Influence of Local Mechanical Properties of High Strength Steel from Large Size Forged Ingots on Ultrasonic Wave Velocities

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In the metallurgical industry, ultrasonic inspection is routinely used for the detection of defects. For the nondestructive inspection of small high strength steel parts, the material can be considered isotropic. However, when the size of the parts under inspection is large, the isotropic material hypothesis does not necessarily hold. The aim of this study is to investigate the effect of the variation in mechanical properties such as grain size, Young's modulus, Poisson's ratio, chemical composition on longitudinal and transversal ultrasonic wave velocities. A 2 cm thick slice cut from a 40-ton bainitic steel ingot that was forged and heat treated was divided into 875 parallelepiped samples of 2x4x7 cm³. A metallurgical study has been performed to identify the phase and measure the grain size. Ultrasonic velocity measurements at 2.25 MHz for longitudinal and transversal waves were performed. The original location of the parallelepiped samples in the large forged ingot and the measured velocities were used to produce an ultrasonic velocity map. Using a local isotropy assumption as well as the local density of the parallelepiped samples calculated from the chemical composition of the ingot provided by a previously published study [1], Young’s modulus and Poisson’s ratio were calculated from the longitudinal and transversal wave velocities. Microtensile measurements were used to validate Young’s modulus obtained by the ultrasonic wave velocity and an excellent match was observed.

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