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Ultrasonic vibration-strengthened adhesive bonding of CFRP-to-aluminum joints

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Abstract: The strengthening mechanism of an ultrasonic vibration-strengthened adhesive bonding method was studied via experimental and numerical analyses. This processing method was found to enhance the bonding strength and stability of CFRP-to-aluminum joints by 40% and 60%, respectively. Ultrasonic vibration could promote the flow of adhesive to fill the bonding gap through the vibration conversion and transmission in the CFRP laminate. The high-frequency vibration of the adhesive caused large bubbles in the adhesive layer to stretch, deform towards the nearby flow front and burst on account of the asymmetric resistance offered by the bubbles to the vibration-induced flow. Ultrasonic vibration made it easier for the adhesive to permeate into the fine structure of the surface, because the permeation was driven by the hydraulic pressure difference produced by the prompted flow of the adhesive. The processing method improves the adhesion strength and bonding stability by utilizing external energy to effectively facilitate the adhesive bonding process; hence, it is an active enhancement method.

Key words: Ultrasonic vibration; Strengthen; CFRP; Adhesive bonding; Mechanism

1. Introduction

Adhesive bonding is an important processing method employed in applications of carbon fiber reinforced plastic (CFRP). CFRP is a promising light-weight material that finds extensive applications in many fields because of its high specific strength, high stiffness, good resistance to corrosion, and excellent fatigue resistance (Arenas et al., 2013). Most applications of CFRP