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Section 4 - Paper Strength Testing Application Information

Introduction

During stock preparation, and particularly at the refining stage, the properties of fibers are drastically changed due to:

- breaking of intra-fiber hydrogen bonds
- fibrillation of the exposed secondary wall
- creation of inter-fiber or fibril bonds
- fiber shortening
- production of fiber debris

The extent to which any one of these properties is developed depends on the mechanical characteristics of the item of plant involved and, to a major degree, on the power input to the refiners.

The problem in developing the required characteristics in the type of paper being manufactured lies in the fact that these fiber properties are interdependent. For example, increasing bonding (to promote strength and stiffness) causes fibrillation and a larger surface area that results in lower permeability. Hence, the developed characteristics in a paper are usually a compromise.

This group of instruments tests various properties of strength in paper and board and those properties that also apply to converted products. The application of each instrument and its relationship to fiber characteristics is discussed in detail.

The TMI Group of Companies offers many Burst Testers. This section provides specific details for Burst Testers 13-10-00 and 13-11-00.

BURST TESTER FOR PAPER AND FOILS

Product link: <http://www.testingmachines.com/product/13-60-burst-tester-for-paper-and-foils>

The Burst Tester is designed for measuring the bursting strength of fabric materials subjected to an increasing hydrostatic pressure. This pressure is applied to a circular region of the specimen via an elastic diaphragm. The specimen is firmly held round the edge of this circular region by a pneumatic clamping device. When the pressure is applied, the specimen deforms together with the diaphragm. The bursting strength corresponds to the maximum pressure supported by the specimen before failure. Identical, in the principle to the multi-directional tensile test, Ball Burst Method for Fabrics, this measurement is independent from the cutting direction of the sample (machine or cross) since the failure naturally occurs in the least resistance direction.

The rubber diaphragms with specific thickness and shore hardness must have a bulge versus pressure pattern within the tolerance of the standards related to the type of material tested.

Features

- The clamping pressure is measured with a pressure transducer and displayed in bar/PSI
- Software to transfer data to Excel: GraphMaster
- Pneumatic sample clamping
- Date of last calibration stored in memory (clamp pressure, bursting pressure, and height gauge)
- Menus allow programming to meet pre- defined test methods and international standards
- Number of test performed with diaphragm stored in memory

INTERNAL BOND TESTERS

Internal Bond Tester

Product link: <http://www.testingmachines.com/product/80-20-internal-bond-tester>

Lab Master Z-Directional Tensile Tester

Product link: <http://www.testingmachines.com/product/84-92-lab-master-z-directional-tensile-tester>

Application

Predicting the paper and board failures that occur during the printing and converting requires a test in the Z-axis.

The z-direction rupture, which gives rise to blistering and delamination problems, follows the relationship with the fundamental fiber properties enjoyed by the tensile strengths. However, the dynamic nature of the “real world” stresses imposed on the paper also relates to its ability to absorb energy. Materials that are more elastic tend to “give” and hence absorb more energy. The fiber properties that give the paper its semi-elastic state are those which introduce fiber flexibility. These are intra-fiber bond breaking and removal of the restraining outer walls, both achieved by refining. Excessive refining, however, will weaken the fibers.

The sheet network, formatted by good average fiber length and fiber fibrillation, also relates to rupture resistance by allowing movement within the sheet together with tenacity to hold the sheet together.

The Scott method, producing a high-speed z-direction rupture of paper and board without introducing shearing is a dynamic test, which defines strength in terms of energy absorption. It has been widely adopted and is used in the Monitor/I-Bond Tester. An alternative test sandwiches the sample between adhesive strips on two platens and applies Z-directional tensile force until the sample is pulled apart. This is the principle used by the Lab Master ZDT Tester, which can also display the force-distance measurements that show the ductility of the sample as it separated.

In recent years applications have expanded to include the prediction of blistering for coated web offset printings, picking, manufacturer’s flap failures, delamination, ply separation and shock-induced failures during the converting processes in addition to the evaluation of stock preparation, refining and the addition of strength additives.

INTERNAL BOND TESTER

Product link: <http://www.testingmachines.com/product/80-20-internal-bond-tester>

This Digital instrument uses the basic principle of the Scott operation but incorporates new design features that enhance performance.

The Monitor/Internal Bond Tester displays test results and statistical data in addition to providing an RS232C serial output for data acquisition purposes.

A solid pendulum provides a single range of 0 to 0.500-ft. lbs. per sq.in.) 0 to 1050 J per sq.m.). The pendulum release is pneumatically controlled for positive positioning and repeatable action.

The sample press is pneumatic with individual cylinders equalizing the clamping force on each specimen with the sample clamping controlled by push button. The pressing time is electronically controlled. The cutting operation is done automatically increasing throughput while protecting the operator from the dangers of the manual cutting operation.

Operational Characteristics

The Monitor Internal Bond Tester requires little technical training since the procedure is simple and straightforward. The digital readout eliminates possible errors involved in taking readings and reduces operating time due to the statistical presentation of data.

The Sample Preparation Station goes further with the introduction of automatic cutting, which greatly speeds up operating times and provides added safety by removing the need for hand-held cutting blades.

Maintenance requirements are minimal. The free swing of the pendulum must be periodically checked, otherwise all components give years of use without need of attention.

LAB MASTER Z-DIRECTIONAL TENSILE TESTER

Product link: <http://www.testingmachines.com/product/84-92-lab-master-z-directional-tensile-tester>

This instrument provides an advanced alternative to the traditional Scott-type pendulum testers. The Lab Master ZDT Tester measures and graphically displays internal bond strength *during* the test to provide insight into how the delamination occurs. Peak force is measured by applying a force to the sample in the Z-direction until ply separation occurs.

Internal bond strength up to 113kg can be determined with 4.5 gram resolution and $\pm 0.02\%$ full-scale accuracy.

The user can specify force, position speed and test duration or select the conditions of TAPPI T 541.

The Lab Master ZDT Tester displays test results and statistical data in addition to providing an RS232C serial output for data acquisition products such as TestLink.

BENDING RESISTANCE TESTER

Application

Bending resistance in paper and board is a complex property that involves the network characteristics of the sheet as well as its fundamental fiber properties. It varies with type of paper, the fibers used, the production process and the bulk and grammage of the finished sheet.

The two main criteria which govern stiffness are fiber dimensions and bulk. Rigidity has been found to be linearly proportional to:

- the square root of weighted average fiber length
- the square of thickness for a given grammage

Since the bulk density of a sheet is closely related to the degree of bonding and fiber strength, a change in any of the fundamental fiber properties will affect bending resistance.

Additional influences on bending resistance also include:

- fiber length
- cell wall thickness
- lignin content
- fiber orientation in the sheet

Bending resistance can therefore be increased or decreased according to the configuration of the refiner and the power input.

This property has many implications in paper and board uses since every type of paper needs a degree of rigidity. In fact, the reason why plastics, a more uniform raw material, are not more widely used is the unique hydrogen bonding potential of cellulose which gives rigidity in the sheet form. Hence, the application of the bending resistance test is practically universal.

ISO 2493, SCAN P29, AS/NZ 1301-4535 AND BS 3748.

BENDING RESISTANCE TESTER: 79-25

Product link: <http://www.testingmachines.com/product/79-25-bending-resistance-tester>

This is electronic instrument measures bending resistance by the two-point method.

The load ranges from 0 to 5000 mN, the instrument having accuracy better than +/- 1% of the range or +/- 2% of the reading. An electronic overload protection operates at 100% loading and precision setting of the bending angle is also electronic with a range 0 to 90 degrees in 0.1-degree steps. A motorized setting of bending length has an automatic stop for greater accuracy. Bending lengths may be 5, 10, 25 or 50 mm.

The clamp accommodates a 38mm wide specimen. As research has indicated that the measuring value can be influenced by the clamping pressure, the clamp is operated pneumatically to achieve a constant clamping force.

The clamped test piece moves to the fixed load-cell when the test starts. The measurement begins at the moment of contact, thus compensating for curved material. Flat samples will give the most accurate test results. The bending clamp will return automatically to the start position.

The peak value is stored and processed into the statistics after a chosen number of measurements.

Calibration is by the deadweight method and is checked electronically.

The instrument has a standard RS232 output and is TestLink compatible.

Operational Characteristics

The instrument is designed and built to conform to International Standards and the traceable calibration route gives proven precision of results.

The two point bending method gives direct contact between specimen and load cell, eliminating possible energy loss and the electronically set bending angle provides accurate and repeatable values.

The easy keyboard operation of menu driven software and a clear digital display contribute to a rapid way of testing with elimination of many sources of human error.

TENSILE TESTERS

Horizontal Tensile Tester 84-56

Product link: <http://www.testingmachines.com/product/84-56-horizontal-tensile-tester>

Universal Tester 84-02

Product link: http://www.testingmachines.com/product/84-02-universal-tester-2_5kn-ct

Application

The wide application of tensile measurement in assessing the suitability of a product for its end use and the close relationship between tensile strain and fiber bonding make this a very important test.

Tensile strength increases with increasing refining energy due to the generation of bonding potential as the fibers swell and the relatively inert outer walls are removed. The increase in bond distribution with increasing surface area, the degree of fibrillation and evenness of formation in the sheet also improve tensile strength but fiber length has been shown to have little influence. Hence, this test contributes extensively towards knowledge of changes in fiber morphology with refining and how the sheet structure is likely to affect other sheet properties.

Both instruments have a wide range of applications in:

- the evaluation of pulps
- for web printing to assess the resistance to stress imposed in the draw
- for paper bags to check the ability to resist shock loads
- any situation where the product is exposed to stress

The instruments are both suitable for use with all types of paper and board within the range of the load cell (up to 1000N with the 84-58). They are also suitable for use with many other sheet materials such as plastics, metal foils and textiles. Both are suitable for measurement of wet tensile and stretch in papers.

The Universal Tester is also used extensively for testing the crush, compressive and adhesion characteristics of corrugated board.

Both instruments conform to the following standards: ISO 1924/2, AS/NZ 1301.448, BS 1924-2, CPPA D34, DIN 53112, TAPPI T494 SCAN P38.

HORIZONTAL TENSILE TESTER: 84-56

Product link: <http://www.testingmachines.com/product/84-56-horizontal-tensile-tester>

The model 84-56 Horizontal Tensile Tester combines a modern contemporary look with a robust mechanical design and new improved electronics including a color touch screen and user-friendly interface. The menus are interactive and the large buttons are designed for easy access.

The main results, i.e. force, strain, strength, T.E.A and tensile stiffness including the rolling average of force and strain, are presented on the color touch screen after each test.

The new clamp design allows handling of test pieces up to 3 inches (75mm) wide, suitable for measuring paper tissue. To ensure that the test piece is perfectly aligned, different guides are available, which can be replaced by the operator if another test width is required.

As an option, the instrument can be adapted for testing wet strength of paper tissue according to ISO 12625-5. There is a water container available that can be placed between the clamps. If the wet test option is selected in the menu, the software will allow the operator to select the soaking time in seconds. A sensor detects if the water container has been placed in position and the wet tensile test sequence automatically will be performed.

UNIVERSAL TESTER 84-02

Product link: http://www.testingmachines.com/product/84-02-universal-tester-2_5kn-ct

This universal bi-directional tester, although designed primarily to test tenacity may also be used with various specifically designed accessories, to measure many other properties requiring tensile strain or compression as the actuating force. These include the compression and adhesion characteristics of corrugated boxboard and crush resistance of its components, wet tensile, coefficient of friction, modulus of elasticity and many other properties.

The instrument consists of a crosshead travelling vertically in a rigid frame and fitted with grips attached to a load cell. It is microprocessor controlled from a console containing the keypad and digital display.

Results may be transmitted to data acquisition systems such as TestLink via an RS-232 serial port and the tester controls can be used for single commands to the computer.

Operational Characteristics

Horizontal Tensile Tester

The instrument has a traceable calibration route allowing proven precision. The reduction of human error and increase in speed of operation is facilitated by the provision of a digital display, selectable units, infrared sample detection and initiation of clamping, push button generation and display of statistics and a user friendly menu which gives ease of section from a comprehensive range of test parameters. The RS232 serial data output enables the transfer of results into data acquisition systems.

Maintenance is straightforward and is facilitated the modular construction of the instrument. A calibration attachment enables on-site calibrations to be carried out. An optional footswitch is available to free both hands of the operator when larger and more inconvenient specimens are tested.

BOX COMPRESSION TESTER

Product link: <http://www.testingmachines.com/product/17-40-box-compression-tester-ct>

Application

This tester determines the effect of compressive forces to which a transport case is subjected, either in transit, or stacked in a warehouse. This is the ultimate test to confirm whether the tests of the box materials predict the performance of the carton in actual use. In addition to the 17-40 described here, other sizes and load ranges are available.

Specification

The instrument is floor standing with adjustable position console controls. It consists of four substantial guide columns supporting an upper platen operated by a servo-driven motor via recirculating ballscrews. The bottom platen is fully adjustable to give precise parallelism and is supported by four averaging load cells giving an accurate measurement of load regardless of loading position.

The Auto-loading range is 40 N to 30 kN and boxes up to 1 meter cube can be accommodated. Units of compression may be selected in N, kgf or lbf. Boxes may be tested to complete collapse or held at a specific load for a given elapsed time for evaluation of stacking properties. Cycling between pre-set loads or extension limits may be conducted.

Results are displayed digitally and have an accuracy better than 0.5% of the indicated load, exceeding BS 1610:1985 Grade 0.5, DIN 51221 Class 1 and ASTM E-4.

Speed control is digitally selected from 0.1 mm/min. (or in other units) with accuracy better than 1% of the indicated speed over the full load range. Full load holding is achieved in the stop position.

Outputs are available via RS232 to transfer results to data acquisition systems such as TestLink or a chart recorder.

Optional equipment includes a graphic recorder; IBM or compatible PC and software for compression and load hold testing.

Operational Characteristics

The tester requires no special skills and only limited training to operate. The electronic configuration and digital display helps reduce human errors during operation.

PUNCTURE TESTER

Product link: <http://www.testingmachines.com/product/13-50-puncture-tester>

Application

In addition to the risk of damage from transport and stacking there is the potential of being struck by sharp objects.

The puncture tester is designed to determine a carton's resistance to puncture by measuring the force required to penetrate the case. This is defined as the energy required to force a puncture head of specific design through a sample under specified conditions.

These conditions are given in various standards to which the instrument conforms, namely: SCAN P23, DIN 53142 and other relevant standards.

Specification

A puncture head, consisting of a stainless steel right-angled triangular pyramid is attached to a solid arm. The arm, under load, swings through an arc until it contacts the specimen clamped between two horizontal plates. The upper plate is fixed; the lower is spring loaded. Each has a triangular hole to accommodate the puncture head.

A collar, loosely fitted to the cylindrical extension to the puncture head, detaches after penetration and adheres to the specimen, keeping the hole open and preventing and braking action on the pendulum.

Safety guards are fitted over the fixed specimen retaining plate.

The scale is calibrated in four energy ranges as a standard feature. These are:

- 0 to 5 Nm in divisions of 0.1 Nm
- 0 to 10 Nm in divisions of 0.1 Nm
- 0 to 20 Nm in divisions of 0.2 Nm
- 0 to 36 Nm in divisions of 0.2 Nm

Interchangeable weights are supplied for each of these energy ranges.

The instrument is built to avoid any vibration that would affect the test values.

Operating Characteristics

The instrument requires no special skills and minimal training to operator. Since it has moving parts, however, safety measures should be observed.

No maintenance apart from normal housekeeping is required but it is advisable to carry out calibration procedures at regular intervals.

Application

Resistance to tear is another test that has long been used to assess a paper's ability to stand up to the stresses imposed upon it, particularly in the production of printing, writing and packaging papers.

Internal tear strength is a property which suffers as a result of the increase in burst and tensile achieved with refining a papermaking stock. Although tear resistance is improved by fibrillation resulting from the action of the refiner in the early stages, the later reduction of fiber length creates a net reduction in tear strength. Other factors, such as increased homogeneity resulting from the refining action, are also said to reduce tear but to a lesser extent. Hence, the refining energy must give sufficient tensile strength without excessive loss of tearing resistance.

Wrapping papers, intended to protect an item in transit, are therefore made from strong long fiber pulps such as unbleached kraft softwood, and printings and writings consist of a blend of long fibers for strength with shorter, finer fibers to give smoothness.

The Elmendorf tear test exerts a shearing force perpendicular to the surface of the paper, simulating the tearing action that occurs in practice. This force is generated by the release of a quadrant pendulum to which one half of the paper sample is clamped. The other half is attached to a stationary clamp. The pendulum is calibrated to give the tearing force in milliNewtons. The range of values, between 200 and 64000 mN, varies according to the chosen quadrant.

The instrument is suitable for testing all types of paper within the stated range and for light boards and textiles. It is not recommended for use with corrugated fiberboard or for determining the cross machine direction tearing resistance of highly directional paper or board.

Both instruments are designed and built to comply with the following standard procedures:

ISO 1974, AS/NZ 1301, 400, CPPA D9, BS. EN 21974, SCAN P11, TAPPI T414.

ELMENDORF TEAR TESTER 83-11

Product link: <http://www.testingmachines.com/product/83-11-monitor-tear>

This instrument consists of a rigid frame supporting a pendulum and pointer assembly, together with a standard clamping system. The pendulum is free to swing on essentially frictionless bearings and the pointer is provided with sufficient friction to maintain the arrest position.

Six interchangeable pendulums cover the range 200 to 64000 mN and an integral knife provides the initial cut to give the required tearing length. Tear resistance is read directly from the scale attached to the pendulum.

ELMENDORF TEAR TESTER 83-20

Product link: <http://www.testingmachines.com/product/83-20-tear-tester>

The test is carried out on a specimen composed of one or more samples of standard dimensions, usually with a distance of 1.7 in (43mm) remaining to be torn after initiating the tear. The energy of a pendulum of suitable weight is used to completely tear the specimen. The difference in the angle from the vertical of the center of gravity of the pendulum between the downswing and the upswing is a measure of the energy absorbed in tearing the sample. This angular movement is measured with a digital encoder and is immediately converted to the mean tearing force for a single sheet by the microprocessor incorporated in the apparatus.

Operational Characteristics

Both instruments provide proven precision of test data and the range of pendulum enables a wide range of materials to be tested. The mechanical condition of the instrument may be checked using the calibration weight traceable to the reference instrument. Both are simple to use and require little maintenance.

SHORT SPAN COMPRESSION TESTER – STFI TYPE

Product link: <http://www.testingmachines.com/product/17-34-short-span-compression-tester>

Application

The compressive index of a material (the failure load per width/basis weight) increases with sheet density in much the same way as the tensile index. Hence, fiber characteristics which contribute to density and flexural modulus of the sheet and the resilience of the fibers themselves are likely contributing factors.

These properties, when applied to fluting media and liners in corrugating board, provide an important basis for the prediction of the compressive strength of the board components is a property, which therefore assumes great importance.

Various tests have been devised to measure the true compressive resistance of the components of corrugating board but these have been shown to be influenced by other factors believed relate to loading conditions and unfavorable stress concentrations at the free edge of the specimen. The results which yield a material property virtually unaffected by grammage and density.

This Short Span STFI Type instrument is an advanced compression strength tester which conforms with international and All major National Standards including: ISO 9895, TAPPI T826, SCAN P46 AND BS7325.

Specification

This short span compression tester is fully microprocessor controlled with contemporary single board electronics, software and mechanical design.

Pneumatic clamps 15.5 x 30 mm. exert a force of 2300 ± 500 N on each jaw assembly at a supply pressure of 500 kPa. The free span between the jaws is 0.7 ± 0.05 mm. and the rate of loading is 3 ± 0.1 mm/min. Precise alignment of the hardened stainless steel clamps ensures trouble free operation.

The standard load cell capacity is 500 N, which is suitable for almost all papers up to very strong kraft liners. Alternative 250 or 100 N load cells are recommended for lower range papers, however. Each cell has an accuracy better than 0.5% between a reading of 5 and 100% of all load range. Cells are protected against overloading.

Automatic zeroing occurs before each test and calibration is checked electronically. Certified calibration weights together with a necessary attachment are available for recalibrating the instrument.

An RS232 C output for transferring results to data acquisition systems such as TestLink is standard. A specialized IBM compatible software pack is also an option. This features on-screen display of up to 50 results, continuous display of statistics updated in real time, comprehensive report print-out and data save and recall facility.

The instrument internal software is available in English, Dutch, French, German OR Spanish and the tester is available for use with either 240V, 50Hz, 1ph or 110V, 60Hz, 1ph supply. It requires instrument air at a line pressure of 600 kPa, using approximately 25 ml per cycle.

Operational Characteristics

The menu-driven software allows for rapid setup of operating parameters such as test direction, specimen detail, grammage, rupture sensitivity, units, language and selection of the calibration program in conversation mode. Statistical information is automatically generated after the first few tests have been completed.

The test specimen number can be incremented automatically after each machine and cross direction cycle, with automatic toggling between the two directions.

These user-friendly facilities together with the clear 20mm display allow rapid testing with minimum possibility of error.

The design of the instrument ensures years of maintenance free operation.

CREASE AND BOARD STIFFNESS TESTER (PIRA)

Product link: <http://www.testingmachines.com/product/79-11-crease-board-stiffness>

Application

The instrument is used in conjunction with the Carton Board Creaser to evaluate commercially formed creases, validate creasing efficiency and measure the bending resistance of the board itself.

Measured under conditions simulating the conversion process, the efficiency of the fold is tested for resistance which causes runability problems, also for any residual moment which would cause bulging of the final box plus possible glue line failure.

Research has shown that the critical factor for efficient conversion of carton blanks into boxes is the ratio of crease stiffness to board stiffness, both measurements being made in the same direction in the board. Typical ratios which permit the successful anticipation of conversion are 1.5 to 3 in the machine direction and 3 to 7 in the cross direction. All tests are carried out under controlled temperature and humidity.

Any necessary reduction in stiffness, achieved by increasing the groove depth, obviously should be at the optimum width which avoids visual defects in the fold.

The instrument conforms to BS 6965 and the technique used gives results that are now familiar to carton board manufacturers, converters and carton users.

Specification

This dual purposes instrument measures crease resistance and board stiffness in the range 0 to 399 gf (0 to 3.91 N).

The tester measures the force required to hold a creased sample folded to 90 deg. or a board sample bent through 15 deg. The digital display automatically stabilizes after 15 seconds and shows the measured force in grams. The reading is cancelled automatically at the start of a new test or manually by press button. This button also serves as the zero check.

A power supply of 240V, 50Hz, 1ph is required to operate the instrument.

The instrument is supplied with a sample cutter.

Operation Characteristics

Simple and straightforward to operate, the instrument requires only basic skills and little technical knowledge in use to limit the possibility of human error.

Calibration is recommended at yearly intervals.

Maintenance is normally limited to normal cleaning procedures. Excessive pressure on the load bar must be avoided.

COMPRESSION TESTER 17-76

Product link: <http://www.testingmachines.com/product/17-76-compression-tester>

FIXTURES FOR SAMPLE PREPARATION – ECT, RCT

Product link: <http://www.testingmachines.com/product/17-76-compression-tester>