Ultrasonic Material Characterization and Testing of Anisotropic Components

Eckhardt Schneider and Christian Boller

Abstract All components are more or less anisotropic. In many cases, the anisotropy is beneficial and reduces the quality costs of the deep drawing process of automotive parts. In other cases the anisotropic behavior is tried to be reduced in order to minimize the deflection of rolled parts during machining. During the ultrasonic testing of anisotropic components the anisotropy causes a beam skewing and hence difficulties to precisely localization detected defects. The characterization of anisotropy is an issue and ultrasonic techniques offer appropriate possibilities applicable on automotive and aeronautical components. The anisotropic structure of the metallic single crystal causes a more or less significant direction dependency of material properties. Most of the automotive and aeronautical components are of Al- and Fe-alloys exhibiting a texture, means a preferred grain orientation. Among others, texture causes direction dependent elastic, plastic, and electromagnetic properties. The evaluation of X-ray pole figures is a widely used method to describe texture quantitatively, a variety of mechanical and magnetic techniques are in use for the quantitative texture analysis. The mentioned state-of-art techniques request samples of the component. Ultrasonic technique allows a nondestructive characterization of the anisotropic material behavior and the testing of components exhibiting anisotropy. The contribution presents in its first part the potential of ultrasonic techniques to evaluate texture of components and to characterize texture. The elastic anisotropy of fcc and bcc single crystals is described in terms of the ultrasonic velocities and the change of the times-of-flight of different ultrasonic wave modes are used to determine the texture symmetry axis and to evaluate the strength of the texture. Correlations of ultrasonic time-of-flight data are used to characterize the drawability parameters of rolled products which will be cold or hot pressed into automotive body parts. Among others texture also influences the stiffness and strength values of Al- and Fe-alloys. Ultrasonic techniques enable the evaluation of the mentioned quality measures and hence support the appropriate heat treatment of the parts. Stress states also cause a direction dependent elastic

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behavior and inhomogeneous distributed residual stress states cause spring back reaction of sheets and plates during the cutting and shaping process of the part. The ultrasonic stress analysis supports the needed heat treatment and the optimization of the machining sequence. The second part deals with the ultrasonic testing of anisotropic structures as welds of austenitic steel on one side and particle and fiber reinforced components on the other. The orientation of the dendritic structure of an austenitic weld causes beam skewing resulting in significant errors of the localization of welding defects. Using basic results of experimental investigations performed on samples cut from a real austenitic weld, a technique is developed to iteratively evaluate the appropriate material elastic constants, and hence to calculate the skewing angle and to correctly localize the welding defect. In particle reinforced metallic (MMC) or ceramic (CMC) components the transversal isotropy of particular planes are a quality measure. The application of linear polarized ultrasonic shear waves allows the check of that measure. The determination of the glass or carbon fiber orientation in reinforced components using the direction dependent change of ultrasonic times-of-flight is limited to thin sheets and plates because of the high ultrasonic attenuation of that material.

Keywords Material characterization · Anisotropic components · Quality cost · Reinforced metallic · Reinforced ceramic · Glass of carbon http://www.springer.com/978-981-10-1770-4

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