

Investigation of welded joints using modal analysis

Abstract

This doctoral dissertation presents research involving the application of modal analysis for detecting inconsistencies arising during the multipoint embossing welding process.

In the introductory part of the dissertation, the test samples and the welding station equipped with the necessary components for conducting experimental modal analysis are presented.

The first part of the study involved conducting a finite element modal analysis of the welding fixture, and the sample, the quality of which is being verified. The research identified 221 resonance frequencies along with their mode shapes. The resonance frequencies exhibiting the highest amplitude and deformation concentrated on the tested sample were compiled into tables. Based on these, locations for mounting the accelerometer for further experimental considerations were selected. The numerical studies concluded with a dynamic test in the form of an impulse excitation simulation, allowing for the verification of the influence of clamping force on the conducted experiment.

The second part of the research involved conducting an experimental modal analysis at the points selected during the numerical studies. For this purpose, preliminary configuration of the equipment necessary for modal analysis was performed, and an initial examination of the frequency response of the components selected for testing was carried out. The next step in the experimental analysis was focused on conducting a modal analysis on the welding station, which consisted of the welding machine, fixture, and the test sample. These studies concentrated on measurements in which the directions and location of the excitation point relative to the system's response were determined to achieve a frequency spectrum with the highest signal quality. Upon establishing the best configuration, an experiment was conducted to verify the changes in resonance frequencies due to the presence of joint inconsistencies.

The experiment proved that all resonance frequencies of the samples changed. The resonance frequencies from the experiment matched the results recorded through numerical analysis.

The third part of the study involved comparing the dynamic resistance method applied to the multipoint embossing welding process with the modal analysis method. The research demonstrated the ineffectiveness of dynamic resistance measurements compared to the modal analysis method.

The final part of the study involved developing an algorithm and testing its capabilities in verifying inconsistencies in the multipoint embossing welding process. The algorithm verification was conducted using statistical tests, scanning acoustic microscopy (SAM), and strength tests. The algorithm correctly distinguished samples with different process parameters based on changes in resonance frequencies.