Effects of Medium Strength Properties and Component Rotation on Corrugated Endurance

Roman E. Popil, Barry Hojjatie[*], Michael K. Schaepe[†]

Institute for Paper Science and Technology
Georgia Institute of Technology
Atlanta, Georgia 30332
USA

Abstract

This experimental study seeks to determine the impact of corrugated fluted medium physical properties, box component orientation, and hygroexpansivity on the cyclic humidity creep response. Several series of custom-made corrugated boards and test boxes were produced using the IPST pilot single-facer and manual double-backing. All sample series were subjected to static loads at about 20% of their failure load and placed in cyclic humidity environments ranging from 50 to 80% RH.

One set consisted of A-flute boards devised to examine the effects of out-of-plane shear, ECT, BCT, SCT, and fluting basis weight on lifetime. The basis weight of the fluted medium varied from 68 to 205 g/m^2 while the basis weight of the linerboard facing remained fixed at 205 g/m^2. This selection of materials varied the out-of-plane shear stiffness by a factor of three. Additionally, investigations included the role of horizontal flap edges in RSC container creep, rotation of component orientation, and the effect of barrier coating on C-flute HSC containers. Both ECT and BCT creep response to failure were measured for the A-flute variable medium basis weight series.

Variability of creep rate and lifetime for A-flute RSC containers was about 50% and for the equivalent boards of this series, it was approximately 25% about mean values. This variability in the data obfuscates firm quantification of relationships between lifetime and the selected physical properties including shear. However, in general, boards and boxes made with heavier basis weight medium substantially outperformed boards/boxes made with lighter weight medium when all are

[*] Valdosta State University, Valdosta Georgia, USA.
[†] Cargill, Cedar Rapids, Iowa, USA.

loaded to the same safety factor. The secondary creep slope was inversely proportional to lifetime for all data sets. Measurement of ECT creep rate with its reduced variability compared to BCT creep appears to be a reasonable means to assess relative box performance.

Component orientation effects on creep used C-flute container samples prepared with rotation of linerboard, medium or both by 90 degrees to equalize hygroexpansivity. For the board that were produced with MD of all components in the direction of loading (linear corrugating), the lifetime of the RSC containers increased by a factor of two. We attribute this to reduced hygroexpansivity and higher strengths in the MD. Reduced hygroexpansive oscillations in creep response were also observed with application of experimental pigmented barrier coatings to the double-facing in another series of corrugated test boxes. In this case, the reduced vapor permeability resulted in boxes lasting several months compared to less than two weeks for untreated boxes.

The results of this study show that increased lifetime of the containerboard is obtained by increased homogenization of the component properties. Increased medium basis weight relative to the linerboard weight, component rotation (lateral or linear corrugating), application of vapor barrier coating, all increased lifetime significantly. These observations tend to support the concept of moisture sorption induced stress gradients in the board as being the dominant mechanism driving accelerated creep.