Caractérisation ultrasonore haute résolution d’un film adhésif dans un assemblage aéronautique

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Abstract
This thesis focuses on the characterization of the properties of an adhesive film in a three-layer aeronautical assembly of the Titanium-Adhesive-Composite type, representative of the fan blade in the LEAP engine. The main objective is to accurately determine the thickness of the adhesive film, its mechanical properties, and the quality of adhesion it provides between the titanium and the composite, using high-frequency, and therefore high-resolution, non-destructive ultrasonic methods. However, this precise determination of the thickness of the bonded joint and its mechanical properties, which are key indicators of the quality of the bond, remains an unresolved technological challenge in the aeronautical industry due to the significant impedance contrast in this type of structure : high between the titanium and the adhesive, and low between the adhesive and the composite. Therefore, the challenge of this thesis is to address the detection of the background echo at the Adhesive-Composite interface at high frequency. This challenge is further complicated by the significant attenuation associated with high frequencies. It is essential to find an optimal compromise between a frequency high enough to match the wavelength to the thickness of the adhesive, but not too high, in order to detect the background echoes, particularly the background echo at the Adhesive-Composite interface, with a sufficiently exploitable amplitude. Initially, a qualitative study was conducted on six three-layer samples (TA6V-Epoxy-Composite, provided by Safran) using the PVA TEPLA 301 scanning acoustic microscope (SAM), which allows the precise measurement of the epoxy adhesive film's thickness and the assessment of the quality of the adhesion by analyzing the background echo of the epoxy film and examining the amount of energy transmitted to the composite layer using X-scan imaging. Different levels of adhesion were identified : strong, medium, and weak. A quantitative study was then carried out using an interphase model solved by the Debye series method, which allowed for the quantification of the adhesion levels in these samples: a strong adhesion level for sample 2 with adhesion coefficients ($\alpha = 1$ and $\beta = 1$), a weak adhesion level for sample 1 with ($\alpha = 1$ and $\beta = 10^{-3}$), and a medium adhesion level for samples 3, 4, 5 and 6 with $\alpha = 1$ and intermediate β values.