Background Report Reference

AP-42 Section Number: 9.7

Background Chapter: 2

Reference Number: 8

Title: Primary and Secondary Cleaning of Lint Cleaner Exhaust Air: A Progress Report

M.N. Gillum et al.

Transactions of the American Society of Agricultural Engineers

1981

AP-42 Section 9.7
Reference —
Report Sect. 2
Reference 8

Primary and Secondary Cleaning of Lint Cleaner Exhaust Air: A Progress Report

M. N. Gillum, S. E. Hughs, R. N. Rakoff, T. E. Wright

This article is reprinted from the TRANSACTIONS of the ASAE (Vol. 24, No. 6, pp. 1605-1607, 1612, 1981)
Published by the American Society of Agricultural Engineers, St. Joseph, Michigan

ABSTRACT

A preliminary evaluation was made of the effectiveness of cyclone collectors as primary, and a wet scrubber as secondary particulate collector on a lint cleaner exhaust. The cyclone collectors captured about 97 percent by weight of the particles as a primary cleaner. The wet scrubber removed 50 percent by weight as a secondary cleaner.

INTRODUCTION

Particulate emissions from cotton gins has been a problem since mechanical cotton harvesters replaced hand picking. Mechanical picking increased the rate at which seed cotton is harvested, and the levels of foreign material in seed cotton delivered to the gin (Harrell and Moore, 1962). Consequently, gins had to increase process rates and the amount of seed cotton and cotton lint cleaning equipment. These increases required that the gin use more process air and air that contained higher levels of particulates.

Gin process air streams are roughly divided into two primary categories, high pressure and low pressure (Harrell and Moore, 1962; Stedronsky, 1968). The straight blade, centrifugal fans used for high-pressure air streams are capable of operating against resistance pressures of about 46 cm (18 in.) of water column. High-pressure air streams are used for conveyance in the seed cotton cleaning and moisture conditioning section of the gin prior to the gin stand where the fiber and seed are separated.

The axial-type fans used for low-pressure air streams can operate against a resistance of about 15 to 20 cm (6 to 8 in.) of water column. Low-pressure air streams are used for conveyance in the lint handling section of the gin after the gin stand.

Trash is removed from the seed cotton and cotton lint at several points during the ginning process. Either a high- or low-pressure air stream usually conveys the cotton trash from the various removal points to the exterior of the cotton gin. The air stream is exhausted to the atmosphere, and the trash is collected in some manner outside the gin building. The nature of the trash collection device depends on whether a high- or low-pressure air stream is used to convey the trash.

Article was submitted for publication in August 1980; reviewed and approved for publication by the Electric Power and Processing Division of ASAE in April 1981. Presented as ASAE Paper No. 80-3077.

J. K. Jones handled the arrangements for funding the installation by Cotton, Inc.

The authors are: M. N. GILLUM, Agricultural Engineer, S. E. HUGHS, Acting Research Leader, R. N. RAKOFF, Mechanical Engineer, and T. E. WRIGHT, Former Agricultural Engineer, Southwestern Cotton Ginning Research Laboratory, USDA-SEA-AR, WR, Mesilla Park, NM.

Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the U.S. Department of Agriculture and does not imply its approval to the exclusion of other products that may be suitable.

REVIEW OF CURRENT GIN EMISSION CONTROL METHODS

Small diameter cyclone collectors (Baker and Stedronsky, 1967; Wesley, McCaskill, and Columbus, 1970) are the most common pollution control method used on high-pressure air stream exhausts. These devices, when properly sized, operate with a pressure drop of about 10 cm (4 in.) of water column and remove over 99 percent of particulates by weight. Cyclone collectors are relatively easy to build and install and are rugged and simple to operate.

Skimmers (Kirk et al., 1976) can be used on high-pressure exhausts in place of cyclones. They can also be used on low-pressure exhausts by adding additional fan power. The particulates removed from air streams by skimmers must be trapped by a secondary device, such as a small diameter cyclone, but one cyclone can handle the exhausts from several skimmers on several air exhausts. Skimmers are durable and have lower pressure drops than cyclones, so they require less energy. Kirk's data indicate that the collection efficiency of skimmers is about 50 percent.

Unifilter collectors (McCaskill and Wesley, 1976) were designed to handle trash from all high- and low-pressure exhausts simultaneously. Laboratory test measurements indicated the unifilter prototype with foam-filter media had an average efficiency of 99 percent when collecting trash from both high- and low-pressure gin plant exhausts. The prototype unit tested was designed to have a pressure drop of 1.3 cm (0.5 in.) of water column or less. Unifilters installed in commercial high capacity gins have had some operational problems. The performance of the foam-filter media degrades rapidly when picker oil and lint fly clog the filter surface. As a result of clogging problems, gins run exhausts into a unifilter selectively. The filter media also are susceptible to damage by the fires that are common in gins.

Screen cages (Harrell and Moore, 1962), which often are used for pollution control on low-pressure exhausts of gins, are simple, rugged, and have a low-pressure drop. Their overall efficiency is probably relatively low, but data are not available. Screen cages must be kept dry, or they become clogged with caked lint and dust that must be manually removed.

Inline air filters (Alberson and Baker, 1964) also are used on low-pressure exhausts. There are several designs of inline filters (Baker and Parnell, 1971), but they all operate with pressure drops of less than 2.5 cm (1 in.) of water column. The efficiency of a properly designed inline filter is about 75 percent (Wesley, Cocke, and Garner, 1976).

Wet scrubbers have also been tried by the ginning industry as primary controls without much success. They require a large amount of water that creates a disposal problem. Scrubbers have the potential for high efficien-

TABLE 1. COTTON GIN SOURCE TEST RESULTS

State	Seed cotton process rate*	Total emissions	High pressure side	Low pressure side	Allowable emissions†
	Kg/h (lb/h)	Kg/h (lb/h)	Kg/h (lb/h)	Kg/h (lb/h)	Kg/h (lb/h)
Arizona	2313 (5100)	3.4 (7.5)	1.9 (4.1)c	1.5 (3.4)l	2.7 (6.0)
Arizona	5851 (12900)	13.4 (29.5)	7.2 (15.9)c	6.1 (13.5)l	5.1 (11.2)
California	8845 (19500)	23.7 (52.2)	11.9 (26.5)c	12.0 (26.6)l	7.0 (15.3)
California	14016 (30900)	15.6 (34.3)	10.1 (21.9)u+c	5.6 (12.4)‡u+c	9.3 (20.4)
California	15649 (34500)	18.0 (39.6)	9.5 (20.0)‡u+c	8.5 (18.8)u+c	9.9 (21.8)

*Using 680 kg (1500 lb) of seed cotton per bale of cotton lint.
†From process weight table for appropriate state.
‡Not measured, a calculated estimate, c = cyclones, l = lint cages, u = unifilter. Some of the low pressure exhausts may have not been going into the unifilter.

cy, if they can be successfully adapted to the ginning industry. More work should be done on the use of wet scrubbers as secondary, rather than as primary, collectors.

EMISSION STANDARDS AND PARTICULATE EMISSION LEVELS

Cotton gins are classified by the Environmental Protection Agency (EPA) as stationary emission sources for the purpose of setting standards and regulating emission levels. Allowable particulate emission levels for stationary sources have been set by various state pollution control boards based on the weight of material processed in one hour (Wilmot et al, 1974). These allowable emission levels are published in process weight tables, where maximum allowable emission rates are shown for a range of process weight rates.

Kirk et al (1979) reported particulate emission rates from two commercial cotton gins that were "moderately well-equipped with emission-control devices." Process rating was eight bales/h for one gin and 30 bales/h for the other. The measured emission rates were 2.3 and 43.9 kg/h (5.0 and 96.8 lb/h), respectively. At the time the gins were measured, the allowable emission rates for the 8 and 30 bale/h gins were 4.5 and 10.4 kg/h (10.0 and 23.0 lb/h), respectively.

EPA and California air pollution control agencies have measured other western gins in the past three years (Cotton Gin Emission Tests, 1976; Emission Test Report, 1978; Kern County APCD, 1977; Fresno County APCD, 1977). Their results are listed in Table 1. All of the measurements in Table 1 were made with an EPA Method 5 sampling train (Environmental Protection Agency, 1977).

The first three gins in Table 1 were equipped with cyclone collectors on all high-pressure exhausts and lint cages on all low-pressure exhausts. At the last two gins, all exhausts go to a unifilter. The particulates caught by the unifilter were in turn fed through a fan and finally trapped by a set of cyclone collectors.

All gins in Table 1 and the 30 bale/h gin measured by Kirk et al. (1979) exceeded the various states' process weight emission rates that were in effect at the time of measurement. Some gins exceeded allowable emission rates by a factor of two or more even though they were using what might be termed as "best standard" cotton gin industry pollution control practice.

PAST GIN LABORATORY RESEARCH

Since 1972, scientists at the Southwestern Cotton Ginning Research Laboratory have worked to adapt wet scrubbers to cotton gin exhausts. The work was concentrated on the exhaust from the No. 1 lint cleaner, low-pressure gin exhaust, which is one of the most heavily loaded in the low-pressure exhaust system. The No. 1 lint cleaner exhaust is also one of the hardest to control, because it contains both fine dust and lint fly.

The major drawback to use of wet scrubbers in cotton gins is disposal of the large volume of water and wet sludge. Some wet scrubbers are emptied into a sewage lagoon, which is not very practical for operations that run only two or three months a year. Wright (Unpublished annual reports, 1972-78) concentrated his wet scrubber research on devices that used relatively small amounts of water that was continuously recirculated. Recirculating the scrubber water necessitates concentrating and removing the sludge from the circulating system but greatly reduces the water disposal problem. Methods of sludge concentration also were tested.

Cleaning tests from 1974 to 1977 involved three types of wet scrubbers, a submerged nozzle, an impingement and a wet cyclone type, and three methods of sludge concentration, a liquid cyclone, a centrifugal separator and a settling tank. All tests were run using the wet scrubber as a primary particulate collector. The tests yielded the following conclusions and observations:

1 The cyclone wet scrubber gave the most satisfactory performance due to its low-pressure drop and collection efficiency.

2 The cyclone wet scrubber reduced the emissions of the lint cleaner exhaust from 2.6 to 0.14 kg/h (5.7 to 0.3 lb/h).

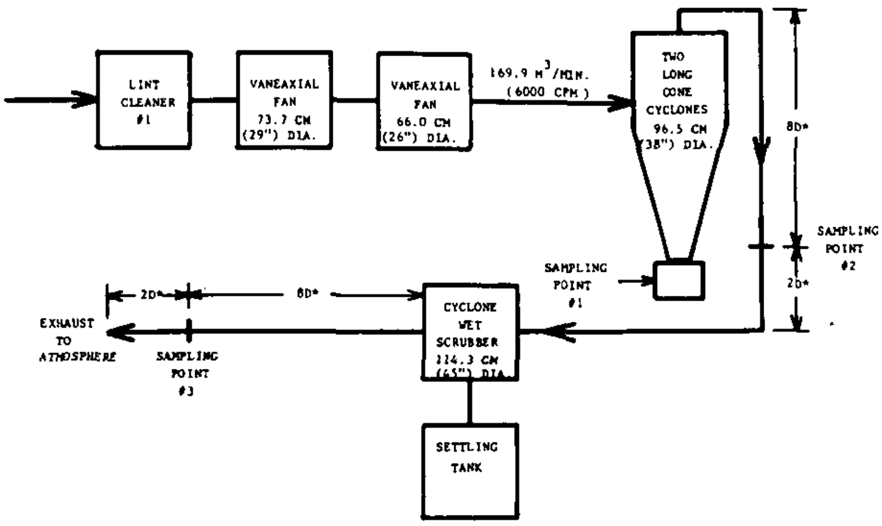
3 A settling tank was the preferred method of sludge concentration because of simplicity of operation and the relatively large volume of sludge it can contain.

4 Wet scrubbers should not be used as primary collectors on lint exhausts because of the large volume of sludge generated and subsequent sludge handling and disposal problems.

Evaluation of the wet scrubber for use as a primary cleaner on cotton gin exhausts was discontinued in 1979. Further work is needed on evaluation of a wet scrubber as a secondary cleaner.

1979 TEST INSTALLATION

Fig. 1 is a schematic diagram of the current test installation at a commercial gin. The cyclone wet scrubber and sludge settling tank were kept in place. A set of small diameter, short bodied, long cone cyclone collectors (Parnell and Davis, 1979) was installed in the No. 1 lint cleaner exhaust to serve as a primary collector instead of the inline filter that was removed. A second fan



* "D" DENOTES AIR DUCT DIAMETER

FIG. 1 Cyclone test installation.

was installed to overcome the additional back pressure created in the lint cleaner exhaust line by the addition of the cyclones.

The test installation was constructed so that dust could be sampled at the long cone cyclone collectors, between the long cone cyclone collectors and the wet scrubber, and after the wet scrubber. A dust sampling station at the long cone cyclone collectors consisted of a "Y-valve" installed at the bottom of each cyclone collector. Plastic bags could be attached to the outlets of the valves. Dust and cotton lint removed from the exhaust air stream could be collected in the plastic bags during sampling periods. The bags were removed at the end of a test run and weighed to determine the total amount of trash caught by the cyclone collectors. A sampling station for a Method 5 sampling train was located on the air discharge duct of the long cone cyclone collectors. Another Method 5 sampling station was located on the air discharge of the wet scrubber. These two sampling stations were for determination of the rate of particulate emissions from the long cone collectors and the wet scrubber. Data from these three sampling points (refer to Fig. 1) should give a complete picture of the rate of emissions and the effectiveness of the devices used to control emissions.

RESULTS AND DISCUSSION

Delays in installation of equipment limited testing time to five preliminary sampling runs during the 1979 crop season. Each sampling run lasted only 1 h because of cotton shortages. Thus, only small quantities of particulates were collected on the Method 5 sampling filters. Measurement of the small mass of particulate on each filter was difficult due to the masking effect of handling and weighing variability. The weighing problem was particularly acute for the Method 5 filters from sampling point #3 due to the very light loading of the air stream. Sampling runs of 5 or 6 h would be needed to overcome this weighing problem. The overall performance of the long cone cyclone collectors and the cyclone wet scrubber was calculated approximately even with the weighing problems. As a primary cleaner, collection efficiency of the long cone cyclone collectors was 97 percent. Collection efficiency of the secondary cyclone wet scrubber was about 50 percent. We think that the efficiency rating of the long cone cyclone collectors is a good estimate by question the estimated efficiency of the wet scrubber because of the filter weighing problem.

These preliminary results suggest that if all the low-pressure exhausts shown in Table 1, particularly those now using lint cages, were subjected to a cleaning method that removed over 97 percent by weight of air-borne particulates, the total emissions of each gin would be greatly reduced. If total emissions were cut in half, each gin would approach the allowable emission standards under the process weight regulation.

FUTURE RESEARCH

All the pollution control equipment diagrammed in Fig. 1 is in place at a cooperator's gin plant. Emissions will be tested during the 1980 cotton ginning season. These tests should give a reliable estimate of the efficiency of the long cone cyclone collectors as primary and the cyclone wet scrubber as secondary emission control devices on the No. 1 lint cleaner exhaust.

References

1 Alberson, D. M. and R. V. Baker. 1964. An inline air filter for collecting gin condenser air pollutants. USDA ARS 42-103.

2 Baker, R. V. and C. B. Parnell, Jr. 1971. Three types of condenser exhaust filters for fly lint and dust control at cotton gins. USDA ARS 42-192.

3 Baker, R. V. and V. L. Stedronsky. 1967. Gin trash collection efficiency of small diameter cyclones. USDA ARS 42-133.

4 Cotton Gin Emission Tests, Marana Gin, Producers Cotton Oil Co., Marana, AZ. National Enforcement Investigations Center, Denver, CO, and EPA Region IX. Publication No. EPA-330/2-78-008. May 1978.

5 Emission Test Report, Westside Farmers' Cooperative Gin No. 5, Tranquility, CA. PEDCo Environmental, Inc., Cincinnati, OH. Prepared for U.S. EPA Division of Stationary Source Enforcement, Contract No. 68-01-4147, Task No. 47, PN 3370-2-D. February 1978.

6 Environmental Protection Agency. Standards of performance for new stationary sources. 1977. Federal Register, Vol. 42, No. 160.

7 Fresno County APCD. 1977. Source Test of Farmer's Firebaugh Coop, Firebaugh, CA.

8 Harrell, E. A. and V. P. Moore. 1962. Trash collection systems at cotton gins. USDA ARS 42-62.

9 Kern County APCD. 1977. Source Test of Farmer's Coop Gin No. 2, Buttonwillow, CA.

10 Kirk, I. W., A. L. Vandergriff, M. N. Gillum and C. G. Leonard. 1976. An alternate method of emission control for cotton gin exhausts. Texas Cotton Ginners' Journal and Yearbook. March 1976.

11 Kirk, I. W., T. E. Wright, and K. H. Read. 1979. Particulate

(Continued on page 1612)

Cleaning Lint Cleaner Exhaust Air

(Continued from page 1607)

emissions from commercial cotton ginning operations. TRANSACTIONS of the ASAE.

12 McCaskill, O. L. and R. A. Wesley. 1976. Unifilter collecting system for cotton gin waste materials. USDA ARS-S-144.

13 Parnell, C. B. and D. Davis. 1979. Predicted effects of the use of new cyclone designs on agricultural processing particulate emissions. Paper presented at the 1979 Southwest Region Meeting of ASAE. Hot Springs, AK.

14 Stedronsky, V. L. 1968. A primer for trash handling. Ginners' Journal and Yearbook. March 1968.

15 Wesley, R. A., J. B. Cocke and W. E. Garner. 1976. Efficiency of inline filters in cleaning condenser exhausts at cotton gins. USDA ARS-S-95.

16 Wesley, R. A., O. L. McCaskill and E. P. Columbus. 1970. A comparison and evaluation of performance of two small diameter cyclones for collecting cotton gin waste. USDA ARS 42-167.

17 Wilmot, C. A., Z. M. Looney and O. L. McCaskill. 1974. The cost of air pollution control to cotton ginners. USDA ERS-536.

18 Wright, T. E. 1972-78. Unpublished Southwestern Cotton Ginning Research Laboratory Annual Reports. Mesilla Park, NM.