METHOD TO REDUCE THE FORCE REQUIRED TO PACKAGE COTTON

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Abstract

A method to reduce compression force requirements was developed and tested to either retrofit or replace existing platens on bale presses. Several versions of the device were tested and found to reduce compression forces for a gin universal density cotton bale by 20 to 35%. The device can also be used to provide additional compression using the existing bale press and to substantially reduce the resilient forces exerted on bale ties. A patent application has been filed and the devices will be available to the public in the near future.

Introduction

More than 95% of the cotton bales produced annually in the U.S. are packaged at universal density (UD). These 500 lb. bales are typically compressed to over 40 lbs/ft^3 in a 54" by 20" by 20" space before six to eight 86" to 89" ties are applied to restrain the bale at a density of about 28 lbs/ft^3 within dimensions of about 55" by 21" by 28" (at the tie). The steel platens that are on the top and bottom of the bale compression chamber are 20" by 54" in cross-section with eight slots 1" wide by 1.5" deep slots spaced about 6" apart across the width of the press. The slots are sufficiently narrow so that they are bridged by the cotton and the compressive area is subsequently about 1,080 in.^{2}.

The UD press typically requires about 300 horsepower. High initial costs, large connected horsepower and the associated hydraulics are problems for the cotton industry. About 0.5% of the bale ties break and create a financial burden and a safety hazard for operators. The purpose of these studies was to develop methods to reduce the force required to package cotton and to reduce bale tie failures.

Discussion

Several types of devices inserted in the platens to reduce compression force requirements were evaluated. One of the more promising types was a specially configured insert affixed inside the existing slots in the platen and protruding beyond the platen surface about 4" (Figure 1). The inserts were shaped like an inverted, hollow, truncated V with a 1-inch hole in the center for wire tie insertion and a 0.25-inch groove in the top for tie exit (Figure 2). The devices preform the bale and allow compressive force to be applied primarily in the area where the ties are to be placed. The compressive area for the inserts is 1" by 20" times eight inserts or 320 in.^{2} instead of 2,160 in.^{2} for the two standard platens. At maximum compression, the cotton assumes the shape of the platen so that the density is 40 lbs/ft^3 at the insert tip but decreases to about 33 lbs/ft^3 between the inserts (Figure 3). The inserts can be combined and constructed as one large device for the top or bottom platens in which the entire surface is preformed. In initial studies with small-scale systems, compressive forces were reduced by 20 to 35% depending on factors such as moisture, density, and device dimensions (Anthony 1997).

Five tests were conducted with different configurations of the device to ascertain commercial utility and to develop additional validation data.

Study 1

In Study 1, 16 bales of cotton weighing from 450 to 500 pounds each were compressed in a Continental BESPRESS. Six of the bales were compressed to about 20" separation between the platens with special 1" wide by 4" high inserts installed in the bottom platen; four bales were compressed with inserts in both the top and bottom platens; and six bales were compressed with only the standard platen. As shown in Table 1, more pressure was required to compress the bale when inserts were used on the bottom platen (identified as Bot) (21%) and on both platens (identified as Two) as compared to the original platen, all pressed to about 20 inches. Conversely, when the platen separation at the tip of the inserts was 20" and 23" at the base platen, the force was reduced 13%. As a result of this favorable finding, further studies were conducted. Although not measured, the bale tie forces appeared to be much less when inserts were used. In fact, the ties could be easily moved by hand after the bales were released from the press.

Study 2

Eight additional bales were ginned and compressed to a 20" platen separation. For this study, "platen separation" was measured between the tips of the inserts when top and bottom inserts were used, between the tips of the inserts and the top platens when only bottom inserts were used, or between the standard top and bottom platens when no inserts were used. The actual separation between the original standard platens was 28", 24", and 20" for the top/bottom inserts, bottom only inserts, and no inserts configurations, respectively. Inserts similar to those in Study 1 were used. Compressive force was reduced 28% when inserts were used on only the bottom platen and 35% when they were used on both the top and bottom platens.

Study 3

Six bales were ginned and compressed with and without inserts. Bale thickness at the hump after the bale was released from the press was measured for each tie on several

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bales packaged either with or without the inserts. Bale thickness averaged about 0.44-inches greater for the bales packaged with the benefit of platen inserts.

Study 4

Eleven bales were ginned for Study 4 and the standard platen was compared to platens with either 4⅛" or 5⅛" inserts on the bottom platen (Table 3). When the inserts were used on the bottom platen, the compressive force to achieve the same density at the tip of the inserts was 22.5% less when the inserts were not used on the bottom platen, and 31.7% less when inserts were used on the top and bottom platens. Analyses of variance revealed that the compression force required by the standard platen was significantly greater than that required by the inserts, and that there was no difference between the inserts (Table 4). The lint was packaged at 2 to 4% moisture. Tables 4 and 5 show the bale thickness at the hump after packaging. The thickness at the hump averaged 0.7" greater for the bales packaged with inserts. The cotton was more fluffy at the hump for the bales packaged with benefit of the inserts. Note that the calipers were not forced vigorously into the cotton when the measurements were made at the hump. No difficulty was encountered in placing the bagging over the bales at the warehouse four weeks after packaging. Similar comparisons with the woven polypropylene under the ties yielded no differences in bale thickness at the hump between bales packaged with and without inserts.

Strain gauge transducers were borrowed from Belton Industries and installed on the middle four ties of a bale (Figure 4). One bale was compressed with inserts and one was compressed without inserts and the transducer installed on each. Force readings were taken for about 10 days and bale tie forces data is shown in Table 7. Over an eight-day period, forces increased about 38 pounds per tie on the bale packaged with inserts and increased about 78 pounds per tie on the bale packaged without inserts (Table 8).

Study 5

Fifteen bales were ginned for Study 5. The force required to compress cotton with a standard platen and with a bottom platen that had eight 4⅛" tall inserts were compared for 12 bales. In addition, flat plates (shims), 0.5", 1", 1 ½", and 2" high by 4" wide were placed between the inserts for some bales to determine how much of the cotton touched the platen between the inserts. This was done because it appeared that the bales packaged with the inserts were not as firm between the ties as the ones packaged with the standard platens. Results are given in Tables 9-10. The lint lightly contacted the 1½" shim and firmly contacted the 2" shim, however, the smoothness of the bale exterior did not appear to change. The compression force did not differ statistically among the shims, and averaged 804,223 pounds as compared to 981,978 for the standard platen, or 18.8% less. The bale thickness at the hump after over four months of storage at Leland Compress was about 33.2" for the bales packaged with the platen inserts as compared to 32.8" for the standard platen (Table 11). Inserts were also used on the top and bottom platens for three bales and the force was reduced by 28.5% from that required for the standard platens. For these three bales, the final thickness (32.9") after four months storage was not different from the bales packaged with the standard platens.

Summary

The purpose of this study was to develop methods to reduce the force required to package cotton. This study evaluated specially configured inserts affixed inside the existing slots in the gin press platen and protruded about 4" beyond the platen surface. Some were shaped as an inverted, hollow, truncated V with a 1-inch hole in the center and a 0.25-inch groove in the top to allow the tie to exit. The inserts preformed the bale and applied compressive force primarily in the area where the ties were to be placed. The compressive area for each insert was 1" by 20" each or 320 in.^{2} instead of 2,160 in.^{2} for the standard platens. The cotton assumes the shape of the platen with inserts so that the density at maximum compression is 40 lbs/ft^3 in the tie area but only about 33 lbs/ft^3 between the inserts. The inserts can be combined and constructed as one large device for the top or bottom platens. Compressive forces were reduced by 20 to 35% depending on a number of factors such as moisture, density, insert height, and number of inserts used.

An alternative use of the device is to compress bales to higher densities with the inserts and dramatically reduce restraint tie force requirements and bale tie breakage. Presses that typically have a high percentage of bale tie failures could also be retrofitted with these devices to reduce bale tie breakage occurrence.

Disclaimer

Mention of a trade name, proprietary product, or specific machinery does not constitute a guarantee or warranty by the U.S. Department of Agriculture and does not imply approval of the product to the exclusion of others that may be available.

References

Anthony, W. S. U. S. Patent Application Number 08/890,890. Device to reduce bale packaging forces. Filed July 1997.

Table 1. Initial data for the standard and modified platens.

Bale number	Bale weight, lb	Platen separation, in.	Platen type[1]	Pressure, PSI	Lint moisture, %
8171	461	20.38	Bot	2350	4.96
8173	464	20.38	Bot	2460	4.60
8175	452	20.38	Bot	2420	4.30
8177	474	23.81	Bot	1775	3.96
8181	450	23.44	Bot	1500	4.18
8179	484	23.50	Bot	1950	3.94
8180	471	20.38	Std	2140	3.68
8176	472	20.38	Std	2125	3.82
8170	470	20.38	Std	1890	5.22
8178	471	20.38	Std	2090	4.05
8174	452	20.38	Std	1850	4.24
8172	464	20.38	Std	1900	4.66
.	501	19.38	Two	3000	3.00
.	503	25.12	Two	2450	3.20
8209	510	25.06	Two	2160	4.84
8213	506	25.12	Two	2470	3.00

[1] Two = inserts in both platens
Bot = inserts in bottom platen
Std = standard platen

Table 2. Data from standard platen versus model 4125 and model 5125 (Study 4).

Bale No.	Bale weight,lbs	Platen separation, in	Platen type	Pressure, PSI Gauge	Pressure, PSI Transducer	Bale weight,lb	Lint moisture	Shut height, in.	Force, lbs.	Density, lb/ft^3 1[1]	Density, lb/ft^3 2[2]
8264	487	24.19	Bot 4.12	2200	2387	484	1.74	20.07	809,448	33.63	40.54
8266	486	24.18	Bot 4.12	2200	2254	483	2.85	20.06	764,376	33.58	40.47
8271	500	24.19	Bot 4.12	2250	2353	497	3.42	20.07	797,949	34.54	41.63
8262	486	25.06	Bot 5.12	2150	2276	483	4.03	19.94	771,837	32.40	40.72
8269	490	25.12	Bot 5.12	2125	2265	487	1.89	20.00	768,107	32.59	40.93
8273	493	25.12	Bot 5.12	2100	2254	490	2.42	20.00	764,376	32.79	41.18
8263	508	20.44	Standard	2825	2950	505	2.96	20.44	1,000,404	41.53	41.53
8265	510	20.38	Standard	2900	2983	507	2.64	20.38	1,011,595	41.82	41.82
8268	496	20.31	Standard	2700	2850	493	3.00	20.31	966,492	40.80	40.80
8270	514	20.31	Standard	2800	2950	511	2.31	20.31	1,000,404	42.29	42.29
8272	521	20.25	Standard	2850	2983	518	2.70	20.25	1,011,595	43.00	43.00

[1] 1 = density between inserts
[2] 2 = density at inserts

Table 3. Summary of data for standard platen versus model 4125 and model 5125 only on bottom.

Platen	Bale weight,lbs	Platen separation, in.	Lint moisture, %	Pressure, PSI Gauge	Pressure, PSI Transducer	Shut height, in.	Force, lbs.	Density, lb/ft^3 1[1]	Density, lb/ft^3 2[2]
Bot 4.12	488	24.19	2.67	2217	2331	20.07	790,602	33.92	40.88
Bot 5.12	487	25.10	2.78	2125	2265	19.98	768,107	32.59	40.94
Standard	510	20.34	2.72	2815	2943	20.34	998,098	41.89	41.89

[1] 1 = density between inserts
[2] 2 = density at inserts

Table 4. Analysis of variance for compression forces for the standard platen versus the model 4125 and model 5125 platen inserts (Study 4).

Source	DF	Mean Square	F Value	Pr > F
PLATEN	2	6.56279E+10	210.02	0.0001
Error	8	3.12483E+08		

FORCE Mean	R-Square	C.V.	Root MSE
878783.236	0.981310	2.011551	17677.18

Kratio= 100 df= 8 MSE= 3.1248E8 F= 210.021
Critical Value of T= 2.14204
Minimum Significant Difference= 28782
Harmonic Mean of cell sizes= 3.461538
Means with the same letter are not significantly different.

Mean	N	PLATEN
998098A	5	Standard
790602B	3	Bottom 4.12
768107B	3	Bottom 5.12

Table 5. Thickness at hump for bales with inserts (Study 4).

Hump number	8262	8264	8266	8269	8271	8273
	Thickness, in., with inserts for bale number					
1	33	33 1/2	33 1/4	33	33 3/4	32 5/8
2	33	33 1/2	33 1/4	33	33 1/2	32 5/8
3	33 1/4	33 1/4	33	33	32 3/4	32 7/8
4	33 1/4	33	33 1/4	33	33 1/4	32 7/8
5	33 1/2	33	33 1/2	32 3/4	33 3/4	33
6	33 1/4	33 1/4	33	33	33 1/4	33 1/8
7	33 1/4	33	33 1/2	33	33 1/8	33

Table 6. Thickness at hump for bales without inserts (Study 4).

Hump number	Thickness, in., without inserts for bale number				
	8263	8265	8268	8270	8272
1	32 5/16	32 1/2	32 1/2	32 5/8	32
2	33	32 1/4	32 1/2	32 1/2	31 1/2
3	33 1/4	32 5/8	32 1/2	33	32 1/4
4	32	32 3/8	32 1/4	32 1/2	31 1/2
5	33 1/8	32 3/4	32	33 1/4	31 3/4
6	32 1/4	32 1/4	32 3/4	32 1/2	32
7	32 5/8	32 1/4	33	32 1/2	32

Table 7. Change in bale tie force with time for two bales [1].

Date	Time	Bale #8272 force for tie				Bale # 8273 force for tie			
		3	4 [2]	5	6	3	4	5	6
3/25/97	8:00	863	.	919	818	892	1093	832	879
3/25/97	8:30	866	.	919	818	894	1094	834	883
3/25/97	11:30	875	.	913	821	897	1097	836	879
3/25/97	12:45	878	.	910	824	900	1100	839	881
3/25/97	2:20	884	.	903	828	903	1104	843	882
3/26/97	7:50	908	.	857	857	919	1125	864	879
3/26/97	8:21	903	.	849	847	940	1142	871	889
3/26/97	11:18	904	.	850	846	926	1136	869	870
3/26/97	2:37	905	.	852	845	923	1135	868	864
3/26/97	12:24	920	.	871	858	933	1147	881	865
3/28/97	8:10	952	.	909	882	964	1174	911	879
3/28/97	11:25	950	.	920	888	969	1178	914	881
3/28/97	12:55	959	.	923	888	969	1178	917	883
4/1/97	10:30	986	.	959	899	985	1168	947	800
4/1/97	3:30	990	.	958	897	983	1167	943	798
4/2/97	8:25	991	.	958	896	983	1167	941	800
4/2/97	9:25	991	.	957	896	983	1167	941	800
4/2/97	10:25	990	.	956	895	981	1166	940	799
4/2/97	11:25	988	.	955	892	982	1166	939	801
4/2/97	.	988	.	955	892	981	1165	938	800

[1] Bale 8272 was pressed with inserts and bale 8272 was pressed without inserts.

[2] Transducer did not function correctly.

Table 8. Bale tie forces.

Day	Force, pounds, at tie for:							
	Insert				Standard			
	3	4	5	6	3	4	5	6
1	863	-	919	818	892	1093	832	879
8	988	-	955	892	981	1165	938	800

Table 9. Analysis of variance with general linear models procedure, standard platen versus model 4125 on bottom only with 0.5, 1.0, 2.5, 2.0 shims(Study 5)

Source of variation	Degree of freedom	Mean square	F
Platen	1	68741730112	73.52**
Shim	3	176509478	0.19 ns
Error	7	4349775.8	

ns = not significant at the 5% level of probability

** = not significant at the 1% level of probability

Table 10. Data from standard platen versus model 4125 on bottom only with 0.5, 1.0, 2.5, 2.0 shims (Study 5).

Bale No.	Bale weight, lbs	Shim, in.	Platen separation in.	Platen type	Lint moisture,%	Pressure, PSI Gauge	Pressure, PSI Transducer	Bale weight, lb.	Shut height, in.	Force	Density, lb/ft^3 1 [1]	Density, lb/ft^3 2 [2]	Thickness, in.[3]
8286	499	0.5	24.25	Bot 4.12	3.20	2200	2352	496	20.13	797,610.00	34.38	41.41	33.2
8283	501	1.0	24.12	Bot 4.12	3.23	2325	2486	498	20.00	843052.32	34.71	41.85	-
8287	496	1.0	24.31	Bot 4.12	3.30	2150	2299	493	20.19	779636.88	34.09	41.04	33.1
8291	495	1.0	24.25	Bot 4.12	2.89	2125	2272	492	20.13	770480.64	34.10	41.08	33.4
8285	499	1.5	24.25	Bot 4.12	3.24	2225	2379	496	20.13	806766.48	34.38	41.42	-
8289	494	1.5	24.25	Bot 4.12	3.00	2150	2299	491	20.13	779636.88	34.03	41.00	33.2
8293	498	1.5	24.25	Bot 4.12	2.99	2350	2512	495	20.13	851869.44	34.31	41.33	33.4
8290	498	2.0	24.37	Bot 4.12	2.84	2175	2325	495	20.25	788454.00	34.14	41.09	33.2
8294	504	2.0	24.52	Bot 4.12	3.06	2250	2406	501	20.40	815922.72	34.34	41.28	33.1
8284	503	0	20.19	Standard	3.22	2750	2940	500	20.19	997012.80	41.63	41.63	32.8
8288	501	0	20.19	Standard	3.09	2675	2860	498	20.19	969883.20	41.46	41.46	32.6
8292	501	0	20.25	Standard	3.15	2700	2887	498	20.25	979039.14	41.34	41.34	33.0

[1] 1 = density between inserts

[2] 2 = density at inserts

[3] Thickness at the hump measured August 12, 1997 after over four months of storage at Leland Compress. Each bale had gained about 12 pounds of weight. The thicknesses for three bales pressed with top and bottom platens were 32.9 inches.

Table 11. Summary data from standard platen versus model 4125 on bottom only with 0.5, 1.0, 2.5, 2.0 shims (Study 5).

Platen	Shim, in.	Bale weight,lb	Platen separation, in.	Lint moisture, %	Pressure, PSI Gauge	Pressure, PSI Transducer	Force	Shut height, in.	Density, lb/ft^3 1 [1]	Density, lb/ft^3 2 [2]	Thickness, in.[3]
Bot 4.12	0.5	496	24.25	3.20	2200.00	2352.00	797,610	20.13	34.38	41.41	33.2
Bot 4.12	1.0	494	24.23	3.14	2200.00	2352.33	797,723	20.11	34.30	41.33	33.2
Bot 4.12	1.5	494	24.25	3.08	2241.67	2396.67	812,758	20.13	34.24	41.25	33.3
Bot 4.12	2.0	498	24.45	2.95	2212.50	2365.50	802,188	20.33	34.24	41.19	33.2
Standard	0.0	499	20.21	3.15	2708.33	2895.67	981,978	20.21	41.48	41.48	32.8

[1] 1 = density between inserts

[2] 2 = density at inserts

[3] Thickness at the hump measured August 12, 1997 after over four months of storage at Leland Compress. Each bale had gained about12 pounds of weight. The thicknesses for three bales pressed with top and bottom platens were 32.9 inches.

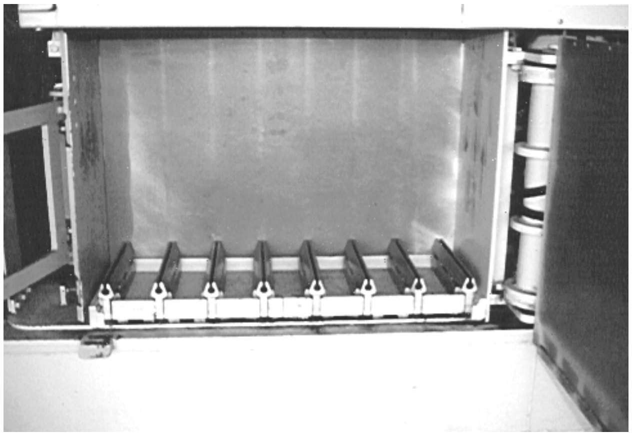

Figure 1. Inserts installed in the bottom platen.

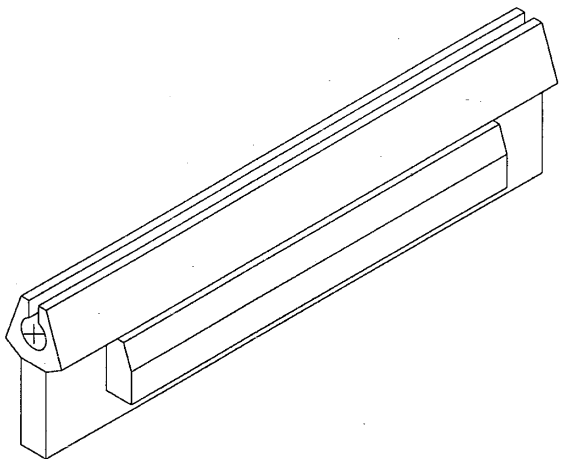

Figure 2. Drawing of one of the devices.

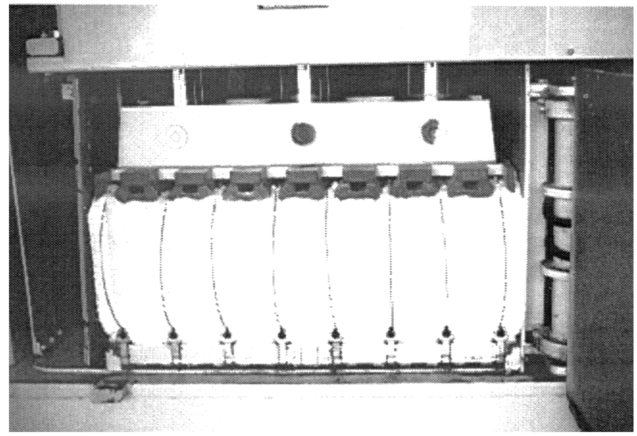

Figure 3. Bale under compression with force reduction device in bottom platen.

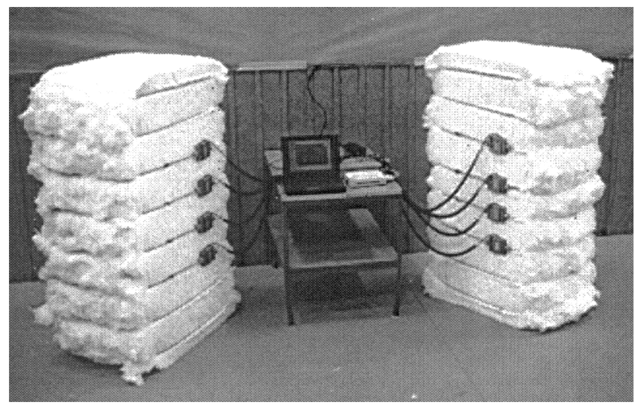

Figure 4. Measurement of bale tie force for bale compressed with device (left) and without the device (right).