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THE INFLUENCE OF MATERIAL PROPERTIES DISTRIBUTION OF WAVES IN 1D: APPLICATION TO CRYOULTRASONICS

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Abstract. Additive manufacturing (AM) is a transformative approach for industrial production that enables lighter and stronger parts or systems. However, when considering the fabrication of safety-critical components, manufacturing defects may limit the benefits associated with AM or even pose a significant barrier to its acceptance. Non-destructive evaluation (NDE) enables the inspection and detection of manufacturing defects in high-performance parts obtained by AM. In particular, ultrasonic testing (UT) is an NDE method that allows the examination of pieces thoroughly, but it has drawbacks when detecting defects in parts with complex shapes. To alleviate these difficulties, cryoultrasonic NDE is a technique recently developed to inspect metal parts with geometries. This technique embeds the piece of metal in ice-capable of transmitting the ultrasonic signal more clearly. Although preliminary results have been promising, practical issues require a more profound study of the size and material properties of the ice. Therefore, it is of the utmost importance to characterize and analyze the propagation of an elastic wave through numerical simulations as a function of variables such as the size and orientation of the ice grains, material properties, frequency, and type of wave, among others. In this work we study through numerical simulations, using the finite element method, how the distribution of the material properties of ice affects the attenuation of a propagating wave. We consider a one-dimensional model with uniform grain sizes, constant material properties at the ends and random material properties in the center, mimicking a filter of a heterogeneous material made of ice. An external force is applied at one end and the wave amplitude is measured at both ends where the properties remain constant. The results suggest that the attenuation varies quadratically with respect to the standard deviation of the difference in the material properties of adjacent grains.