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Flaw classification in bonded joints using multivariate statistical analysis and artificial intelligence

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Abstract-

Adhesives play an important role in multiple industries, offering versatile bonding solutions for diverse applications. However, their incorporation in structures where safety is critical has been met with hesitation due to potential degradation risks. Addressing this concern, this study introduces the preliminary assessment of a pattern recognition method aimed at automatically identifying damage in adhesive joints through acoustic signal analysis. This method was tested on experimental samples consisting of aluminum substrates bonded with an acrylic adhesive. Artificially generated defects on the samples was related to the percentage of bonded surface. Damaged samples contained either 25 %, 50 %, or 75 % of bonded surface, whereas healthy samples contained 100 % of bonded surface. Experiments involved applying an impulsive load at one end of the sample and recording the acoustic signal emitted in response to the load using a microphone located at the opposite end. Two classification algorithms were evaluated for discriminating the amount of damage of the samples. First, a multivariate statistical analysis extracted the fundamental frequencies from the acoustic signals to create a model that achieved 95 % of classification accuracy. Second, an Artificial Neural Network (ANN) model was trained and validated with features extracted from the sound pressure level (SPL) signal obtaining an average accuracy of 97.1 % for a 9-fold cross-validation. The results indicate that there is potential for further exploration of the proposed approach, leading to the development of a robust system capable of automatically detecting damage in bonded joints. Future work will explore the performance of the classification techniques for detecting other types of defects related to the lack of adhesion and inadequate curing times.

Index Terms- Artificial intelligent; Bonded joints; Flaw detection; Neural networks; Acoustic signals

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