FIELD EVALUATION OF THE LUMMUS BALE MOISTURE MONITOR

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Abstract

The Lummus Bale Moisture Monitor (BMM) is a lint moisture measurement system that determines an average bale moisture content (mc) through the application of the bale compression algorithms developed in the 1970's, by the USDA ARS Stoneville Ginning Lab. While it has been successfully used on both down-packing and up-packing bale presses around the world since its commercial introduction in 2006, the stand-alone model had never been scientifically evaluated for accuracy by an independent source. In this study, two BMM units on independent presses, operating side-by-side in the same ginning facility, were calibrated by Lummus personnel. An independent consultant was contracted to obtain lint samples from bales, whose final moisture contents were logged based on results shown on the BMM's. The lint samples then had their moisture contents determined using the oven-based method covered in the ASTM-D2495 protocol, and these results were compared to the original moisture content readings from the BMM's. In addition to this testing, other operating parameters of the side-by-side moisture restoration systems were also evaluated.

Introduction

The Lummus BMM is based on the system developed by scientists at the USDA ARS, Cotton Ginning Research Unit, Stoneville, MS and described by Byler and Anthony (2003). Research on this type bale moisture determination was started by Anthony and McCaskill (1973 and 1976) and continued by Anthony in 1998. The system measures bale moisture content based on three inputs: bale weight, bale volume, and measured pressure (Byler and Anthony, 2003).

Lummus Corporation introduced the first commercial BMM in 2003, as a part of the features included with the "Savannah Class" Lift-Box Dor-Les® Universal Density Bale Press. In 2006, the stand-alone BMM model was introduced, which allowed the system to be retrofitted on any make/model of bale press (see Figure 1). These units have been installed on both up-packing and down-packing baling presses in numerous installations across the U.S. Cotton Belt and around the world.

Figure 1. The Lummus Bale Moisture Monitor (stand-alone model).

While the accuracy of the developmental USDA system was shown to be within +/- 0.4%, the commercial BMM units, in many cases, had not been calibrated on a regular basis, so it was important to perform a field evaluation and see how well they were performing under typical operating conditions in their normal environment.

A test was designed to evaluate the Lummus Bale Moisture Monitor (BMM) at Lubbock Cotton Growers Coop Gin in Lubbock, TX (LCG). LCG is a 6 "Less 1" 222-saw gin plant that was originally constructed in 2009, and is unique in that it is one of only a few ginning facilities that features two complete bale pressing systems (see Figure 2). Each Premier™ Dor-Les® up-packing press is fed by a Moisture Conditioning (MC™) battery condenser that injects humid air directly to (and through) the batt of lint cotton prior to compressing the batt and discharging it down the lint slide. Each press is equipped with its own BMM.

Figure 2. Lubbock Cotton Growers' Press "A" (right) and Press "B" (left).

Humid air for each MC™ Condenser is generated by a Lummus Mist-A-Matic™ Moisture Unit while dry, hot air for each system (to prevent undesired condensation within the condenser doffing assembly or on the condenser drum itself) is produced by a 1 MBTU "Pony" Burner with integral blower.

An item of note with regard to the two LCG press installations is that each MC™ Condenser system is piped with the moist air and dry/hot air connected differently. The south press (Press "A") is piped in the more traditional manner, in which the moist air is directed to the bottom inlet of the heated air jacket on the lint slide, where it migrates to the top of the jacket, and is directed to the moist air inlet on the MC™ Condenser (see Figure 3).

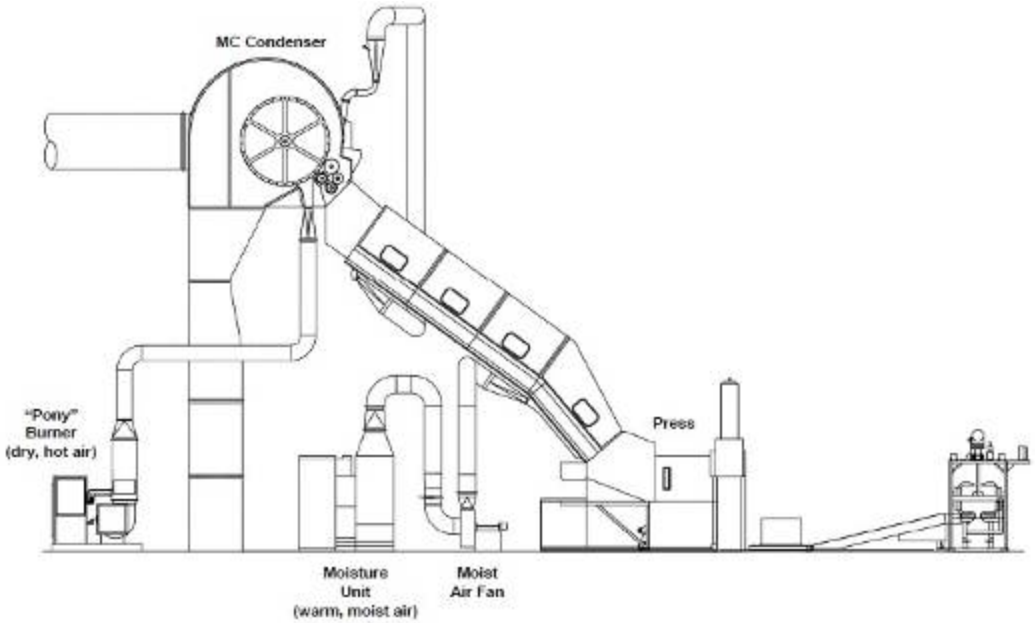

Figure 3. Moist air and dry/hot air piping on Lubbock Cotton Growers' Press "A".

The north press (Press "B") had the system piping modified to what was actually the initial configuration for the early MC™ Condenser systems from the late 1980's and early 1990's. It routes the moist air directly from the Moisture Unit to the moist air inlet on the MC™ Condenser, while the 1 MBTU "Pony" Burner provides the heated air for the lint slide heated air jacket, directing it from there into hot air inlet of the condenser doffing assembly (see Figure 4).

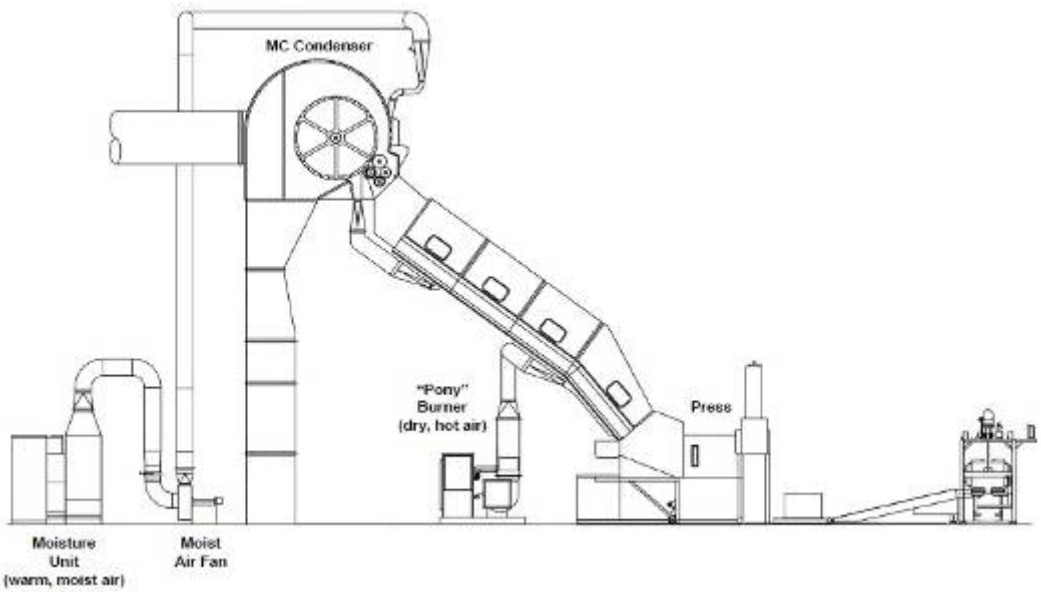

Figure 4. Moist air and dry/hot air piping on Lubbock Cotton Growers' Press "B".

The different piping scenarios on these condensers offered a rare opportunity to evaluate the moisture restoration

effectiveness of the two systems. One school of thought believed that the piping on Press "B" would restore more moisture since the moist air was going directly to the condenser and not used for any other purpose. Another school of thought believed that using the moist air to heat the lint slide (though more messy, due to some condensation within the heated air jacket), then directing it to the moist air inlet on the condenser would restore more moisture, since the moist air was closer to complete saturation and more readily conditioned to surrender moisture to the lint.

Materials and Methods

BMM Calibration

Prior to the actual testing of samples, it was essential to calibrate both BMM's to ensure the best possible readings. On October 27, 2012, lint samples were obtained from bales out of both presses at LCG, and the BMM moisture readings were recorded for these bales. For all official moisture readings, all samples were taken to the USDA ARS, Cotton Ginning Research Unit, Lubbock, TX, for oven moisture determination using the ASTM-D2495 method. Based on these actual moisture content results, new parameters were programmed into each BMM, and follow-up sampling (to confirm accuracy) was performed on November 5, 2012.

Test Protocol

Testing was performed on November 15 and November 26, 2012. For each test day, the sampling protocol was the same. Ten (10) seed cotton modules were used for each test day, with ten (10) bales per module being sampled – five (5) bales per press per module. This resulted in fifty (50) lint samples per press on each sample day. A seed cotton sample was obtained from each module to determine initial seed cotton moisture for the cotton entering the gin, and one sampled per module was taken out of the overflow hopper to determine how much drying the seed cotton conditioning equipment had performed.

Lint sampling points for both presses are shown in Figure 5. Sampling point "A" in the lint flue riser to the condenser represents the lint cotton moisture content "before" any moisture restoration. Sampling points "B" (condenser discharge) and "C" (bale sample) had their oven-determined moisture results averaged and represent the moisture content "after" moisture restoration (which are the results compared to the BMM readings).

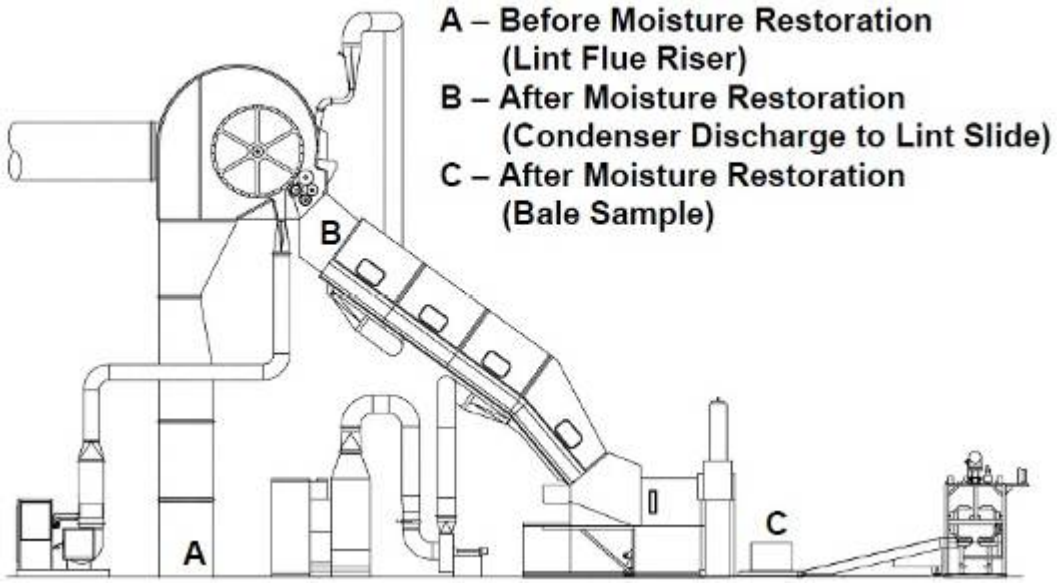

Figure 5. Lint sampling locations at Lubbock Cotton Growers (both presses).

Results and Discussion

BMM versus Oven Method

The comparison of results from the respective BMM's and the oven moisture determinations for both test dates are found in Table 1.

Table 1. Comparison of results from BMM versus oven moisture for 11/15/12 and 11/26/12 tests.

Date	Press	Average difference (%)	Minimum difference (%)	Maximum difference (%)	Median difference (%)	Average bale mc (%)
11/15/12	A	0.20	0.01	0.57	0.17	4.53
11/15/12	B	0.34	0.00	1.05	0.28	4.36
11/26/12	A	0.22	0.00	0.74	0.15	4.71
11/26/12	B	0.20	0.00	0.75	0.17	4.48

The incoming seed cotton mc of the modules for the November 15, 2012 test ranged from a low of 5.56% to a high of 8.48% with an average mc of 6.37%, while the incoming seed cotton mc of the modules for November 26, 2012, ranged from a low of 5.71% to a high of 6.85% with an average mc of 6.46%. Because of an extremely optimal 2012 harvest season for this gin's crop (little to no precipitation), the seed cotton was fairly dry, although the gin did do some additional drying to facilitate adequate seed cotton cleaning. To offset this drying, moisture was added to the seed cotton prior to ginning through the use of moist air conditioning hoppers above the extractor feeders. Despite restoring moisture to the lint in both "A" and "B" systems, one can see that the final bale mc averages for both presses were fairly low (below 5.00%), which demonstrates the drying that takes place in the lint flue even when conveying the lint with ambient air.

Based on the fact that the Lummus BMM has been marketed to provide results within 0.40%, the average differences for Press "A" (0.20 and 0.22) and Press "B" (0.34 and 0.20) for the respective tests confirmed that, when properly calibrated, the BMM will provide reasonably accurate mc results.

Moisture System Piping Effectiveness

An additional analysis that was performed based on the results of this testing was with regard to the moisture restoration effectiveness of the moist air and dry/hot air piping for Condenser "A" versus that of Condenser "B." The summary of these results are found in Table 2.

Table 2. Moisture restoration effectiveness for alternative moist air and dry/hot air piping in MC condenser installations.

Date	Press	Average moisture restored (%)	Minimum (%)	Maximum (%)
11/15/12	A	1.11	0.76	1.30
11/15/12	B	0.80	0.59	1.00
11/26/12	A	1.03	0.86	1.23
11/26/12	B	0.67	0.35	0.93

Based on the results from both days of testing, the moist air and dry/hot air piping schematic for Condenser "A" (using the warm, moist air to heat the lint slide's heated air jacket, then directing this moist air from the top of the jacket to the moist air inlet on the MC™ Condenser) was more effective in restoring moisture to the lint than the more-recent system of Condenser "B" (where the moist air goes directly from the moisture unit to the moist air inlet of the MC™ Condenser). It is believed that through improvement of the controls system to take into account atmospheric conditions, along with reducing the temperature of the warm, moist air (to bring it closer to complete saturation), the piping schematic for Condenser "B" can be significantly improved in its ability to restore more moisture, while providing a cleaner installation that requires less maintenance and upkeep.

Summary

Testing on two Lummus BMM systems at Lubbock Cotton Growers Coop Gin demonstrated that, when properly calibrated, the Lummus BMM works quite well at predicting the average mc of lint cotton at accuracies even better than the advertised +/- 0.40%. Without a doubt, additional testing with a wider range of incoming seed cotton moisture contents and climatic conditions, along with testing at additional gin installations would certainly add to the body of knowledge in finding ways to more accurately measure bale moisture. This will result in improved, yet responsible moisture restoration system performance and monitoring.

Acknowledgements

The authors would like to express their appreciation to the staff at the USDA ARS Cotton Ginning Research Unit in Lubbock, TX, for their assistance in performing the oven moisture determinations for these tests. Additional thanks are extended to the management and staff of Lubbock Cotton Growers Coop Gin in Lubbock, TX, for their cooperation in this study.

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