SAMUEL JACKSON DRYING SYSTEMS

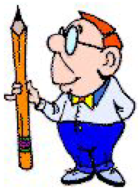
Background and Design Principles

The name Samuel Jackson has been known for many years in the field of cotton humidification. The study of fiber moisture characteristics has naturally developed into systems and components for drying as well as moisture restoration. This is a summary of the principles and techniques used in Samuel Jackson seed cotton drying systems.

1. *OBJECTIVES OF SEED COTTON DRYING SYSTEMS*

1.1 ***Priorities in Drying System Design*** -- We rank the objectives of a seed cotton drying system in the following order of economic importance:

(1) To maximize the ***value*** of the ginned cotton
(2) To maximize ***throughput***, or bales per week
(3) To minimize ***horsepower*** consumption per bale
(4) To minimize dryer ***fuel*** consumption per bale



Priorities 1 and 2 -- On the subject of cotton value, there are three viewpoints to consider: The textile mill wants good spinning quality. The producer wants high lint turn-out and market price. The ginner wants to put the cotton through the gin as fast as possible to lessen his per-bale costs for labor, electricity and fuel.

With a properly designed drying system, spinning quality need not be sacrificed for high market value. We can have both clean cotton and high lint turnout without overdrying the cotton or using high temperatures. Proper drying keeps the pre-cleaners from entangling trash particles in the fiber, and this greatly reduces lint cleaner waste. Contrary to traditional beliefs, inadequate drying results in lower lint turnout as well as a trashier sample.

Effective drying not only solves the apparent conflict between spinning value, market value and lint turnout, it also raises the <u>average</u> throughput of the gin plant. While it usually does nothing for maximum bales per hour, it can dramatically increase the bales per week by efficiently drying wet seed cotton so the gin does not have to slow down.

Priority 3 -- Reducing the connected horsepower in the gin plant does not always reduce the power cost per bale. There are proper places to use smaller motors, but if a small motor reduces the average throughput, it will increase the total cost of power, labor and fuel per bale. One must be careful not to focus all his attention on one factor.

Priority 4 -- Using larger drying heaters does not necessarily increase the fuel cost per bale. In high air/cotton drying systems, large heaters are necessary to maintain maximum throughput with wet seed cotton on cold days. On warm dry days, high air volume uses the natural drying capacity of the ambient air to reduce fuel consumption. The overall result is usually the same or lower fuel cost per bale, but with greatly reduced labor and power costs per bale. Again, it is wise to consider all economic factors.

1.2 ***Drying Before Cleaning*** -- We must dry seed cotton thoroughly before cleaning it, use reasonable temperatures, and avoid machining the seed cotton until it is dry. Of course, we need to break up wads to dry the cotton uniformly.

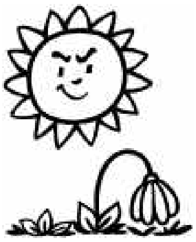
There are two advantages to drying before cleaning. We naturally obtain higher grades as the pre-cleaners can clean dry cotton more efficiently. Curiously, we get higher lint turn-out as well. Pre-drying avoids entangling trash in wet cotton fibers. The lint cleaners then throw away less lint with the motes. The result is a cleaner sample and higher lint turn-out, as well. Samuel Jackson system designers watch this occur with each system, as Sam Jackson observed when building his first high air volume system in 1965.

1.*3* *"Overdrying" Damage and Moisture Restoration* -- As we make drying systems more effective, we must avoid "overdrying damage" to the cotton. This term is loosely used to describe two different types of damage.

The first type, "overheating damage," is caused by drying with high temperature air, which permanently injures the fibers. We find this in systems of many types today. It occurs wherever air volume is restricted and production pressures are high. Even when before-mix point temperatures are monitored or limited, it is not uncommon to find these limits ignored or bypassed by operators in the name of production during a wet season. Often, especially when pulling through shelf dryers or other devices with a significant resistance to free flow of air, air volume is high when the system is lightly loaded. The resistance of the system becomes apparent when trying to handle large volumes of wet or trashy cotton. The operator often resorts to raising temperatures above recommended maximums. Samuel Jackson designers avoid this type of damage by using three elements.

1. The system is designed for high volumes of drying air.
2. The system is designed with an eye toward eliminating resistance to air flow throughout the system.
3. A cascaded temperature control system is used to gently limit temperatures before the mixpoint while avoiding nuisance shutdowns.

Drying cotton fiber to a low moisture content does not, in itself, injure the fiber. Nature often dries cotton in the field without bad effects. While the fiber is dry, however, it is susceptible to damage if it is treated improperly. This second type of damage is usually inflicted by gin saws and lint cleaner saws on cotton fibers that are temporarily brittle because of low moisture content. The symptoms of this type of damage include staple shortening, poor length uniformity and excessive short fiber content. Interestingly, this type of damage is <u>not caused</u> by the gin's drying system. Samuel Jackson research has led our designers to suspect that this is due to inherent protection of the fiber by moist seed. The fiber damage cannot be avoided by adjustment of drying temperatures or even with all heaters in the system turned off. It can only be helped by increasing the moisture of the fiber before ginning. This should be of concern in any arid cotton ginning region. Ironically, this effect is the most pronounced in very wet regions where flooding of the field has washed the natural protective waxes from the fiber. When this fiber dries naturally in the field and is then harvested, there is no more extreme case of vulnerability to damage in dry ginning conditions.



Samuel Jackson designers recommend preventing this second type of damage by applying humid air to the seed cotton in conditioning hoppers above the extractor feeders (see Figure 3). A Humidaire Unit provides humid air to the special hoppers. Longtime users of these hoppers report longer staple length (1/16" span-length), better length uniformity ratio, improved short fiber index, and blessings from the spinning mill for the reduced ends down and higher yarn strength they achieve. Special research in this area is ongoing by Samuel Jackson, Inc. and is updated frequently.

2. *ASSUMPTIONS FOR DRYING SYSTEM DESIGN*

2.1 ***A Basic Drying Assumption*** -- We formerly assumed that any seed cotton drying system dried only the fiber, with negligible effect on the seed and trash. Recent experience with Samuel Jackson systems has shown that we dry the leaf trash sufficiently to eliminate problems of trash accumulation in the extractor-feeders. We still assume that the seed loses very little moisture during the seed cotton drying process.

2.2 ***High Air Volume, Low Temperature*** -- We use as much air as possible in the first drying stage, typically 50 cubic feet of air per pound of seed cotton. This is the only way to avoid three undesirable alternatives:

1. Using high temperature drying air, or
2. Accepting poor cleaning performance, or
3. Slowing the ginning rate.

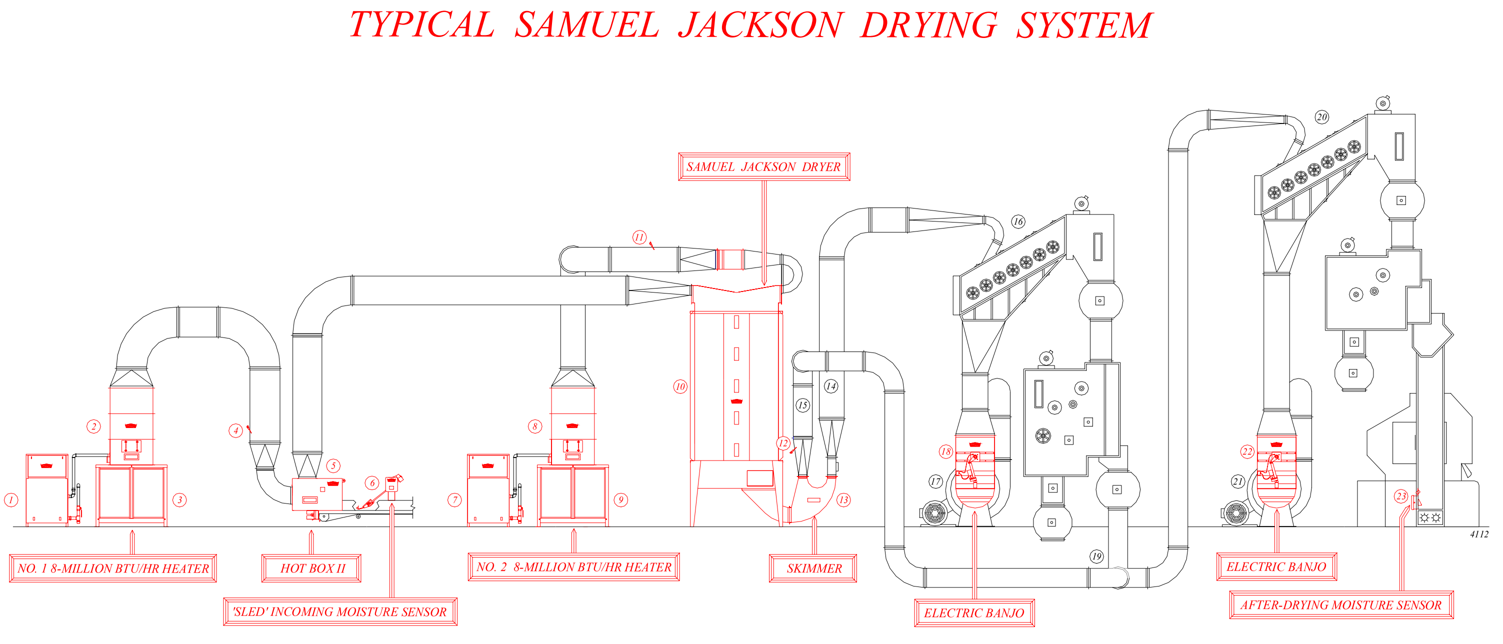
When we dry with a high volume of low temperature air, we can expect a longer staple length. High temperature air embrittles the ends of the fibers and subsequent ginning and lint cleaning breaks them off. We limit the air temperature before the mix point with cascaded temperature controls.

2.3 ***Multiple Stage Drying*** -- As pointed out in Section 1.2, drying should be done before the cotton enters the first precleaner. We do use multiple drying effects, and all of these, but one, take place before precleaning. Depending on air volumes available in the system and the cotton varieties being processed, additional dryers may be desired in subsequent stages with turbulent injections or collisions of fresh hot air. These devices should be applied toward the goal of improving grade (especially on hairy leaf varieties) through opening and fluffing of the already dry cotton. The vast majority (98%) of Samuel Jackson drying systems employ a single stage of drying and simply keep the dried cotton warm as it is conveyed through second stage cleaning equipment.

2.4 ***Drying Seed Cotton for Storage*** -- In some countries, gins use hot air to dry seed cotton before storing it for later ginning. These systems are usually not effective because they only dry the fiber. The moisture soon migrates from the seed to the fiber. We also have the problem of storing <u>hot</u> wet seed cotton, which means quality degradation.

As a general rule, we should store seed cotton only when its moisture content is less than 12%, at most 14%. We should not use hot air to dry it before storage. Cotton wetter than this should be ginned immediately so only the seed, not the fiber, will deteriorate in storage. If it is

Figure 1



1. CONTROL CABINET FOR 8M HEATER
2. NO. 1 8-MILLION BTU/HR HEATER
3. SCREEN AND SUPPORT STAND FOR HEATER
4. HIGH LIMIT THERMOCOUPLE FOR NO. 1 8M HEATER
5. HOT BOX II
6. CONVEYOR BELT MOISTURE SENSOR
7. CONTROL CABINET FOR 8M HEATER
8. NO. 2 8-MILLION BTU/HR HEATER
9. SCREEN AND SUPPORT STAND FOR HEATER
10. SAMUEL JACKSON DRYER
11. HIGH LIMIT THERMOCOUPLE FOR NO. 2 HEATER
12. AFTER-MIX THERMOCOUPLE
13. COTTON SKIMMER
14. COTTON AND HOT AIR TO FIRST STAGE INCLINED CLEANER
15. HOT AIR FOR SECOND STAGE
16. FIRST STAGE INCLINED CLEANER
17. FIRST STAGE PULL FAN
18. ELECTRIC BANJO FOR FIRST STAGE FAN
19. COTTON PICKUP POINT FOR SECOND STAGE
20. SECOND STAGE INCLINED CLEANER
21. SECOND STAGE PULL FAN
22. ELECTRIC BANJO FOR SECOND STAGE FAN
23. AFTER-DRYING MOISTURE SENSOR

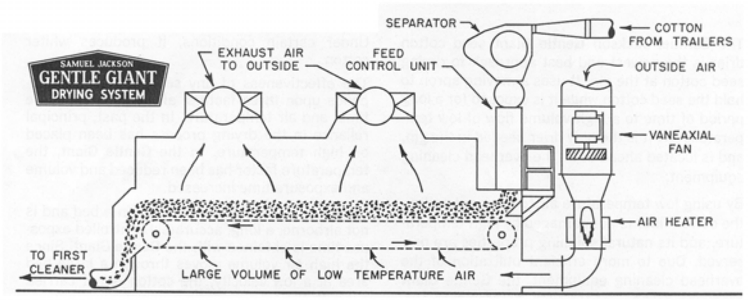
necessary to store wet seed cotton or cottonseed, the storage building should be equipped to circulate outside air through the cotton. Such long- term drying will dry both fiber and seed.

Where the gin purchases seed cotton, the ginner can use a moisture meter and discount the purchase price for moisture content. The discount should reflect more than the weight of water purchased. It should cover also the cost of drying, the economic cost of having to gin the cotton immediately, and the economic loss due to probable deterioration of the seed.

3. *DRYING METHODS AND TECHNIQUES*

3.1 ***Historical Notes*** -- For centuries, seed cotton was not dried before ginning. It was hand-picked, usually during dry weather. The ginners bought the seed cotton prior to ginning it, and they were reluctant to buy wet seed cotton. Research on cotton drying began at the USDA's Stoneville Cotton Ginning Laboratory in the 1920's. This work resulted in the tower or shelf dryer, which has been widely used since then. Other dryers have been commercially available at various times, including the screw conveyor dryer, the Big Reel dryer and the Counterflow dryer. Most of these were abandoned in favor of the shelf dryer. The advent of mechanical picking and stripping greatly increased the need for seed cotton drying. The change, in America, to ginning farmer-owned cotton made drying essential.

In the early 1990’s there was some interest in drying seed cotton lying on a slowly moving conveyor. The method has several advantages. It can have a very high ratio of drying air to seed cotton if designed to take advantage of this capability. Properly designed, the moving bed dryer can be mechanically reliable. Samuel Jackson designed and installed a moving bed dryer in a commercial gin in 1966, and it remains in commercial use at this writing at the same gin. The method has some disadvantages, such as its high first cost and large floor space requirement. Its principal weakness is the "front" which advances through the bed during the drying process. Behind this front, the cotton is very dry. Ahead of the front, the cotton can be wetted by the "drying" process. Unless belt speed and bed depth are carefully monitored, unacceptable non-uniformity can result.

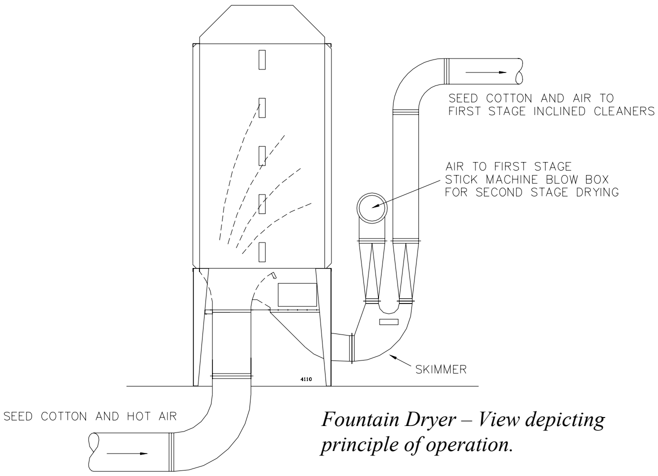


In 1983, a large grower-ginner conducted tests to find the ideal number of shelves for a tower dryer. These tests showed that the cotton fiber did not lose any significant amount of moisture to the air in the tower dryer nor in the conveying pipes. Their conclusion was that the ideal number of tower shelves is zero and they subsequently removed their shelf dryers. Since that research, many industry leaders acknowledge that the primary characteristic given to seed cotton by shelf dryers is not drying of the fiber, but heat imparted to the seed. Some feel that hot seed helps keep downstream cleaners and gin stands warm. Samuel Jackson designers feel that hot seed is best avoided due to the reasons given in section 2.4. The relatively cool temperature of the seed has never prevented a high air volume pull-through system from delivering excellent performance in respect of both capacity and fiber quality over tens of millions of bales. As a bonus to avoiding shelf dryers, seed quality is enhanced, power consumption is reduced, and push fans are not necessary.

As the shelf dryer conferred no fiber drying benefit, the question remained, “Where did the drying take place?” They found that in a typical tower dryer stage, most of the drying occurred at the mix-point where the wet seed cotton entered the hot air stream. The slippage of air past the seed cotton while accelerating it up to the air velocity apparently did the job. Their studies also found that significant drying occurred in the inclined cleaner that separated the air from the seed cotton. Here, like the mix-point, there is slippage of air past the seed cotton. Today, cotton drying systems referred to as “slip” systems take advantage of this effect. In many cases however, they are limited by insufficient air-to-cotton ratios that limit capacity and raise drying temperatures. Samuel Jackson system designers use turbulence and calculated collisions between cotton and hot air to increase slippage. These techniques permit high air-to-cotton ratios and keep drying temperatures low.

3.2 ***Drying “in the pipe”*** – In the 1980’s and early 90’s, many gins in West Texas and other areas where drying was traditionally not a critical problem, simply removed their tower dryers and push fans. Those simple pull-through drying systems performed better than the tower systems they replaced. Those pull-through systems put more hot air through the cotton with less horsepower and many remain in operation today with profitable results. Gins with these simple systems often remark that they are "drying in the pipe," but this is not an accurate statement. The length of pipe that replaces the tower is not important. In fact, when dealing with high capacity systems, pipe length ultimately becomes a limiting factor to drying system capacity. No drying takes place in the pipe, just as no drying takes place within the shelves of a tower. This is because there is no turbulence or slippage of air through the cotton in the pipe, except immediately following the mix point. The gins enjoyed their improvement because they eliminated a major restriction to the air flow.

In recent years, harvesting practices have changed significantly and green, wet cotton is common in West Texas. Powerful dryers traditionally used in wet growing areas are now needed to handle these conditions. The dryers must have the ability to handle greatly increased volumes of seed cotton due to the stripper varieties still common on the high plains. These dryers must have the ability to break up this material and provide it with as much turbulence as possible in hot air without choking or restricting air flow.



Fountain Dryer – View depicting principle of operation.

3.3 ***Early devices*** – In 1987 Samuel Jackson introduced a dryer called the “Fountain Dryer” to the gin industry. The design of the Fountain was chosen because of the extra slippage and turbulence it introduced to the cotton and hot air mix, without restricting the air volume critical to high capacity drying and ginning.

The Fountain’s principle of operation is to spew a mixture of hot air and seed cotton upward like a fountain at one side of an empty chamber. The velocity of the jet is adjustable to make the seed cotton float lazily in the hot air. It then falls to the bottom of the chamber where the same hot air picks it up and accelerates it to the normal conveying velocity. The slippage which occurs during acceleration actually does the drying. The Fountain Dryer makes a significant improvement in drying performance over towers or "pipe drying", while the pressure drop across it is only 0.3 inches of water.

A Fountain Dryer with hot air injection before the inclined cleaner.

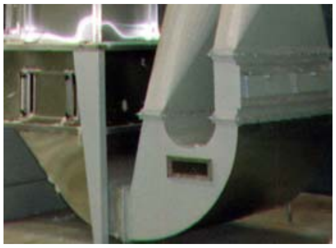
The Fountain Dryer is a mature product and has been widely used and copied worldwide. Its success has spurred cotton industry leaders to enthusiastically embrace high air volume, low temperature drying techniques in their efforts for developing better and faster cotton gins in many forms. This universal progress in improved drying has been rewarding to Samuel Jackson system designers.

Later introductions were made to enhance the effectiveness of Fountain drying systems. One or more auxiliary heaters were added for high-velocity streams of air to turbulate the cotton in conjunction with the Fountain. This is simple to do in a pull-through system, as no push fan is required. In some cases, the collision method used had special modifications to precisely separate rocks, green bolls, and rotten seed cotton, dramatically helping ginning rate in extreme conditions.

A Fountain Dryer with a collider-rock trap to separate debris with hot air

In other applications, the added hot air was simply injected at the Fountain discharge just before the skimmer. This method was used where the total air volume was greater than that recommended for the Fountain. It was an effective and popular drying technique, as the added hot air followed the seed cotton into the first-stage inclines, greatly improving the drying done there.

3.4 ***Skimmer Method for High Air Volume*** – Samuel Jackson uses an unusual method of increasing the air volume in the first stage of drying. This large volume of hot air takes the seed cotton to the dryer. Coming out of the dryer, the seed cotton and air pass through a skimmer (see Figure 2), which slings the cotton to the outside of a curved path by centrifugal force. Half the air and all the seed cotton enter the first cleaner.



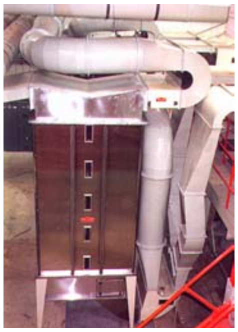
Left: A seed cotton skimmer to double drying air volume.

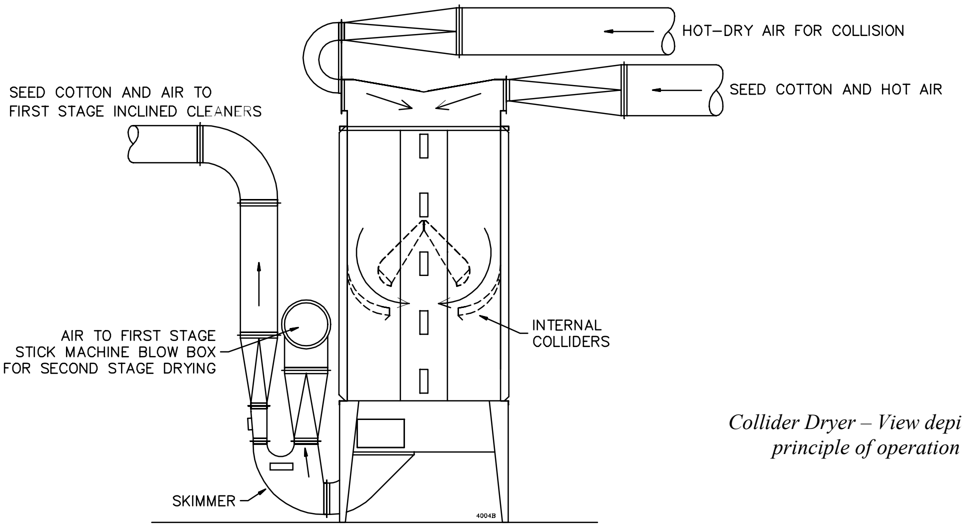
Right: High speed photo of seed cotton inside skimmer.

The other half of the hot air goes to the blow box under the stick machine below the first inclined cleaner. It takes the cotton directly to the second inclined cleaner over the conveyor distributor. We have thus applied all the hot air to the cotton in the first stage. Although the second half of the air does double duty, it still keeps the cotton dry. The technique is not new, and has been applied on millions of bales of cotton in the wettest growing regions of the world. The skimmer can be used only on pull-through drying systems.

Since a single Samuel Jackson dryer will handle a huge air volume relative to a conventional shelf dryer, we often use one pull-through dryer to replace four towers in small gins. The skimmer divides the cotton to two first-stage cleaners and the second-stage air to the other cleaners. This provides greatly improved drying by eliminating the multiple air bottlenecks imposed by the towers.

3.5 ***Collider Dryer*** – Although there are many good possible dryers when pull-through techniques are used, our system designers feel they have found a good balance in a device referred to as the "Collider Dryer". This dryer brings cotton and hot air from the module feeder into a chamber where a direct collision with additional drying air takes place. Following this point of extreme turbulence, the cotton and hot air mixture is divided and taken through a second collision just above the outlet to the skimmer. Although the pressure drop is slightly higher than the traditional Fountain, the drying effect is greatly magnified because of multiple collisions and turbulence.





Collider Dryer – View depicting principle of operation

3.6 ***System Approach Necessary*** -- Simply buying a good dryer and installing it in an existing plant will seldom produce an effective drying system. Every element in the fore part of the gin plant from the module feeder down to the conveyor distributor must be considered. Although Samuel Jackson is pleased to offer high air volume heaters for use in almost any type of drying system available, our dryers are placed only as a component of a complete system. Our designers specify the pipe sizes, fan types, and cyclones, as well as providing any necessary construction prints for blow box changes and transitions. It would be safe to say that our dryers are often given credit that rightfully belongs to related air flow corrections made in the course of implementing the drying system.

4. *SYSTEM DESIGN CONSIDERATIONS*

4.1 ***High Air Volume and Fuel Economy*** -- A common fear is that a high air volume drying system will use more fuel. Our experience with such systems has been that the fuel cost per bale is usually about the same as with a conventional system. Under the worst conditions (wet seed cotton and cold, damp air) the hourly fuel consumption might be twice that of a conventional system.

However, the ginning rate continues at a high capacity. When the atmospheric air conditions are warm and dry, the high- volume system uses less fuel because of natural drying. Through the peaks and valleys, the result is that average fuel cost per bale is usually about the same as for a conventional system. It should be noted here that if a high air volume drying system is run at a high temperature regardless of cotton moisture content, fuel cost for the season will be higher than with a conventional system as air volume to heat is greater. In addition, if a moisture restoration system is used at the press, its effectiveness will drop by at least 5 pounds per bale due to the difficulty of restoring moisture to overheated, dry fiber. Samuel Jackson designers take time to educate gin personnel in these matters and they recommend use of an automatic moisture control device to set drying temperatures appropriately.

4.2 ***Limitation on Air Volume*** -- The practical limitation on the air volume used in a drying system is the air handling capacity of the inclined cleaners that separate the seed cotton from the air. We use the rule that we can pull from each cleaner about 1500 cfm per foot of width. This would be 12,000 cfm from an 8-foot wide cleaner. We may substantially increase the operating air volume through the use of devices like the "Electric Banjo" that unload a pull fan while the gin is at idle. This device loads a centrifugal pull fan fully when air is warm and the system is fully loaded with cotton, thus providing an additional 30% air volume over the normal maximum limit. This increase in hot air volume is a welcome addition when system designers are allocating hot air volumes to various injections and collisions throughout a system.

4.3 ***Pull-Through Operation*** -- Almost all of the drying systems we have designed have been pull-through systems, instead of push-pull. By designing with an eye to elimination of air flow restrictions, push fans are not necessary. In fact, they become limitations to high air volume. We do specify high-efficiency pull fans capable of operating with stability at high static pressures.

There are several advantages to the pull-through arrangement. The gin plant is cleaner because air is leaking into instead of out of the system. Vacuum feeders last much longer, because a small amount of cold air leaks through into the system, instead of hot air leaking out. Another plus is the ease of applying air from one heater to more than one drying point, as described in Sections 3.3 and 3.5.

System commissioning involves checking air leakages against the charts to find surprises before operation.

4.4 ***Air Leakage Into the System*** -- In designing a pull-through system, we must allow for air leakage into system, or there may not be enough air to convey the seed cotton properly at the mix point. This leakage occurs at the inclined cleaners, vacuum feeders, and Hot Box.

Our estimates of leakage into inclined cleaners are based on our experience. Typical leakages range from 2000 to 4000 cfm per incline. We allow 1000 cfm for leakage through each vacuum feeder at the second stage mix points.

When Samuel Jackson commissions a new system, careful air measurements are taken multiple times and compared to those projected on the system design charts. All conveying velocities, air volumes, and system backpressure readings are checked and verified again. Any surprises are found well before cotton enters the system. This type of work is not considered "insurance" or a luxury. It is absolutely critical on any high air volume pull through system, as these systems can be unforgiving if the designer is neglectful.

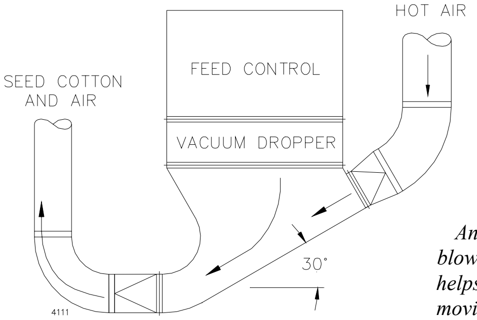
A Hot Box II installed with a fixed head module feeder. Seed cotton travels into the gin with hot air – rocks and green bolls are dropped.

4.5 Hot Box at Module Feeder -- Wet seed cotton can clog the screens of the unloading separators. In 1986, we devised a simple way to apply hot air to the seed cotton at the module feeder belt. It is a mature product, widely copied (with many variations) called the Hot Box. Today Samuel Jackson designers use the "Hot Box II", with greatly improved performance. Its place and function in the drying system is shown in Fig 1. We enclose the module belt at the pickup point with the Hot Box II. The seed cotton on the conveyor belt is pulled by the belt into the box under a pivoted door that restricts the entry of air. The air that pulls the seed cotton into the gin plant comes out of this box, producing a vacuum in it. This pulls hot air from a heater. We not only remove a bottleneck in the cotton flow stream, but do additional drying economically. The Hot Box II needs neither push fan nor vacuum feeder. It has no motors and needs no regular maintenance. When installed per our recommendations, green bolls and rocks are removed in large quantity through its trash gate and an efficient trash conveyor is strongly recommended.

At one time, only moving-head module feeders had conveyor belts. Now, 36"-wide conveyor troughs are commonplace on stationary-head module feeders, primarily so the Hot Box II may be used. The Hot Box II may be equipped with a sensor to automatically adjust drying temperature based on moisture of incoming seed cotton on the belt. This greatly enhances fuel savings.

A chain flail located above the Hot Box can disperse wet UNR and stripper cotton for better drying and cleaning.

4.55 Flail over Hot Box -- When processing wet stripper cotton, it is possible for wet, undispersed clumps of trashy cotton to pass through the dispersing cylinders of some module feeders and the Hot Box. These clumps impede drying and pre-cleaning efficiency and can cause chokes in situations where feed rate is high and conditions are challenging. Samuel Jackson engineers have addressed this problem by the use of a chain flail option that can be placed directly above the outlet of a Hot Box II. The rotating heavy chains help further disperse challenging cotton and maintain drying and pre-cleaning efficiencies.



An inclined blowbox design helps cotton get moving quickly.

4.6 ***Blow Boxes*** -- The blow box at the mix point where wet seed cotton enters the first-stage hot air stream has long been a source of trouble. We incline the bottom of the blow box at 30° from the horizontal to help slide the seed cotton down into the pipe where the hot air can capture and convey it. We specify the usual horizontal blow box at the second stage mix points under the stick machines, since the seed cotton is dry and fluffy at this point. If properly designed, both longitudinal and cross blow boxes can provide trouble-free operation.

4.7 ***Feed Control Units*** -- When using a module feeder at a gin that receives mostly moduled cotton, it is desirable to avoid passing the moduled cotton through unloading separators and feed control units. We handle this by using hot air to pull cotton from the Hot box directly into the drying system, as shown in Fig. 1. The advance speed of the module feeder regulates the cotton feed rate. For trailer cotton, the feed control unit drops it on the conveyor belt so it passes under the moisture sensing “Sled” and through the Hot Box into the drying system. The unloading fan, separator and feed control can be turned off when ginning modules.

Another reason for avoiding the feed control is that it compacts wet seed cotton into wads that are difficult to dry and clean. Where one must use a feed control, it should have a good disperser.

We have prepared a memorandum, "Layout of New Gin Plants", which treats in detail the possibilities of various arrangements of module feeders, feed control units, cross conveyors and moisture measuring methods. Its ideas have been incorporated into many new and existing gin plants. We will send this memo upon request.

4.8 ***Unloading Fans*** -- Where a gin handles both moduled and trailer cotton, the ideas of Section 4.7 should be used because if a separator handles both types, we have another problem. The suction pipes for trailers need high suction to break the tightly packed cotton away from the load. We will have to run the unloading fan fast enough to make high suction. Then when we pick up dispersed moduled cotton, the low resistance usually results in such high air volume that it overloads the fan motor, and the high air velocity can crack the seed. This can ruin the germination and put seed coat fragments into the ginned lint. The “Electric Banjo” mentioned in section 4.2 is also applicable when considering unloading fans. Unloading suction power is increased 30% without an increase in motor size.

The Electric Banjo can be used on unloading fans or on drying system pull fans to increase operating air volume 30%

On moduled cotton, the pull fans for the drying system move the cotton from the module feeder. For this use and for unloading separators, we recommend using high static pressure No. 60 fans having 44” diameter blast wheels. With such fans, it is not necessary to use two fans in tandem to get the necessary suction.

4.9 ***Selection of Heaters*** -- A cotton gin cannot perform any better than its drying system. A drying system cannot perform any better than the air heaters used. The following check list can help avoid problems.

(1) Will the heater actually put out the heat needed?

(2) Is the heater designed to handle high air volume?

(3) Does the heater have wide operating range (20:1)?

(4) Does the heater provide clear diagnostics and operation statistics?

(5) Can the heater controls connect to automatic moisture controls?

(6) Does the heater have adequate combustion safeguards?

(7) How efficient is its combustion?

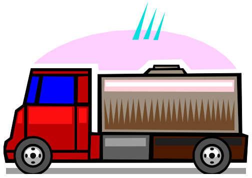
Samuel Jackson heaters are designed and built specifically for pull-through drying.

4.10 ***Calculation of Heat Required*** -- Determine the amount of heat required to raise a known volume flowrate of air (CFM) from one Fahrenheit temperature T_1 to another T_2 by using the following formula:

$$\text{Btu/hr} = 1.08 \text{ X CFM X } (T_2 - T_1)$$

4.11 ***Calculation of Fuel Consumption*** -- Determine the maximum rate of fuel consumption in order to specify the proper size of gas meter, supply pipe, vaporizers and regulators. Do this by adding up the Btu/hr ratings of all your burners, then divide the total by the lower heating value of the fuel. Lower heating values of some common fuels are as follows:

Natural Gas	913.	Btu/ft^3
Propane, gas	2,385.	Btu/ft^3
Propane, liquid	84,240.	Btu/US gallon
Propane, liquid	43,870.	Btu/kilogram
Diesel fuel	132,100.	Btu/US gallon
Diesel fuel	34,900.	Btu/liter



Remember that the maximum consumption rate will be much greater than the average rate. It is important to have the maximum flow available to keep from slowing ginning when adverse conditions occur.

4.12 ***Air Velocities*** -- We use a design velocity of 4500 to 5000 feet per minute when conveying wet seed cotton in drying air. If an abnormal circumstance reduces this even down to 3500 fpm, the system will still operate. For conducting hot air from the heater to the mix point, we use a design velocity of about 4000 fpm based on standard air. This allows for thermal expansion of the hot air.

5. *AUTOMATIC CONTROLS FOR THE DRYING SYSTEM*

5.1 ***Temperature Control of the Drying System*** -- The best way to make the heater responsive to cotton moisture conditions is to place its temperature sensor after the cotton-air mix point. This turns the burner down when the gin is idling, and turns it high when the cotton is wet.

There is something lacking here. We also need to limit the temperature of the hot air ahead of the mix point to prevent heat damage to the fiber. In some cases the maximum permissible temperature will be specified by the mills buying the cotton to preserve fiber quality.

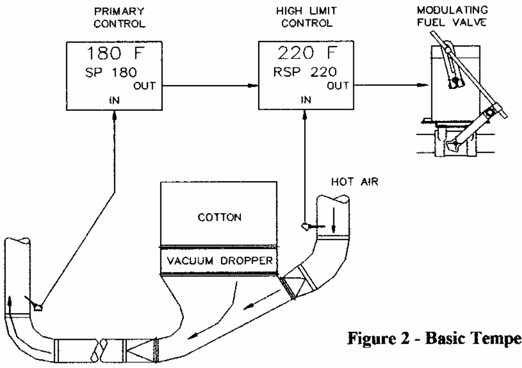
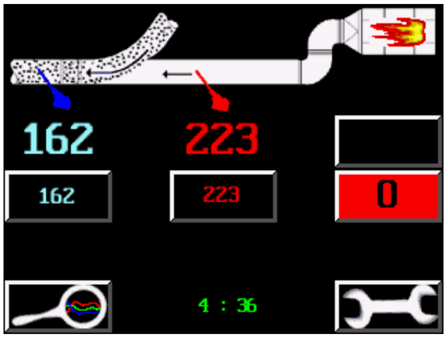


Figure 2 - Basic Temperature Control

In the late 1980's our company pioneered the use of cascaded temperature controls for cotton drying systems. We used Honeywell digital temperature controls to accomplish this as depicted in Figure 2. Its principle was as follows. The primary controller has its temperature sensor after the cotton mix point while the high limit controller has its temperature sensor before the mix point. The output of the primary controller determines the temperature set point of the high limit controller, while the output of the high limit controller modulates the fuel valve of the heater. We programmed the high limit controller to accept only a specified range of set points. The result was a smooth modulation of the hot air temperature up to the desired maximum.



Beginning in 2004 our product line migrated toward accomplishing the cascaded temperature control wholly within each burner's PLC control system, with overall coordination by a Moisture Mirror II. This arrangement has the advantage of making the control simpler to understand for the gin operator and the wiring simpler for the installing electrician. Conventional Ethernet cable is used to connect the components. We assign color codes to the temperature sensors to make the system easier to understand and troubleshoot.

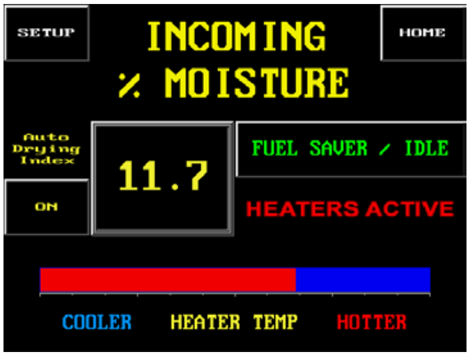
5.2 ***Moisture Control of the Drying System*** -- For years, there have been cotton dryer controls that use the moisture content of the cotton to modulate the burner fuel valves. Since this control arrangement cannot take into account the ambient air temperature, heater efficiency or the feed rate of the cotton, it is easy to over-dry the cotton, especially in hot weather.

This problem has been solved with controls that measure the incoming cotton moisture and then raise and lower the temperature set points of all the drying heaters in the gin. Using these controls, the operator can bias the general drying temperature level upward or downward. Each heater's primary controller can be programmed to progress through a different temperature range as the moisture content changes from low to high.

The cascade arrangement, in which the moisture content produces changes in temperature instead of simply modulating a gas valve, has several advantages. The control system will adapt the heater output to climatic conditions, using more heat in cold weather than in hot. The primary temperature controllers, having their sensors after the mix point, also react to the wetness and feed rate of the cotton, using more heat on wet cotton. We also have the benefit of the high limit control, which avoids exposing the cotton to excessively hot drying air.

A sensor like the sled pictured here can provide an advance signal to turn drying temperature up or down in response to moisture..

A little-known feature on Samuel Jackson moisture controls is an alarm contact that can be programmed to open and close at a specified moisture content of the incoming cotton. If one assumes that the fiber moisture is the same as the seed moisture on this incoming cotton, this alarm can signal gin personnel or the automation system to divert wet seed to separate storage. This avoids a common problem of having to dig out tons of dry seed to take care of a hot spot in seed storage.



Fully automatic control for the drying system can be biased by the operator by adjusting the red and blue bar on the lower screen.

In 2001 the Moisture Mirror product was introduced. This “Moisture Coordinator” uses a color touch screen to let the operator know about changing moisture values and lets the operator easily program control action to compensate for the changes. In 2003 the Moisture Mirror II was introduced to augment this product line. Among its other enhanced capabilities, the Mirror II permits on-line cotton classing instruments to change drying system settings in order to achieve a target cotton grade.

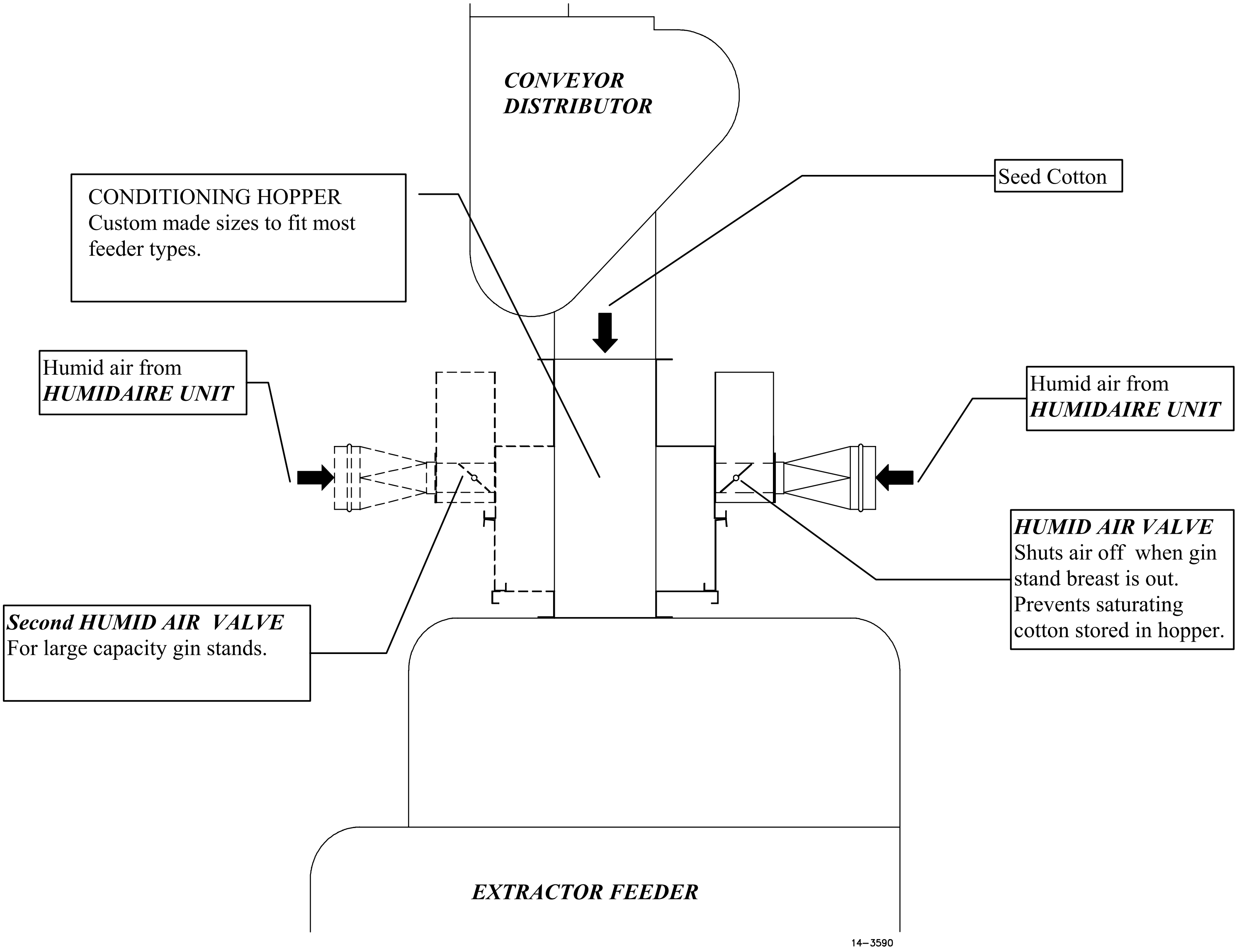


Figure 3 - Seed Cotton Conditioning Hopper