OVERVIEW OF NEW EMISSION CONTROL STRATEGIES FOR COTTON GINS

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Abstract

Cost effective control of particulate emissions has become a major objective of most U.S. cotton ginners. This need has been driven not only by changes in a number of State and Federal regulations, but also by the ginners' desire to be good neighbors to local residents and businesses. A good neighbor policy helps reduce nuisance complaints and leads to an improved image in the local community. An effective trash handling and emission control system has also become an essential element in modern high-production ginning. As a result, a lot of excellent work has been done in the past few years to reduce emissions from cotton gins. Basic emission control technology, including several alternative methods of control, are reviewed in this paper. Researchers and vendors continue to research and develop new and potentially more effective control systems. Even though most of these new systems have not been thoroughly tested under a wide range of conditions, a general description of some of the more promising ones are also presented.

Introduction

One definition of strategy is "a plan or method for obtaining a specific goal or result." In our case this definition can be expanded to "a plan for meeting required air quality emission standards at a cost that does not break the gin." To develop such a strategic plan, one first has to establish the desired goal or objective. This means becoming familiar with the specific requirements of the air quality control agencies having jurisdiction over your gin. Understanding these requirements and how they impact your gin begins with consideration of the 1990 Federal Clean Air Act (CAA). One major effect of the CAA was under Title V, the federal operating permit program (Wakelyn, 1995). Title V established the funding authority for implementing the CAA by the states. Annual fees collected by the states are intended to pay for the permitting process in each state.

Under Title V of the CAA, each state is required to develop its own compliance program. As a result, there is considerable variation between states, and sometimes within states, as to the requirements and administration of each state's particular program. All emission sources subject to regulation under the CAA are, or eventually will be, required to obtain an operating permit. At the current time, PM10 particles (those particles whose aerodynamic diameter is less than 10 microns) are the particulate matter emissions from gins that are regulated by under Title V (Wegman, 1995). However, there is some indication that the regulated sizes for particulate matter may be changed at some future date to include the smaller PM2.5 fraction as well as the current PM10 fraction (EPA, 1995). There is also some concern, principally in non-attainment areas of California, about NOx and CO emissions from gin burners. This issue is currently under study and has yet to be resolved.

Some states are already charging fees under Title V, but other states do not yet have their permitting program in place. Also, there is a broad range of fee schedules, and compliance and reporting requirements between states that leads to some confusion for individual ginners about what requirements they must meet. National Cotton Ginners Association has compiled a state air quality permit data base that summarizes each state's current permitting requirements for reference use by the ginning industry (Johnson and Wakelyn, 1995). Other sources of information include the applicable regulatory agency for your state or county. A good relationship with the regulatory people is an essential ingredient in any valid strategic plan. You also may obtain information and help from your state or regional ginner organizations and from emission control equipment vendors. The latter sources can be especially helpful in the preparation of permit applications.

An important factor in the permitting process is how a state determines that the controls, once installed, meet the permit requirements. Again, there is a wide range of how this is done with the simplest being the control equipment required by the permit being in place with no further performance stipulations. In other cases there is an operating performance specification for the emission controls with the permit compliance being determined by monitoring. Monitoring is either by a visual opacity determination (maximum of 20 or 40% depending on the state) by a trained opacity reader, or by source tests using a Method 5 type particulate sampling technique. Also, permits can be based on process weight tables. Once permit compliance has been determined, a gin is then usually free to operate within the bounds of its permit.

Even though there is some uncertainty and confusion as to the eventual outcome of the overall regulatory process, it is certain that cotton gins will need to comply with some level of emission control regulation. Specific control strategies, of course, will vary from area to area depending not only on the state implementation plan, but also on the type of cotton being ginned, the size of gin, its location relative to local dwellings and businesses, its annual volume, and the general air quality expectations of the neighboring

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community. Despite such variation, however, there are some basic control devices that are used almost everywhere. The remainder of this report will be devoted to a review of these basic emission controls for cotton gins. In addition, there are special devices or variants of the basic controls that are being used in some areas. Even though the new devices have a relatively short track record and have not been thoroughly tested under a wide range of conditions, a description of some of these systems also will be presented for your general information.

Basic Emission Controls

The most widespread emission control system in use today consists of cyclone collectors on all high-pressure exhausts and fine mesh screen on the condenser exhausts (Mayfield et al., 1992). These systems have an excellent track record under a wide variety of ginning conditions, and may be all that is required at your cotton gin.

Cyclones

Cyclone collectors are the preferred means of collecting gin trash and controlling particulate emissions at cotton gins. These simple and relatively inexpensive devices collect almost 100% of the particulate larger than 20µm in size, and substantial amounts of particulate as small as 5 to 10µm in size. Cyclones have proven to be reliable under a wide variety of ginning conditions, and they require little attention during the active ginning season. While the life of a cyclone will vary with the type of cotton being ginned and the amount of abrasive sand contained in the trash, its life-cycle maintenance cost tends to be very competitive when compared to other types of collection devices.

Modern day cyclones are based on the older 2D2D design or on the more recent 1D3D design. While both designs are very effective, the 1D3D design is a little more efficient when operated under ideal conditions. Ideal conditions for this design include use of the standard flat-on-top inlet transition and a 3200 fpm inlet air velocity, and collecting trash containing very little fiber. Under less than ideal conditions, the 1D3D design usually has no advantage over the 2D2D design. Actually, it may be less effective than the 2D2D design when the inlet transition is turned up-side-down to avoid trash settling out and choking its narrow inlet.

Regardless of the type of cyclone selected, make sure that it is properly sized. Inlet velocities of 3000 fpm and 3200 fpm are standard for the 2D2D and 1D3D designs, respectively. Large departures (greater than 10%) from these velocities can led to poor performances in one of two ways. If the cyclone is too large (velocity too low), collection efficiency might suffer. If too small (velocity too high), the cyclone will create an excessive pressure drop that will reduce the amount of air available for conveying purposes in the gin. Information on correct sizing procedures for cyclones is available in the Cotton Ginners Handbook (Parnell et al., 1994).

Finely Perforated Condenser Drums and Screen Covering

Conventional condenser exhaust systems for lint cleaners and battery condensers are powered by vaneaxial fans that are severely limited in their ability to overcome the 3.5- to 5-inch (w.g.) pressure drop created by standard cyclone systems. However, special condenser drums made from finely perforated metal or a fine mesh screen covering (70 mesh or finer) over the conventional condenser drum provide an effective low-pressure-drop means for controlling fly lint emissions from condensers. While these special condenser drum constructions are effective for controlling fly lint, they are not particularly effective for controlling fine dust. There are many situations, however, where this shortcoming in performance is not large enough to cause the gin to exceed its allowable emission limits. In those cases, finely perforated drums or covered condenser screens offer ginners the most cost effective means for controlling their condenser emissions.

Mote Collection Systems

The main problem with motes in air pollution abatement systems is that they tend to rope in cyclones, causing emission and operational problems. The most obvious and effective way of eliminating these problems is to remove the motes from the air stream before they reach the cyclone.

A separator may be used to remove the motes from the air stream. The separator can be mounted over the mote press or mote cleaner. One large pull fan may be used to pull motes from all lint cleaners into the separator. A push-pull system may also be used, with the existing mote fans acting as push fans, and a single fan pulling on the separator. With the separator system, the cyclones will be handling only the pin trash that makes it through the separator. Chokages in the cyclones, and emissions, are both greatly reduced. This system also eliminates the need for two sets of mote cyclones.

A typical mote system will have one set of cyclones over the mote press, and a second set located on the main bank to use when bypassing the mote press. With a separator, the only cyclones needed are those located in the main bank. To bypass the mote press, you simply bypass the separator, and blow both motes and air into the cyclones.

There are several advantages to this type of mote handling system. First of all, the separator is much shorter than cyclones, so the problem of having the mote cyclones protruding through the gin roof is eliminated. The trash from any mote cleaner can be pulled into the separator pull fan, which eliminates the need for a dedicated mote trash fan. This is especially advantageous in states where the addition of a new fan triggers permitting requirements.

In very large gins, it may be a problem to find a separator capable of handling the quantity of air needed to pull from all of the lint cleaners. Here, some ginners have installed large cyclones behind the gin to handle the air from all of the lint cleaners. The motes are then pulled from the cones of these cyclones with a second fan. This second fan then operates as described in the above paragraph. If enough air is pulled from the cones of the large cyclones, the roping problem is eliminated.

Alternative Collection Methods

Cyclones on Condenser Exhausts

Very few air control districts are requiring cyclones on lint condenser exhausts, but several states are allowing cyclones to be installed on low pressure exhausts and the trend may continue to grow. Gillum et al. (1981) showed that 1D3D cyclones could operate on lint cleaner exhausts with a collection efficiency of about 97%. The resulting additional back pressure on the exhaust system, however, required an additional vaneaxial fan to be installed in series with the original fan to overcome the additional back pressure of the cyclones. Since then, both 2D2D and 1D3D cyclones have been used with good results on lint cleaner exhausts in the West. Generally, in these situations the additional cyclone pressure drop was overcome by use of a high-pressure centrifugal fan instead of the series vaneaxial fans used in earlier studies. Additional benefits of centrifugal fans in this application include lower maintenance costs and lower noise levels.

Recent research has indicated that re-circulation or build up of lint fly at the trash exit of the 1D3D cyclone may cause a decrease in particulate collection efficiency, especially when the cyclone is used to control condenser emissions. In an attempt to find a better control device for these exhausts, Kasper and Parnell (1994) tested a laboratory model 1D2D cyclone. The design goals for the cyclone were a maximum pressure drop of 2.5 inches of water, and a minimum 80% collection efficiency. The 1D2D was also intended to overcome the lint build up at the trash exit because of a larger diameter trash opening than the 1D3D. The model 1D2D cyclone met the low-pressure-drop and collection efficiency goals, but lint re-circulation at the trash outlet was still a problem. Full size 1D2D cyclones have been installed on at least one commercial gin with reported satisfactory results, although no measurements have been taken of their actual performance as particulate collectors.

There are a few gins that use pot belly or large diameter cyclones on their lint exhausts. While a pot bellied cyclone's collection efficiency is probably in the range of 60 to 80% (Harrell and Moore, 1962), much lower than a high efficiency cyclone, it probably would compare favorably in performance with screen baskets or fine mesh screens on lint cleaner exhausts.

Series Cyclones

Prior research has shown that cyclones in series have some potential to reduce particulate emissions from high-pressure exhausts. Gillum et al (1982) showed that using either a 2D2D or 1D3D cyclone in series with a primary 2D2D cyclone reduced particulate emissions by an additional 45 to 54% respectively. A few gins have installed series cyclones on at least some exhausts to reduce visible emissions. No field performance data is available, but laboratory data indicates that series cyclones could be a method to decrease emissions on some of a gin plant's heavier loaded exhausts. Because of using two cyclones, the pressure drop of the cyclone collection system would be about doubled over one cyclone at standard design entrance velocities of 3,000 to 3,200 feet/minute. However, Gillum and Hughs (1983) showed in the laboratory that the entrance velocity to a set of series cyclones could be reduced as low as 2,300 fpm and still maintain their system collection efficiency. The system pressure drop at this lower velocity was reduced from about 8 to about 5 inches of water. An application of this kind would require careful design and operation of the air system.

New Cyclone Designs

Researchers continue to investigate new cyclone designs in the hopes of finding cost effective means of further improving gin emission controls. In addition to the previously mentioned work on the 1D2D cyclone design for condenser exhausts, recent studies have indicated significant potential improvements for a 1D4D cyclone on high-pressure exhausts (Hughs and Baker, 1995). In laboratory tests using 12-inch-diameter cyclones, particulate emissions from the 1D4D design were about 15% lower than those of the standard 1D3D design. Additional laboratory tests using full-sized cyclones and stripper-cotton trash are planned to evaluate further this new design under conditions that more closely correspond to actual gin service.

Expansion Chambers for Cyclones

Recent studies (Baker et al., 1995) have shown that re-circulation of lint and trash material in the lower portion of a 1D3D cyclone's cone section is associated with an increase in particulate emissions from the cyclone. Unsealed trash systems that allowed air to be induced into the cyclone through its trash exit contributed greatly to this re-circulation problem. On the other hand, only slight to moderate levels of re-circulation were observed with sealed trash systems.

Cyclone trash exit designs and discharge conditions that caused a small amount of air to exit the cyclone with the trash eliminated any visual evidence of re-circulation and produced the lowest particulate emissions encountered in the study. These conditions were created by an air bleed system that used a small fan to extract a small amount of air along with the trash, and a design that feature a short straight rib attached to the wall of the lower cone. A sealed large expansion chamber in the lower cone also effectively reduced re-circulation when used with a well-sealed trash system. Even though this system did not completely eliminate re-circulation, it produced a marked improvement in emission performance over that of the regular 1D3D cone. Actually, the large expansion chamber produced emissions that were roughly comparable to those of the air bleed and straight rib designs.

Relatively poor control of the re-circulation problem was provided by sealed and unsealed regular cones, and unsealed large and small expansion chambers. These four arrangements also tended to produce the study's highest particulate emissions. Of the three designs producing the lowest emissions, a sealed system with the large expansion chamber appears to be the one that could be most easily adopted at existing cotton gins. The other two low-emission systems, while effective from an emission standpoint, suffer the disadvantage of not completely separating collected trash material from the air.

Inline Air Filters

Inline air filters can also be used to control condenser emissions (Alberson and Baker, 1964). While they have proven to be reasonably effective (60-90% efficient) in controlling both fly lint and dust in the past, they are not used to any great extent today (Wesley et al., 1976). However, some air quality control agencies still recognize them as alternative control devices.

Rotary Drum Filters

A few cotton gins utilize rotary drum filters as their primary collection device for some or all of their exhausts. The modern rotary drum, when used in this manner, is similar to the unifilter trash collection system tested by USDA in the 1970's (McCaskill and Wesley, 1976). Those tests indicated that drum type filters, depending on type of filter media used, had potential for producing collection efficiencies comparable to those of cyclones collectors. Since the pressure drop of the unifilter system was only about 0.5 inch (w.g.), it could be used as the primary collection method for condenser exhausts as well as for the high-pressure exhausts. While a few of these older systems were installed at commercial gins, the idea never really caught on with the entire U.S. ginning industry. It was found that the units required much closer attention during the gin season than many ginners were prepared give, especially since they were accustomed to operating cyclones that required practically no attention during the season. Also, some of the filter media used in these early devices was not fire proof and, consequently, could be severely damaged during a gin fire.

Rotary drum filter systems are two to three times more costly to install than the more conventional cyclone systems (Hughs 1991, Brinkly et al., 1992). They also appear to be substantially more costly to maintain. Consequently, only a few rotary drum filter systems have been installed at U.S. cotton gins and most of these installations have utilized used rotary drum filters salvaged from other industries. Some foreign gins, however, make extensive use of rotary drum filters. The overseas' units are most often used as secondary collectors following conventional cyclones. While this arrangement improves the reliability of these filters, they still require considerable in-season and between-season maintenance which along with a high initial cost makes these systems very expensive.

Pre-separation Chambers

A number of gins in Texas, Arizona and California have installed pre-separation chambers to settle out most of the large trash particles from the exhaust air before it reaches the cyclones (Baker et al., 1995, Green, 1995). Consequently, these chambers take a considerable load off the cyclones, which in turn tends to prolong their useful life and to reduce annual maintenance costs. Since the air from several exhausts are combined in a pre-separation chamber, it can then be redistributed to a number of like-size cyclones attached directly to the chamber. This arrangement simplifies not only the initial installation, but it also helps ensure accurate sizing of the cyclones for maximum overall system performance.

The pre-separator/cyclone system also offers ginners a lot of flexibility when fan size or speed changes have to be made in one or more of their exhaust systems. The extra air generated by such changes is evenly distributed in the pre-separator to all the cyclones, and often the small additional load on each cyclone is not enough to throw it out of compliance with recommended inlet air velocity specifications. Even in cases when the increased air flow is too large to distribute safely, one or two additional cyclones can be easily added to the chamber to bring the entire system back into compliance.

Pre-separation chambers have somewhat of a mixed track record with respect to their effects on particulate emissions. A source test at a gin in the west indicated an improvement in emissions when the cyclone was preceded by a pre-separator. Other tests using stripper-cotton trash, however, have shown effects ranging from a modest improvement of about 9% to a slight increase in emissions depending on type of cyclone employed and on how much fiber was present in the gin trash (Baker et al., 1995). Much of the fiber in the trash escaped the chamber and entered the cyclones. This fiber interfered with the performance of the cyclones, especially the long cone 1D3D type.

While there was some variation in performance in these stripper-trash tests, for the most part the pre-separation chamber had little effect one way or another on final cyclone emissions. These results suggest that pre-separation chambers probably should be considered to be more of an improved trash handling system than an improved particulate abatement device. When fibrous trash is avoided, these chambers should at the very least maintain current cyclone performance, and sometimes they may improve performance to some modest degree. Such improvements are especially likely in cases where the use of a chamber improves the accuracy of sizing the cyclones for the optimum inlet air velocity.

Waste Handling Systems

Bur Hoppers

The bur hopper has been used for many years as the primary method of storing waste for loading into a truck. This system has the advantage of allowing the driver to load the truck without the use of a mechanical loader. The main disadvantage of the bur hopper is that it drops the entire load of waste into the truck at one time, often creating an unacceptable amount of fugitive emissions.

In urban areas, the fugitive emissions are often reduced by enclosing the bur hopper. The sides of the hopper are enclosed with sheet metal, and doors are installed on each end. Usually, an extension must be built on one end to enclose the cab of the truck. This method has been very effective, but does pose some operational problems.

In an enclosed hopper, the truck is subject to a lot of dust, creating additional maintenance problems. In addition, the driver must open and close the enclosure doors each time the truck is loaded. The operator typically opens the hopper doors from outside the enclosure, so he cannot see the truck as he is dumping into it. There is one type of hopper used in the Mid-South with an improved door design that would be especially beneficial with an enclosed loading area. This hopper has “clam-shell” type doors that are hydraulically operated. It is reported that these doors are strong enough to cut off the flow of gin trash into the truck, should the truck fill up before the hopper is empty.

Several ideas have been tried to reduce dust within the enclosure. A ventilation fan has been added to pull air from the enclosure, blowing it to cyclones on top of the hopper. Spray mists have been used to control the dust within the enclosure. The ventilation fan has been effective, but requires an additional fan and cyclone. The spray has also been effective, but does require care to keep the hopper area from becoming muddy.

Trash Trailers

In some areas, trash trailers are used. When trailers are used, a hopper is usually not needed. The trailers are simply pulled into an enclosure, and the trash is trickle-fed into the trailer by an auger. This design eliminates the cost of a hopper, and also eliminates the dumping problem. The drawback to this solution is that a steady supply of trailers must be available, since there is no storage capacity in the system. A new trailer must literally be used to push the full trailer out of the house, so that the auger may continue to dump.

Stacking Systems

On the other end of the spectrum, many gins are installing auger operated stacking systems. These systems will hold from a few weeks to a full seasons worth of trash, depending on the type of cotton being ginned, and the size of the stacking system. These stacking systems may have a straight auger, or a pivoting auger, depending on the model. The stacking system is very clean, once the initial pile is built up to the auger, since the rest of the trash trickles out of the auger onto the existing pile.

The main advantage to these systems is that the trash does not have to be hauled away continually. In the event of a large rain, the trash can be stored in the stacking system. The disadvantage is that an additional piece of equipment is required to load the trucks. This system is generally very clean, however, from a fugitive emission standpoint. Finally, the stacking system does allow for composting of the gin waste without any additional handling. Several ginners are composting the trash right under the auger.

General Maintenance

Most ginners tend to look at the cyclones and lint cleaner exhausts whenever they have an emissions problem. Although these areas are the main source of emissions from a gin, there are several other areas that also may contribute to the problem.

The waste handling systems often can be a source of fugitive emissions, as described in the previous section. In addition, truck traffic itself may be a major contributor to fugitive dust. Care must be taken that gin yards use materials that minimize dust, especially if a gin is in a populated area. Using caliche or gravel on heavily traveled routes on the gin yard will greatly reduce the dust. Gins located near coal fired power plants have found some of the ash from the plant to be very good material for covering gin yards.

Many ginners keep a water truck or trailer on hand to use as needed when the yard becomes dusty. Some ginners in small towns have even watered the city streets immediately surrounding the gin, in their effort to be good neighbors.

Keeping the gin yard and surrounding area neat is another important consideration. If your facility and surrounding lands are covered with old machinery, piping, and cotton bags, it will affect how your immediate neighbors feel about your operation. It also will affect how the regulators perceive your operation, should they visit your facility.

The method by which trash is moved from the air pollution equipment to the waste handling equipment is also very important to consider. As a general rule, it is better to use augers or belts to move trash, since augers and belts use less horsepower and do not require air pollution abatement equipment. Many gins that process stripper cotton are using augers to move the trash from the stick and bur machines to the waste handling system, eliminating the traditional main trash fan in the process.

There are two main rules to follow when using augers. First of all, the lint in gin trash tends to wrap up in augers, especially if the augers are under-sized. It is important to size the augers properly for the job, and to remember that the trash will contain lint. The second rule is the augers must be completely sealed. The importance of this cannot be over-stated. Belts do not have the lint wrapping problems that augers have, but sealing a belt is also critical, and it can be more difficult to seal a belt than to seal an auger.

The auger under the main cyclone bank is especially critical. Research has shown that the 1D3D cyclone may tend to pull air up through the cone, if the bottom is not sealed (Baker et al., 1995). If the auger under the cyclone bank is not sealed well, dust may literally be pulled up from the auger, and blown out the top of the cyclone.

It is also very important to maintain a good seal at the vacuum dropper under the auger. If the vacuum flights are in poor condition, high-pressure air from the trash line will leak into the auger and pressurize the entire auger trough. If the auger trough is not well sealed, some of this air will blow out of the auger trough and increase fugitive emissions. If the lids on the auger trough are well sealed, the pressurized air will blow up through some of the cyclones and adversely affect their collection performance. Either scenario will result in significant additional emissions.

Summary

A lot of excellent work has been done over the years to reduce emissions from cotton gins. As a result, air pollution abatement equipment has been greatly improved. Researchers and vendors continue to research and develop new and potentially rewarding control products. While this effort will likely continue to pay large dividends in the future, it is important to remember that we are in reasonably good shape with our current technology right now. Our high efficiency cyclones have been doing an excellent job of keeping U.S. cotton gins in compliance with some very stringent particulate standards and are likely to continue to meet any foreseeable air standards in the future. Consequently, cyclones will probably continue to be the control device of choice for years to come. It is comforting, however, to realize that alternative control strategies are available or are being developed to provide U.S ginners with additional ammunition for use in its ongoing war with particulate emissions. All this new and existing technology is useless, however, if fugitive emissions are not controlled, or if good housekeeping practices are not followed. Any successful strategic plan for meeting emissions standards must ensure that the waste be collected, loaded, and removed from the property in the most efficient manner possible.

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