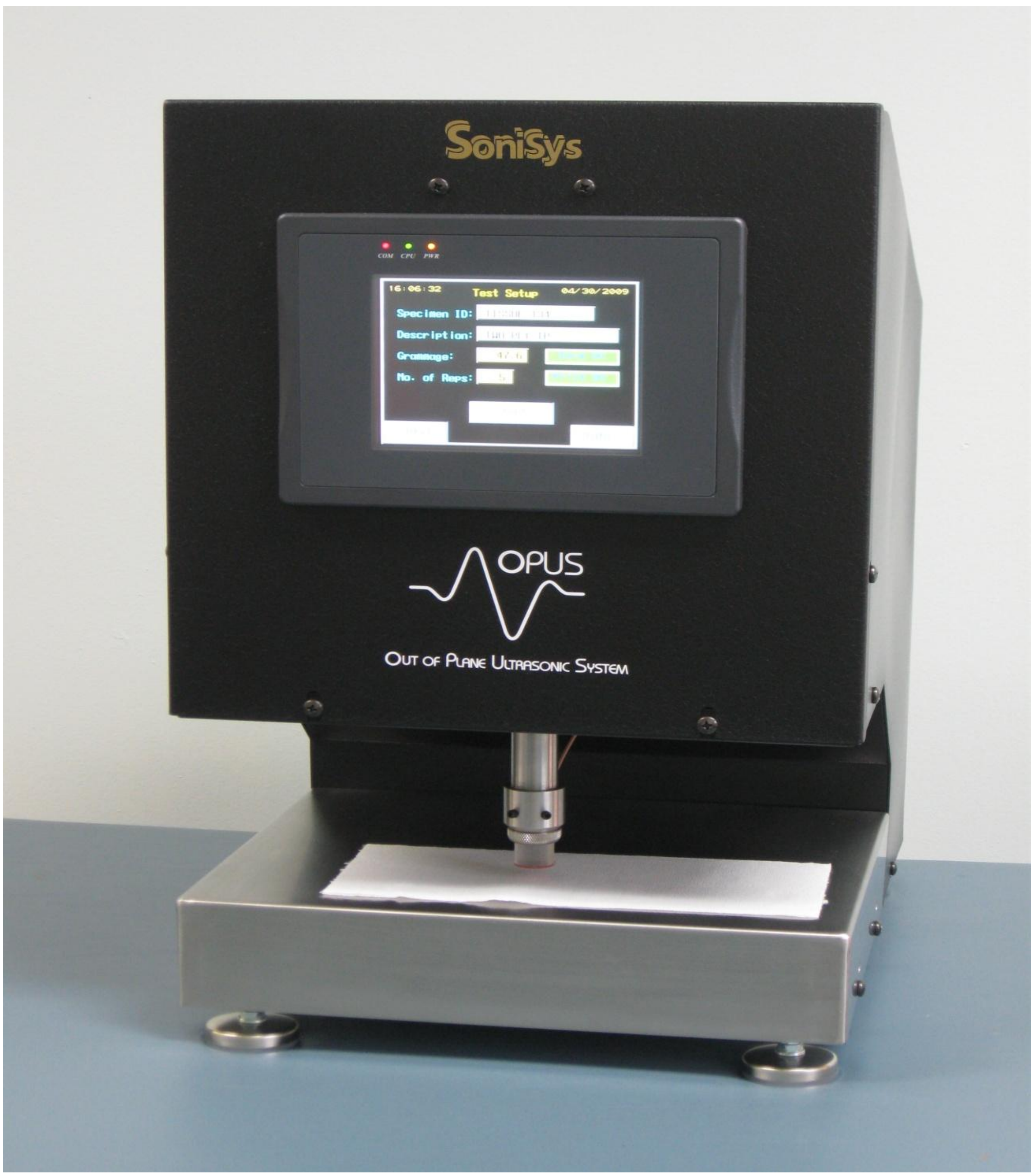
SoniSys

Ultrasonic Instruments for Non-Destructive Testing

OPUS

Out of Plane Ultrasonic System



OPUS

OUT OF PLANE ULTRASONIC SYSTEM

SCOPE

The SoniSys Out-of-Plane Ultrasonic System, OPUS, is a unique ultrasonic system providing non-destructive Z-direction analysis of materials including paper, tissue, board, plastic film, composite materials and gypsum. OPUS provides a number of simultaneous measurements in just a few seconds. Such measurements include but are not limited to: Z-Direction Tensile Stiffness, Soft-Platen Thickness (50kPa, 20kPa for tissue), Elastic Modulus, Acoustic Impedance, Attenuation and Apparent Density. These measurements provide valuable data used in Product Development and Pre-Engineering, Process and Quality Control, and Performance Prediction.

FUNCTION

OPUS is a bench-top instrument similar to caliper instruments. In fact, OPUS measures soft-platen thickness in accordance with TAPPI T 551. The typical caliper platens are replaced with ultrasonic transducer assemblies consisting of a transducer, a delay line, and a thin layer of conformable material. This material helps to optimize ultrasonic energy transmission.

The two transducers are aligned and the top transducer is fitted with a dead weight. Since the fibrous structure of most materials is pressure-sensitive, thickness is a function of the loading pressure, which is standardized at 50 kPa (TAPPI Test Method T 411and T 551). Out of Plane (OP) velocity measurements are typically made at the TAPPI standard load of 50kPa, but 20kPa is used for tissue and similar materials. At 50kPa pressure, for paper samples, most of the sheet is engaged and sheet structure and bonding have influence.

The top transducer is raised to allow for the sample to be inserted in the gap. The transducer is lowered at a controlled rate and the test material is squeezed between the two transducer assemblies. The measurement is made after a fixed amount of time to allow for the neoprene and sample coupling to stabilize. The measured ultrasonic signals are cross-correlated with a reference signal providing the travel time measurement. OP ultrasonic velocity is calculated as the platen separation divided by the travel time. The velocity squared provides a normal mass tensile index (C33/rho), also referred to as Specific Stiffness.

How to Use the Data

ZD fiber orientation and the degree of fiber-to-fiber bonding are important factors influencing the ZD tensile stiffness. Compared to in-plane properties, the ZD tensile stiffness exhibits greater dependence on manufacturing process variations. It has been observed that the specific tensile stiffness will:

- Increase upon refining and wet pressing (Fleischman et al., 1982; Berger and Baum, 1985)
- Decrease when wet straining (Fleischman et al., 1982)
- Decrease when calendering or supercalendering (Berger, 1985; Waterhouse and Charles, 1988.
- Change due to chemical additives and starches (NSF SBIR Final Report, 2006)

Also, furnish (Habeger and Whitsitt, 1983) and yield (Berger and Baum, 1985) is known to affect ZD tensile stiffness. It can further be demonstrated that ZD longitudinal stiffness of single-ply sheets correlates with ZD tensile strength (Fleischman et al., 1982) making it useful as a non-destructive indicator of strength properties. Habeger and Whitsitt indicated that the ZD stiffness is important in modeling the in-plane compressive strength of paperboard, and, in 1987 TAPPI Journal article, Whittsitt and Baum stated that ZD longitudinal stiffness (Ez) correlates with the retention of medium compressive strength during corrugation. These findings support the idea proposed by Baum in 1987 that the measurement of specific stiffness could serve as the basis for real-time control of the papermaking process and could be used to optimize the end-use performance of paper products.

SAMPLE TEST REPORT

SoniSys OPUS Test Results

TEST SETTINGS:

File Name:	3 DOTS_20090817_125841.txt
Specimen ID:	3 DOTS
Test Description:	OPUS005
Test Date:	Monday, August 17, 2009
Test Time:	12:58:41 PM
Loading Pressure:	20.0 kPa
Test Repetition(s):	5
Grammage:	40.0 g/m^2

	Min	Mean	Max	StDv	%COV
Soft-platen Thickness (um)	181	186	190	3.5	1.9
Specific Stiffness (km/s)^2	0.053	0.055	0.057	0.002	2.9
ZD Young's Modulus (GPa)	0.012	0.012	0.012	0.000	1.5
Soft-platen Density (kg/m^3)	210.8	215.3	220.5	4.1	1.9
ZD Impedance (kg/(km^2)s)	0.0498	0.0505	0.0509	0.0005	0.9
ZD Traveling Time (us)	0.785	0.793	0.804	0.007	0.9
ZD Velocity (km/s)	0.231	0.234	0.239	0.003	1.4
Attenuation (dB)	57.05	57.59	58.38	0.54	0.9
Predicted Softness		68.2			

Rep	Thick	Stiff	Young	Dens	Imped	Time	Veloc	Atten
1	188.3	0.0571	0.0121	212.4	0.0507	0.788	0.239	57.14
2	183.0	0.0535	0.0117	218.6	0.0506	0.791	0.231	57.56
3	186.5	0.0549	0.0118	214.5	0.0502	0.796	0.234	57.81
4	189.8	0.0557	0.0117	210.8	0.0498	0.804	0.236	58.38
5	181.4	0.0534	0.0118	220.5	0.0509	0.785	0.231	57.05

Example test result from toilet tissue using OPUS softness model

Technical Specifications

*** OPTIONS AVAILABLE**

- Test area diameter**:** 19mm
- Minimum specimen area diameter: 25mm (1 in.)
- Thickness: for Paper: 20 – 2000µm, and up to 16000µm (5/8 in.) for composites and plastics
- Loading pressure: 20kPa and 50kPa ± 2kPa *
- Removable delay line-terminated piezoelectric ceramic transducer assemblies (2)
    - Active area 19mm *
    - Operating frequency: 1 MHz *
    - Soft-platen terminated plastic delay lines
        - Length: 15 mm (excluding rubber disc)*
        - Rubber disc thickness: 0.76 mm (0.030 inch)*
        - Rubber disc Durometer test: 30 – Shore A scale
- Size: Depth=16" (406 mm), Height= 20" (508 mm),Width=12" (305 mm),
- Weight= 55 lbs (25 kg)
- Required Voltage: 100-240 ac, 2.0 A, 50/60 Hz
- Single-Board Computer: 650MHz CPU w/ 512M RAM using Windows XP Embedded
- Operator interface: 256 color touch screen monitor
- Data Ports: (2) USB for Memory Stick and Printer (both included), (1) LAN, (2) Serial
- Generates Excel compatible data files for data analysis
- Measurements in under 10 seconds

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