TB 1716 (1986) USDA TECHNICAL BULLETINS UPDATA
PRACTICAL AIRFLOW RATES IN SHELF DRYERS FOR SEED COTTON
MANGIALARDI, G.J., JR 1 OF 1

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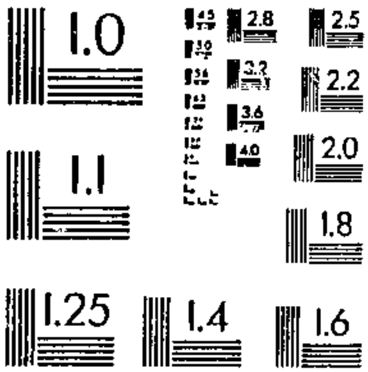

United States Department of Agriculture

Agricultural Research Service

Technical Bulletin Number 1716

Practical Airflow Rates in Shelf Dryers for Seed Cotton

In Cooperation With the Mississippi Agricultural and Forestry Experiment Station

ABSTRACT

Mangialardi, Gino, J., Jr. 1986. Practical Airflow Rates in Shelf Dryers for Seed Cotton. U.S. Department of Agriculture, Technical Bulletin 1716, 12 pp.

A study conducted to evaluate the effect of heated-air velocity and air-to-cotton ratio on the amount of moisture evaporated from seed cotton in cotton gin dryers established minimum practical airflow rates for the dryers. The results can be used to reduce energy requirements in the transport and drying of cotton at gins and in setting guidelines for gin-dryer designs. Machine-picked seed cotton at moisture contents ranging from 9 to 20 percent was conveyed through a two-tower dryer shelf system using a drying temperature of 230° to 240°F, air velocities of 742 to 1,497 ft/min, and air-to-cotton ratios of 8.4 to 36.2 ft^3 air/lb seed cotton. Results showed that an air velocity of 1,200 ft/min in the dryer at a ratio of 13.2 ft^3 air/lb seed cotton is sufficient to convey the dampest cotton expected at the gin through tower dryers. A velocity of 1,000 ft/min at a ratio of 11.4 ft^3/lb can be used on normal cottons. Limiting the airflow to that required to convey seed cotton did not significantly affect the moisture evaporation rate.

Keywords: cotton, cotton gin equipment, dryer airflow rate, gin drying, ginning, gin tower dryers, seed-cotton drying.

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Issued May 1986

PRACTICAL AIRFLOW RATES IN SHELF DRYERS FOR SEED COTTON

by Gino J. Mangialardi, Jr.[1]

INTRODUCTION

Green or damp seed cotton is not only difficult to gin but also results in a lower lint grade than that obtained from dry cotton. Recognition of the benefits to be derived from drying damp seed cotton at gins led to the development of the shelf seed-cotton dryer by the U.S. Department of Agriculture in 1932 (Bennett and Gerdes 1941). In that dryer, the seed cotton was treated with a continuous current of warm air at the rate of 40 to 100 ft^3 of air/lb seed cotton. The dryer itself had no moving parts, and seed cotton was conveyed through it by the warm air. Centrifugal fans and steam radiators provided the energy for conveying and drying the cotton. The shelf dryer, with slight modifications, is the standard used by the ginning industry today.

Machinery layouts of ginneries vary widely so air requirements and drying-exposure periods differ from gin to gin. Because of the wide variations, the ARS cotton-ginning laboratories have refrained from recommending specific operating temperatures. However, in no case should the air temperature in any portion of the drying system containing cotton exceed 350°F, because serious damage to fiber quality can occur (Griffin 1977).

If the volume of air flowing through a dryer is increased while its temperature remains constant, the heat available for evaporating moisture increases, but the extra air increases the air and seed-cotton velocities and results in a shorter exposure period for drying. Gins obtain some control over exposure time in a stepwise fashion by using two or more dryers in the machinery sequence.

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Conventional tower dryers have limited inherent automatic-exposure control, because damp cotton travels through the system more slowly than does dry cotton (Leonard 1964).

Cocke (1975) conducted drying tests in South Carolina in 1971 and 1972 that showed that increasing the air-to-cotton ratio from 31 to 38 ft^3/lb of seed cotton did not significantly affect moisture removal. Neither did the air volume affect the efficiency of the drying system, based on the weight of moisture removed from seed cotton per 1,000 ft^3 of air.

Mangialardi (1977) demonstrated in 1973 and 1974 that air velocities of about 2,500 ft/min at a ratio of 10 ft^3 of air/lb of seed cotton at 20-percent moisture and about 1,800 ft/min at a ratio of about 13 ft^3/lb of seed cotton at 10-percent moisture are sufficient to convey spindle-picked seed cotton in pipes. These experiments were conducted using an 8-inch-diam. pipe system and a suction fan.

Further tests by Mangialardi (1979) in 1975 and 1976, using a one-tower dryer system, showed that an air velocity of about 600 ft/min in the dryer appeared to be the lower limit for transporting seed cotton through the dryer even at 7-percent seed-cotton moisture content. An air velocity of about 1,000 ft/min in the dryer appeared to be the lower limit for transporting damp seed cotton.

Pneumatic transport systems consume from 40 to 60 percent of the total power required in a cotton gin. The heart of the pneumatic system is the centrifugal fan that moves the air that conveys seed cotton to, or through, the various processes in the gin. Seed cotton is usually conveyed through pipes at air velocities of 4,000 to 5,000 ft/min and in the tower dryer at 1,200 to

1,400 ft/min. Dried cotton is conveyed from one processing machine to the next at air velocities of 3,000 to 4,000 ft/min (Stedronsky 1964). Diameters of pipes connecting machines are usually 6 to 36 inches.

Early ginning installations had to accommodate cottons of widely varying physical conditions and had to function even when receiving cotton in "slugs" directly from the unloading system. Cotton delivered to a present-day gin is usually uniform in density and foreign matter content, and properly designed gins include a device for breaking wads and feeding cotton into the seed-cotton drying and cleaning system at a relatively even rate of flow. Modern harvest practices and gin design suggest that in many instances, the air-to-cotton mass ratio could be controlled to save fuel and lower power requirements.

According to theoretical laws of pneumatic conveying, (1) the volume of air moved by fans varies directly with the rotational speed of the fan, (2) resistance pressure varies with the square of the speed, and (3) power required varies with the cube of the speed (McDonald 1958). Reductions in the velocity and therefore the volume of air used at gins would substantially decrease the power required. For example, if a fan that has been delivering 12,000 ft^3 of air/min and using 24 hp of power is reduced in speed so that it delivers only one-half the volume--6,000 ft^3/min--the power consumed will decrease, by a factor of 8, to 3 hp.

This publication is a progress report on seed-cotton drying research at the U.S. Department of Agriculture, Agricultural Research Service, Cotton Ginning Laboratory, Stoneville, MS. The objectives of this phase of the investigation were to (1) evaluate the effect of air velocity and air-to-cotton ratio (in cubic feet of air per pound of seed cotton) on the amount of moisture evaporated and (2) establish minimum practical airflow rates for seed-cotton dryers. The data are useful for reducing energy requirements for drying seed cotton and in setting guidelines for gin-plant dryer designs. Two experimental series were conducted.

EXPERIMENTAL MACHINERY

The Laboratory's commercial-size ginning plant was used for the experiments. The drying and cleaning sequence consisted of a feed controller; 24-shelf tower dryer; 6-cylinder cleaner; stick, leaf, and hull machine; 24-shelf tower dryer; 6-cylinder cleaner; extractor-feeder; gin stand; and two stages of saw-cylinder lint cleaning. Seed cotton was transported through each dryer system by two fans in a push-pull arrangement.

In each 24-shelf dryer system, a 16-inch-diam. pipe transported air to the seed-cotton pickup point, a 14-inch-diam. inlet pipe carried seed cotton from pickup point to the top of the dryer (fig. 1), and a 14-inch-diam. outlet pipe carried the seed cotton from the dryer to a 6-cylinder cleaner. Thus, gravitational force aided seed-cotton flow through the rectangular-shaped shelves from the top to the bottom of the dryer. The tower-dryer shelves were 52 inches wide and 8-1/2 inches high and this cross-sectional area resulted in average air velocities in the dryer that were 35 percent of those in the 14-inch pipe. The inlet pipe lengths were 33 and 43 ft for the first and second tower-dryer systems, and corresponding outlet pipe lengths were 61 and 59 ft.

Stainless steel one-eighth-inch-diam. pitot tubes with built-in compression fittings were installed in portions of the 16-inch- and 14-inch-diam. pipes and connected to water gauges to measure and monitor air pressures and velocities (Bennett 1943). The average air velocity in the pipe was about 90 percent of the velocity at the center of the pipe. Windows in the sidewalls of the dryer permitted observation of the moving cotton.

TEST PROCEDURES

The cottons used in the experiments were grown and harvested by spindle pickers in Washington County, MS. All cottons were of the Delta Experiment Station (DES)-56 variety and were harvested in October. The initial foreign matter content of the cotton at the gin ranged from 3.1 to 8.1 percent.

The cotton moisture levels were controlled by monitoring relative humidity in the field and harvesting at selected periods and by controlling the amount of water applied to the cotton-harvester spindles. Each test lot consisted of one-half bale (725 lb), and the seed cotton was fed into the drying system at rates ranging from 5.0 to 13.7 bales/h.

The experimental design required testing cotton of a constant moisture content at various air velocities and air-to-cotton ratios. The results from experimental series 1 were used to determine which

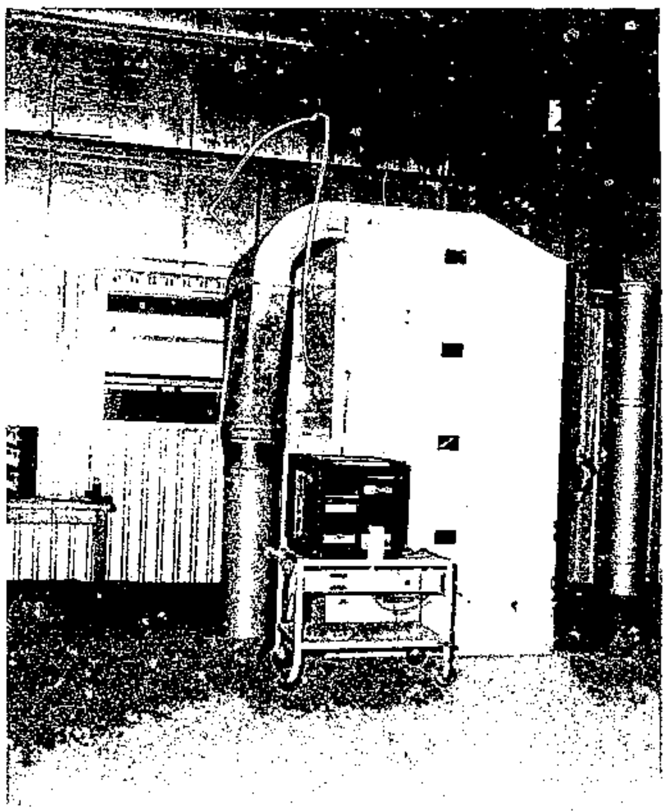

Figure 1—Upper section of 24-shelf tower dryer and 14-inch-diam. cotton pipe used in seed-cotton airflow experiment.

velocities and ratios were to be tested in experimental series 2. Air velocity and air-to-cotton ratios were controlled by adjusting gate valves in the 16-inch pipes and modifying the seed-cotton feed rate.

The moisture content of cotton was determined by oven drying (American Society for Testing and Materials 1971) samples of seed cotton before feeding through the system, seed cotton at the feeder apron, and cottonseed and lint at ginning. The fractionation procedure was used to obtain the foreign matter content of the cottons (Shepherd 1972).

Four flow descriptions were used to describe the ability of the system to transport seed cotton through the dryers at the velocities and ratios tested: A, normal; B, normal-to-sluggish flow in dryer; C, sluggish flow; and D, sluggish flow with some seed cotton sliding on dryer shelves.

Airflow measurements taken during the experiments allowed calculation of the air-to-cotton ratio on two bases: (1) the volume of air flowing with no cotton in the system and (2) the volume of air flowing while transporting cotton. This procedure permitted calculating airflow changes when cotton was introduced into the system.

Forty-eight lots of cotton were tested in the study, which involved three moisture levels, two processing rates, and four air velocities in each of the two experimental series. The seed-cotton moisture contents before drying ranged from 9.0 to 20.0 percent. When measured with no cotton in the system and corrected to standard air conditions of 70°F and 29.92 inches Hg barometric pressure, center-of-pipe air velocities in the cotton pipe varied from 2,390 to 4,824 ft/min and average dryer air velocities ranged from 742 to 1,499 ft/min. Air-to-seed-cotton ratios ranged from 8.3 to 35.4 ft^3 of air/lb of seed cotton for the experiments with cotton in the system. Seed cotton was conveyed with air at a drying temperature of 230° to 240°F. The burners operated under automatic control and were set to maintain this temperature at the air-cotton mix point. Although the tested airmass rate of flow remained constant, the burners increased the actual air velocity in the heated cotton pipes. For example, the dryer air velocity set at 1,000 ft/min at standard air conditions increased to about 1,140 ft/min when heated to 240°F. Ambient temperatures were in the range of 57° to 77°F.

RESULTS AND DISCUSSION

Measurements in the air and cotton pipes, with and without seed cotton flowing through the system, indicated that the flow of air decreased when cotton entered the system (table 1). The greater the cotton feed rate, the more the airflow was reduced. The airflow reduction averaged 8 and 16 percent for the average feed rates of 5.9 and 10.2 bales/h, respectively.

Some air leaked through the vacuum dropper at the main pipe at the feed-controller unit. The amount of leakage depended on the static pressure levels of the air in the pipe near the dropper. It would also depend on the condition of the dropper seals and the speed at which the dropper rotated.

When seed cotton was flowing through the system and the mix-point temperature was 235°F, corresponding temperatures measured at the dryer inlets, dryer

Table 1
Air-to-cotton ratios and airflow reduction for seed cotton transported and dried at 2 feed rates and 4 air-velocity settings[1]

Seed-cotton feed rate (bales/h)	Air velocity in tower dryer (ft/min)	Air-to-seed-cotton ratio: Without cotton flow (ft^3/lb)	Air-to-seed-cotton ratio: With cotton flow (ft^3/lb)	Airflow reduction (%)
	Experimental Series 1			
5.8	1,017	20.9	19.3	8
	1,174	27.0	24.5	9
	1,342	29.4	26.6	10
	1,497	36.2	33.0	9
9.9	1,017	14.4	13.0	10
	1,174	14.2	12.0	16
	1,342	17.7	14.7	17
	1,497	20.0	16.7	17
	Experimental Series 2			
6.0	742	15.8	14.9	6
	893	20.5	18.9	8
	1,032	22.3	20.4	9
	1,170	24.7	22.7	8
10.4	742	9.3	8.4	10
	893	11.6	10.4	10
	1,032	14.7	10.0	33
	1,170	15.7	13.4	14

[1]Data are the averages of 3 replications.

outlets, and air-cotton separation points were 199°, 174°, and 145°F. Heat energy of the drying air for the treatments tested ranged from 31 to 141 Btu/lb cotton at the air-cotton mix point.

Seed-cotton samples taken at the feeder apron after drying averaged 9.8 percent moisture content compared with 12.2 percent before drying. This indicated that the two-tower dryer system removed about 21 percent of the total moisture in the seed cotton (table 2).

Differences among air velocities and seed-cotton feed rates did not cause statistically significant differences in the seed-cotton moisture content after drying, percentage of seed-cotton moisture removed, or lint moisture content at ginning on either experimental series (table 2). However, decreasing the seed-cotton feed rate from 10 to 6 bales/h increased the amount of initial seed-cotton moisture removed from 19.4 to 22.4 percent. No consistent improvement in the average amount of moisture evaporated was obtained by increasing the air volume and velocity. Thus, it was shown that an airflow rate sufficient to convey cotton through the dryers would be sufficient to give satisfactory moisture evaporation.

Relationships between the percentage of total seed-cotton moisture removed and the air-to-seed-cotton ratio and heat energy of the drying air were tested by regression analysis. The regression equations had low correlation coefficients that were not significant. There were factors or combinations of factors, other than air-to-cotton ratio and energy of drying air, that affected the amount of moisture evaporated. Some of these factors include location of moisture within the cotton, foreign matter content, fluffiness of locks, air velocity and period of drying, amount of agitation against pipe and dryer walls, and quite likely the effect of the falling-rate drying curve.

At a constant air velocity, cotton flow improved when the air-to-cotton ratio was increased (table 3). It was also noted, particularly on the low-air-velocity treatments, that cotton flow appeared to be more normal in tower dryer No. 2 than in tower dryer No. 1. This improved performance was attributed to (1) a continuous reduction of the moisture content of the cotton by the heated air during its flow, resulting in a decreased cotton mass, and (2) an increase in the aerodynamic surface of seed-cotton units, due to fluffing.

Data for the 48 test lots are arranged in table 4 according to cotton-flow designations and initial seed-cotton moisture contents. For example, normal seed-cotton flow for the cottons with 17.6- and 14.9-percent moisture content occurred at drying air velocities of 1,170 and 1,032 ft/min. Air-to-seed-cotton ratios at these velocities were 20.7 and 17.8 ft^3/lb measured with cotton in the system. Since the airflow decreased when the dryer was loaded with cotton, the air-to-cotton ratios under "unloaded" conditions were somewhat higher than those depicted in the table.

By using the standard air density of 0.075 lb/ft^3, the amount of air used in the experiments can be converted from volume units to mass units by the equation that

$$M = 0.075 R,$$

where

M = ratio in pounds of air per pound of seed cotton, and

R = ratio in cubic feet of air per pound of seed cotton.

Some sluggish cotton flow began to occur when the cotton with 11- to 16-percent moisture content was conveyed through the dryers at air velocities of 1,018 to 1,032 ft/min and air-to-cotton ratios of 10.6 to 21.8 ft^3/lb. At an air velocity of 893 ft/min, all cottons flowed sluggishly, even at the ratio of 21.6 ft^3 of air/lb seed cotton.

All cottons began to slide on the bottom of the dryer shelf when air velocity in

Table 2
Amounts of moisture removed for seed cotton transported and dried at 2 feed rates and 4 air-velocity settings[1]

Seed-cotton feed rate (bales/h)	Air velocity in tower dryer			
	Experimental Series 1			
	1,017 ft/min	1,174 ft/min	1,342 ft/min	1,497 ft/min
	Seed-cotton moisture content after drying (%)			
5.8	10.1	8.9	8.9	8.9
9.9	9.9	9.1	9.4	9.5
	Moisture removed (%)[2]			
5.8	20.9	20.7	21.9	21.6
9.9	19.6	22.4	12.7	14.9
	Lint moisture content at ginning (%)			
5.8	5.9	5.4	5.1	5.1
9.9	5.6	5.7	5.4	5.4
	Experimental Series 2			
	742 ft/min	893 ft/min	1,032 ft/min	1,170 ft/min
	Seed-cotton moisture content after drying (%)			
6.0	10.9	9.6	9.5	10.0
10.4	9.9	10.1	9.4	11.0
	Moisture removed (%)[3]			
6.0	29.6	22.9	18.1	23.7
10.4	14.4	25.7	27.8	18.1
	Lint moisture content at ginning (%)			
6.0	5.1	4.7	4.4	5.1
10.4	5.2	5.0	4.9	5.6

[1]Data are the averages of 3 replications. Differences among air velocities and between feed rates within series are not significant at the 5-percent level for seed-cotton moistures after drying, percentage of moisture removed, or for lint moisture content at ginning.

[2]Initial moisture content averaged 11.6 percent.

[3]Initial moisture content averaged 12.8 percent.

Table 3
Air-to-cotton ratios and cotton flow designations for seed cotton transported and dried at 2 feed rates and 4 air-velocity settings[1]

Seed-cotton feed rate (bales/h)	Air velocity in tower dryer			
	Experimental Series 1			
	1,017 ft/min	1,174 ft/min	1,342 ft/min	1,497 ft/min
	Air-to-seed-cotton ratio with cotton flow (ft^3/lb)			
5.8	19.3	24.5	26.6	33.0
9.9	13.0	12.0	14.7	16.7
	Cotton flow designation[2]			
5.8	A	A	A	A
9.9	B	A	A	A
	Experimental Series 2			
	742 ft/min	893 ft/min	1,032 ft/min	1,170 ft/min
	Air-to-seed-cotton ratio with cotton flow (ft^3/lb)			
6.0	14.9	18.9	20.4	22.7
10.4	8.4	10.4	10.0	13.4
	Cotton flow designation[2]			
6.0	D	B	A	A
10.4	D	C	B	A

[1]Data are the averages of 3 replications.

[2]Flow designation: A, normal flow; B, normal-to-sluggish flow in dryer; C, sluggish flow; D, sluggish flow with some seed cotton sliding on bottom of dryer shelf.

Table 4
Air-to-cotton ratios and cotton flow designation at various dryer air velocities and cotton moisture contents, 2 experimental series

Cotton flow designation[1]	Seed-cotton moisture content (%)	Air velocity in dryer (ft/min)	Air-to-cotton ratio[2]	Seed-cotton feed rate (bales/h)
D	20.0	742	12.6	7.1
D	14.5	893	11.4	9.1
D	13.7	743	15.4	5.9
D	13.5	742	16.8	5.3
D	11.8	742	8.4	10.1
D	11.5	742	8.4	10.4
D	10.0	743	8.3	10.3
C	12.1	893	21.6	5.0
C	10.7	894	9.8	10.4
C	10.3	893	10.1	10.3
B	16.1	1,018	10.9	10.7
B	15.8	1,018	16.8	7.0
B	15.1	1,032	10.8	10.9
B	14.8	893	16.4	6.4
B	12.3	1,032	10.6	10.9
B	11.3	1,018	14.9	7.9
B	11.0	1,032	21.8	5.6
A	17.6	1,170	20.7	6.7
A	14.9	1,032	17.8	6.7
A	14.4	1,170	12.8	10.1
A	14.3	1,170	11.3	10.8
A	13.7	1,176	22.6	5.8
A	13.1	1,498	28.1	6.2
A	13.0	1,343	25.8	6.2
A	12.9	1,498	13.5	12.0
A	12.3	1,176	10.9	11.2
A	12.1	1,018	20.2	6.1
A	11.9	1,170	24.3	5.7
A	11.8	1,499	19.8	7.8
A	11.8	1,175	12.4	10.1
A	11.8	1,171	16.2	8.2
A	11.7	1,343	17.4	8.2
A	11.6	1,499	35.4	4.8
A	11.6	1,339	25.6	6.0
A	11.4	1,033	8.5	13.7
A	11.0	1,339	13.8	10.9
A	10.8	1,172	26.5	5.2
A	10.8	1,172	12.7	10.6
A	10.6	1,171	23.2	6.0
A	10.5	894	18.8	5.6
A	10.3	1,015	20.8	5.7

Table 4--Continued
Air-to-cotton ratios and cotton flow designation at various dryer air velocities and cotton moisture contents, 2 experimental series

Cotton flow designation[1]	Seed-cotton moisture content (%)	Air velocity in dryer (ft/min)	Air-to-cotton ratio[2]	Seed-cotton feed rate (bales/h)
A	10.2	1,175	24.4	5.8
A	9.7	1,343	28.4	5.4
A	9.7	1,033	21.5	5.7
A	9.5	1,015	13.1	8.9
A	9.4	1,343	12.9	10.6
A	9.3	1,494	35.6	5.1
A	9.0	1,494	16.8	9.8

[1]Flow designation: A, normal flow; B, normal-to-sluggish flow in dryer; C, sluggish flow; D, sluggish flow with some seed cotton sliding on bottom of dryer shelf.

[2]Air-to-cotton ratio is in cubic feet of air per pound of seed cotton and is based on air measurements taken with cotton in the system. Measurements were corrected to air at 70°F and 29.92 inches Hg barometric pressure.

the dryer was reduced to 743 ft/min. At this airflow rate, the air-to-cotton ratio ranged from 8.3 to 16.8 ft^3/lb. Lower air velocities and mass-ratio combinations than those shown in the tables caused cotton to choke the air passages in the tower dryers.

Using the experimental data, tower dryer cross-sectional shelf areas were calculated for normal cotton flow for gin plants handling 3 to 36 bales/h (table 5). The required cross-sectional shelf area can be ascertained from the equation that

$$A = \frac{27.44\ FR}{V},$$

where

A = tower dryer cross-sectional shelf area in square feet,

F = feed rate in 1,450-lb bales per hour,

R = air-to-seed cotton ratio in cubic feet per pound, and

V = shelf air velocity in cubic feet per minute.

A typical tower dryer system in a gin plant with a processing rate of 18 bales/h, a desired air velocity of 1,200 ft/min in the dryer, and an air-to-cotton ratio of 13.2 ft^3/lb would require a shelf cross section of 5.43 ft^2 to obtain normal cotton flow. The 8-1/2-inch-high shelf of the experimental dryer would need a width of 7.67 ft to provide this cross section. If measured with no cotton in the system, the air-to-cotton ratio should average about 12 percent higher than those indicated in table 5 for "loaded" conditions.

Table 5
Cross-sectional dryer shelf areas required for conveying seed cotton through tower dryers at 2 air velocities[1] and air-to-seed-cotton ratios[2]

Seed-cotton feed rate (bales/h)[3]	Shelf area required (ft^2) for -- 1,000 ft/min air velocity, 11.4:1 ratio	1,000 ft/min air velocity, 13.2:1 ratio	1,200 ft/min air velocity, 11.4:1 ratio	1,200 ft/min air velocity, 13.2:1 ratio
3	0.94	1.09	0.78	0.91
6	1.88	2.17	1.57	1.81
12	3.77	4.35	3.14	3.62
18	5.65	6.52	4.71	5.43
24	7.54	8.70	6.28	7.25
30	9.42	10.87	7.85	9.06
36	11.30	13.05	9.42	10.87

[1]Average air velocity in the tower dryer without cotton flow.

[2]Ratio of cubic feet of air per pound of seed cotton (air measured with cotton flow at standard air conditions).

[3]One bale equals 1,450 lb of seed cotton.

CONCLUSIONS

Fuel use and power requirements at gins can be minimized by providing only enough air to ensure conveying seed cotton through the dryer and from machine to machine. The experiments showed that the minimum quantity of conveying air at 230° to 240°F would also be sufficient for adequate moisture removal in shelf drying systems.

The minimum air velocity in the shelf dryer, measured under standard air conditions, should be about 1,200 ft/min for seed cotton at 18-percent moisture and about 1,000 ft/min for cotton at 10-percent moisture. These velocities should be used with air-to-cotton ratios of 11.4 to 13.2 ft^3 of air/lb seed cotton. Problems with cotton flow can be expected at velocities below 900 ft/min and air-to-cotton ratios below 9.7 ft^3/lb.

Power requirements and fuel use could be reduced by inserting a gate valve in the portion of the air line containing no cotton and by reducing the rate of airflow when dry cotton is being processed. Airflow could be cut off completely in some pipes when cotton is not being conveyed, but a minimum flow should be maintained in the heated air lines because complete cutoff would interfere with safe operation of the burner.

Since vacuum droppers are used for moving seed cotton into and out of air lines, some air leakage is unavoidable at these openings. One way to reduce the amount of leakage would be to redesign the air system so that the point in the pipes where static pressure is neutral could be near the droppers.

In drying systems that have shelf dryers, the airflow rate in the heated pipes is influenced by the width of the dryer and the clearance between shelves. The air velocity must be adequate to maintain seed-cotton flow within the dryer.

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