Theoretical analysis and operation optimization of eddy current flaw detector sensor interface

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Abstract

The use of input devices of resonance-type in flaw detectors is advisable at frequencies above 100 - 200 kHz. However, in the practice of non-destructive testing by eddy currents, it is often necessary to use lower frequencies. In this case, one should connect the eddy current probes to devices with a non-resonant interface such as a bridge circuit. The functioning of bridge circuits used in eddy current sensors is significantly different from its functioning when used for components measurement because eddy current sensors operate under linear parametric modulation. In this case, it is advisable to perform the measurements by the self-comparison method, when a pair of closely located identical probes are placed in adjacent arms of the bridge.

In this article, we first provide a detailed mathematical analysis of the operation of such a bridge circuit used as a flaw detector interface device. We use impedances of arbitrary finite values as disturbances. It is shown that despite the non-resonant character of the bridge circuit, it exhibits good selectivity for different loading (insertion) impedances. The isolines of the output signal and the probe's complex impedance diagram (hodograph) in balanced and imbalanced bridge circuits are jointly built. In this way, it is possible, for the first time, to construct hodographs in the complex plane for both selective signal suppression, and maximum sensitivity. Although this method is already used in series flaw detectors designed for aircrafts testing, the theory behind this method is presented here for the first time.