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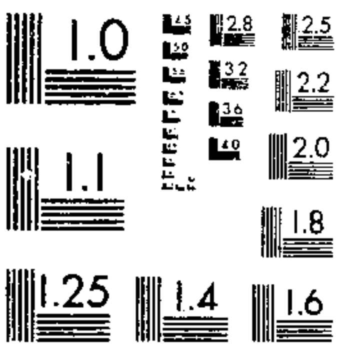

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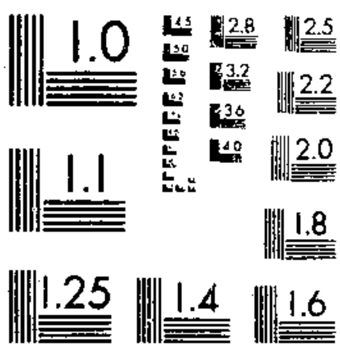

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Properties of Roller Gin Roller Covering Materials

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CONTENTS

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Properties of Roller Gin Roller Covering Materials

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INTRODUCTION

The roller gin roller is the major component of a roller gin stand. These rollers are commonly covered with a gin roller packing made of multiple layers of cotton fabric bonded together with a rubber compound.

The objectives of this research were to define the physical properties of a roller material that contribute to its energy consumption and ginning rate potential and to search for a better roller covering material.

Prior to 1940, most of the ginning rollers in this country were covered with walrus hide.[1] With the advent of the high-capacity, rotary-knife gin stand, the potential ginning rate was increased, and the roller material wear-life became a limiting factor in ginning rate. The rate at which cotton can be ginned is related to the roller-to-stationary-knife (RSK[2]) force and roller surface speed. Assuming other gin adjustments are in a reasonable range, increasing RSK force and roller surface speed increases the rate at which cotton can be ginned. These increases cause an increase in roller temperature and roller wear rate. The roller material's resistance to temperature and abrasion, its energy consumption (work required to gin a pound of lint), and ginning rate potential (pounds of cotton ginned per unit of time at maximum practical feed rate) are factors in an economic balance between long roller life and high ginning rate.

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[1] BENNETT, CHARLES A. ROLLER COTTON GINNING DEVELOPMENTS. Texas Cotton Ginners' Association and The Cotton Gin and Oil Mill Press, joint sponsors, 90 pp. 1959.

[2] RSK is used to refer to the interface between the ginning roller and the stationary knife.

TEST EQUIPMENT

Gin Roller Investigation Device

A special laboratory built, 8-inch-wide, McCarthy-type reciprocating-knife gin stand, referred to here as a gin roller investigation device (GRID), was designed to test the various roller materials. The GRID was designed to make speeds, pressures, and adjustments measurable and controllable. The roller was mounted on the machine frame with pillow block bearings and was stationary with respect to its drive motor, thus eliminating the problem of the unknown forces in the roller drive chain. The stationary knife was mounted on rails, which allowed the knife to move toward or away from the roller surface. The forces resulting from the frictional force between the roller and the knife were supported on antifriction wheels mounted in the rails.

The RSK force was applied and controlled through two pneumatic cylinders attached to the knife rail assembly and machine frame. A variable speed motor was used to drive the roller at the desired speed. The reciprocating knife was driven by a motor mounted on the knife rail assembly, thus eliminating any drive forces between the rail assembly and the machine frame. The torque to drive the roller was measured with a strain gage torque cell.

Test Roller Material

Sixteen different gin rollers were constructed to provide a range of material characteristics for testing. Six different types of roller covering materials were used: (1) Fabric and rubber packing, (2) leather, (3) cotton (experimental), (4) rubber (experimental), (5) rubber and cork (experimental), and (6) fluorinated ethylene propylene (experimental). The packing-type roller coverings were selected to give a range of hardness and number of plies of fabric per unit of roller length. The method of roller construction depended on the type of roller covering material. Conventional fabric and rubber packing rollers (roller code numbers 1 through 7 and 10 through 11) were constructed by spool winding the packing onto a wooden core.[3] The leather roller (roller 8) was made of walrus leather disks with $1\frac{7}{16}$-inch-square holes in their centers. This roller was constructed by clamping the disks between the end plates. The cotton and rubber rollers (rollers

[3] See footnote 1.

9 and 12) were constructed by bolting the disk-type materials between each roller's two end plates. The end plates were secured from turning on the roller shaft by keys. Rollers 13 through 15 were assembled by bonding the flat sheet material to the surface of a wooden core. The covering material was heat shrunk onto a knurled fiber board core for roller 16. Roller covering material and construction details are shown opposite roller code numbers in table 1.

The width, depth, beveled sides, and orientation of the layers of cotton fabric in a packing-type roller covering material are shown in figure 1. The necessity of beveling the sides of the material is dependent on the amount of cross section distortion (keystoning) due to bending the material around the roller. Distortion increases as depth increases and roller diameter decreases. The 16 trial rollers are shown in figure 2.

Additional physical characteristics of trial rollers are shown in table 2. These data were taken on the rollers after completion of the comparison test. The roller surfaces were observed with the aid of a 20-power stereoscopic microscope.

Instrumentation

Instruments were used to measure roller drive torque, roller surface speed, roller surface temperature, roller material hardness, ginning time, and weight of the ginned lint. A strain gage

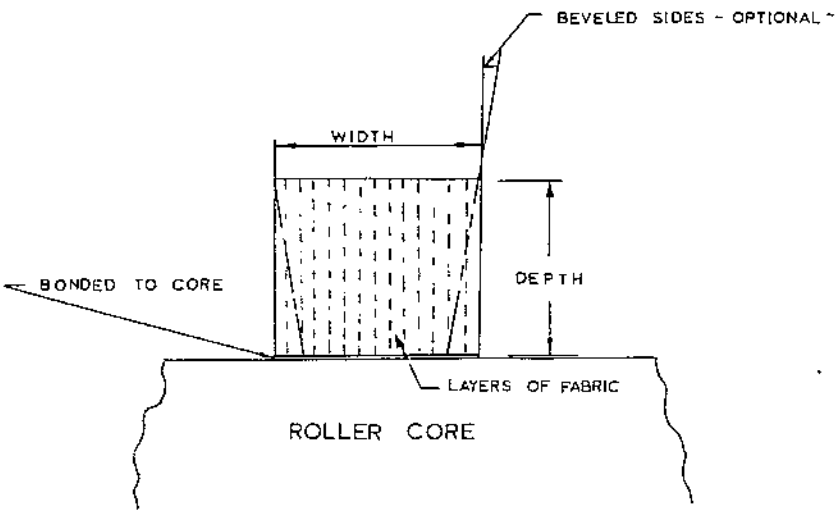


FIGURE 1.—Cross section of packing-type roller covering material made ready for bonding to roller core.

TABLE 1.—*Roller covering material and construction details of the 16 trial rollers*

Roller code	Roller covering material	Method of construction	Core material	No. of roller material edges beveled [1]	Roller material dimensions [1]		Method of fastening material to core	Year roller was constructed
					Width	Depth		
					Inches	*Inches*		
1	Fabric and rubber packing	Spool wound	Wood	1	0.75	0.94	Epoxy adhesive	1969
2	Do	do	do	2	.75	.88	do	1966
3	Do	do	do	1	.75	.94	do	1969
4	Do	do	do	1	.81	.81	do	1966
5 [2]	Do	do	do	1	.75	.75	do	1965
6	Do	do	do	1	.75	1.0	do	1966
7	Do	do	do	0	.50	.50	do	1965
8	Walrus leather	Compressed disk.	Steel (1 7/16 inch square).	(3)	.56	(4)	Clamped between end plates.	1966
9	Cotton buffing disk (½ white and ½ colored).	do	Steel (15/16 inch diameter).	(3)	.25	(4)	do	1966
10	Fabric and rubber packing.	Spool wound	Wood	1	.75	1.0	Epoxy adhesive	1966
11	Do	do	do	1	.50	.50	do	1966
12	Black rubber	Compressed disk.	Steel (15/16 inch diameter).	(3)	.12	(4)	Bolted between end plates.	1966
13	Brown sponged cork and black rubber.	Flat sheet	Wood	(3)	7.5	.12	Pressure-sensitive adhesive.	1966
14	Brown cork and synthetic rubber.	do	do	(3)	7.9	.12	Epoxy adhesive	1966

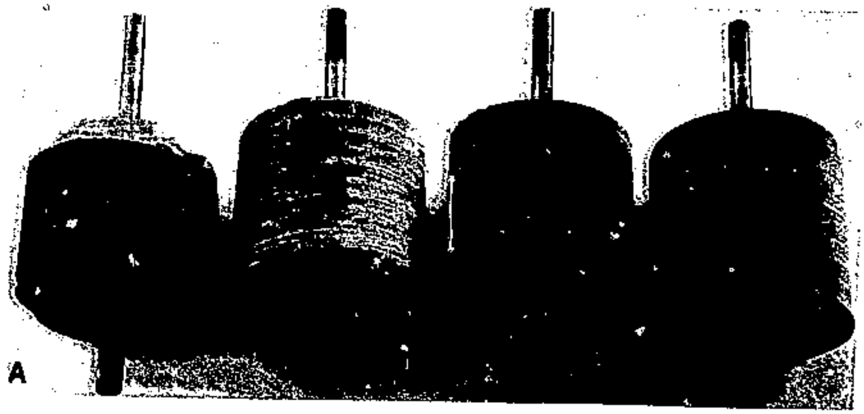
15	Gray synthetic rubber.	do	do	([3])	7.5	.083	do	1966
16	Fluorinated ethylene propylene.	Tube	Knurled fiber board.	([3])	5.5	.025	Heat shrink	1966

[1] These terms are depicted in figure 1.

[2] Roller 5 was a conventional white gin roller packing of the type used in 1965.

[3] Not applicable to this type of roller construction.

[4] The depth extends to the steel shaft, but normally only ½ to ¾ inch of depth would be available for wearing in a ginning operation.



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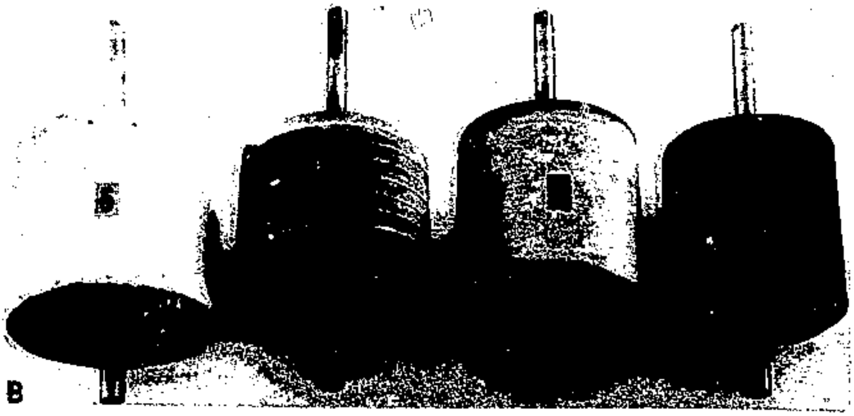

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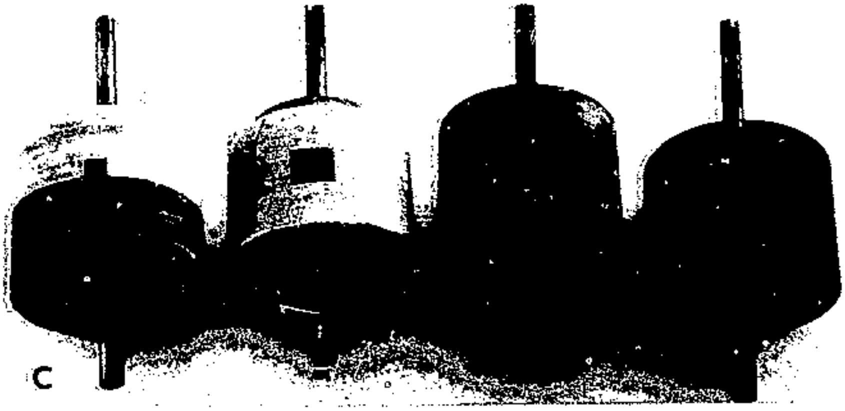
FIGURE 2.—Trial rollers: *A*, 1 through 4; *B*, 5 through 8;

torque cell was used to measure the torques applied to the ginning roller. Strain gage bridge signals were transmitted through a slip-ring assembly to a carrier amplifier-demodulator. The amplified direct current voltage signals were converted to proportional frequency signals. The average frequency for a 1-second time period was measured, and printed on paper tape by a digital recorder at 2-second intervals. The torque measuring system was zeroed by adjusting the amplifier to produce a signal of about 20 inch-pounds (in-lb) on the digital recorder when the roller was running with no RSK force applied. A zero of 20 in-lb was used because the torque measuring system would not integrate across zero volts. The torque measuring system was calibrated by applying a 55-pound load to a 3.1-inch-radius pulley and adjusting the output to read 170.5 + 20 in-lb. Roller surface speeds were measured with a chronometric tachometer. Roller surface



C

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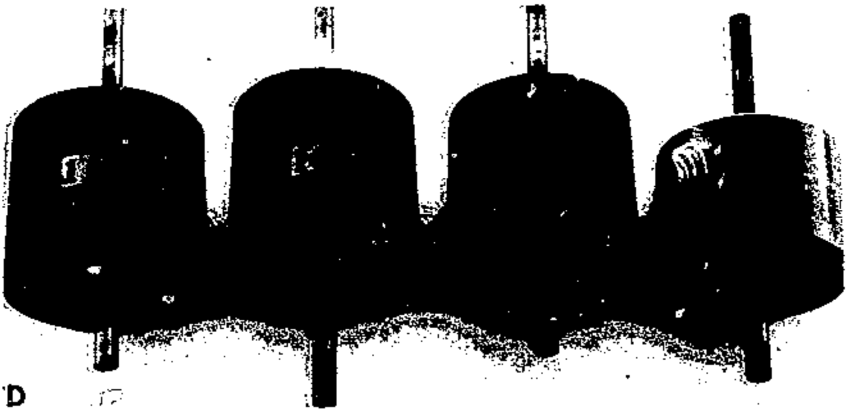

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C, 9 through 12; *D*, 13 through 16.

temperatures were measured with a sliding thermocouple-type surface pyrometer.

Roller indention hardness was measured with a type DO durometer. The type DO durometer was selected to reduce the irregular effect of the coarse surfaces of some of the materials. A type DO durometer has a 3/32-inch spherical indenter and a 10-pound mainspring. The durometer was graduated from 0 to 100. The indenter protrudes 0.100 inch at dial reading zero. Durometer hardness numbers, although arbitrary, have an inverse relation to indentation by the indentor in thousandths of an inch. For example, a reading of DO 56 durometer on a packing-type roller indicates an indentor indentation of 0.044 inch under 5.6-pound load. The hardness of roller covering materials was measured at the ginning surface after the rollers had been tried. Durometer readings for a given material are usually temperature

TABLE 2.—*Physical characteristics of trial rollers*

Roller code	Average effective roller length	Roller diameter	Layers of fabric	Fabric fiber color	Layers of fabric well defined at ginning surface	Approximate distance fiber bristles protrude above rubber surface	Rubber compound	
							Color	Elastic condition
	Inches	*Inches*	*Ply/inch of roller length*			*Inch*		
1	5.0	7.83	17	White	Yes	0.02	Light brown	Resilient.
2	7.0	8.09	18	do	No	.04	White	Do.
3	7.6	7.82	16	do	Yes	.02	Light brown	Do.
4	7.6	7.95	18	do	Yes	.04	Light gray	Some resilience and gummy.
5	7.5	8.07	17	do	No	[1]	White	No resilience and gummy.
6	4.8	8.02	17	do	Yes	.02	Light gray	Some resilience.
7	7.5	7.67	82	do	Yes	[1]	White	Damp and powdery.
8	7.0	7.22	[2]	Brown	No	[2]	[2]	[2].
9	6.5	7.86	40	White[3]	No	[2]	[2]	[2].
10	5.6	8.00	29	White	No	[1]	White	Chalky.
11	7.5	7.84	45	White[4]	Yes	0	Brown	Hard and waxy.
12	5.9	7.98	[2]	[2]	[2]	[2]	Black	Resilient.
13	7.5	8.13	[2]	[2]	[2]	[2]	do	Do.
14	7.9	8.10	[2]	[2]	[2]	[2]	Brown	Do.
15	7.5	8.02	[2]	[2]	[2]	[2]	Gray	Do.
16	5.5	8.06	[2]	[2]	[2]	[2]	[2]	[2].

[1] Rubber surface not exposed to allow measurement.
[2] Not applicable to this type roller material.
[3] One-half of the roller was made from dyed material.
[4] Fibers cemented down with brown rubber compound.

dependent. The durometer and corresponding roller surface temperatures of rollers 13 through 16 were measured at room temperature. The durometer and corresponding roller surface temperatures of rollers 1 through 12 were measured during the comparison test.

PRELIMINARY TESTING

Procedure of Preliminary Testing

The rollers made with experimental covering materials were tested first to find obvious shortcomings in performance, such as short roller life, lint contamination, or no ginning rate potential. Rollers with obvious shortcomings were not to be included in the comparison test. Rollers were tested on GRID using various roller surface speeds and RSK forces.

Commonly used roller surface speeds range from about 200 ft/min for a McCarthy-type reciprocating-knife gin stand to about 325 ft/min for the high-capacity, rotary-knife gin stand. RSK forces range from about 30 lb/in of roller length for a McCarthy-type reciprocating-knife gin stand to about 50 lb/in for a high-capacity rotary-knife gin stand. The roller speeds and RSK forces for the high-capacity, rotary-knife gin stand can be increased substantially above those given with an attendant reduction in roller life.

Results of Preliminary Testing

Roller 16 was rotated at a surface speed of 20 ft/min and 10 and 20 pounds of RSK force per inch of roller length. Durometer hardness was DO 92. It was operated dry (no cotton) for 24 minutes; then, seed cotton was hand-fed while the reciprocating knife was not in operation. The seed cotton lodged under the stationary knife and slipped on the roller surface, destroying it.

The results from rollers 15, 14, and 13 were similar. Durometer hardnesses were 48, 35, and 38, respectively. Roller surface speeds were 200 ft/min. RSK forces were about 8 lb/in of roller length. Difficulties in doffing (removal of the ginned lint from the roller surface) were encountered, and a considerable amount of roller material was observed in the lint. Roller 15 was reduced in diameter about 0.080 inch in 11 minutes of ginning. Roller 14 was reduced about 0.024 inch in 24 minutes, and roller 13 was reduced about 0.004 inch in 28 minutes. The adhesive failed on roller 13, and a section of roller covering was destroyed. Rollers 16 to 13 were not included in comparison tests because of obvious shortcomings in performance.

Roller 12 was rotated at a roller surface speed of 200 ft/min and an RSK force of 11 and 22 lb/in of roller length. The roller covering material rubbed off onto the lint when the roller slipped on the lint. However, it was included in the comparison test because its physical characteristics are similar to the rubber used to bond the cotton fabric together in packing-type roller covering material.

Preliminary testing was also conducted on roller 9, a cotton material, and it demonstrated ginning rate potential and no lint contamination. It was included in the comparison test.

COMPARISON TEST

Procedure of Comparison Test

The test compared 11 trial roller covering materials with a conventional roller covering material (roller 5) on the basis of work required to gin a pound of cotton, ginning rate potential, and roller covering material hardness. Testing of the 12 roller covering materials was performed on the GRID (fig. 3).

Ginning time for each run was 36 seconds. Each run was started by manually starting the timer, which operated the reciprocating knife. The lint was weighed to the nearest 0.1 gram. Lint weights ranged from 47 to 142 grams. The reciprocating-knife rate was 581 strokes per minute. Knife-to-knife overlap was five-eighths of an inch and knife-to-knife clearance was 0.032 inch (fig. 4). The edge of the stationary knife was three-sixteenths of an inch past the center of the roller. Roller surface speed was adjusted to 200 ft/min. The RSK force was varied by adjusting the air pressure regulator supplying air to the two pneumatic cylinders used to pull the stationary knife against the roller.

All rollers were broken in before the comparison test was run. Packing-type rollers were broken in in a normal manner. Each roller was operated for 1 to 7 hours. Dry operation (no ginning) and light ginning were alternated during this period. This procedure was continued until the rubber was abraded from the surface layer (fiber bristles extended about 0.02 inch beyond the rubber surface). The fiber bristle or nap was then more distinct and sloped away from the direction of rotation. Cotton wax was also apparently added onto the abraded ends of the bristles giving the roller surface a polished appearance. When broken in, a conventional packing-type material exhibits principally a cotton bristle surface.

The test was a randomized complete block design with four replications. A lot of cotton was ginned with each roller per replication. A Pima S–2 cotton was used for this test. Each lot consisted of six sublots. During each sublot, 12 measurements were made on each of 5 parameters: (1) Torque required to rotate the roller with no RSK force (zero), (2) torque with 170.5 in-lb calibration weight applied, (3) torque with RSK force applied not ginning, (4) torque with RSK force applied ginning cotton, and (5) roller hardness measured with a type DO durometer at the end of each run. The roller surface temperature was also measured in conjunction with the hardness measurement. The

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FIGURE 3.—GRID and associated instrumentation.

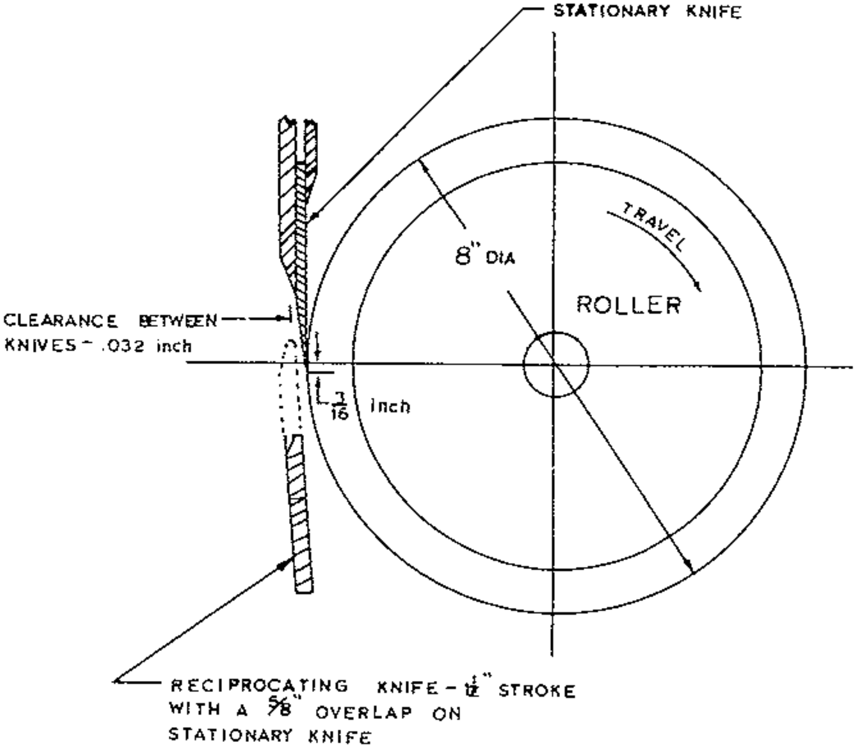

FIGURE 4.—Cross section of a reciprocating roller gin.

six sublots were repeated as fast as the lint could be weighed, durometer and temperature readings made, and the roller brought back up to steady-state temperature attained on the first sublot. Rollers were removed from the gin when six sublots were completed and the next roller was installed.

To provide an equitable base (constant input energy) of comparison, a target not-ginning torque value was calculated. This would provide 35 watts of input power per inch of roller length by correcting for differences in roller length, diameter, and coefficient of RSK friction. The rollers were run until a steady-state temperature was approached and the RSK force was adjusted until a calculated torque reading was obtained before the first sublot of each lot, except on roller 12. The coefficient of RSK friction on roller 12 was so large and the rate of temperature rise was so fast that a low value of RSK force (8 lb/in on the first lot and 7 lb/in on the remaining three lots) was used. The 12 measurements (24 seconds) of not-ginning torque were made on roller12 without any warmup period.

The RSK force used and the roller surface temperature obtained on the first sublot of each lot were used on the remaining five sublots of that lot. The force and the attendant steady-state temperature for each replication of each roller were governed by the calculated torque without reference to what force or temperature had been used previously.

Results of Comparison Test

Results of the study are shown in table 3. The numbers shown are averages of four replications. The RSK force was obtained from air cylinder areas and air pressure gage readings. The RSK force was varied to maintain a constant power to drive the roller of 35 watts per inch of roller length. RSK frictional forces were obtained from the torque readings divided by the roller radius. Coefficients of friction were obtained by dividing the frictional force by the RSK force. The power to drive the roller per inch of roller length was obtained from the product of the frictional force and the roller surface speed divided by the roller length. The ginning rate was obtained by dividing the quotient of lint weight and roller length by the ginning time. The work to gin a pound of lint was obtained by multiplying the power to drive the roller while ginning by the ginning time and dividing the product by the weight of the ginned lint.

Frictional force is a combination of sliding and rolling friction. The work to gin a pound of lint is the work to drive the roller and not the work to pull the fiber from the seed. Roller 5 had been subject to long-term, high-temperature usage before the start of the study. This had changed the appearance characteristics of the surface of the roller. The roller was used in this condition for replications 1 and 2 and was then turned down in a lathe to provide a new ginning surface for replications 3 and 4. The roller was broken in before the study was continued. The only change noticed was a decrease in RSK coefficient of friction from 0.32 to 0.22, but there was no change in the work to gin a pound of cotton.

Closeup photographs of the roller surfaces were taken after the completion of the comparison study. Figure 5 is a composite photograph of all 16 roller surfaces. The roller code numbers are in the lower right-hand corner of each block. Equal magnifications were used on all blocks. Note that the roller code numbers in table 3 correspond to increased work to gin a pound of lint for rollers 1 through 11.

TABLE 3.—*Means of frictional and ginning*

Roller code number and type of analysis	Roller surface temperature at start of run [1]	RSK [2] force [1]	Not ginning			
			RSK [2] frictional force	RSK [2] Coefficient of friction [1]	Power to drive roller	Cotton and RSK [2] frictional force [1]
No.	° *F*	*Lb/in*	*Lb/in*		*Watts/in*	*Lb/in*
1	175ab	34 fg	7.6	.227 b	34.5	8.4 cd
2	181a	40 cde	7.7	.192 bcd	34.9	9.6ab
3	172abc	39 de	7.7	.198 bcd	34.9	9.0abc
4	170abc	43 bcd	7.8	.182 cde	35.3	9.8a
5 [3]	178a	31 gh	8.0	.271a	36.2	7.2 e
6	176ab	42 bcd	7.9	.189 bcd	35.7	9.4abc
7	174ab	46 b	7.7	.169 de	35.0	8.7 bc
8	178a	28 h	7.7	.276a	35.0	7.4 de
9	172abc	36 ef	7.7	.213 bc	35.0	8.9abc
10 [4]	164 bc	44 bc	7.7	.175 cde	35.0	7.6 de
11 [4]	161 c	53a	7.6	.144 e	34.2	7.6 de
12 [5]	88	7	11.4	1.63	51.6	4.2
Level of significance of differences in rollers [6]						
Analysis of variance	*	*	NS	*	NS	*

[1] Averages followed by the same letter are not significantly different at the 99-percent level as determined by Duncan's Multiple Range Test.

[2] RSK = Roller-to-stationary-knife.

[3] Roller 5 was covered with a conventional-type gin roller packing used in 1965.

DISCUSSION OF RESULTS

Three types of roller covering materials (cotton buffing disks, leather disks, and conventional rubber and fabric packing) were compared. One of the packing-type roller covering materials (roller code 1) required significantly (1.0-percent level) less energy to gin a pound of lint.

The hardnesses of the packing-type roller covering materials were compared (rollers 1 through 7 and 10 and 11). The softer materials required less energy to gin a pound of lint.

In comparing figure 8 to the data in table 3, note that the rougher roller covering materials generally required less work to gin a pound of lint. Also, in figures 2 through 4, note that rollers 1, 2, 6, and 10 were incompletely covered due to the limited amounts of material available. This incompleteness, particularly on rollers 1 and 6, made it difficult to determine the roller's effective length, thus reducing accuracy of calculations using these values.

Rollers 12 through 16 were abandoned primarily due to high *properties of rollers 1 through 12*

Ginning				Additional power required to drive roller while ginning	Roller covering hardness, type DO durometer [1]	Roller surface temperature when hardness was measured [1]
Coefficient of friction [1]	Power to drive roller [1]	Ginning rate [1]	Work to gin 1 lb of lint [1]			
	Watts/in	*Lb/in/hr*	*Watts-hr/lb*	*Watts/in*	*No.*	*°F*
.250 b	38.0 cd	3.8ab	10.1 e	3.5	56 f	117 bc
.239 cd	43.4ab	3.9a	11.2 de	8.5	56 f	123 bc
.233 de	40.9abc	3.5ab	11.7 de	6.0	56 f	119 bc
.228 ef	44.2a	3.8ab	11.8 de	8.9	53 g	123 bc
.234 de	32.4 e	2.6 def	12.3 d	−3.8	50 h	132a
.224 f	42.3abc	3.3 bc	12.7 d	6.6	53 d	120 bc
.190 g	39.2 bc	3.1 cd	12.8 d	4.2	76 c	133a
.264a	33.5 de	2.6 ef	13.2 cd	−1.5	61 e	116 c
.245 bc	40.2abc	2.7 de	15.1 bc	5.2	38 i	121 bc
.173 h	34.4 de	2.2 f	15.5 b	−0.6	84 b	124abc
.145 i	34.5 de	1.8 g	19.9a	0.3	90a	126ab
.594	19.0	[4]	.. [4]	−32.6	31	96
*	*	*	*	*	*	*

[1] Moting groove cut in roller before test.

[3] Roller 12 not included in statistical analysis.

[4] Unginned seed in lint.

[1] * = Significant at or beyond 99.9-percent level; NS = not statistically significant at 95-percent level.

wear rates and obvious lint contamination, which are not satisfactory roller covering material characteristics.

CONCLUSIONS AND RECOMMENDATIONS

Six types of roller covering materials were tested: (1) Fabric and rubber packing, (2) leather, (3) cotton, (4) rubber, (5) rubber and cork, and (6) fluorinated ethylene propylene. From this study, it was concluded that some specimens of the fabric and rubber packing-type roller gin roller covering material were superior to all other types tested in ginning rate potential (pounds of cotton ginned per unit of time at maximum practical feed rate) and in amount of energy consumed (work required to gin a pound of lint). Roller covering materials should be selected that have physical characteristics similar to these superior specimens (rollers). These specimens were similar in hardness and type to conventionally used roller gin roller covering materials. Their hardness (type DO durometer) ranged from 50 to 63 with 56 the

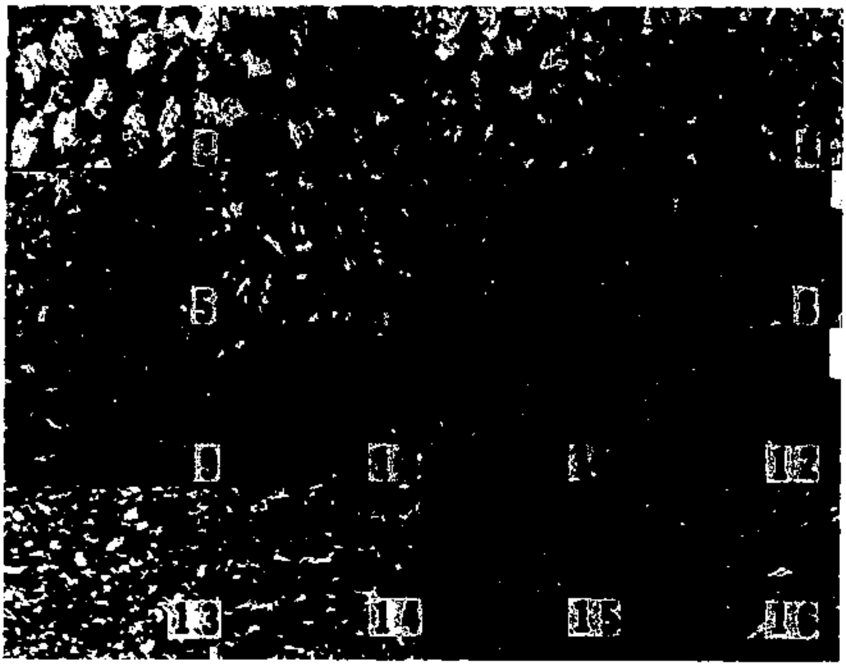

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FIGURE 5.—Closeups of the ginning surfaces of all 16 trial roller covering materials.

norm. They had 16 to 18 layers of fabric per inch of roller length. The rubber compound used to bond the layers of fabric together was resilient. The fiber bristles (fabric) protruded about 0.02 to 0.04 inch beyond the rubber surface on these rollers at the completion of the test. The bristles, although sloping away from the direction of rotation, were erect and not matted or cemented down. These tests were performed on a reciprocating-knife gin stand, but the test results will probably also apply to the high-capacity, rotary-knife roller gin stand.

SUMMARY

The roller gin roller is the major component of a roller gin stand. These rollers are commonly covered with packing-type roller covering material made from multiple layers of cotton fabric bonded together with a rubber compound. Prior to the advent of this packing-type material, the rollers were covered with walrus leather.

The objectives of this study were to define the physical properties of a roller material, which contribute to its energy con-

sumption and ginning rate potential, and to search for a better roller covering material.

A special laboratory-built, 8-inch-wide, McCarthy-type reciprocating-knife gin stand was designed to test the various roller materials. Six types of roller covering materials were tested: (1) Fabric and rubber packing (nine rollers), (2) leather, (3) cotton (experimental), (4) rubber (two rollers, experimental), (5) rubber and cork (two rollers, experimental), and (6) fluorinated ethylene propylene (experimental). The rollers made with experimental covering materials were tested (1) to find obvious shortcomings in performance such as short roller life and lint contamination and (2) to establish the existence of some ginning rate potential. The rubber and cork type was abandoned due to high wear rate and attendant lint contamination. The fluorinated ethylene propylene roller surface was destroyed soon after testing was begun. The remaining roller material types were compared to find which rollers ginned most rapidly and consumed least power per pound of cotton ginned. Some specimens of the fabric and rubber packing-type roller gin roller covering material were superior to all other types tested in ginning rate potential (pounds of cotton ginned per unit of time at maximum practical feed rate) and in amount of energy consumed (work required to gin a pound of lint).

Conventional fabric and rubber roller gin roller covering materials should be selected with the following optimum characteristics: A hardness of 56 (type DO durometer), 17 layers of fabric per inch of length, and the rubber compound should be resilient and abrade away in such a way that 0.03 inch of fiber bristles protrudes beyond the rubber surface.

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