Control of Waste

in

Picking and Carding

A Thesis

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by

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Abstract

The object of this study is to show the effect on the tensile strength of cotton yarn when the percent of waste is increased. This increase is accomplished by changing the setting and speeds on the picker and card.

Purpose

The purpose of this thesis is to show and compare the strength and evenness of yarns spun from the same grade of cotton but processed under varying conditions of settings and speeds on the picker and card.

This comparison is to determine the setting and the speed of picker and card and the amount of waste taken from each at which the maximum strength and uniformity of yarn is obtained.

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Introduction

The greatest problem in the cotton mill is how to increase the production not only by speeding up the machinery but also by correct setting and speeds of each machine so that the right amount of waste can be taken off. We all know that it is impossible to produce 500 pounds of yarn from a 500 pound bale of cotton. That 500 pound bale of cotton contains varying amounts of short fibers, dust and dirt and broken leaves. The more of this waste the less the production of the desired yarn. We cannot argue about having a bale of cotton without any foreign matter and short fibers in it, but it is possible to reduce this waste, -- especially the foreign matter, to a great extent. Most of this foreign matter, is added to the cotton while it is being picked from the plant; that is, picking the cotton together with leaves around the boll, careless handling after picking, and failure to keep the storage places clean.

The ginning operation has an effect on the formation of waste. The saws in the gin increase the percentage of short fibers by breaking and cutting the fibers during the ginning action. The addition of short fibers left on the gin from previous operations also increases the waste. This can be prevented very easily if the gin is cleaned more often. But in the opinion of the ginner he can get just as much money by cleaning the gin once in every ten lots as if he cleans once at every lot. So why run through all this trouble? If some way of determining the amount of short fibers produced in the ginning operation could be developed and paying the operator accordingly, it would save a great deal of trouble in the successive operations with two to five per cent increase in the yarn production. We not only pay for short fibers when we buy them with the regular cotton but we spend much more for the power, labor and depreciation of machinery. The sooner we get rid of this waste the less it will cost us.

In calculating the per cent of waste it has always been difficult to find a way to get the total and actual per cent. To show this Thomas Thornley (1), gives the rule below. Rule: " 100 pounds of raw Egyptian cotton is passed through all the processes and made into yarn. It is found there are the following losses in waste.

In the blowing room .... 5 per cent
At the carding engine ...... 4 per cent
At the combing machine .... 15 per cent
Frames and mules .... 4 per cent

Now ascertain the loss in pounds at each stage, the total loss in pounds and the total loss per cent.

1- In the blowing room 100 pounds loses 5 per cent, which equals 5 pounds.

2- At the card 95 pounds loses 4 per cent.

Therefore: $\frac{95 \text{ X } 4}{100} = 3.8$ pounds loss at cards.

3- At the combers 91.2 pounds loses 15 percent

Therefore: $\frac{91.2 \times 15}{100} = 13.68$ pounds at comber.

4- At the latter process 77.52 pounds loses 4 percent.

Therefore: $\frac{77.52 \times 4}{100} = 3.10$ pounds loss.

The total losses in pounds and percent are shown below:

Percent	Pounds
5	5
4	3.8
15	13.68
4	3.10
28 percent	25.58 pounds

The question naturally asked is: We start with 100 pounds and finish with 74.42 pounds, so how can we lose 28 percent? The whole explanation of these cases rests on the fact that the losses in all intermediate stages are not on 100 pounds weight, but on the amount fed at each machine."

The waste made by the bale breaker and opener contains more large particles than that made by any other machine in yarn manufacture. These machines not only open the cotton which is packed in the bale by pressure but they also extract the larger and heavier impurities such as seeds, sand, leaves, and part of the other foreign matter together with fly. The control of the air current has a great effect on the kind of the droppings produced. The direction and the amount of the current must be regulated in order to obtain best results. Increased air current will cause the good fibers to be dropped into the box or to fly away. It will also cause the dust and leaf particles to enter back into the open cotton. The direction of the current has the same effect on the cleaning of the cotton as the increased current. Therefore the air current after entering through the bars must be discharged in careful manner.

In opening process the waste to be taken also depends on the type of the opener, the distance of the bars from each other, the type of the bars, and the way it is fed into the machine. In some openers the cotton passes through sets of bars before and after being opened. This additional cleaning space causes the cotton to be more thoroughly cleaned. The bars over which the cotton passes through before being opened are farther apart than the ones over which it passes after being opened. The speed of the various parts of the opener also has a great effect in the cleaning and opening of the cotton. Increased speed will open up the cotton faster, but it will not produce as clean cotton as with regular speed. The reason for this is that the cotton passes through so fast that it has a very short time to be cleaned. The right speed depends on the type of the opener and the amount of the air current. Too high speed is not recommended.

In classifying the waste in cotton mill, Testex (2) shows in the following manner:

" Waste is broadly devisable into two classes.

1- Preventable

2- Non-preventable

Causes of the preventable waste:

1- Faulty feed regulators in the blowing room.

2- Excessive fly loss

3- Faulty action of the full lap knock-off motion.

4- Insufficient calender roll weighting.

5- Lap splitting at cards.

6- Cans over-filled at the cards.

7- Portion of the web is not passing through the trumpet.

8- Roller laps

9- Too much clearer waste

10- Oozy yarn

11- Oozy places in the yarn.

On draw-frames and fly-frames waste is produced by carelessness, not piecing up the ends right, and leaving too much yarn on the bobbin when reeling.

Non-preventable waste is produced at every machine in the cotton mill. It is different in character and value at different processes.

Waste is classified into two groups according to character:

1- Soft waste

2- Hard waste

Soft waste is made at the earlier mill processes and does not contain twisted threads. Hard waste before it can be processed, must be broken up into fiberous form by a waste opener or picker.

Subdivisions of classes of waste may be made as follows:

1- Blow room droppings

2- Fan fly

3- Card fly and strippings

4- Comber waste

5- Roving waste

6- Clearer waste

7- Spinner's waste

8- Sweepings

9- Winder's and beamer's waste

10- Mixable wastes

Preventable waste may return into the mixing. Also some non-preventable waste is mixed in the production of lower grades.

Waste percentages:

The percentage of various classes of waste vary with different mills, according to the quality of cotton used and the type machinery employed. A general idea of the proportions of waste made, however, in the production of carded yarns from American cotton may be gathered from the following:

Blowroom droppings usually head the list, varying between 3% and 4% of the weight of cotton processed. Next follow card flat strips and cylinder strippings from 2 1/4% to 3%, while taker-in droppings are generally about 1%. The rest of the wastes are usually each well below 1% if invisible loss, which is chiefly moisture, is excluded."

Picker

The cotton, after it is opened, is in a more fluffy form than it ever was before and also cleaner, but it still has a great part of foreign matter in it. It contains lumps that need to be opened more by some beating operation. Seed, leaf, and dust are so packed with the cotton that it needs several beating operations to take them out. This is the main purpose of the picker.

The amount of unnecessary waste taken out in this operation is due chiefly to the incorrect settings and speed for the grade and staple of cotton being run. The settings on the machine may produce just the desired laps (clean and with the minimum amount of lumps) while running 1 1/8" staple cotton of certain grade. Then it might not produce as clean laps when running 1" staple cotton with different grade. It may produce more fly than necessary and more droppings may result under the bars. All these are the results of the machine not being set for that certain staple and grade. We know that low grade needs more cleaning than the high grade cotton. Shorter staple and more packed cotton needs more beating than longer staple with less lumps.

In changing from high grade cotton to a lower grade cotton, not considering the staple length, the following changes are necessary:

1- Increase the speed of the beater. This results in giving more beats per inch and also causes the fan speed to increase proportionally unless the fan pulley is changed. In some cases it is necessary to increase the speed of the beater while holding the speed of the fan. But this is unusual. If the cotton needs more beating because of being low grade it will need more air current to move the strongly bound foreign matter.

2- Setting of the grid-bars from each other and from the beater is also necessary. The distance between the bars should increase as the amount of foreign matter increases. The setting of bars from the beater has also great influence on the amount of waste droppings. For lower grade of cotton the bars nearer to the feed rolls must be set a greater distance from each other. The distance between the beater and the bars gets closer as they approach the feed rolls. Therefore, if any change is made in these settings it must be proportional to the grade or amount of foreign matter present.

When changing from long staple cotton to short staple the following changes must be made.

1- Set the feed rolls closer to the beater so that the fibers will not fall in bunches to be acted upon by the beater. This distance must always be slightly greater than the staple length being run.

2- Set the grid-bars closer to each other. This is very important because if not the fibers will fall through the bars. This will also cause a great amount of fly.

If, for any reason, too much good fiber is deposited under the beater box, North Carolina Notes (3) give the following reason. " The waste droppings under the beater box may be attributed to the beater revolving too quickly, the grids set too far apart, or the speed of the fan being so slow as to cause a weak current of air and thus fail to carry the fibers away before they are permitted to fall between the bars. On the other hand if the lap from the machine contain too much seed, leaf, etc. the causes may be directly the reverse of the above, viz.:- the beater may be revolving too slowly, failing to throughly open the cotton; the bars may be too close together, preventing the impurities from passing between them; or the fan may be running too high speed and creating an air current sufficient to carry the heavier impurities with the cotton in place of allowing it to fall out while passing over the bars. Having obtained the desired amount of air current it is next advisable to regulate the proper distribution of the same in order to lay the cotton evenly on the cages; thereby preventing one portion of the sheet being thicker than the other."

The correct angle of the grid-bars is also of great importance in the directing the fibers over the cages. If the angle is too great or too small it will cause uneven laps. Most of the late patents have an adjustment so that it is possible to change the angle of each bar wanted. In the old patents they were all fixed on a rod and it was impossible to change the direction of one or two bars wihtout influencing the others.

The evennes of a lap depends a great deal on the evener motion. Therefore, the evener motion must be watched carefully and not allowed to be out of operation while the machine is runing.

Uneven distribution of the air current will result in the production of uneven laps. This may cause part of the sheet to be thicker on one side and thiner on the other, or one yard of it not to be the same weight as the next yard. Of course, a free passage of the air is necessary to prevent this. The passage way through which the air current passes should be kept clean, so that there will be nothing to obstruct the free movement of the air and cotton. This will result in the air not being distributed evenly on the cages and pushing the cotton more on one side than the other and making an uneven sheet.

In connection with uneven laps there are other causes which produce defects as mentioned below; N. C. State notes (3)

" 1- Soft laps: The chief cause of this may be located in the friction which holds the racks upon the lap roll or in some cases the leather may be soft with oil, or be worn to such an extent that it does not offer enough resistance to the pulley, which permits the racks to be raised too easily. This may be remedied in some cases by moving the weight of the friction lever, so as to give more pressure against the pulley.

2- Laps hard on one side and soft on the other: The first thing to do in this case is to see that the racks which bear upon the lap roll are in line with each other, so that they will exert the same pressure upon the roll. Next, see that the screens are perfectly clean, so that the cotton is not drawn to one side more than to the other.

3- Dirty laps:

(a) The beater may be revolving too slowly.

(b) The grid bars may be too close or the air current may be too strong. If too much good cotton is found under the beater box, the opposite of the foregoing may be the cause."

Card

When we think of the card we think of it as a machine to change the cotton from the lap form into the sliver form. The purpose of the card is not only to change the form of cotton, but also to perform other duties which are far more important than merely this. Let us analyze these duties.

1- One of the main duties of the card is to disentangle and separate the fibers so that they may be more easily paralleled at the drawing operation, fly-frames, and spinning frames. This is accomplished by the construction of the wire, the relative direction in which the teeth are pointing and the relative surface speed of the teeth on various parts. Some of the fibers that are not opened stick to the flats and after a while are moved away as waste.

2- The next important duty of the card is to clean the cotton by removing the short fibers and foreign matter that have not previously been removed. This removal will be taken up in detail on the following pages.

To compare the waste taken out by the card with that removed in the previous process, a portion of an article in the Textile Institute (4) is quoted.

" The amount of waste produced falls from the opener to the second scutcher and then increases again at the card. The fly waste at the opener and the waste carried away with seed and dust particles at the scutcher consists of comparatively good material. The fibers actually attached to the seed particles are very short. In the card waste the most frequent length zone 6 m. m. When the carding process is repeated practically the same amount of waste is produced in both second and third processes as in the first process. The mean length of the waste rises with repeated carding. "

The effect of the speed of the licker has a great importance on the production of desired sliver with a minimum amount of waste. This is the first action of the card mechanism on the cotton, the sheet of the fibers is in a tightly bound form, and the cylinder itself cannot operate unless these fibers are fluffed-up before they come in contact with the wires of the cylinder. The effect of the speed of the licker is important in opening the sheet. If too great a speed of the licker is introduced it will loosen the fibers, but it will cause many of them to be broken. These broken fibers will either fall through the licker or they might cause an increase of fly. If these broken fibers remain in the stock, they detract from the making of a smooth, strong yarn.

The setting of the mote knives to the licker with the right angle is also a good step to be watched for the best production. When a new setting of this part of the card is made it must be done with care so as not to let the knife touch the points of the licker. It will be advisable if a little space is left between the knife and the licker, otherwise the knife would knock off part of the cotton. This could be judged by the droppings under the licker. If too much droppings are found on the floor it might be the result of too close a setting of the feed plate to the licker. For short staple or light lap the plate should be set closer to the licker.

The cylinder speed is one of the main things upon which the good results depend. It must be known that excess speed for any part of the machine will result in a sacrifice of quality for quantity. At this part of my discussion I refer to a research in Textile Institute (5).

" The lower and upper limits to cylinder speed for the Egyptian cotton are approximately 135 and 210 r.p.m. and for the American 135 and 225 r.p.m. The lower limit is indicated by the cloudiness of flat strips and card web, the upper limit by neppiness and the cloudiness of the web in the case of the Egyptian cotton, and by cloudiness of the web only in the case of the American. Raising the cylinder speed increases the amount of the licker-in waste, flat strip, doffer strip in a less degree so that on balance the total waste increases slightly. The strongest Egyptian yarns are produced at speeds of approximately 165 to 195 r.p.m. and the most regular but least hairy yarns at speeds of approximately 150 to 195 r.p.m. At high (210 and 225 r.p.m.) and low (135 r.p.m.) speeds the yarns are equally irregular and hairy but the high speed yarns are neppy and stronger. The yarns are equally clean at all speeds. The strengths of the American yarns increase from the lowest to the highest speed. The most irregular yarn is produced at the lowest cylinder speed; at all other speeds the yarn irregularity is unchanged. Changes in the cylinder speed do not effect the cleanliness and hairness of the yarns. Analysis of these results: (a) Total Waste: for approximately 30 minutes after stripping, the total waste percentage increases. For a normal working period of 150 minutes an increase in the cylinder speed from 135 to 180 r.p.m. causes an increase in the total waste percentage of 0.15

for the Egyptian cotton and 0.12 for the American. Further increases in speed to 225 r.p.m. increases the total waste percentage by 0.36 for the Egyptian and by 0.66 for the American cotton."

Setting and the speed of the flats also has a great effect on the regularity of the sliver produced with fluctuating percent of waste. If the cotton is of low grade it needs much more cleaning than high grade. This cleaning must be completed at the card as this is the last cleaning machine used in producing a regular carded yarn. Setting the flats closer and increasing the speed will give a cleaner sliver. This will naturally increase the flat strips. A good practice, to see whether or not the setting, or the speed, or both, is correct by examining the flat to see if too many good fibers are being lost. If so the flats must be moved further away from the cylinder or they must be slowed down or both the speed and the setting must be changed.

In order to produce the best sliver on the card, care should be taken in obtaining the correct number and type of clothing for the cylinder, doffer, and flats. The setting of the flats together with the speed may be right but the card may not give clean slivers. In this respect the clothing needs stripping and grinding or one of the two may be the cause.

The setting of the cylinder and licker screens, although they have some effect on the production of waste, are not importamt. Setting these screens closer increases the amount of waste produced. Similar to the previous settings these screens must be set closer if the cotton needs more cleaning.

The setting of the front plate has a greater effect on the amount of the flat-strips produced than the setting of any other part of the card. It is really an unsolved problem to see why if the plate is set further away from the cylinder, there is an increase of waste (flate-strips). But we all know it does. There is a suggestion on this problem which I refer to (6) by Thomas Thornley.

" It is probable that factors which enter into this problem are:

1- Centrifugal force

2- Air currents

3- The adjustment and condition of such parts as the flats and back plate.

4- The bite between the front plate and the cylinder or the nip.

One argument is: If the top edge of the front plate is put closer to the cylinder it breaks up the air current better, that is lying close to the cylinder and taken along with it. By thus breaking up the air current the fibers of the cotton have a better tendency to stand out from the cylinder.and can be taken from the doffer better by the cylinder. The net result is that the cylinder is kept cleaner, the cotton penetrates and sticks to the cylinder wire better, so that less is taken off the cylinder by the flats, thus reducing the flat strips.

A second possible explanation has been offered as follows: There is always a tendency for a quickly revolving body to throw off anything that may be upon its surface owing to the effects of centrifugal force. This being so there must be a tendency for the cylinder to throw off the fibers that it carries from taker-in to doffer, a tendency which is more or less resisted by the back and the front plates and also by the flats themselves. If the front plate is set farther away at its top edge it permits this tendency to be developed more strongly at the final point of contact surfaces, and hence the flats succeed in bringing away more fibers as waste. Against this explanation is that the flats are charged with the fibers from the very commencement, and therefore do not thus take away the extra fibers as suggested. Moreover a very closely set front plate can in some cases be made to almost prevent flat strips altogether, although by taking flats out over the cylinder it can be proved that they are charged with fiber at that point."

The main things that result in the better control of waste have been mentioned on the previous pages. In addition, there are other means of partially accomplishing this control. but they are not as important as those first mentioned. Of, course, if an uneven lap is feeding behind the card, no matter how accurate each setting and speed is arranged on the card, it will result with uneven sliver. This unevenness will go all way to the yarn causing it to be uneven.in counts. Other causes which effect the sliver are: atmospheric conditions—wet or dry; improper setting of doffer comb to doffer—if too far away or too high the fibers will slip; improper cleaning and oiling; improper meshing of gears—binding results from this.

More information could have been included in this thesis if the study had covered all the processes that produce waste in a cotton mill. It is hoped that this specific investigation of waste in the picking and carding processes may prove helpful to the cotton manufacturer.

Procedure

In doing the experimental work, one-half of a bale of one inch American upland cotton of middling grade was opened by running it through the vertical opener. Since this study covers the waste control, only in picking and carding, no tests were made in the opening process.

This opened cotton was divided into four lots. Each of these four lots was processed through the picker under varying conditions of settins and speeds. At each process the hopper was filled with exactly 50 pounds of the above mentioned opened cotton. The pin to be used for the lap produced from this cotton was weighed. The picker was started, and when the cotton started coming in front the lap was broken off until it was running evenly. This cotton was kept to weigh with the lap. The lap was removed before all the cotton ran out (to have even lap) and the rest of the cotton was run through the machine until it fell in front. Then the lap was weighed together with the cotton that was broken both before and after forming the lap and with the pin. From this weight the weight of the pin was subtracted and this gave the exact weight of the cotton. This weight was subtracted from 50 pounds and the result was the waste taken off in pounds. This figure was changed into the percentage form.

The picker used in these experiments was a Kitson single process picker, 1918 model, with a bladed beater in the breaker section and a carding beater in the finisher section.

The formation of these different laps are as follows:

(a) A lot of 50 pounds of cotton was run through the machine with the regular settings and speeds. They are:

Breaker Section

R. P. M. of the beater 850

R. P. M. of the fan 840

Setting of the grid bars from beater ... 5/8" top, 13/16" bottom.

Setting of the feed rolls from the beater .... 1/4"

Finisher Section

R. P. M. of the beater 750

R. P. M. of the fan 1170

Setting of the grid bars from beater ... 3/16" top, 1/4" bottom.

Setting of the feed roll from beater .... 1/8"

Result: 1.2 percent of waste taken off."LAP NUMBER ONE"

(b) A lot of 50 pounds of cotton was run through the machine with the regular and settings except the feed roll was set closer to the beater (only the breaker section). The settings and speeds are:

Breaker Section

R. P. M. of the beater 850

R. P. M. of the fan 840

Setting of the grid bars from beater... 5/8" top, 13/16" bottom.

Setting of the feed roll from beater .... 1/8"

Finisher Section

R. P. M. of the beater 750

R. P. M. of the fan 1170

Setting of grid bars from beater ... 3/16" top, 1/4" bottom.

Setting of the feed roll from beater .... 1/8"

Result: 2.5 percent waste taken off. " LAP NUMBER TWO "

(c) A lot of 50 pounds of cotton was run through the picker with the regular speeds and settings except the grid bars on the breaker section were set closer to the beater. The settings and speeds are:

Breaker Section

R. P. M. of the beater 850

R. P. M. of the fan 840

Setting of grid bars from the beater ... 3/8" top, 13/16" bottom.

Setting of the feed roll from beater .... 1/4"

Finisher Section

R. P. M. of the beater 750

R. P. M. of the fan 1170

Setting of grid bars from beater ...... 3/16" top, 1/4" bottom.

Setting of feed roll from the beater .... 1/8"

Result: 1.3 percent of waste taken off. " LAP NUMBER THREE "

(d) A lot of 50 pounds of cotton was run through the machine with the regular speeds and settings except the r. p. m.'s of both beaters and fans are increased . The settings and speeds are:

Breaker Section

R. P. M. of the beater 1113

R. P. M. of the fan 1113

Setting of the grid bars from beater ... 5/8" top, 13/16" bottom.

Setting of the feed roll from beater .... 1/4"

Finisher Section

R. P. M. of the beater 1094

R. P. M. of the fan 1094

Setting of the grid bars from beater ... 3/16" top, 1/4" bottom.

Setting of the feed rolls from beater .... 1/8"

Result: 1.5 percent waste is taken off. " LAP NUMBER FOUR "

Tests on the card.

After weighing the lap carefully, 5 yards was cut from each lap and run through each setting and speed. On this operation eight different settings were made together with the regular mill setting of the machine. Before running the lap and the pin were weighed. The 5 yards of lap was wound on the pin and weighed together with the lap. The weight of the pin was subtracted from the total weight of the lap. This gave the weight of the cotton. After running it was weighed in the can and the weight of the can was subtracted. This gave the weight of the cotton after being run. This weight was subtracted from the weight before going through. This difference was divided by the weight before going through. This gave the percent of waste taken off.

(a) By the operation explained above was run 5 yards of lap in the regular mill settings, which are:

1- Speed of flats .... 3 1/4 inches per minute

2- Setting of the front plate from the cylinder .. 34/1000"

3- Setting of the flats from the cylinder ... 12/1000"

4- Setting of the mote knives from the licker ... 1/4"

5- Setting of the cylinder screens to the cylinder.. 50/1000"

6- Setting of the licker screens to the licker ... 1/8"

7- Speed of the licker .... 450 R. P. M.

Result:

No. 1 lap 5.2 percent waste. Lot No, 1

No. 2 lap 5.34 " " . Lot No. 2

No. 3 lap 5.61 " " . Lot No. 3

No. 4 lap 4.47 " " . Lot No. 4

(b) The speed of the flats was increased from 3 1/4 inches per minute to 4 1/4 inches per minute, leaving all other speeds and settings as in (a).

Results:

No. 1 lap 5.71 percent waste. Lot No. 5

No. 2 lap 5.42 " " . Lot No. 6

No. 3 lap 5.85 " " . Lot No. 7

No. 4 lap 5.33 " " . Lot No. 8

(c) The upper edge of the front plate was moved further away from the cylinder. From 34/1000" to 44/1000", leaving all other speeds and settings as in (a).

Result:

No. 1 lap 7.2 percent waste. Lot No. 9

No. 2 lap 6.96 " " . Lot No. 10

No. 3 lap 7.47 " " . Lot No. 11

No. 4 lap 6.73 " " . Lot No. 12

(d) The mote knives were set closer to the licker with increased angle. The setting was 15/1000", leaving all other speeds and settings as in (a).

Result:

No. 1 lap 5.28 percent waste . Lot No. 13

No. 2 lap 5.42 " " . Lot No. 14

No. 3 lap 5.52 " " . Lot No. 15

No. 4 lap 5.36 " " . Lot No. 16

(e) The cylinder screens were set closer to the cylinder. The setting was 35/1000", leaving all other speeds and settings as in (a).

Result:

No. 1 lap 5.81 percent waste . Lot No. 17

No. 2 lap 6.17 " " . Lot No. 18

No. 3 lap 5.75 " " . Lot No. 19

No. 4 lap 5.04 " " . Lot No. 20

(f) The licker screens were set closer to the licker. The setting was 35/1000", leaving all other speeds and settings as in (a).

Result:

No. 1 lap 5.36 percent waste . Lot No. 21

No. 2 lap 5.47 " " . Lot No. 22

No. 3 lap 5.68 " " . Lot No. 23

No. 4 lap 5.41 " " . Lot No. 24

(g) The speed of the licker was increased to 525 R. P. M. leaving all other speeds and settings as in (a).

Result:

No. 1 lap 5.97 percent waste . Lot No. 25

No. 2 lap 5.38 " " . Lot No. 26

No. 3 lap 5.71 " " . Lot No. 27

No. 4 lap 5.09 " " . Lot No. 28

(h) The flats were set closer to the cylinder. The setting was 10/1000" and leaving all other settings and speeds as in (a). Result:

No. 1 lap	6.59	percent waste	. Lot No. 29
No. 2 lap	5.93	" "	. Lot No. 30
No. 3 lap	6.02	" "	. Lot No. 31
No. 4 lap	5.41	" "	. Lot No. 32

Table showing the percent of waste taken at each

operation in the formation of each sliver

Picking Operation

Carding Operation	No. 1 Lap 1.2% Waste Regular Setting	No. 2 Lap 2.5% Waste Set feed roll closer to beater	No. 3 Lap 1.3% Waste Set grid bars closer to beater	No. 4 Lap 1.5% Waste Increase speed of both beaters and fans
No. 1 Regular Setting	5.2% waste	5.34% waste	5.61% waste	4.47% waste
No. 2 Increase speed of flats	5.71% waste	5.42% waste	5.85% waste	5.33% waste
No. 3 Move front plate farther from cylinder	7.2% waste	6.96% waste	7.47% waste	6.73% waste
No. 4 Move knives closer to cylinder	5.28% waste	5.42% waste	5.52% waste	5.36% waste
No. 5 Set cylinder screen closer to cylinder	5.81% waste	6.17% waste	5.75% waste	5.04% waste
No. 6 Set licker screen closer to licker	5.36% waste	5.47% waste	5.68% waste	5.41% waste
No. 7 Increase speed of licker	5.97% waste	5.38% waste	5.71% waste	5.09% waste
No. 8 Set flats closer to cylinder	6.59% waste	5.93% waste	6.02% waste	5.41% waste

The slivers were run through one process of drawing (six doublings) with all the settings of the rolls and the weights, etc., corresponding to the standard mill conditions. Then in the same way the stock was passed through the slubber, making two doffs. This slubber roving was doubled in the creel of the first intermediate and made into six doffs of intermediate roving for each lot.

The yarn was spun from these first intermediate bobbins by placing them in the creel of Saco-Lowell long draft spinning frame and arranging the draft gearing to produce 25^s yarn and the twist gearing to give regular warp twist for 25^s. The roving was spun single. In this operation six full bobbins were made of spun yarn of each lot (making one full bobbin of spun yarn from each first intermediate bobbin).

In testing laboratory five skeins were wound from six bobbins of each lot, giving 30 skeins of each lot. These skeins were conditioned four hours at 70 F. and 65 percent relative humidity. Then the skeins were broken on a standard pendulum type of break testing machine. Each broken skein was weighed to get the counts. After calculating the counts of each skein, six skeins were taken from each lot and bone dried and the percent regain was found for each lot. Then all the counts and breaks were corrected to a standard 7 percent regain. Then all the breaks were corrected to 25^s counts. The corrected break of each lot is shown in the following tables with the average strengths and deviations. For comparison of all these lots please refer to these tables on pages 28 to 36.

The Breaking Strength in Pounds

of the Skeins

for Lots 1, 2, 3, and 4

Corrected to 25^{s} counts

Skeins	Lot No. 1 Break lbs	Lot No. 2 Break lbs	Lot No. 3 Break lbs	Lot No. 4 Break lbs
1	77.60	78.75	76.55	83.72
2	76.50	78.65	80.65	78.48
3	77.92	77.00	79.92	75.02
4	72.61	75.22	76.55	74.50
5	75.78	77.91	73.20	69.78
6	78.24	76.70	70.25	76.13
7	80.72	76.74	72.50	75.65
8	76.97	78.65	69.45	68.78
9	76.48	75.48	75.50	78.46
10	76.48	76.80	73.00	72.22
11	73.15	77.97	76.80	74.00
12	72.68	80.75	72.88	80.78
13	78.44	77.77	80.85	73.45
14	78.51	78.75	75.40	71.00
15	75.51	77.62	74.38	74.44
16	76.25	73.80	77.50	76.00
17	75.48	79.22	75.50	81.75
18	78.48	76.22	70.00	80.28
19	76.38	76.26	76.65	77.60
20	73.30	75.20	80.30	77.32
21	71.80	72.30	75.70	78.25
22	79.62	73.05	79.50	71.33
23	71.15	77.14	77.50	72.42
24	79.12	70.04	81.32	79.78
25	79.20	78.80	73.40	71.10
26	75.50	79.18	80.26	70.80
27	77.95	70.62	78.50	78.00
28	76.04	80.00	68.86	73.72
29	74.14	78.00	76.65	73.00
30	77.48	70.87	73.00	75.23
Average	76.31	76.48	75.75	75.47

The Breaking Strength in Pounds

of the Skeins

for Lots 5, 6, 7, and 8

Corrected to 25^{s} counts

Skeins	Lot No. 5 Break in lbs.	Lot No. 6 Break in lbs.	Lot No. 7 Break in lbs.	Lot No. 8 Break in lbs.
1	73.40	74.82	68.20	76.15
2	75.68	74.64	75.26	78.82
3	74.10	83.25	71.78	72.22
4	66.91	67.28	74.30	80.68
5	78.37	72.08	73.56	72.65
6	69.95	82.68	75.25	74.78
7	79.75	83.36	74.25	73.50
8	76.40	75.45	77.10	70.40
9	70.20	72.77	79.80	74.55
10	79.95	69.93	71.65	75.22
11	72.50	74.18	71.37	76.25
12	70.92	67.01	75.13	71.35
13	77.75	74.04	68.80	75.36
14	73.42	75.62	76.35	79.65
15	74.04	72.52	70.10	75.50
16	70.75	75.85	72.16	79.33
17	71.92	75.06	74.82	75.70
18	80.11	76.08	73.80	78.70
19	77.14	74.70	70.00	73.52
20	76.16	76.02	70.00	74.50
21	74.85	75.18	71.80	71.11
22	65.72	71.25	76.32	76.75
23	71.20	76.61	69.45	75.75
24	72.47	69.75	76.50	70.35
25	75.72	76.48	76.65	71.54
26	78.82	78.38	70.62	68.00
27	70.75	78.04	72.50	74.00
28	71.46	69.20	73.60	76.42
29	76.13	77.65	73.00	69.50
30	73.98	70.75	69.80	74.09
Average	74.14	74.59	73.13	74.54

The Breaking Strength in Pounds

of the Skeins

for Lots 9, 10, 11, and 12

Corrected to 25[s] counts

Skeins	Lot No. 9 Break in lbs.	Lot No. 10 Break in lbs.	Lot No. 11 Break in lbs.	Lot No. 12 Break in lbs.
1	74.75	74.72	76.53	77.15
2	76.48	77.65	78.52	74.18
3	83.25	79.65	74.25	77.52
4	79.25	79.12	80.20	78.18
5	71.32	80.00	77.22	76.54
6	79.25	76.22	76.02	78.13
7	67.65	75.40	80.50	73.85
8	69.42	75.78	77.86	78.18
9	74.85	71.43	77.37	76.85
10	74.80	76.38	81.70	79.12
11	71.10	79.40	78.80	75.75
12	73.50	81.35	73.28	72.68
13	71.78	74.78	82.15	77.15
14	71.10	75.46	76.52	74.52
15	79.90	76.00	77.50	78.52
16	71.12	83.25	82.28	78.14
17	77.18	77.52	76.52	80.00
18	74.51	85.65	81.38	76.40
19	74.14	76.48	79.50	78.36
20	73.80	80.25	78.18	73.30
21	77.00	81.16	77.00	74.00
22	81.49	75.53	82.75	76.52
23	74.52	70.22	80.48	77.04
24	79.60	74.95	77.82	79.02
25	77.00	82.25	80.78	81.26
26	75.48	74.51	75.34	82.78
27	77.90	70.00	80.30	72.17
28	72.10	77.68	80.40	75.53
29	70.00	79.38	79.62	78.75
30	75.82	77.82	76,20	79.33
Average	75.04	77.37	78.37	76.93

The Breaking Strength in Pounds

of the Skeins

for Lots 13, 14, 15, and 16

Corrected to 25[s] counts

Skeins	Lot No. 13 Break in lbs.	Lot No. 14 Break in lbs.	Lot No. 15 Break in lbs.	Lot No. 16 Break in lbs.
1	78.50	70.13	77.65	74.50
2	80.20	75.05	78.00	74.52
3	85.14	71.18	80.80	74.35
4	78.40	72.78	71.95	71.62
5	80.55	75.03	75.13	70.78
6	84.15	76.65	77.35	72.60
7	76.44	71.70	76.52	71.78
8	78.70	75.52	72.62	70.65
9	84.12	76.23	81.35	67.20
10	78.40	71.70	72.15	67.00
11	76.72	76.50	75.80	69.10
12	78.75	74.38	74.32	74.80
13	73.20	67.62	72.90	67.48
14	82.82	77.48	78.50	79.48
15	77.00	67.88	70.25	70.30
16	79.00	75.85	78.50	74.10
17	80.42	74.35	77.35	73.75
18	81.75	76.35	74.62	73.50
19	77.25	72.26	74.50	72.85
20	76.75	79.45	76.65	70.25
21	82.22	71.90	75.50	77.00
22	83.00	76.08	80.00	72.60
23	75.00	78.00	73.65	77.35
24	78.02	71.70	76.35	70.49
25	85.78	71.37	78.32	71.50
26	79.40	75.23	76.40	73.25
27	80.75	70.00	71.58	74.62
28	82.35	72.10	74.40	78.20
29	79.40	71.95	80.35	76.45
30	79.82	70.20	76.08	75.75
Average	80.13	73.56	76.64	72.92

The Breaking Strength in Pounds

of the Skeins

for Lots 17, 18, 19, and 20

Corrected to 25^{s} counts

Skeins	Lot No. 17 Break in lbs.	Lot No. 18 Break in lbs.	Lot No. 19 Break in lbs	Lot No. 20 Break in lbs.
1	70.20	79.11	76.81	70.38
2	79.92	83.40	80.00	70.70
3	77.62	80.37	78.42	72.22
4	68.10	73.62	73.51	74.56
5	74.51	72.55	76.35	71.75
6	79.22	74.48	77.05	71.80
7	77.12	70.34	79.75	74.62
8	81.50	74.36	81.95	77.52
9	68.10	68.47	78.22	70.70
10	68.00	78.82	75.48	69.75
11	73.78	75.36	77.20	74.00
12	71.93	79.30	75.02	72.88
13	65.35	87.98	72.50	72.32
14	73.92	80.48	77.20	78.78
15	80.25	75.33	72.65	71.62
16	76.50	76.37	75.22	76.18
17	73.12	76.28	79.27	71.72
18	76.12	72.00	74.12	72.22
19	75.48	74.10	77.75	72.17
20	73.49	76.28	74.32	78.05
21	74.68	73.38	73.41	72.17
22	75.00	78.81	73.00	71.00
23	76.50	77.28	76.01	74.22
24	77.55	70.34	77.01	74.25
25	79.42	77.48	78.78	73.66
26	77.51	79.85	79.02	74.15
27	72.25	72.20	70.52	72.82
28	74.81	73.18	75.28	79.10
29	75.72	72.85	79.58	75.02
30	68.78	67.08	72.75	71.96
Average	74.52	75.55	76.20	73.34

The Breaking Strength in Pounds

of the Skeins

for Lots 21, 22, 23, and 24

Corrected to 25^{s} counts

Skeins	Lot No. 21 Break in lbs.	Lot No. 22 Break in lbs.	Lot No. 23 Break in lbs.	Lot No. 24 Break in lbs.
1	80.70	71.52	76.85	74.45
2	75.15	75.13	71.62	79.22
3	77.15	75.80	76.78	80.12
4	78.45	68.68	73.30	75.00
5	72.52	76.00	74.00	82.32
6	77.92	81.28	75.97	76.57
7	78.00	81.12	78.95	75.00
8	73.25	72.65	79.70	74.10
9	85.30	80.55	73.02	75.50
10	78.20	68.66	75.26	73.33
11	78.95	78.63	79.48	79.25
12	70.67	78.65	73.20	69.40
13	79.02	73.50	77.55	79.04
14	74.95	82.42	76.10	79.22
15	74.75	76.26	76.22	79.25
16	73.85	76.52	76.50	74.55
17	74.27	80.37	75.20	80.48
18	74.04	80.22	81.25	80.57
19	79.00	77.50	83.82	77.25
20	72.02	77.11	72.25	81.68
21m	77.22	71.45	76.52	76.77
22	74.22	75.35	72.04	74.87
23	83.50	80.26	72.00	71.38
24	72.28	73.48	84.00	71.23
25	74.68	76.36	75.80	67.40
26	79.38	78.23	73.22	73.12
27	73.82	77.72	82.00	67.16
28	72.00	74.62	78.35	71.00
29	75.90	79.68	78.65	75.25
30	78.60	70.48	67.33	78.22
Average	76.33	76.33	76.23	75.76

The Breaking Strength in Pounds

of the Skeins

for Lots 25, 26, 27, and 28

Corrected to 25^s counts

Skeins	Lot No. 25 Break in lbs.	Lot No. 26 Break in lbs.	Lot No. 27 Break in lbs.	Lot No. 28 Break in lbs.
1	78.75	74.48	74.52	81.28
2	73.27	78.68	81.48	82.64
3	78.17	81.25	77.72	74.95
4	76.24	80.13	77.41	76.30
5	70.57	78.65	79.52	81.80
6	69.78	76.37	78.38	76.62
7	80.55	72.98	76.77	77.68
8	70.50	76.97	81.92	71.66
9	73.75	70.86	77.95	78.32
10	78.60	74.75	76.47	71.95
11	69.97	79.25	79.78	72.25
12	74.00	71.65	71.00	71.52
13	73.05	75.95	73.42	78.35
14	69.12	73.98	75.18	75.39
15	74.85	74.32	71.25	67.00
16	74.92	71.65	76.77	77.11
17	75.85	79.65	75.00	75.04
18	78.75	73.10	74.20	79.03
19	77.00	72.60	74.10	80.00
20	76.79	77.00	68.87	75.18
21	74.05	78.10	74.96	78.26
22	70.45	78.32	76.75	79.25
23	77.75	73.04	74.92	77.46
24	74.10	71.72	77.15	72.50
25	70.70	74.48	74.70	72.67
26	78.52	73.41	72.52	76.12
27	78.00	73.18	74.20	73.02
28	72.55	77.68	76.40	75.42
29	68.62	74.01	72.52	78.22
30	75.80	73.99	77.15	78.35
Average	74.43	75.38	75.60	76.18

The Breaking Strength in Pounds

of the Skeins

for Lots 29, 30, 31, and 32

Corrected to 25^s counts

Skeins	Lot No. 29 Break in lbs.	Lot No. 30 Break in lbs.	Lot No. 31 Break in lbs.	Lot No. 32 Break in lbs.
1	77.00	76.23	76.20	81.26
2	84.00	72.52	77.48	81.46
3	71.12	77.60	79.45	86.28
4	78.32	72.28	74.47	75.75
5	78.78	68.28	72.33	82.28
6	70.20	69.15	72.71	75.71
7	75.48	79.38	76.10	73.78
8	78.06	79.38	73.02	79.50
9	69.46	66.11	71.95	75.82
10	82.00	79.80	72.53	72.73
11	80.78	74.50	74.02	78.60
12	66.25	70.54	75.45	77.68
13	79.85	73.25	71.97	71.84
14	80.62	75.25	77.65	81.10
15	73.78	76.82	71.86	71.08
16	78.50	79.00	70.92	86.02
17	79.08	71.51	76.71	82.92
18	80.00	76.14	79.47	72.73
19	78.58	77.15	65.22	77.32
20	71.80	69148	75.32	71.25
21	76.20	73.70	70.33	73.62
22	75.48	76.12	74.38	81.40
23	78.50	78.00	76.25	87.08
24	74.25	74.50	74.23	73.92
25	77.48	73.68	74.38	76.06
26	81.28	74.66	77.91	71.73
27	69.78	75.00	77.75	71.51
28	66.50	68.71	72.16	76.36
29	82.62	72.00	72.02	74.95
30	75.25	78.16	75.81	71.16
Average	76.33	74.30	74.33	77.09

Table of Comparison of Tensile Strength

of the Lots

Lots	Means of breaks corrected to counts	
16	72.92	lbs.
7	73.13	"
20	73.34	"
14	73.56	"
5	74.14	"
30	74.30	"
31	74.33	"
25	74.43	"
17	74.52	"
8	74.54	"
6	74.59	"
9	75.04	"
26	75.38	"
4	75.47	"
18	75.55	"
27	75.60	"
3	75.75	"
24	75.76	"
28	76.18	"
19	76.20	"
23	76.23	"
21	76.33	"
29	76.33	"
22	76.34	"
15	76.64	"
1	76.31	"
[illegible]	76.48	"
[illegible]	76.93	"
[illegible]	77.09	"
[illegible]	[illegible].37	"
[illegible]	[illegible].37	"
[illegible]	[illegible].13	"

Statistical Analysis of the Data

Since the computed means were obtained by breaking samples of the yarn spun, it was necessary to measure the amount of error introduced by the sampling process. The measure selected for this purpose was the standard error of the mean and it was computed by the formula (7).

$$\frac{\sigma}{X} = \frac{\sigma}{\sqrt{N}}$$

Where N the number of samples and σ is the standard deviation of the samples from the mean.

The standard deviation gives a measure of the variation of the samples tested and was computed by the formula(8).

$$\sigma = \sqrt{\frac{\Sigma d^2}{N} - \left(\frac{\Sigma d}{N}\right)^2}$$

Where d is the deviation from an assumed mean.

To measure the error introduced into the standard deviation, the standard error of the standard deviation was calculated by the formula (9).

$$\sigma_{\sigma} = \frac{\sigma}{\sqrt{2N}}$$

Since the standard error of the mean for the majority of the lots tested is approximately 6/10 of a pound, a difference of that amount or less between any two means is probably not significant but due to pure chance in sampling.

To illustrate the method of calculating the statistical data, all calculations for lot No. 2 are given on page 38.

Breaking strength of skeins in lbs. X	d' deviation from assumed mean X - 70	d'^2
78.75	8.75	76.5625
78.65	8.65	74.8225
77.00	7.00	49.0000
75.22	5.22	27.2484
77.91	7.91	62.5681
76.70	6.70	44.8900
76.74	6.74	45.4276
78.65	8.65	74.8225
75.48	5.48	30.0304
76.80	6.80	46.2400
77.97	7.97	63.5209
80.75	10.75	115.5625
77.77	7.77	60.0625
78.75	8.75	76.5625
77.62	7.62	58.0644
73.80	3.80	14.4400
79.22	9.22	85.0084
76.22	6.22	38.6884
75.26	5.26	27.6676
75.20	5.20	27.0400
72.30	2.30	05.2900
73.05	3.05	09.3025
77.14	7.14	50.9796
70.04	0.04	00.0016
78.80	8.80	77.4400
79.18	9.18	84.2724
70.62	0.62	00.3844
80.00	10.00	100.0000
78.00	8.00	64.0000
70.87	0.87	00.7569
Totals	194.44	1490.6566

$$\frac{194.44}{30} = 6.48$$

Therefore $70 + 6.48 = 76.48$ mean.

$$\sigma = \sqrt{\frac{d'^2}{N} - \left(\frac{d'}{N}\right)^2}$$

Where $\Sigma d'$ is the algebrac sum.

$$\sigma = \sqrt{\frac{1490.6566}{30} - \left(\frac{194.44}{30}\right)^2}$$

$$\sigma = \sqrt{49.6885 - 42.0034}$$

$$\sigma = \sqrt{7.6851}$$

$\sigma = 2.77$ Standard deviation from mean.

$$\frac{\sigma}{\sqrt{N}} = \frac{2.77}{\sqrt{30}}$$

$$= \frac{2.77}{5.477} = 5.05$$ Standard error of the mean

$$\frac{\sigma}{\sqrt{2N}} \doteq \frac{2.77}{\sqrt{60}} = .3447 =$$

Standard error of standard deviation.

Tabulation of Results

Lots	Mean of breaks corrected as to counts (in lbs.)	Standard error of mean $\frac{\sigma}{\sqrt{N}}$	Standard deviation from mean $\sigma = \sqrt{\frac{\Sigma d^2}{N} - C^2}$, $C^2 = \left(\frac{\Sigma d}{N}\right)^2$	Standard error of standard deviation $\frac{\sigma}{\sqrt{2N}}$
1	76.31	.430	2.41	.3111
2	76.48	.505	2.77	.3447
3	75.75	.667	3.65	.4712
4	75.47	.665	3.64	.4699
5	74.14	.655	3.59	.4635
6	74.59	.645	3.53	.4557
7	73.13	.513	2.81	.3628
8	74.54	.564	3.09	.3989
9	75.04	.687	3.77	.4867
10	77.37	.610	3.32	.4289
11	78.37	.674	3.67	.4738
12	76.93	.486	2.66	.3434
13	80.13	.248	1.36	.1756
14	73.56	.537	2.94	.3796
15	76.64	.323	1.77	.2285
16	72.92	.570	3.12	.4028
17	74.52	.738	4.04	.5216
18	75.55	.725	3.97	.5125
19	76.20	.517	2.83	.3653
20	73.34	.464	2.54	.3279
21	76.33	.628	3.44	.4441
22	76.34	.676	3.70	.4777
23	76.23	.679	3.72	.4802
24	75.76	.723	3.96	.5112
25	74.43	.630	3.45	.4454
26	75.38	.526	2.88	.3718
27	75.60	.590	3.23	.4170
28	76.18	.628	3.44	.4441
29	76.33	.844	4.62	.5964
30	74.30	.655	3.60	.4648
31	74.33	.548	3.00	.3873
32	77.09	.871	4.77	.6158

Discussion of Results and Conclusion

1- From the results of the breaking strength tests on the various yarns spun, the yarns produced from lot No. 13 was found to have the greatest tensile strength. This yarn was made from the picker lap which was produced under regular settings and speeds on the picker. The waste taken off in the picking operation was 1.2 percent. The sliver made from this lap was delivered from the card having the mote knives set closer to the licker (setting was 15/1000 inch). All other speeds and settings of the card were regular. The waste removed in carding process was 5.28 percent. The mean breaking strength of this yarn was 80.13 pounds.

2- The results of the statistical data show the yarn from lot No. 13 to have the smallest standard error of the mean, this figure being .248 pounds.

3- Statistical data shows the yarn from the lot 13 to vary less in breaking strength than any yarn from the other lots. This standard deviation from the mean is 1.36 pounds.

4- The yarn from lot 13 was found to have the smallest error of the standard deviation, this figure being .1756 pounds.

The results show that by increasing the percentage of the total waste removed from the cotton in picking and carding a stronger yarn will not necessarily be produced. Evidently some of the changes in the speeds and settings of the various parts of these machines, in an effort to increase the percentage of the total waste removed, must have caused some of the long fibers to be bróken or weakened. This damage to the long fibers is a probable cause of the lower breaking strength of the yarns in some of the other lots. It would seem that certain settings and speeds on the picker used in conjunction with certain settings and speeds on the card tend to produce yarns of maximum evenness and strength. On other types of cotton, different in grade and staple from the type of cotton used in this study, this particular combination of settings and speeds on the picker and card will probably have to be modified in order to produce the best quality of yarn.

References

(1) Cotton Waste, by Thomas Thornley

(2) By Testex, Textile Recorder, Aug. and Sept. 1935

(3) North Carolina State College Notes

(4) Textile Institute A-118, 1935

(5) Textile Institute T 88-100, 1936

(6) Same as (1)

(7) Practical Business Statistics by Croxtan and Cowden, P. 223

(8) Same as (7), P. 212

(9) Same as (7), P. 225