

Incorporation of Post-Consumer Pizza Boxes in the Recovered Fiber Stream

Impacts of Grease and Cheese on Finished Product Quality

There is a lot of confusion regarding the recyclability of pizza boxes, despite relatively high acceptance at paper mills and in recycling programs¹. Grease and cheese are often cited as the reason pizza boxes are not recyclable.

Grease is hydrophobic, and in sufficiently high concentration, could interfere with inter-fiber bonding resulting in paper strength loss. Cheese is comprised of fats and proteins. Proteins are essentially hydrophilic and should not hinder inter-fiber hydrogen bonding.

The purpose of this study is to determine whether grease or cheese contamination levels typically associated with pizza boxes impact finished product quality. Findings from this study will be used to determine the viability of recycling pizza boxes at current and future concentrations in the old corrugated containers (OCC) recovered fiber stream. These findings will also be used to inform the acceptability of pizza boxes in the recycle stream and educate consumers about acceptable levels of grease or cheese residue found on these recycled boxes.

SUMMARY OF FINDINGS

- The number of pizza boxes placed on the market in the U.S. annually is estimated to be 3 billion boxes equating to 600,000 tons of corrugated board. Pizza boxes represent 1.7% of the 35.9 million tons of corrugated containerboard produced in the U.S. annually.
- If all pizza boxes were recovered for recycling, they would represent approximately 2.6% of the OCC stream or 2.2% of the OCC and mixed paper stream combined.
- Pizza boxes currently found in the recycling stream have an average grease content of approximately 1 - 2% by weight level.
- Grease is hydrophobic and when pizza boxes approach a 20 wt% concentration of the furnish, grease interference with inter-fiber bonding begins to result in significant paper strength loss (~5%). At pizza box concentrations under 10%, paper strength loss is low.
- The strength loss as a function of “greasy” fiber and pre-consumer board was almost linear in the 0-20 wt% blend level.
- Cheese, comprised of fats and proteins, is hydrophilic and does not hinder hydrogen inter-fiber bonding of fibers. Cheese tends to solidify and get screened out during the pulping process.

¹ A total of 73% of the US population are estimated to have recycling programs available for pizza boxes. More specifically, 27% of the population is served by programs with explicit acceptance of pizza boxes and 46% of the population has access to programs that implicitly accept pizza boxes.

CONCLUSIONS

The general conclusion of this work is that the strength loss of the resulting product made with recovered fiber that incorporates post-consumer pizza boxes should be minimal at typical levels of grease expected to be received in a recycling facility (<2%) and when included in the recovered fiber at expected levels of <3% of furnish. The addition of small amounts of cheese will not impact the fiber bonding in a negative way. It is expected that the larger chunks of cheese will be screened out of the process. **Therefore, there is no significant technical reason to prohibit post-consumer pizza boxes from the recycle stream.**

STUDY DETAILS

First, the number of pizza boxes available for recycling and the average grease level on those boxes was established.

- Based on industry data (and validated by the Fiber Box Association) it was estimated that the number of pizza boxes placed on the market in the U.S. annually and available to be recycled is 3 billion boxes equating to 600,000 tons of corrugated board. According to the American Forest and Paper Association, in 2018, U.S recycled paper mills consumed 22.6 million tons of recovered old corrugated containers (OCC). If all pizza boxes were recovered for recycling and included in OCC, they would represent approximately 2.6% of the OCC stream. Assuming some pizza boxes would end up in the mixed paper stream rather than OCC, **pizza boxes represent 2.2% of OCC and mixed paper streams combined.**
- To evaluate the average grease level in pizza boxes as received by recycling facilities, several WestRock single stream material recovery facilities (MRFs) pulled pizza boxes out of their incoming streams and took pictures of the inside of the pizza boxes. The relationship between grease levels (by weight) and visual staining was established separately in the lab using locally procured pizza boxes of varying grease levels (**see appendix A**). These data were compared to the visual staining found on the pizza boxes collected at the MRFs. Based on the discoloration of the boxes collected at the MRFs, **it was estimated that on average, pizza boxes had a grease content of approximately 1 – 2% level.**

Next a correlation curve was developed between (increasing) grease levels in the incoming pizza boxes and (decreasing) physical strength levels of the resulting handsheets made from those recycled boxes.

To do this, pizzas were selected with a relatively high grease content equating to 8% of the box weight (measured as the difference in box weight pre- and post-pizza). These high grease content boxes were blended with pre-consumer pizza boxes at various levels (5, 10, 20, & 40%) to represent a broad range of concentrations of grease contamination in the furnish. High concentration (8%) grease-containing pizza boxes were selected to ensure a worst-case scenario situation with respect to physical property strength loss resulting from pizza boxes blended into the recycle stream was examined. It was reasoned that if the strength loss was deemed to be in an acceptable range with the high grease content box that a blended level of the lower grease content pizza boxes in the recycle stream would definitely be acceptable. In addition to using higher than expected levels of grease contamination in the reclaimed pizza box, the amount of reclaimed boxes (5, 10, 20 and 40%) in the blends represent about 2, 5, 10 and 20 times higher levels than expected based upon the average amount of available boxes for recycling as described above.

Lab handsheet data were generated from these blends and strength properties measured. The strength loss as a function of “greasy” fiber and pre-consumer board was almost linear in the 0-20% blend level (see appendix B).

This linear relationship allowed for interpolation of the strength property impacts at much lower, more practical levels of pizza box grease contamination and pizza box recovery levels. Table 1 represents handsheet physical property changes from observed grease contamination levels of 2% added to the furnish over the 0-20% concentration range. Note that expected concentrations in recovered fiber furnish are estimated to be in the 2.2% to 2.6% range.

Table 1

Strength Property decreases at 2% grease level in pizza box and 5%, 10% and 20% concentrations of pizza boxes in the OCC furnish.

| USED PIZZA BOX IN BLEND % BY WT | DENSITY DECREASED | POROSITY INCREASED | MULLEN BURST DECREASED | STFI DECREASED | ZDT DECREASED | TENSILE DECREASED |
|--|-------------------|--------------------|------------------------|----------------|---------------|-------------------|
| 0 (reference with unused pizza box) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 5 | 0.83% | 3.95% | 2.2% | 1.1% | 2.3% | 1.5% |
| 10 | 0.73% | 1.8% | 3.3 % | 2.3% | 2.7% | 2.8% |
| 20 | 1.3% | 5.3% | 4.8% | 6.0% | 5.0% | 4.6% |

Table 2

Coefficient of Friction was not significantly affected at 2% grease level in pizza boxes and 8% concentration of pizza boxes in the OCC furnish. The slide angle was estimated from reference²

| USED PIZZA BOX IN BLEND, % BY WT | STATIC COF | % CHANGE IN COF | ESTIMATED SLIDE ANGLE, DEGREE ² |
|--|------------|-----------------|--|
| 0 (reference with unused pizza box) | 0.540 | | 28.4 |
| 8 | 0.542 | 0% | 28.4 |
| 100 | 0.526 | 3% | 27.8 |

² Garoff, N. (2002). *The Friction between Paper Surfaces* (PhD dissertation). Pg 11, Institutionen för pappers- och massateknologi. Retrieved from <http://urn.kb.se/resolve?urn=urn:nbn:se:kth:diva-3415>

APPENDIX A

| PIZZA DESCRIPTION | INSERT | PIZZA PLACEMENT | GREASE & CHEESE CONTENT* (% OF BOX BY WEIGHT) |
|---------------------------------------|----------------|------------------|---|
| Reference box (no pizza) | | | 0 |
| Meat; pan base | With insert | Cheese side up | 1.4 |
| Meat; pan base | Without insert | Cheese side up | 4.4 |
| 3-cheese with alfredo sauce; pan base | Without insert | Cheese side up | 12.1 |
| 3-cheese with alfredo sauce; pan base | Without insert | Cheese side down | 34.5 |



Figure 1.

Meat Pizza: Pan crust – Cheese side up – with insert



Figure 2.

Meat Pizza: Pan crust – Cheese side up – no insert



Figure 3.

Cheese Pizza: Pan crust – Cheese side up – no insert



Figure 4.

Cheese Lover's: Pan crust – Cheese side DOWN – no insert

APPENDIX B

Effect of increased percent (by weight) of thick crust cheese pizza boxes on percent strength reduction. Reference material was pre-consumer pizza boxes. The cheese pizza boxes had about 8% grease as measured by weight difference pre- and post-pizza.

| USED PIZZA BOX IN BLEND, % BY WT | DENSITY DECREASED | POROSITY INCREASED | MULLEN BURST DECREASED | STFI DECREASED | ZDT DECREASED | TENSILE DECREASED |
|---|--------------------------|---------------------------|-------------------------------|-----------------------|----------------------|--------------------------|
| 0 (reference with no used pizza box) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 5 | 3.3% | 15.8% | 8.8% | 4.3% | 9.1% | 5.8% |
| 10 | 2.9% | 7.2% | 13.0% | 8.7% | 10.7% | 11.2% |
| 20 | 5.3% | 21.1% | 19.3% | 24.1% | 19.9% | 18.5% |
| 40 | 4.0% | 17.1% | 29.3% | 28.3% | 26.2% | 28.8% |
| 100 | 1.4% | 23.7% | 41.2% | 34.8% | 27.6% | 38.6% |

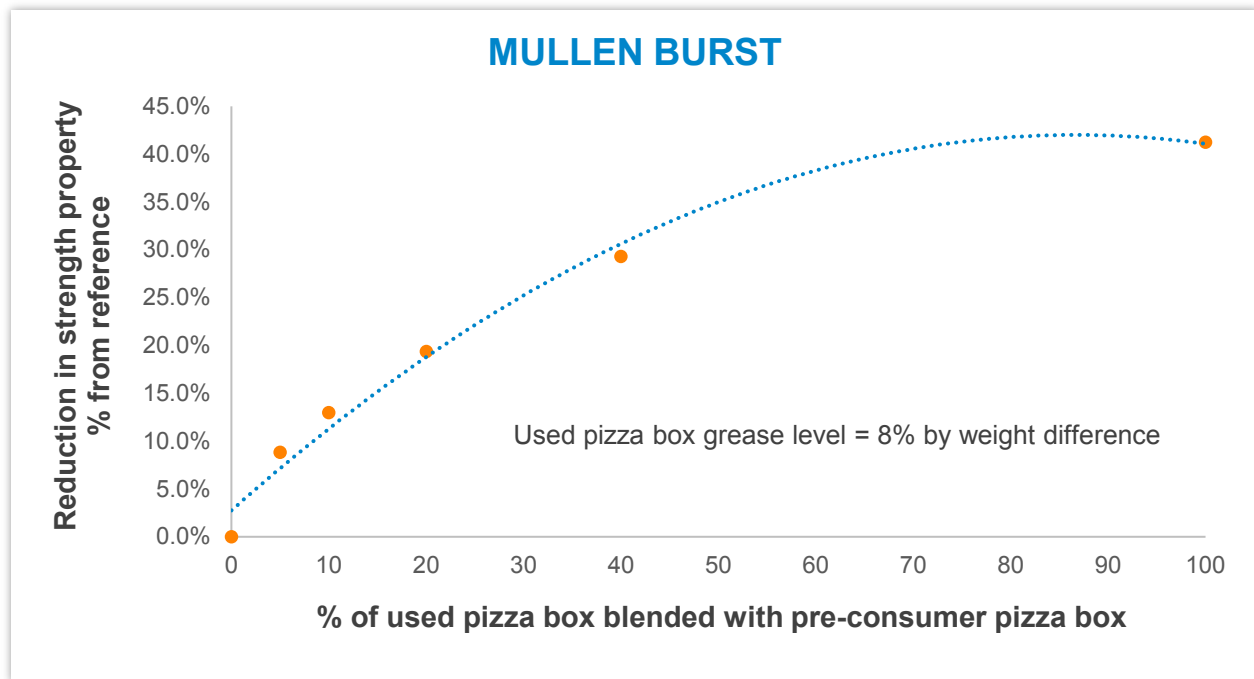


Figure 1. Percent decrease in burst strength with increasing ratio of greasy fiber

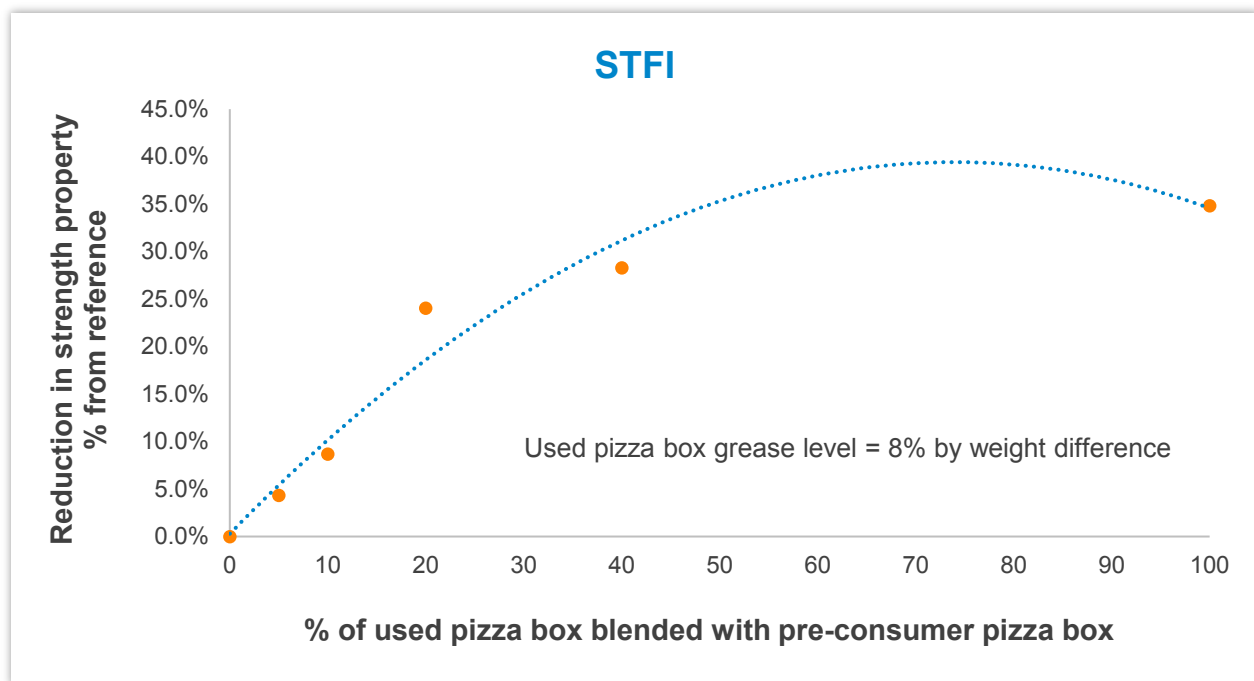


Figure 2. Percent decrease in STFI (short span compression) with increasing ratio of greasy fiber

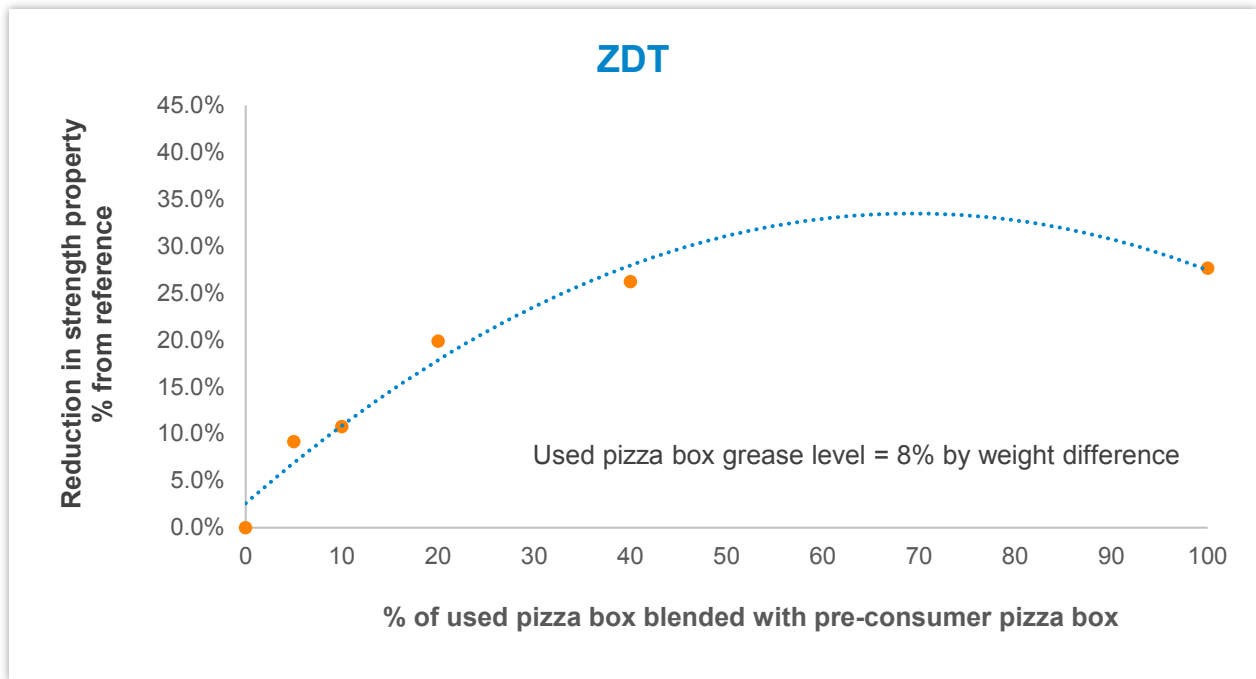


Figure 3. Percent decrease in ZDT with increasing ratio of greasy fiber

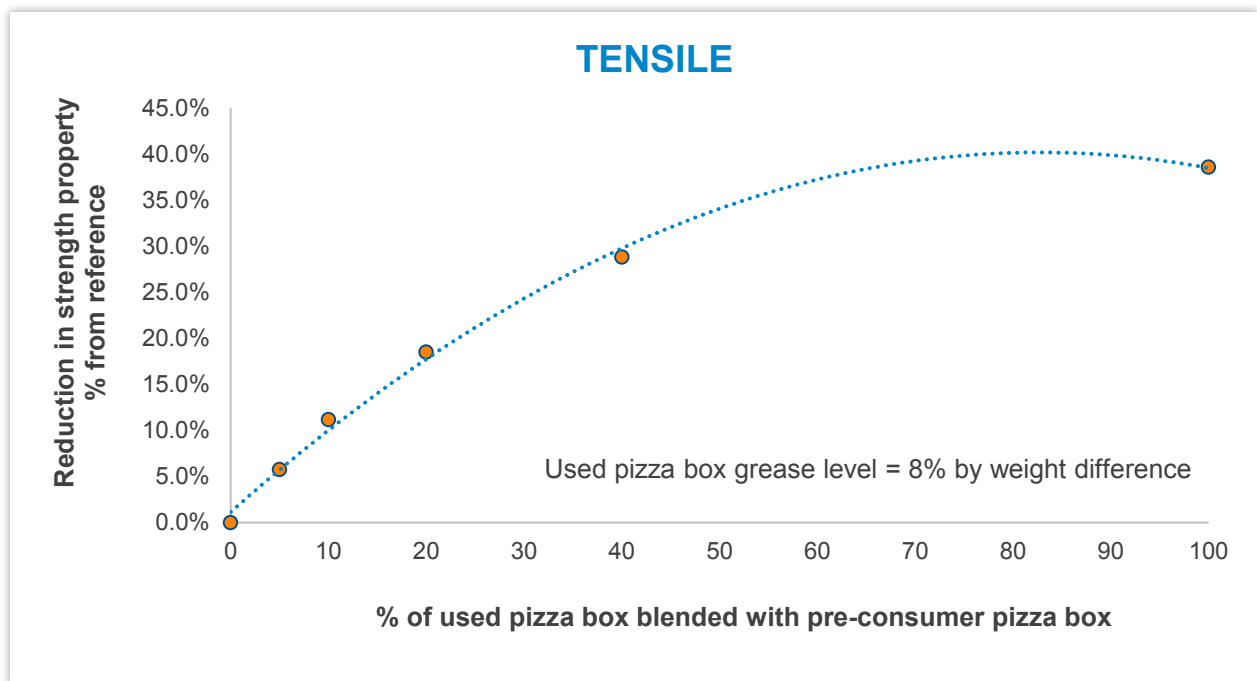


Figure 4. Percent decrease in tensile strength with increasing ratio of greasy fiber