EXCESSIVE COTTON BALE tie failures at gins and during shipping and warehousing place unnecessary financial strain on the cotton industry. Analysis of the cause of failures on bales from specific gins is not simple and direct because many factors affect the forces in the restraining ties. Previous research (1, 2, 3 and 4) has shown that bale tie forces are primarily a function of three factors:

1) Compression density
2) Restraint density
3) Lint moisture content

The systematic analysis of the potential causes of bale tie failure can be divided into the same three areas that govern the stresses within the bale ties. In addition, consideration must be given to the distribution of lint within the bale. A decision matrix must be created for isolated bale tie failures that involve a few bales at random, but its use will be invaluable to locate causes when failures occur in the restraining ties of numerous bales.

The flow-chart type decision matrix in Figure 6 is key to an index number that is positioned outside the upper left hand corner of each box. To use the matrix, enter block one entitled "Excessive bale tie breakage" and follow the directional arrows until the cause of the failure is isolated. At that point, three possible courses of action are possible:

1) Take corrective measures as indicated.
2) Contact supplier of bale ties.
3) Consult press manufacturer.

Each numbered decision block will be explained in the similarly numbered paragraphs that follow:

1. Excessive bale tie breakage. Entry point of matrix.

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2-inch increase in bale tie length decreases the bale tie forces more than 20 percent. Bale tie forces increase about 15 percent as the lint moisture content decreases from six percent to four percent (wet basis).

Approach

The systematic analysis of the potential causes of tie breakage and suggests solutions to the problem.

The maximum compression density in ginning terms is the bale weight divided by the bale volume (length times width times thickness). Because calipers are required to measure the bale dimensions, it is more convenient to estimate the restraint density from the bale circumference. Figures 1 and 2 demonstrate the relationship between restraint density, bale weight and bale circumference for gin universal density (GUD) and gin standard density (GSD) bales that are 20 and 21 inches wide, respectively.

The restraint density is the final density of the bale after it is removed from the press and may be determined by dividing the bale weight by the bale volume (length times width times thickness). Because calipers are required to measure the bale dimensions, it is more convenient to estimate the restraint density from the bale circumference (5). Figures 1 and 2 demonstrate the relationship between restraint density, bale weight and bale circumference for gin universal density (GUD) and gin standard density (GSD) bales that are 20 and 21 inches wide, respectively.

The force required to compress lint cotton varies greatly due to variations in lint density and lint moisture content (Figure 3). The resilient force exerted on bale ties can be estimated from the platen separation, lint moisture content, and bale circumference (Figure 4). Small changes in platen separation and bale circumference dramatically affect the force exerted on the bale ties (Figure 5). Table 1 indicates that a 2-inch decrease in platen separation decreases the bale tie forces by more than 30 percent whereas a

Figure 1. Relationship of density, net weight, and bale circumference for gin-universal-density bales 20 inches wide and 35 inches long.

Figure 2. Relationship of density, net weight, and bale circumference for gin-universal-density bales 21 inches wide and 35 inches long.

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Figure 3. Predicted force to compress lint cotton in a gin universal density or gin standard density bale press to given densities at three moisture contents.

Figure 4. Maximum tie force per tie exerted by 500-pound, gin standard or gin universal density bales of Upland cotton at five percent lint moisture content (based on 15 percent of the total bale tie force per tie).

Figure 5. Effect of bale expansion on the maximum force on one tie of a compress universal density bale (with three percent moisture) 20 minutes after release of platen pressure.

6. Repair/adjust: If problems are noted in block five, they should be resolved before proceeding.
7. Proceed to block 23: After the problems are resolved, additional checks should be made by advancing to block 23.
8. Big-sided bale: These bales may have more cotton in the front or rear section of the bale.

9. Check lint slide angle...: Lint cotton is carried from the condenser to the lint feeder by a sheet-metal trough called a lint slide. The lint slide is normally installed on a 40- to 45-degree angle. A larger or smaller angle may cause the lint to be deposited in the front or rear of the press box rather than distributing it evenly.
10. Change angle: If the angle is not between 40 and 45 degrees then it must be changed.
11. Is lint feeder too aggressive...: The lint feeder is used for moving lint from the lint slide into the charging box of the press. There are four basic types of feeders: (1) the revolving paddle kicker, (2) the belt feet used with the kicker, (3) the lint pusher, and (4) the air suction feed.

The lint feeder is intended to deposit lint into the charging box with a fast but gentle action, without agitation, turning, rolling, tumbling, tearing, or otherwise breaking up the bale as it is received from the condenser. The speed or rate of sweep of the lint feeder determines whether the lint will be deposited in the front, middle, or rear of the charging box. If the discharge is too strong, more lint will be deposited in the front of the charging box than in the rear. The opposite effect will be observed if the discharge is too weak.

12. Change speed if necessary: If the lint feeder is too fast or too slow, the speed must be adjusted before advancing to the next step.

13. Defective connection: Two types of connections are used—one for wire and one for flat strapping. Identify the type in use and proceed.

14. Wire engaged properly: The wire connection (knot) can be improperly engaged by inexperienced personnel. In such instances, the failed loop in one end of the wire will be nearly straight.

15. Proceed to Block three: If the wire was properly joined, a problem exists with the lint distribution within the bale. Proceed to Block three.

16. Check procedure or equipment: Instruct personnel in the correct method of making the wire connection, or adjust automatic-strapping device to indent or crimp seals properly.

17. Contact supplier: After all available expertise has been exhausted, contact the supplier of the tie or equipment for assistance in solving the problem.

18. Seal indented properly?: Inspect the seal and strap to ensure that seal indentations do not significantly cut into the strap and that the seal indentations are sufficiently deep to allow the seal to make strong connection. A new crimped joint does not cut into the strap. Inspection of the seal may require guidance from the manufacturer.

19. Proceed to Block three: Since the seal was properly indented or crimped, a problem must exist with the lint distribution within the bale. Proceed to Block three.

20. Failure not in joint: For most wire and strapping, the joint is the weakest point. If the failure occurs in the straight length of the tie, then the supplier should be contacted.

21. Contact supplier: The supplier can provide strength data for the ties.

22. Failure in joint at different tie position: Failures at different tie positions on different bales suggests that the lint is evenly distributed.

23. Examine failed ties for external damage: Handling equipment such as cart trucks may damage ties after they are installed on the bale. External nicks that weaken the tie can occur before or after they are placed on the bale.

24. Review bale handling procedures and correct: When external damage is ascertained it can usually be traced to the source by following a bale through its handling procedure.

25. Proceed to Block 26: After poor handling procedures are corrected, the cause of the failures should be further investigated since failures may be the result of multiple causes.

26. Random tie breakage: No consistent pattern exists as to which of the bale ties is broken.

27. Lint moisture above five percent?: Lint moisture samples should be taken at the gin to ensure that the lint is above five percent moisture content (wet basis).

28. No drying, add moisture: If the moisture content is below five percent, moisture should be added to the cotton before the gin stand or before the bale press. A reduction in moisture of two percentage points increases the forces exerted on the bale ties by about 15 percent.

29. Minimum platen separation...: Based on 1982 specifications for bale packaging materials (7) and on bale tie force equations developed at the U.S. Cotton Ginning Laboratory, the following guidelines for minimum platen separations are suggested for bale presses:

20" or less for GUD bales
26" or less for GSD bales
13* or less for CUD bales

These guidelines are intended as points of reference rather than standards. Minimum platen separations should be equal to or smaller than the reference points. As mentioned previously, a two-inch decrease in platen separation decreases the bale tie force by over 30 percent. Note, however, that about 30 percent more force is required to compress the bale an additional two inches.

30. Same minimum platen separation...: After considerable usage bale presses may become somewhat misaligned. Compress a bale of cotton and measure the platen separation on each end and in the middle of the platen. If the variation is greater than one-half inch, then it must be corrected.

31. Final bale circumference...: Based on the 1982 specifications for bale packaging materials and on bale tie force equations developed at the U.S. Cotton Ginning Laboratory, the following guidelines are suggested for bale circumference:

85" or less for GUD bales
95" or less for GSD bales
82" or less for CUD bales
These guidelines are intended as points of reference rather than standards. Caution must be exercised to ensure that packaged bales meet the required density standard (28 lb/ft³).

32. Consult the supplier for strength data: At this point all possible sources of breakage problems other than the tie should have been investigated.

33. Consult tie supplier for longer ties: If the current ties are shorter than those identified in block 31, a slightly longer tie would reduce the force exerted on the tie. A two-inch increase in tie length reduces the bale tie force about 20 percent.

34. Consult press manufacturer for press capabilities: The press manufacturer can suggest methods to realign the press and advise on the hydraulic capabilities of the press.

35. Adjust, or change hydraulics and adjust: This should be accomplished by the press manufacturer or with his guidance.

Summary

Analysis of the causes of excessive bale tie failures was simplified by development of a decision matrix that allows the user to systematically eliminate possible causes of tie failures. The matrix is sufficiently complete for use as a stand-alone aid, or it may be used in conjunction with the entire report. The report graphically documents the forces involved in packaging cotton and provides the information necessary to support the strength requirements for bales ties.

Table 1. Changes in bale tie forces as platen separation, bale circumference and lint moisture changes.

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<th>Platen separation, inch</th>
<th>Bale circumference, inch</th>
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1 Based on 15 percent of the total force exerted on all 8 ties.
2 Bale tie forces were about 15 percent less at six percent lint moisture than they were at four percent lint moisture.
3 Used as basis for calculating the force reductions at the six percent moisture level.
4 Used as basis for calculating the force reductions at the four percent moisture level.

References


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Figure 6. Decision matrix for the analysis of excessive tie failures in cotton bales.