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High-resolution ultrasonic characterization of an adhesive film in an aeronautical assembly (Oral Presentation)

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The reduction of weight in aeronautical structures is a significant challenge in decreasing aircraft fuel consumption and reducing polluting emissions. Adhesive bonding addresses this need for weight reduction and offers numerous advantages compared to more conventional techniques like welding or riveting. Hence, there is a necessity to perform non-destructive evaluation (NDE) to assess the quality of the adhesion. Several non-destructive methods are currently employed for this purpose [1, 2], including the identification of imperfections such as porosities, cohesive delamination within the adhesive bond, as well as adhesive delamination between the adhesive and the substrate [3]. In this study, the sample under investigation is representative of the Leap engine fan blade and is provided by Safran. It is composed of three materials: a 994 μm titanium alloy TA6V (Ti) bonded to a 13.5 mm thick 3D woven composite (Comp) using an epoxy resin AF191K (Epo) with an estimated thickness of 135 μm . As a result, the studied structure is a trilayer stack made referenced as (Ti/Epo/Comp), and the epoxy adhesive film requires the use of transducers with a centre frequency of a few tens of MHz. The aim of this work is to develop an acoustic method to assess the viscoelastic properties of the adhesive film. Up to now, it is still a challenge to bring a robust information on the level of adhesion, which is strongly dependent on the adhesive thickness and the acoustical impedances ratios. The difficulty in obtaining an ultrasound evaluation with a favourable signal-to-noise ratio arises from the acoustical impedance contrast. This contrast is high between TA6V and epoxy resin, and low between epoxy resin and the composite, making the detection of the epoxy/composite interface particularly challenging. Additionally, the material's inherent attenuation contributes to the loss of ultrasonic wave energy during its propagation.

This assessment is carried out using a non-destructive evaluation with an ultrasonic method with high frequency and high resolution, utilizing the scanning acoustic microscope (SAM) PVA TEPLA 301 (pulse-echo method). Preferably, a focusing transducer is used for imaging and a planar transducer for characterization (amplitude). Another method for modelling signals reflected at different interfaces is the Debye series method developed by J.M. Conoir and implemented by P. Marechal [4], which allows expressing the reflection and transmission coefficients at various interfaces. Subsequently, the expression of the overall reflection coefficient enables the reconstruction of the signal with echoes associated with each layer of the assembly. The model also provides the possibility to introduce viscosity and change interface conditions, allowing the simulation of defects of cohesive or adhesive nature. Numerical and experimental results are in good agreement and presented to assess adhesive film thickness and impedance, aiming to provide an estimation of the adhesion quality in an aeronautical assembly of TA6V/Composite.

References:

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