MANAGEMENT OF BALE TIE LOADS THROUGH THE EFFICIENT PRESSING AND PACKAGING OF COTTON

Shay L. Simpson
National Cotton Council
Memphis, TN
W. Stanley Anthony
U.S. Cotton Ginning Laboratory
Stoneville, MS

Abstract

The cotton industry is plagued by broken bale ties each year. High stresses inside cotton bales can cause one or more ties to fail which may result in exposed lint. Four main ginning techniques for reducing high stresses on bale ties include maintaining a lint moisture content between 5 and 8 percent at the press box, hold platen separation (shut height) to 19 or 20 inches, make sure lint distribution on the condenser drum remains uniform, and provide tie lengths of no greater than 87 to 89 inches (plastic strap 86 2 inches maximum). Two additional recommendations for reducing stresses on ties are to rotate wire knots to the ball (sample side) of the bale and to recess ties into the flat side of the bale. Following these six guidelines for preventing broken bale ties should prove useful.

Introduction

Broken ties on cotton bales are a hindrance for all segments in the cotton industry. Average occurrence of bales with one or more ties broken in the U.S. Cotton Belt each year is about 3%. This percentage for individual gins can reach as high as 35%, or more, in cases where a gin is experiencing severe problems with pressing or packaging systems. There are several practices that can be followed for reducing these localized problems. These suggested practices for forming and pressing cotton bales to reduce the forces on bale ties that cause breakage follow.

Problems & Effects of Broken Ties

The ultimate problem with broken ties is that textile mills cannot process the affected bale. Tie breakage affects the bloom height or growth of the bale in the opening room of a mill. If the bloom heights of cotton bales are not uniform, then automatic lint feeders do not operate efficiently. Generally, a bale is rejected with more than one tie broken or missing or a fan head.

When mills reject a bale, it might be sent back to the warehouse and the shipper must pay the extra costs. The shipper could then bill the warehouseman for lost expenses. The warehouseman could even bill the ginner for costs associated with broken ties. Essentially, tie breakage causes unnecessary costs for all segments in the cotton industry.

If warehousemen don't want to risk having a bale rejected, bales with broken bands must be repaired before they leave warehouse facilities. Repairs are very labor and cost intensive. Depending on the method and extent of repair, it could cost from 6 to 17 dollars and take 7 to 30 minutes to restore the bale to shipping condition.

Compresses once used to press flat bales now may be used for repairing bales with broken ties. It takes a short time to press one bale, however the labor and start-up costs are high. Dinky presses often are used to repair bales at less costs than a compress or hand repair. However, warehouses many times do not have a compress or dinky press. In those cases workers hand repair the bales by squeezing the bale with forklift clamps and using a ratchet-wrench to apply a flat band.

No matter what method is used for repairing bales, the size of the repaired bale is never as uniform as a bale with its original ties in tact. This non-uniform size bale could cause handling, storage, and shipping problems. Fork lift operation efficiency may decrease, shipping space may be used poorly, and stack stability may decrease.

Other Problems Due To Tie Breakage & Tie Itself

Other problems due to tie breakage are important not to overlook. Sharp edges from broken wire and strapping create a safety hazard for forklift drivers, bale repair workers, and even the occasional passer-by. Also, the decreased stack stability from non-uniform bales is very hazardous. Workers may enter an unstable area to inspect, clean, or flag bales for shipment. If an unstable bale or section of bales suddenly looses 'grip' or overcomes the slip characteristics of the bag and falls, there could be a serious accident.

Problems associated with tie breakage also could occur at the textile mill. Lint contamination from wire and strapping is possible when tie breakage occurs. As a result pieces or chunks of wire and strapping could become caught in the mill machines and cause expensive and extensive damage or even fires.

Causes of Broken Ties

So, what causes broken ties? Many different things occur alone or in combination to cause broken ties. The most common of which are uneven lint distribution, low lint moisture content, insufficient platen separation or compression density, rough handling techniques, inadequate tie length, and possibly wire metallurgy.

Wire metallurgy, however is not the largest concern for tie breakage. The method of drawing wire has been perfected over the years. Molecular formulas of metal compounds are constantly being reviewed and tested in order to yield the

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strongest, most ductile wire viable. It is possible that the wire forming process could, nevertheless, produce a weak section or weak spot in the wire.

The annual publication, Specifications for Cotton Bale Packaging Materials, developed by the Joint Cotton Industry Bale Packaging Committee and adopted by USDA for Commodity Credit Corporation loan eligibility, requires that manufacturers follow a regular procedure of testing and inspection which involves a "quality" test from each 2,000 pound lot of wire or steel or plastic strapping carrier.

Tensile tests are performed on joints and straight sections with a universal testing machine. If any wire or strapping does not meet the requirements set forth in the Specifications, then the whole lot is rejected.

Four Factors To Watch When Ginning

There are four main factors to be more concerned with than metallurgy that might lead to tie breakage.

First, lint moisture content has an effect on tie forces and the force required to press the bale. Lint that has a low moisture content is very springy and more resilient than lint with a moisture content of 5% to 8%. The higher the lint moisture content, the easier the lint will compress in the bale. Over-drying lint can cause an increase in the press energy consumption and more importantly, prevent the bale from being compressed to the correct density, which will increase bale tie forces due to the lint's higher resiliency.

Second, uneven lint distribution can be a big culprit of tie breakage. Uneven lint distribution is attributed to incorrect air flow through the battery condenser drum, improperly designed lint ducts, obstructions, the lint slide angle being too great or too small, improper speed of the lint feeder, or a combination of all five.

Third, compression density and restraint density are the two factors that affect bale tie forces the most. Compression density is the density that a bale is pressed to before it is tied out and released. The restraint density is the density that the bale settles to over time with ties restraining the bale. The distance of minimum platen separation is the defining factor of compression density. If a sufficient platen separation is **not** achieved, the compression density will be too low and the tie forces required to restrain the bale will be too high. This could result in tie breakage.

Measures must be taken to prevent excessive tie breakage and the associated costs incurred by ginners, warehousemen, shippers, and manufacturers.

Techniques To Avoid Excessive Broken Ties

Preferred conditions for compressing the lint and forming gin universal density bales include an even distribution of lint in the press box, a lint moisture content of 6-8% before packaging, a platen separation of 19 inches, and a minimum tie length of 87 inches. There are two differences for standard density bale preferred conditions. A gin standard density bale would be pressed to a 21-inch platen separation and restrained with a minimum tie length of 90 inches.

Optimal Conditions

Using these optimal conditions for a gin universal density bale, the normal forces that eight ties might encounter restraining a 500 pound bale are illustrated in Figure 1.

The first and eighth ties experience approximately equal forces which are considerably less than the forces on the middle fourth and fifth ties. This indicates that the middle of this formed bale exerts more pressure on the middle ties and surrounding cotton than the outer or end sections of the bale. Generally, the average load that a tie on a well formed bale will undergo is less than 1500 pounds.

The Specifications for Cotton Bale Packaging Materials, requires certain characteristics of wire ties. These requirements have been refined over the past 25 years to include adequate specifications for gin standard and gin universal density bales. Correspondingly, wires should be no less than 9 gauge and the joint strength must be no less than 2,100 pounds, steel strapping with a controlled-slip connection must slip at no less than 2,000 pounds and plastic strapping's average joint strength must be no less than 2,150 pounds.

In order to restrain cotton, the bale tie must overcome the force that the cotton applies to each tie. If the force of the cotton is greater than the bale tie joint strength, the result will be a broken tie. Anthony and McCaskill (1978) present an equation for calculating the forces gin universal density pressed bales exert on bale ties. Modifying this equation from Scientific Units to English Units, the following equation results:

$$Log_{10}(F) = 19.7093 - 0.0303M - 10.5484Log_{10}(C) + 3.7667Log_{10}(PS)$$

where:

F - total force, pounds
M - moisture content, %
C - bale circumference at tie, inches
PS - platen separation, inches.

In order to calculate forces exerted on the individual bale ties from the gin universal density bales, the following equation is used:

$$f = \frac{F}{T}$$

where:

f - force exerted on individual tie, pounds
T - number of ties restraining bale.

Using these equations gin universal density bale tie loads in non-optimal or worse case conditions can be calculated.

This will help diagnose bale tie failure problems and pinpoint what systems should be adjusted to correct the problems.

Effect of Moisture Content

Figure 2 shows three bales all weighing 500 pounds, with gin universal density dimensions, 87-inch tie lengths, normal lint distribution, and pressed to a platen separation of 19 inches. The first bale is pressed at 3% lint moisture content, the second at 6% moisture content, and the third at 8% moisture content. In these cases the tie load decreases with increasing moisture content. The preferred moisture contents are 6 and 8%. Even at these moisture contents, we see that at the higher 8% moisture content the tie load decreases 25 percent more than at the 6% moisture content.

In order the keep an adequate moisture content in the lint, dryer temperatures and air flow rates should be adjusted and maintained properly. Retaining moisture in the bale throughout processing is recommended for quality preservation rather than recharging the lint after drying. The preferred lint moisture contents for pressing a bale are 6-8%.

Effect of Platen Separation

Minimum platen separation or compression density is a significant factor related to bale tie performance. Platen separation is the distance between the fixed platen and the platen on the follow block. The minimum platen separation at the time of tying the bale out should be sufficient to result in low lint resilient forces. The minimum platen separation for gin universal density bales should be at least 20 inches but preferably 19 inches.

Figure 3 shows three more bales, all 500 pounds, with gin universal density dimensions, and 87 inch tie lengths. The bales are all pressed with moisture contents of 6% and an even lint distribution. The first bale was pressed to a platen separation of 19 inches, the second to 21 inches, the third to 23 inches. The benefits of bale tie force relief are very evident on the bale pressed to 19 inches. Pressing the bale to 19 inches created a high compression density and decreased lint fiber resilient forces.

Effect Of Tie Length

In 1994, the Joint Cotton Industry Bale Packaging Committee adopted wire tie length standards for gin universal and gin standard density bales. For bales pressed in a 54-55 inch long by 20-21 inch wide press box, a gin universal density bale should be tied with 87-89 inch wire ties and a gin standard density bale should be tied with 90 to 93 inch wire ties. In 1997, the Committee adopted plastic (PET) strapping lengths of no longer than 86 inches. With these fixed length ties, bales have become more uniform in size creating better stack stability, ease in handling, and a regular bloom height or growth in the mill opening room.

In Figure 4, again two bales both 500 pounds, with gin universal density dimensions, are pressed to a platen separation of 19 inches, with moisture contents at 6%. Two bales are tied with different lengths of ties - 89 and 87 inches.

The tie load on the shorter 87 inch ties is higher than the longer 89 inch ties. Since gin universal density bales' dimensions are defined as being bound with ties 87 to 89 inches in length, 89 inches is the longest tie available for use.

Effect of Lint Distribution

The distribution of lint across the press box is a very important factor in controlling high forces within a bale. If a large percentage of the lint in a 500 pound bale is distributed over a small area in the press box, then only a few ties will be restraining that lint. This is when tie breakage becomes a serious problem. A gin that has un-even lint distribution in the press box could have as many as 3 or 4 ties break per bale. In these cases, the ties usually break in the same tie position of the bale.

Figure 5 illustrates a possible tie load scenario that un-even lint distribution could cause. Both bales are pressed at 6% moisture content to a 19 inch platen separation and tied with 89 inch ties. One bale has a uniform lint distribution in the press box and the other is un-evenly distributed. This un-even bale could represent a big-ended bale.

The highest load on bale ties occurs on the non-uniform distributed bale. Here, the load will vary at the eight tie positions depending on the amount of lint under each tie.

If the follow block is not level with the length of the bale when it is being formed and tied out, the resulting bale will be big-ended. If this happens, check the condenser for correct operation, check to make sure the air flow rate to the condenser is adequate, check for any obstructions to the air flow, and check for any bent or dented lint flues. Rectangular elbows and ducts should be used near the battery condenser to defeat the 'swirling' motion of the lint in the air stream.

Effect of Rotating Knots

The Specifications require that gin universal density and gin standard density bales be tied with the knots on the ball or rounded surface of the bale. This is to ensure that hand tied knots will be rotated from the flat side of the bale to the ball or sample side. There is definitely an advantage to rotating the knots to the crown. The tension forces pulling on the knots placed at the crown of the bale may be 10% less than the tie forces on the flat side of the bale.

Figure 6 shows the effect of rotating wire knots from the flat side to the crown or sample side of the bale. The effective strength of the knot increases 10% from 2100 pounds to 2300 pounds. This 200 pound difference allows a "safety factor" for heavy bales or bales not formed at optimal lint moisture content, platen separation, or other condition.

Effect Of Recessing Ties

Placing ties in recesses or channels of the flat sides of the bale is a technique ginners are using to reduce tie breakage due to handling. Since the tie is recessed into the lint, forklift clamps and other handling equipment do not contact the ties as roughly or at all. This could reduce the number of broken ties due to handling. The recessing of ties could also help in keeping bag damage to a minimum as forklift clamps avoid sheering the bag.

Channels or grooves are created by the installation of vertical steel flat stock or other bars on the inside of gin press boxes. Resulting indentations in the bale coincide with the locations of straps or wires. Gin operators should be advised that improper installation of steel bars may create potential risks to bale or fiber quality, equipment or workers. Therefore, ginners should consult with their respective gin press manufacturers prior to any addition or modification to the gin press.

Comparison Of Tie Forces Due To Combined Problems

Figures 7 and 8 compare the ranges of bale tie forces that result when problems associated with pressing and packaging cotton are combined. Both figures show five different bales pressed at different platen separations and moisture contents. The first bale two bales pressed are both optimal characteristics, the third bales are pressed with worse characteristics yet typical of bales pressed in the U.S., and the fourth and fifth bales are pressed to too large of a platen separation and too little amount of moisture in the lint. Figure 7 shows bales tied with 89 inch tie lengths, while Figure 8 shows bales tied with 87 inch tie lengths.

In Figure 8 both of the last two bales pressed combine enough packaging problems that the resilient forces of the cotton are too great for the tie joint strength to restrain. These two bales would most likely experience tie breakage at one or more tie positions. However, in Figure 7, a longer tie length in used and a little load relief is seen. The load relief is great enough to prevent tie breakage in the fourth bale, but the fifth bale will most likely experience tie breakage.

If an un-even lint distribution problem were combined with these problems, any or all of these bales could have extra ties broken.

Conclusion

Remember the four main ginning techniques for reducing high stresses on bale ties --

Lint Moisture Content 5 - 8%,
Platen Separation (shut height) 19-20 inches,
Lint Distribution to remain uniform, and
Tie Length 87-89 inches (plastic strap 86 inches maximum).

Using these guidelines, bale tie breakage will decrease and aid in handling, shipping, stacking and consumption at the gin, warehouse, textile mill and all points in between.

References

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Anthony, W.S. and McCaskill, O.L. 1978. Bale tie forces exerted by modified flat and gin universal density cotton bales. Transactions of the ASAE 21(5): 833-837.

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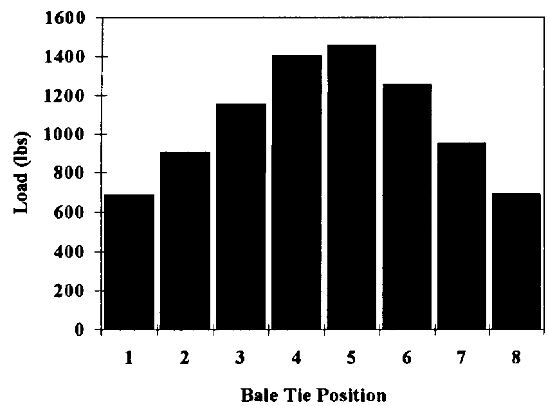

Figure 1. Typical bale tie force distribution.

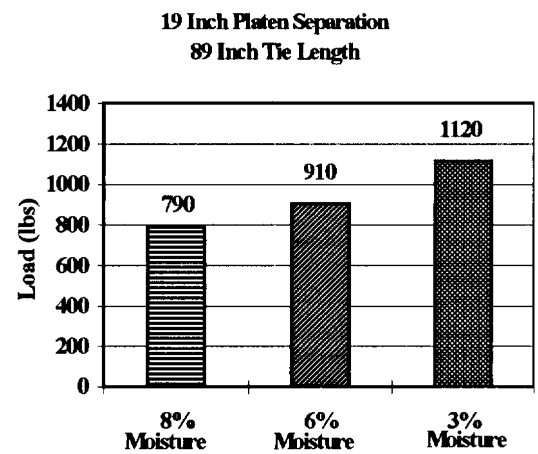

Figure 2. Effect of change in lint moisture content on bale tie loads.

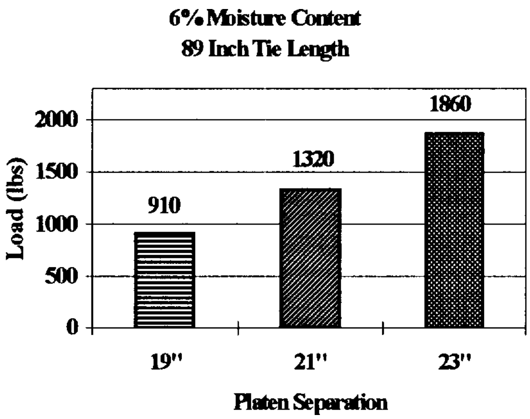

Figure 3. Effect of platen separation changes on bale tie loads.

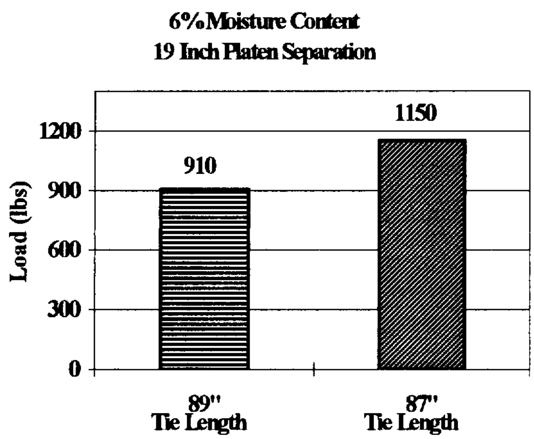

Figure 4. Effect of tie length changes on bale tie loads.

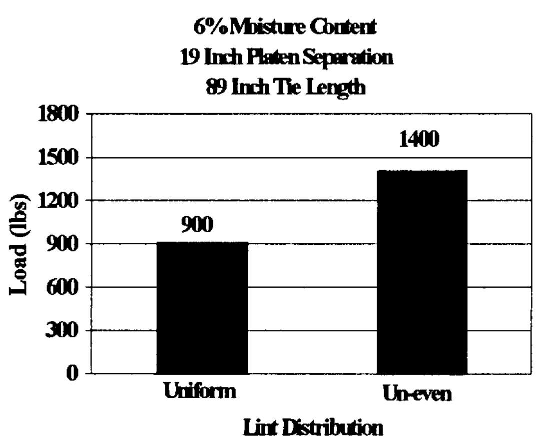

Figure 5. Effect of lint distribution on bale tie loads.

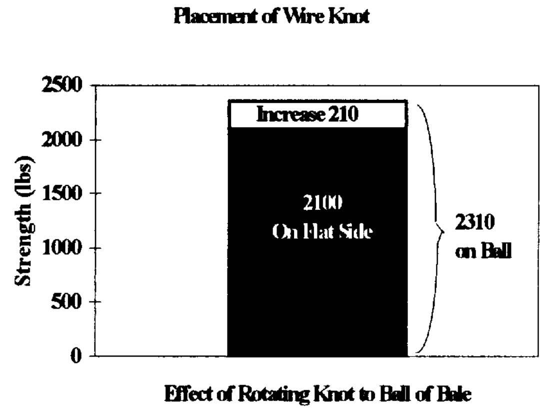

Figure 6. Effect of rotating wire knots to ball of bale.

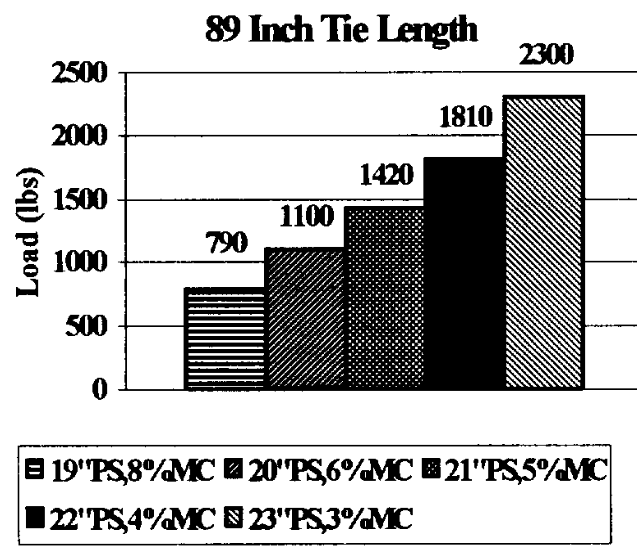

Figure 7. Effect of different packaging techniques on 89 inch bale ties.

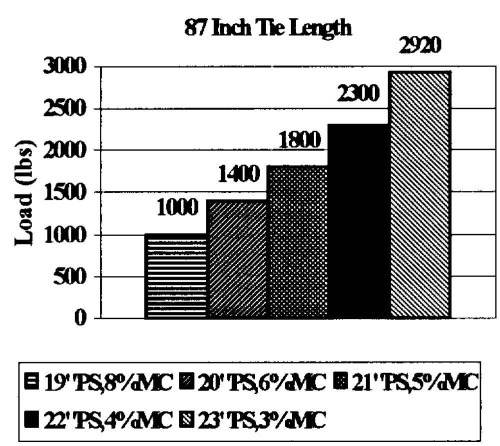

Figure 8. Effect of different packaging techniques on 87 inch bale ties.