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Non-Linear Ultrasonic Method For Assessment of Material Characteristics

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Abstract

When a finite amplitude ultrasonic wave of particular frequency propagates through a solid, it interacts with the solid medium. As a consequence of this, higher harmonics are generated in the medium. Detection and measurement of these small amplitude harmonics in through-transmission mode allows one to determine a non-linear parameter called,β which can be correlated with microstructural features and mechanical properties of the material. Hence, non-linear ultrasonic methods are useful for assessment of material degradations. There is a growing interest to correlate β parameter with microstructural changes associated with ageing [1], precipitate hardening [2], dislocation structure and density [3], and material degradation by damage processes such as fatigue and embrittlement. To give an example, a monotonic increase of β with precipitation induced lattice strain reported in [2] has opened up new avenues to examine precipitation hardening process. Similarly, measurement of the non-linear parameter in heat treatable alloys as a function of heat treatment time is reported to provide quantitative information about the kinetics of precipitate nucleation and growth. The authors' laboratory has initiated a program on non-linear ultrasonics and its application to materials characterisation.

This paper discusses the recent work carried out at the authors' laboratory on the study of variation of β parameter with hardness of carbon steel specimens that are subjected to different heat treatment. Using a 2 MHz transmitter and 4 MHz broad band receiver, second harmonic contents have been recorded and analysed. A linear correlation has been observed between the hardness and the β parameter. In this paper, experimental set up, heat treatment details and theoretical background on β parameter and its determination from the harmonic amplitudes are discussed.

Key words: Ultrasonics, non-linearity, carbon steel, heat treatment, hardness.

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