

Original Paper ~~~~~

Effects of Forward Cut Length on Tearing Characteristics of Zipper Lines of E-Flute Corrugated Board.

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To investigate the relationship between the tearing success rate of the E-flute zipper lines and the forward cut length of these zipper lines, the forward cut length was changed in the tearing test while maintaining the connecting portions' length (uncut length) at 3.0 mm, the width of the zipper band at 12.0 mm, and the pulling velocity at 1.0mm/s. The experimental results show that the tearing success rate of the connecting portions increases with the increase in the forward cut length due to the increasing of the horizontal (in-plane) shear displacement by the vertical (out-of-plane) uplift of the forward cut zone band. The lower and upper complementary-critical lengths of 5.0 and 9.0 mm of the forward cut length, respectively, against the uncut length of 3.0 mm were revealed. Two kinds of bent-dented wrinkles and the corresponding two patterns of the tearing force were observed. These are statistically determined by the crossed (glued) position of the corrugated medium and upper/lower liner against the starting /ending position of the connecting portion.

Keywords: perforation, uplift, machine direction, tearing, upper/lower complementary-critical length, crossed position, starting position

1. Introduction

A zipper band designed for opening a flap of packaging box generally comprises two parallel dashed lines, which are perforations for tearing the zipper band apart¹⁾. The tearing test of the zipper-connecting portions (the uncut zone) of the E-flute corrugated board in the fabrication machine direction was reported by Nagasawa et al. when changing the length of the uncut zone, width of the zipper band, phase shift angle between two dashed lines, and the pulling velocity under conditions of keeping the forward cut length at $a=5$ mm against the nominal wave length of 3.2 mm of the corrugated layer²⁾. Regarding the failure behavior of tearing of paper, the mode III tear test (out-of-plane shearing), termed as the Elmendorf test³⁾, in which the

tear propagates across the sheet parallel to the direction of the initial slit, is known and standardized (e.g., TAPPI, T414); additionally, the out-of-plane tearing of thin paper using the tensile testing method shows a tearing resistance similar to that in the Elmendorf testing⁴⁾. Such equivalent tearing strength of the E-flute corrugated board was discussed in the previous report²⁾. Although the primary behavior of the tearing test of the E-flute corrugated board was similar to that of the 310 g/m² white-coated paperboard⁵⁾, the upper and lower critical length of the uncut zone $a_n=3$ mm and 2 mm of the E-flute corrugated board used for determining the success rate of the tearing test²⁾ was affected by the bulging form (uplift) of the forward cut zone, and length of the uncut zone. Herein, the upper and lower critical lengths of the

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