A new and efficient test procedure to measure the internal bond of paper and board

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Abstract

A new fast and very rational test procedure to measure the Z-directional tensile (ZDT) strength of paper and board has been developed by Lorentzen & Wettre. The traditional method to measure the out of plane strength of paper and board in the industry is the manual Scott-Bond method. There are a lot of drawbacks of that method like, the critical and difficult sample preparation, and the high variability of the test results. The new test procedure needs very little manpower and the repeatability number is excellent. It can also be used for cross machine profile measurements. Which means process optimization possibilities. Initial paper machine studies have shown that up to 20-25 % lower ZDT values can be seen in the centre of a Kraft liner CD profile compared to the edges of the web. Also streaks of poor ZDT strength have also been found when doing cross machine measurements.
Introduction

The strength in the thickness direction of paper and paperboard is a very important paper property. Since poor strength in the thickness direction results in delamination and splitting in printing and coating operations. Out-of-plane strength measures the ability of paper or board to withstand tensile stress in the thickness direction. This property has several terms like Scott bond, ZD-strength, delamination strength, internal bond strength, out-of-plane strength and ply-bond strength.

High out-of-plane strength is necessary in various converting and end-use operations. The most important is probably offset printing where the splitting resistance of the tacky printing ink creates a z-directional tensile stress at the exit side of the printing nip.

As poor out of plane strength have very severe consequences. It must be controlled already at the paper mill and to be able to control it an accurate measurement method is necessary. The new SCAN standard P 80 describes a test method that fulfils many important demands on a test method. Such as: it is well defined, gives reliable test results, and has a short testing time and a non-critical sample preparation. With an instrument following this method, paper machine optimization
Converting operations

The problem with tacky printing is already mentioned. Another area of out-of-plane forces is during handling of corrugated board boxes. Low out-of-plane strength contributes to weakness at the manufacturer's joints or other points where two corrugated board surfaces are glued together. Such joints may fail due to stresses applied during set-up packing, or handling by the product user when one of the facings separates internally at a weak point.

Too high out-of-plane strength can sometimes be harmful. To fold paperboard to boxes, a creasing operation is necessary. At this operation, the layers separate from each other and make the box easy to fold without cracks. The separation happens easily if the out-of-plane strength is low.

The jointing of paper rolls during converting operations can also cause out-of-plane stresses. Sufficient out-of-plane strength within the board is then necessary for trouble free operation. The blistering phenomenon is a special case of out-of-plane stress caused by internal forces in the paper. In densely coated papers, the coating obstructs water evaporation from the paper. As a result, water may exit forcefully and cause abrupt local breakage of the surface.
Lowering printing speeds allows drying time at the expense of production efficiency.

High out-of-plane strength is also a traditional requirement of core board.

**Some papermaking variables**

Out-of-plane strength is sensitive to any non-uniformity or layering in the z-direction, since delamination will occur at the weakest plane. The weakest location depends on the z-directional distribution of fines and fillers, the bonding degree, and distribution of size if present. The distribution and shape of the material in the paper depends on the configuration and operation of the forming and pressing sections of the paper machine. In multi-layer boards, the inter-layer strength or ply-bond is also important.

**Single ply paper or board**

**Effect of beating**
Beating has a big influence on the fibre bondings. The refining makes the fibres more flexible which makes them easier to bond to each other. Refining also creates fines, which fill out the voids between the fibres. However, high refining makes the paper more difficult to dewater. Slower paper machine
speeds or higher effects of the dryer section are necessary.

**Effect of wet pressing**
The greater the pressure on the wet paper web, the closer the wet fibres are forced together. The larger area of contact between adjacent fibre surfaces is considered to be responsible for the increase of the internal bond. For example, a fourfold increase in wet pressing led to a 100% increase in out-of-plane strength, accompanied by a 20% higher specific gravity (1).

**Water drainage**
This has a big impact on out-of-plane strength. The style, amount and speed of drainage affect the out-of-plane strength.

**Fibre furnish**
An increase in the ratio of softwood fibre to hardwood fibre shows positive response for both internal bond and tensile strength to increased amount of the stronger softwood. The out of plane strength exhibiting a somewhat greater response than the in plane tensile strength (1).

**Sizing**
Sizing increases out-of-plane strength because it increases bond strength. Internal and surface sizing are effective, although surface sizing may leave the middle layers weaker. Starch is an effective sizing for chemical pulp.
The new IBT Internal Bond Tester realizes a dynamic measuring principle to determine the internal bond strength of paper, board and compound materials. The significant influences of sample preparation and climatic conditions became consideration in the construction. The examination of the internal resistance or bond strength of papers and multi-ply materials in the printing or converting processes is only relevant for evaluation by a dynamic measuring method. Sample preparation integrated for 5 samples simultaneous (bonding, pressing, cutting) Processor controlled clamping pressure and pre... A set of audit procedures prepared to test assertions for a component of the financial statements. Types of Evidence Gathered: consists of examining internal or external records or documents that are in paper form, electronic form or other media. 2 Issues During Inspection of Records: - reliability of evidence - relationship to specific assertions. Reliability of Records and Documents: effective and efficient form of evidence and are increasing in breadth and scope due to increasing use of data analytics -- allowing auditor to visualize and analyze large sets of data for notable relationships. 3 Purposes of Analytical Procedures. 1. Risk Assessment Procedures 2. Substantive Analytical Procedures 3. Final Analytical Procedures. Bond Paper. 0.100-0.200. 0.200-0.400. Roughness (Sheffield Method): This test is an indirect measure of paper smoothness or roughness. It is a measurement of air flow between the specimen (backed by flat glass on the bottom side) and two pressurized, concentric annular lands that are impressed into the sample from top. The standards test procedure is described in TAPPI T538. Roughness (Print-surf Method): Very similar to Sheffield methods. The Internal Bond Tester is designed to determine the internal bond strength of a variety of Paper and Board materials according to TAPPI T 569. The instrument design is based on a falling pendulum which creates a high speed impact on a paper specimen. The paper specimen is sandwiched between two double-coated tape substrates. The pendulum impact measures the total energy required to delaminate the internal fibers of a specimen in a Z type direction into two separate piles. The system also incorporates an automatic sample preparation station which allows five specimens to be accurately prepared simultaneously. The Prep Station requires a filtered air supply meeting IG4 Industrial Grade Air: ISO Class 1-4-1. FEATURES. APPLICATIONS. Three methods are used to measure the internal bond strength of papers made from TMP, CTMP, and kraft pulps. These are the z-directional tensile test, the delamination test, and the Scott bond test. The comparisons between these methods using the same unit of measure (J/m²) show that even though the results are highly correlated, these tests do not measure the same thing. In addition to the fiber-to-fiber bond breakage energy, the delamination energy includes the energy dissipated in the fibrous network of thick papers, while the z-directional tensile energy includes the energy of intrafiber bond failure especially for papers made from flexible chemical pulp fibers.