Definitions pertaining to Ultrasonic Testing

Acoustic impedance. Acoustic parameter defines as $Z = \rho v$ where ρ and v are the density and phase velocity, respectively.

Bulk longitudinal wave. Elastic wave propagating in a solid material. Longitudinal and shear bulk waves can propagate.

Bulk transducers. Transducers used to excite and detect bulk waves. Transducers can be of two types: longitudinal and shear.

CD. Acronym referring to Cross-machine Direction.

CD/ZD. Acronym referring to the ratio of CD and ZD properties, from which anisotropy in the CD-ZD plane of paper can be evaluated.

Elastic body. Material obeying the Hooke's law, i.e., a material for which the stress is linearly related to the strain when relatively small deformations are considered.

Elastic stiffness constants. Assuming an elastic body described by an orthotropic model, set of nine constants comprising four in-plane constants (C_{11}, C_{22}, C_{12}, and C_{66}) and five out-of-plane constants (C_{33}, C_{44}, C_{55}, C_{13}, and C_{23}). All elastic stiffness constants can be determined using various wave propagation modes.

Elastic wave. Mechanical oscillation propagating in an elastic body and following a sinusoidal function.

Engineering constants. Assuming an elastic body described by an orthotropic model, set of nine constants comprising three Young's moduli (E_{MD}, E_{CD}, and E_{ZD}), three Poisson's ratios (ν_{MD-CD}, ν_{MD-ZD}, and ν_{CD-ZD}), and three shear moduli (G_{MD-CD}, G_{MD-ZD}, and G_{CD-ZD}). Only a subset of these constants can be directly determined by destructive mechanical means. Mathematical relationships exist to relate engineering and elastic stiffness constants.

Extensional stiffness. Parameter defined as $G\,v^2$ where G is the grammage and v is the phase velocity. Since the units for G and v are [kg/m^2] and [m/s], respectively, the units for the extensional stiffness are [kg/s^2].

Frequency. Property of an elastic wave corresponding to the number of oscillations of a given particle per second [symbol: f; units: kHz].

In-plane. This expression refers to waves propagating in the plane of paper or elastic stiffness constants in the plane of paper.

Lamb wave (also called plate wave). Elastic wave propagating in a plate, i.e., a solid medium for which surface waves can no longer propagate because their wavelength is much larger than the plate thickness. Particle oscillation for this type of wave is perpendicular to the surface. Lamb waves can be of two types: symmetric or dilatational waves and asymmetric or bending waves.

Longitudinal wave (also called pressure wave). Wave propagation mode in which the particles of an elastic body are displaced along the direction of propagation.

MD. Acronym referring to Machine Direction.

MD/ZD. Acronym referring to the ratio of MD and ZD properties, from which anisotropy in the MD-ZD plane of paper can be evaluated.

Orthotropic model of paper. Solid mechanics model representing paper as an elastic medium with three mutually orthogonal symmetry planes, i.e., MD, CD, and ZD. This model implies that paper elastic behavior is characterize by a set of nine elastic stiffness constants or a set of nine engineering constants.

Out-of-plane. This expression refers to waves propagating in the thickness direction (Z-direction) of paper or elastic stiffness constants in the thickness direction of paper.

Planar elastic stiffness constants (also plane stress orthotropic stiffnesses). When thickness is neglected in the orthotropic modeling of paper elastic stiffness (two mutually orthogonal symmetry planes), it is preferable to refer to planar elastic stiffness constants Q_{11}, Q_{22}, Q_{12}, and Q_{66} instead of in-plane bulk elastic stiffness constants, i.e., C_{11}, C_{22}, C_{12}, and C_{66}.

Plate wave. See Lamb wave.

Receiver. Transducer used to detect ultrasonic waves.

Separation distance. Distance between a transmitting transducer position and a receiving transducer position (symbol: d; units mm).

Shear wave (also called transverse wave). Wave propagation mode in which the particles of an elastic body are displaced perpendicular to the direction of propagation.

Soft-platen thickness. Thickness as determined using soft platens. Depending upon the degree of surface roughness, the soft-platen thickness is always less or equal to the hard-platen thickness.

Sound velocity (also called speed of sound). Property of an elastic wave corresponding to the product of its frequency and wavelength (symbol: v; units: km/s). It is a characteristic of a material and it is generally constant for any frequency and any wavelength. Different types of elastic wave propagating in a material have different velocities which are characteristics of this material.

Specific Stiffness (also called mass specific elastic stiffness). The specific stiffness is defined as the stiffness to apparent density ratio, i.e., $C' = C/\rho$. This quantity is independent of density. Units are $(km/s)^2$. Please note that C'_{11}, C'_{22}, C'_{66}, *and* C'_{12} are replaced by Q'_{11}, Q'_{22}, Q'_{66}, *and* Q'_{12} for the special case of a planar material such as paper.

Stiffness (also called elastic stiffness). Ability of an elastic body to resist deformation within its elastic regime (symbol: C; units: GPa). Stiffness is also used in reference to elastic stiffness constant.

Symmetric wave (also called dilatational wave). Type of Lamb wave in which the middle zone particles (center plan) perform purely longitudinal oscillations. Other particles have elliptical oscillations.

Transducer (also called electro-acoustical transducer). Device which converts electrical power into acoustical (mechanical) power, or vice versa.

Transmitter (also generator). Transducer used to excite ultrasonic waves.

Traveling time (also called transit time). Time required for a wave to travel from a transmitter to a receiver (symbol: t; units: μs).

Ultrasonic wave (also ultrasound). Acoustic wave with a frequency above the audible range (> 20 kHz).

ZD. Acronym referring to Z-direction, i.e., thickness direction of paper.

Wavelength. Property of an elastic wave defined as the distance between two planes in which the particles are in the same state of motion [symbol: λ; units: mm].