Evaluation of lightweight contamination in an old-corrugated-containers recycling system

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A unique test procedure incorporating image analysis was used to characterize lightweight contaminant levels in an upgraded OCC recycling facility. Comparison of data taken before and after the upgrade showed that the average contaminant size and total contamination level decreased by more than 50% and 40%, respectively.

Between June 1990 and February 1991, Chesapeake Paper Products Co. (CPPC) upgraded a 1000-ton/day old corrugated containers (OCC) system. The objective of the upgrade was to maximize contaminant removal, especially lightweight contaminants.

Figures 1 and 2 compare the original OCC system with the upgraded system stock flow. The following list highlights the major changes:

- The 600-ton-pulper extraction-plate hole diameter decreased by 25%.
- Coarse screening system screen-basket hole diameters decreased by 50%. Deflakers and reject sorters were added to optimize tailing screen operation.
- The fine screening system screen-basket slot width decreased by 50%. Medium-density sand cleaners were installed ahead of the fine screens to increase basket life by reducing erosion.
- Lightweight through-flow and forward centrifugal cleaners were installed in the fractionated long-fiber stock system.
- Lightweight through-flow cleaners were installed in the fractionated short-fiber stock system.
- A reject belt press was installed to dewater rejects prior to disposal.
- A dissolved air flotation unit was installed to clarify rejects from the lightweight cleaners and belt press filtrate.

Prior to the installation of the new equipment, information about lightweight contaminant levels throughout the original system was needed for future comparison. In the past, we had used the hot pressing-fluorescent speck counting method[1] for quantifying lightweight (sticky) contaminant levels in OCC. However, this test method had the following disadvantages:

- Tedious and time consuming
- Only spots of 1.8 mm^2 and greater were counted.
- Tester-dependent or subjective rating of contaminant spot sizes
- Some lightweight contaminants were found not to fluoresce and were not counted.

To develop the baseline information, we looked for a more accurate and repeatable test method.

CPPC/FPL test method

We determined that a test method utilizing image analysis would provide the accuracy and repeatability needed. To use image analysis, a sample must exhibit shade contrast. Minimal shade contrast of lightweight contaminant material to fiber is found in a typical OCC-furnish handsheet.

The problem of minimal shade contrast was overcome with the help of John Klungness at the Forest Products Laboratory (FPL) in Madison, WI. He described a method of dyeing the handsheets with a water-based black ink to help distinguish fiber from lightweight contaminants.[2] The lightweight contaminants, being hydrophobic in nature, will not accept the dye; they remain a light amber color. The hydrophilic fibers accept the ink and turn black.

We took this idea and refined it. The new test method is described below:

1. Produce 10, 1.2-g TAPPI-method handsheets.

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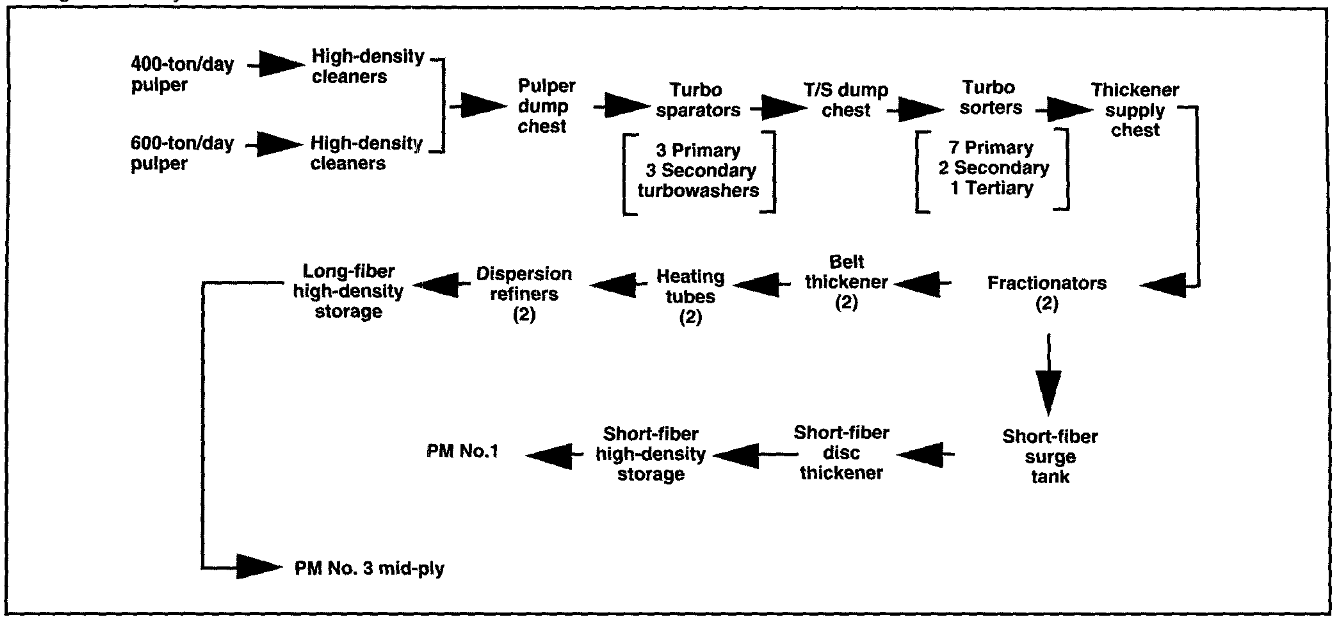
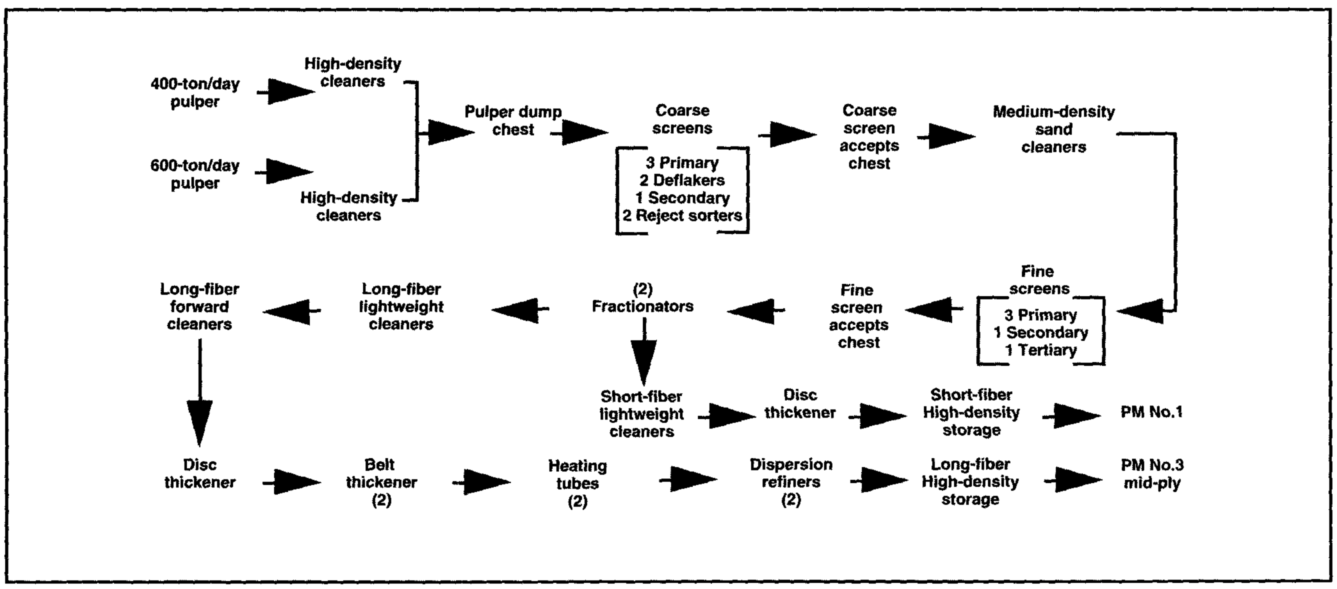
[1]Progress Report to the American Paper Institute, Project 3428, Report 3, Removal of "Sticky" Contaminants from Recycled Fiber, "Detection and Quantification of Sticky Contaminants in Recycled Fiber Systems: Hot Pressing-Fluorescent Speck Counting Method," The Institute of Paper Science and Technology, Atlanta, reprint Sept. 14, 1990, pp. 147–152.

[2]Klungness, J. H. and Evans, J. W., TAPPI 1989 Contaminant Problems and Strategies in Wastepaper Recycling Seminar Notes, TAPPI PRESS, Atlanta, pp. 121–124.

1. Original OCC system



2. Upgraded OCC system



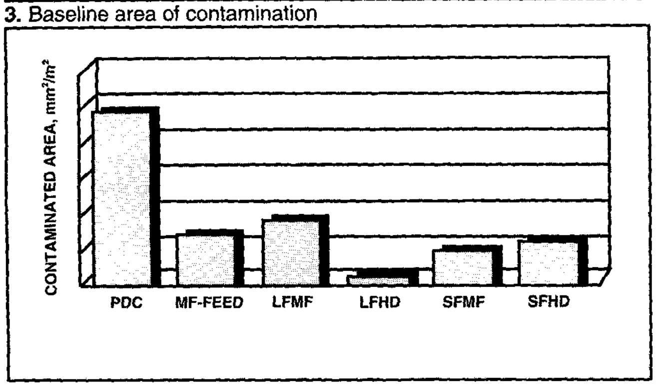
2. Dry the wet handsheets between blotter paper in an Emerson speed dryer on setting 4 for 13 min.
3. Dye the dried handsheets thoroughly using black Parker Super Quink ink.
4. Blot off excess ink and place dyed handsheet between two filter pads.
5. Place in TAPPI-method drying rings and allow to air dry.
6. Test each side of the dyed handsheet on an image analyzer using the inverted video mode. (We use an Optomax V image analyzer.)

Using image analysis allows lightweight contaminant levels to be quantified into average contaminant size, level of contamination (ppm), number of contaminants/m^2 (referred to as contaminants/m^2), and contaminant size distributions.

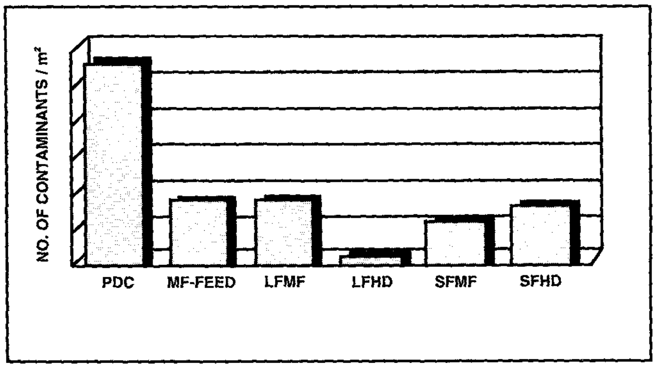
The repeatability of this test method is 5% on an individual and tester-to-tester basis. The TAPPI-method dirt count, which is used to size fluorescent spots, has an individual and tester-to-tester expected repeatability of 10% and 20%, respectively. Hence, the subjectivity associated with the determination of spot sizes is minimized, and spots equal to and greater than 0.1 mm^2 in area are detected.

The CPPC/FPL test method was used to gather baseline information on the lightweight contaminant level in the original OCC system. The results and verification of the test method are discussed in the following section.

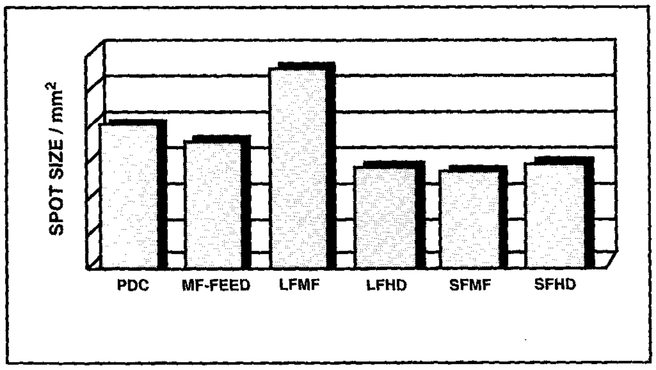
3. Baseline area of contamination



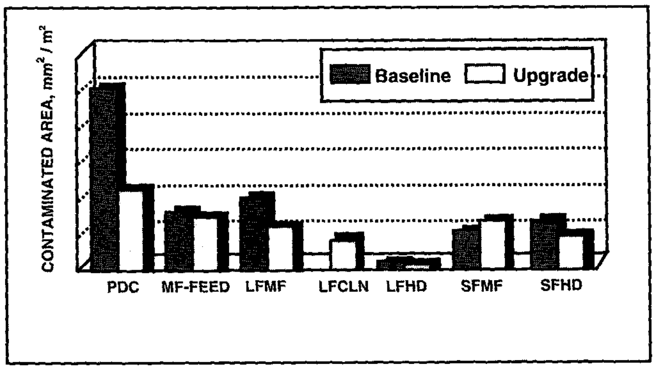
4. Baseline number of contaminants



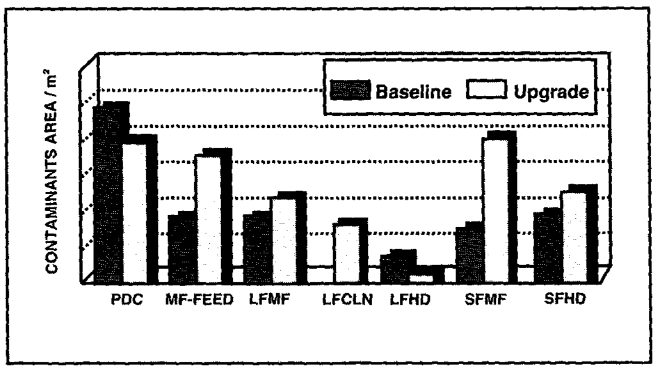
5. Baseline average spot size



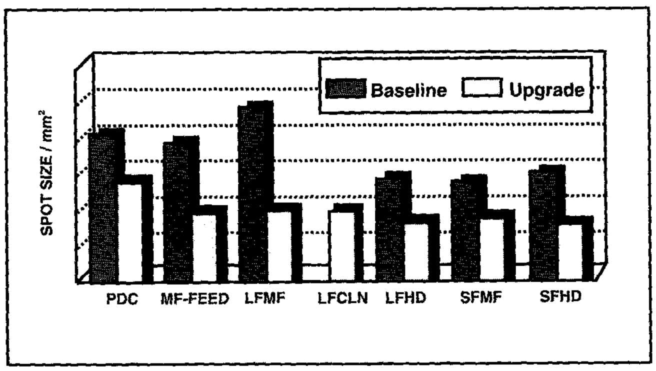
6. Comparative areas of contamination



7. Comparative number of contaminants



8. Comparative average spot size



Quantification of lightweight contamination levels: baseline data

Sampling points in the original system were chosen such that the identical spots could be retested when the upgrade was complete. The points chosen were:

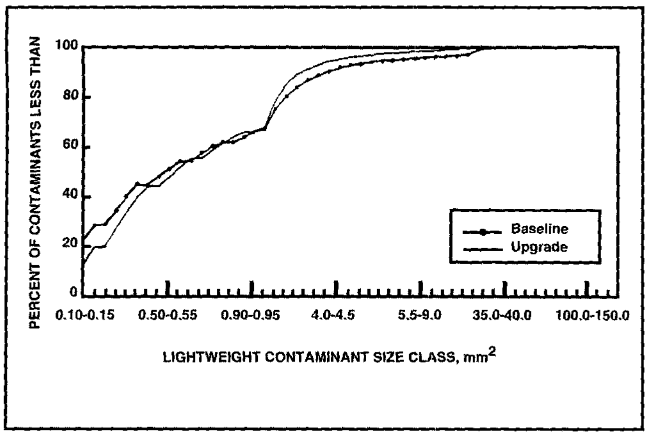
- Pulper dump chest (PDC)
- Multifractionator feed (MF-feed)
- Multifractionator long fiber (LFMF)
- Multifractionator short fiber (SFMF)
- Long-fiber high-density tower (LFHD)
- Short-fiber high-density tower (SFHD).

Figures 3–5 show the contaminant results from the baseline survey. The data indicate that lightweight contaminants were concentrated in the long-fiber stock fraction. The level of contamination, contaminants/m², and average contaminant size of the long fiber had about 50% more lightweight contaminants than the short fiber at the multifractionators.

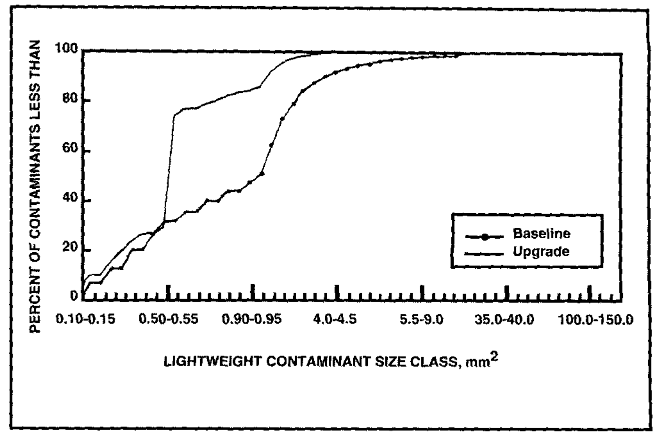
The baseline information also showed the efficiency of the dispersion unit in reducing lightweight contaminant levels. Dispersion reduced the level of contamination by 87%, average contaminant size by 41%, and contaminants/m² by 73%.

The baseline survey verified the test method. No processing was done to the short-fiber stock between the

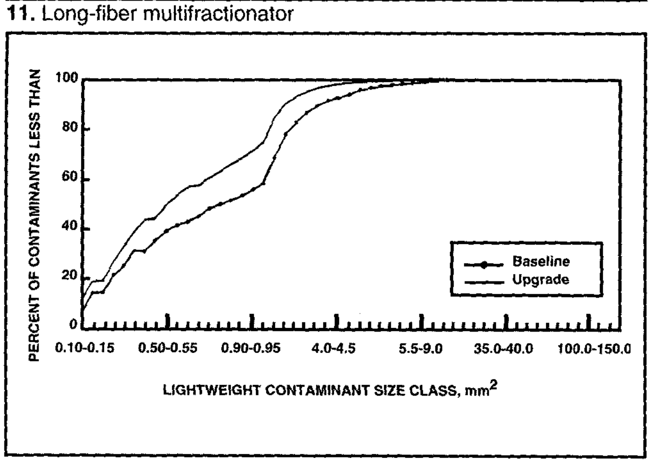
9. Pulper dump chest



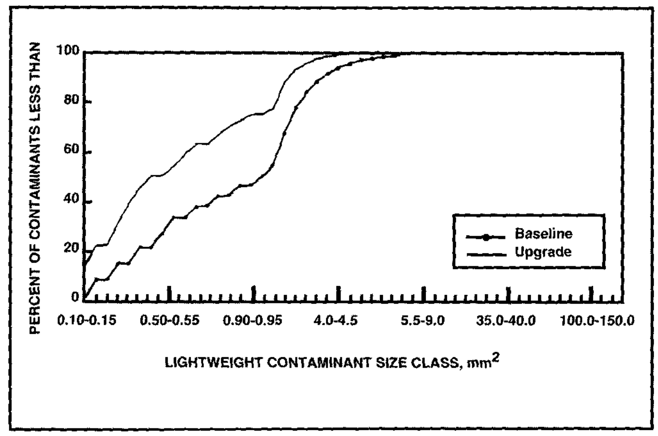
10. Multifractionator feed



11. Long-fiber multifractionator



12. Short-fiber multifractionator



multifractionator and high-density-tower sample points of the original system. Thus, no degradation to lightweight contaminants should occur between these two sample points. All quantification test results between the two points were statistically equal, via hypothesis testing for significant differences between the sample population means. This information placed confidence in the validity of the test method.

Comparison of baseline to upgraded system levels

The upgraded-system survey results described in this paper were collected after all new equipment was operational, not optimized. System evaluation and optimization studies are currently underway.

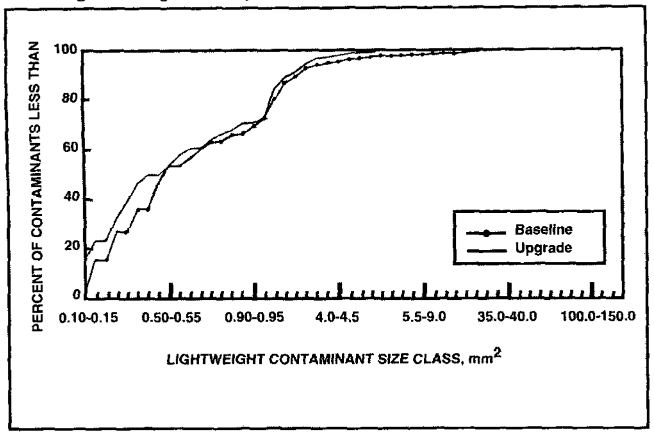
Also, a shift in the purchase of percent OCC to percent clippings occurred during the upgrade time frame. According to our Material Department figures, the purchase of raw material went from 85% OCC–15% clippings for the baseline study to 99% OCC–1% clippings for the upgrade study.

Figures 6–8 show a comparison of baseline to upgraded system contaminant results. **Figures 9–14** compare the contaminant-particle size distributions for the two surveys. Figures 6 and 8 show that the pulper dump chest level of contamination and average size of lightweight contaminants statistically decreased from baseline to upgrade. This shift may be attributed to the 25% decrease in extraction-plate hole diameter for the 600-ton pulper. The contaminants/m^2 values, however, did not prove to be significantly different. Figure 9 shows the impact that decreasing extraction-plate hole diameter size made on contaminant size distribution. In the upgrade survey, there are fewer larger sized particles getting through the pulper extraction plate and into the pulper dump chest.

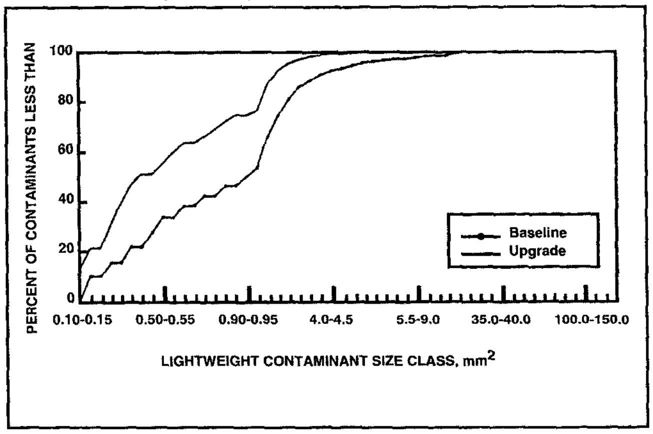
The next sample point in the system survey is the feed to the multifractionator. This point is where a significant change in the lightweight contamination level can be seen. Figure 8 shows that the average spot size to the multifractionator decreased by 54%. Figure 7 also shows that the contaminants/m^2 more than doubled. The combination of these two shifts caused the level of lightweight contamination between baseline and upgrade to be unchanged. Figure 10 displays the dramatic impact the upgraded screening system had on contaminant size distribution.

The shift in the contaminant size distribution feeding the multifractionator also has had an impact on the separation of contaminants through the multifractionator. Figure 6 shows that the long-fiber and short-fiber fractions exiting the multifractionator after the upgrade have statistically equal levels of lightweight contaminants. This is due to the average contaminant size in the long fiber being only 20% greater than

13. Long-fiber high density



14. Short-fiber high density



the short fiber after the upgrade, compared to 50% greater during the baseline study. Also, the contaminants/m^2 in the short fiber are 45% greater than the long fiber now, compared to 50% less in the baseline study. Figures 11 and 12 display the contaminant size-distribution profiles of the fiber fractions, reiterating the shift to smaller average contaminant size.

The long-fiber system had an additional sample point in the upgrade survey. A sample was taken after the long-fiber cleaning system and before dispersion. Figures 6 and 7 illustrate that the new cleaning system, though not fully optimized, was approximately 41% efficient at removing lightweight contaminants [in regard to the level (ppm) of contamination] and reduced the contaminants/m^2 by 33%. Figure 8, however, shows that the cleaning system did not have an impact on the overall distribution of contaminant sizes. The average size of the lightweight contaminants remained unchanged between the multifractionator and cleaner-system sample points.

The long fiber leaves the cleaning system and goes through the dispersion unit. In the baseline data, the dispersion unit proved to be 87% efficient at reducing the lightweight contaminant level. Comparison after the upgrade also showed an 87% efficiency. Reductions in all three quantifiable results from dispersion of the stock may be seen in Figs. 6–8.

The contaminant size distribution profile in Fig. 13 shows that the distribution shift to smaller-sized contaminants follows through dispersion. However, the dramatic shift evident in Fig. 11 on screened stock has been muted by dispersion.

Overall, the lightweight contaminant level of the long-fiber fraction end product has been greatly reduced by the upgrade. The level of lightweight contaminants has decreased by 67%, the contaminants/m^2 by 47%, and the average contaminant size by 54%.

A lightweight-contaminant cleaning system was also installed in the short-fiber stock system. The impact lightweight cleaning had on the short fiber is evident by comparing the multifractionator to high-density-tower contamination levels. Figures 6 and 7 show that the new cleaning system, though not fully optimized, reduced the levels of contamination and contaminants/m^2 by about 40%. The average contaminant size remained unchanged, which coincides with findings from the long-fiber cleaner evaluation. Figures 12 and 14 show the unchanged contaminant size distributions.

The upgrade has also reduced the overall lightweight contaminant level of the short-fiber end product. Lightweight contaminants have decreased by 42%, contaminants/m^2 by 22%, and average contaminant size by 58%.

Conclusions

The test method developed jointly by CPPC and the FPL to quantify lightweight contaminant levels through an OCC system has proven itself through the baseline and upgrade surveys. It provided information regarding the changes in contaminant size distributions caused by installation of the upgrade equipment. Furthermore, it shows that the upgrade has improved the final stock quality by reducing the lightweight contaminant levels in the long- and short-fiber stock fractions by:

- Long fiber

  Level of contamination: 67%

  Contaminants/m^2: 47%

  Average contaminant size: 54%

- Short fiber

  Level of contamination: 42%

  Contaminants/m^2: 22%

  Average contaminant size: 58%. ☐

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