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Non-destructive characterization for thermally sprayed coatings based on ultrasonic pulse-echo technique

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Thermal spray technologies have been widely used in aerospace, nuclear and many other fields. The accurate characterization of coating features—such as thickness, elastic modulus, and interfacial bonding quality, especially in a nondestructive way, is extremely meaningful to ensure coatings manufacturing quality and coated components service performance. As a most commonly used nondestructive testing technique, ultrasonic pulse-echo method is obviously promising for characterization of coatings. Compared to bulk materials, ultrasonic responses to coatings are complicated since ultrasonic echoes reflected from the front and back surfaces overlap and dead zone induces unavailable testing for thin components. The microscale heterogeneity and anisotropy of sprayed coatings, due to tiny pores, cracks, and local fluctuations of density and elastic parameters as produced during manufacturing and/or service in field, lead to significant scattering attenuation, distorted waveform, and acoustic properties varying from frequency. In this work, coating thickness, elastic modulus and interfacial bonding quality are characterized via combining ultrasonic pulse-echo technique with multiple advanced signal processing. Firstly, thickness of WC-Ni composite coatings up to 200 μm was obtained based on ultrasonic reflection coefficient amplitude spectrum analysis (URCAS), the relative error between the true value and ultrasonic measurement is less than 5%. Subsequently, a new scheme of elastic modulus measurement was carried out in relation to wave type conversion principle with oblique incidence, ultrasonic measurements of Young's modulus for WC-Ni composite coatings are consistent with other literatures. Finally, in comparison with that of well bonding samples, local de-bonding of coatings can be distinguished due to sharp increase of ultrasonic reflection coefficient at interface, by which ultrasonic characterizations and metallurgical observations have good consistency.

Keywords

Thermally sprayed coatings
Thickness
Elastic modulus
Bonding quality
Ultrasonic characterization