Ultrasonic Technique for Evaluation of Materials and Components

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Abstract

Propagation of ultrasonic waves is influenced by the microstructure of a material through which they propagate. Hence, ultrasonic waves are used for characterization of various structural features in different alloys, polymers, glasses and concrete. The velocity of the ultrasonic wave is influenced by the elastic moduli and the density of the material, which in turn is mainly governed by the amount of various constituents present and the damage to the material. Whereas, ultrasonic attenuation, which is the sum of the absorption and the scattering, is mainly dependent upon the damping capacity and the scattering from the grain boundary, precipitate-matrix interface, inhomogeneities etc. in the material. Ultrasonic technique is also employed for evaluation of compressive strength of concrete structures, for ensuring construction quality and for assessment of service induced degradation.

Various ultrasonic methodologies developed for characterisation of microstructural features in the size range from a few Angstroms to a few tens of microns in a variety of technologically important ferrous materials, superalloys, titanium alloys, polymers and glasses are presented. These methodologies are developed based on in-depth understanding of the influence of material parameters on the propagation of ultrasonic waves in the material. The talk includes the application of ultrasonic methods for evaluation of degree of recrystallisation in austenitic stainless steels using ultrasonic velocity ratio parameter, imaging of grain size variations in stainless steel specimens forged to different strain levels, imaging of austenitic and ferritic steel weldments, in-situ assessment of in-service degradation of Inconel 625 cracker tubes and identification of β-transus temperature in α+β titanium alloys by measurement on a single specimen in one microstructural condition only.

A new correlation developed between two independent elastic constants, i.e., ultrasonic shear wave velocity and Poisson’s ratio, for various isotropic solid materials is presented, which may lead to the reduction in the number of independent elastic constants required for isotropic solids from two to one, at least for a given alloy system with different microstructural conditions.

Use of ultrasonic measurements for evaluation of degradation of concrete on exposure to sodium fire is also presented as a typical example.