In-situ stress monitoring in aluminium plate using the combinational harmonics generation of Lamb wave

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Stress monitoring is a major challenge in the field of structural health monitoring (SHM). Conventionally, strain gauges or wave velocity-based techniques are used to monitor stress. However, a strain gauge can only monitor a local area of the structure, while the sensitivity of the wave velocity method is limited. Nonlinear guided wave techniques, such as second harmonic generation, have attracted significant research interest in the last decades. It has been demonstrated that nonlinear guided waves not only have long propagation distance, but it is also sensitive to microstructure changes. The current bottleneck in transferring nonlinear guided wave techniques to real applications is the difficulty of distinguishing the source of nonlinearities. In this context, the generation of combinational harmonics phenomenon presents an opportunity to distinguish the source of nonlinearities. This study aims to investigate the stress effect on the generation of combinational harmonics. An experiment under uniaxial tensile stress was conducted, and a finite element (FE) model incorporating Murnaghan's strain energy equation was developed. Both experimental and numerical results show the sum combinational harmonic is sensitive to monitor the stress status. In addition, the FE model was further utilised to investigate the effect of biaxial prestress conditions. The outcome of this study can further advance the application of the combination harmonics method in stress monitoring.