The waste figures increase, particularly at the cards, when the oil content falls below about 3 per cent.

(5) Moisture regain. Dry slivers tend to make more fine dust than those with the proper regain.

(6) Machine speeds and settings. More waste is produced from machinery run at a higher rate than normal, and poorly adjusted machines likewise lead to higher waste figures. At the cards there is an indication that closer settings of the shell, workers, and strippers to the main cylinder bring about a rise in the amount of waste produced.

MATERIAL BALANCE

Because of the waste produced as the material progresses over the system it is inevitable that the weight of bone-dry fibre present in the yarn for sale is less than that in the bales of jute purchased. But since jute spinning on a commercial scale is impracticable without the addition of oil and water this introduces another factor which must be considered when a balance is made between the weight of material fed at the start of the process and the weight of material available for sale at the end of it.

As the batched jute passes over the system the moisture regain steadily falls until, by the time it has been spun into yarn, almost all the water that was added at batching has been lost. The moisture is lost chiefly through evaporation, small amounts being lost in the droppings beneath the machines. Evaporation is greatest at those points where the fibres are exposed to high-speed air-currents, viz., carding and spinning. Inside the cards the fibre on the cylinder travels at roughly 35 m.p.h. and on the spinning frame it is exposed to draughts as high as 15 m.p.h. The quantity of moisture that is lost depends upon the regain of the sliver initially and the relative humidity of the surrounding atmosphere. Table 10.9 gives the results of a series of tests carried out to investigate the effects of these two variables during spinning.

TABLE 10.9. MOISTURE LOSS AT SPINNING

R. H. at spinning (per cent)	*Yarn moisture regain (per cent)*			
	Sliver moisture regain (per cent)			
	12·4	16·1	19·7	22·3
40	10·9	11·8	13·5	14·2
50	11·8	12·9	16·3	16·6
60	12·1	14·4	16·6	17·7
70	14·7	15·4	17·7	17·3
80	15·0	—	20·2	21·5

In addition to this atmospheric effect there are different losses when yarn of various counts is being spun, e.g. for a 12 lb/sp yarn the percentage change in regain is only ⅔ that for 8 lb/sp yarn. Part of this reduced loss is due to the fact that the heavier yarn is spun with less twist and consequently the yarn is exposed to the atmosphere for a shorter time.

The following moisture regains are found in systems for hessian yarns:

Spreader sliver	33 per cent
Breaker card sliver	29
Finisher card sliver	27
Finisher drawing sliver	26
Yarn (on bobbin)	19

For sacking yarns containing root cuttings it is necessary to apply around 30 per cent of emulsion to the cuttings in order to initiate heating in the pile and under these circumstances the regain at the beginning of the process is rather higher than with hessian qualities.

The quantity of batching oil which is lost varies from mill to mill but it is generally of the order of 10 per cent of the amount added.

The term 'yield' is used in calculations of the amount of yarn produced from a certain quantity of raw jute. If 1 ton of raw jute is brought from the warehouse into the mill and processed in the usual manner and from it 0·98 tons of yarn are available for sale, then the yield is said to be 98 per cent, if 0·96 tons of yarn are made then the yield would be 96 per cent and so on

$$\text{yield} = \frac{\text{wt of yarn produced} \times 100}{\text{wt of raw jute used}} \text{ per cent}$$

In calculations of yield three factors should be taken into account, viz., fibre loss, moisture loss, and oil loss. Generally, only gross losses are considered, that is to say the combined loss of fibre plus oil plus moisture. This simplifies the calculations and under normal circumstances is sufficient, but if an investigation into yield is being carried out then it is better to evaluate the losses separately.

The form of the yield calculations can be expressed quite simply.

The yield will be more than 100 per cent if

(1) more oil is applied than fibre is lost and the raw jute and yarn regains are equal;

(2) the same amount of oil is present as fibre is lost but the yarn regain is higher than that of the raw jute;

(3) more oil is present than fibre is lost and the yarn regain is higher than the raw jute regain.

The yield will be 100 per cent if,

(1) the oil in the yarn equals the fibre loss and the raw jute and yarn regains are the same.

The yield will be less than 100 per cent if,

(1) less oil is added than fibre is lost and the raw jute and yarn regains are equal;

(2) the oil added equals the fibre loss but there is less moisture present in the yarn than there was in the raw jute;

(3) less oil is added than fibre is lost and the yarn regain is lower than the raw jute regain.

An illustrative example of a full material balance is given below, taking account of oil, water, and fibre losses separately. For routine purposes this could be simplified but it is considered that the essentials are:

(1) The weight of bales opened.
(2) The weight of oil used.
(3) The weight of yarn spun and its moisture regain.
(4) The weight of waste collected.

Material Balance

Raw jute	
Bales used	152 = 60,800 lb
Bale ropes collected	760 lb
Nett wt into process	60,040 lb
Moisture regain of raw jute	15%
Dry fibre into process	52,100 lb
Moisture into process	7,840 lb

Emulsion	*Water*	*Oil*	*Emulsifier*
Initial meter reading	37,263	1,539	639
Final meter reading	38,148	1,882	656
Gallons used	875	343	17
lb per gal	10	8·9	10
lb used	8,750	3,050	170
Total emulsion mixed		11,970 lb	
Percentage application $\left(\frac{11{,}970 \times 100}{60{,}040}\right)$		19·9	
Percentage oil on dry fibre weight		5·9	
Percentage emulsifier on dry fibre weight		0·3	
Percentage water on dry fibre weight		14·5	

Yarn	
Total wt of yarn spun	61,250 lb
Yield $\left(\frac{61{,}250 \times 100}{60{,}800}\right)$	101·6%
Moisture regain	19%
Oil content on dry wt of fibre	5·5%
Total wt of fibre	49,200 lb
Total wt of oil	2,710 lb
Total wt of moisture	9,350 lb

Material balance	*Into process* (*lb*)	*Out of process* (*lb*)	*Loss* (*lb*)	*Percentage loss*
Fibre	52,100	49,200	2,900	5·5
Oil	3,050	2,710	340	11·1
Moisture–raw jute	7,840			
emulsion	8,750			
	16,590	9,350	7,240	43·6
Total	60,800	61,250	10,480	

Waste	
Dust from shaker	1,900 lb
Re-workable waste	1,850 lb
Bale ropes	760 lb
Total re-workable waste	2,610 lb
Percentage re-workable waste $\left(\frac{2{,}610 \times 100}{60{,}800}\right)$	4·3

PRODUCTION COSTS THROUGHOUT THE SYSTEM

In all systems, whether they are hessian or sacking, the production costs increase as the material progresses through the manufacturing stages. To illustrate this, two items of the running costs have been selected, the power and labour requirements. The latter will vary from mill to mill and country to country but the figures in Table 10.10 have been found to be representative of efficient operation in hessian systems. All the charges have been expressed on the basis of 100 lb of yarn spun.

TABLE 10.10

	Operative hours	*Kilowatt-hours*
Spreader	0·14	0·46
Carding	0·28	2·70
Drawing	0·50	1·90
Spinning	1·00	13·0

It can be seen that spinning is by far the most costly stage as far as power and direct labour costs are concerned, the same applies to other charges such as depreciation, floor-area costs, and lighting.

PRODUCTION ESTIMATES

Jute machinery is particularly suited to the demands of high output; but maximum production can only be achieved under certain circumstances. One of the factors leading to a sub-capacity output is the diversity of counts and qualities that are produced; this certainly makes the task of the production planning department and the mill supervisory personnel more arduous. The more often a machine has to be changed from one quality to another the greater is the lost time and the more chance there is of inadvertent mixing of qualities—this latter point is of particular importance when low oil content and high oil content material are being produced simultaneously. However, it is always necessary to be able to fulfil sales requirements and where these demand relatively short runs on one count or quality, the supervisory system must be sufficiently flexible to cope with them.

In this respect, it is vital to have a reliable estimate of the production capabilities of each stage in the process, the waste and moisture losses, and so on. As an example, one method of arriving at the number of spinning spindles required to meet certain demands will be shown. The first step is to set up the outputs at 100 per cent from one spindle for the range of counts that the mill spins. An example is given in Table 10.11.

Having determined the 100 per cent spindle outputs for the range of counts then the particular numbers of spindles per frame and the operating efficiency of the mill is used to adjust these units to more

TABLE 10.11

Flyer (r.p.m.)	*Count*	*Twist*		*Delivery speed (yd/hr)*		*100% production spindle/hr*	
		Warp	*Weft*	*Warp*	*Weft*	*Warp*	*Weft*
3,900	$7\frac{1}{2}$	4·3	4·0	1,510	1,625	0·787 lb	0·847 lb
	8	4·0	3·8	1,625	1,715	0·903	0·955
	$8\frac{1}{2}$	3·9	3·6	1,670	1,810	0·985	1·070
3,750	9	3·8	3·5	1,645	1,785	1·025	1·115
	$9\frac{1}{2}$	3·7	3·4	1,695	1,835	1·110	1·210
	10	3·6	3·3	1,735	1,900	1·205	1·320

practical ones. For example, if all the frames had 100 spindles, the average spinning efficiency was 90 per cent and an 8 hr day is worked, then the daily frame outputs can be found:

$$100\%\ \text{eff. output} \times 100 \times 8 \times \frac{90}{100}\ \text{lb}$$

Count	*Output/frame/day*	
	Warp	*Weft*
$7\frac{1}{2}$	566 lb	610 lb
8	650	687
$8\frac{1}{2}$	709	770
9	738	804
$9\frac{1}{2}$	800	871
10	866	950

These production constants are then ready for use, e.g. how long will it take to spin 5,000 lb of $8\frac{1}{2}$ lb/sp weft if 2 frames are allocated to the order?

$$\text{Output of } 8\tfrac{1}{2}\ \text{lb/sp weft} = 700\ \text{lb/frame/day}$$

$$\text{Time to fulfil order} = \frac{5{,}000}{770 \times 2}$$

$$= 3{\cdot}25\ \text{days}$$

How many frames must be allocated so that 20 tons of $9\frac{1}{2}$ lb/sp warp will be produced in 7 days?

Output of $9\frac{1}{2}$ lb/sp warp $= 800$ lb/frame/day

$$\text{Number of frames required} = \frac{20 \times 2{,}240}{800 \times 7}$$

$$= 8$$

In exactly the same manner the production constants for each stage in the process can be found so that the time required to meet certain production demands can be found quickly and easily. This is by no means all that is necessary in the way of production planning and programming but it is intended to show one simple approach to the problems of planning machine utilization.