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Using chemometric methods for resolution of multi-frequency eddy current data for reliable diagnostic of conductive materials

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Eddy current testing (ECT) is one of the well-known non-destructive methods for identification of conductive materials as well as for their diagnostics, including detection of flaws (both on and under surface), cracks, corrosion, evaluation of electrical conductivity, thickness and many other properties. The method can be used both with magnetic and non-magnetic objects.

The main part of any ECT device is a sensor, which usually consists of two inductance coils with a magnetic core (or just wire coils in a simple form). An alternating current (AC) source with preset frequency and amplitude is used to activate one of the coils (usually called as transmitting coil), which creates a changing magnetic field around the sensor. If the sensor is located close to a conductive sample, the magnetic field is induced to the sample and creates eddy currents, which, in their turn, produce a secondary magnetic field opposed to the primary field produced by the transmitting coil. The second (receiving) coil collects the superposition of the two fields and generates a signal for analysis

The properties of the secondary field (and, therefore, of the superposition of the two fields) depend on many parameters including type of material (mainly its electrical conductivity), its thickness, distance between the sample and the sensor, as well as the presence of any disturbances on or under the sample's surface, such as cracks, scratches, coatings, and other flaws. This actually leads to the one of the biggest disadvantage of the method — its sensitivity depends on many interfering factors and often it is very difficult to resolve them if more than just one are unknown.

One of the ways to tackle this problem is to use multi-frequency measurements, when the parameters of the magnetic fields are measured for a range of AC frequencies used to activate the induction coil. The results of such measurements are often represented in a graphical form by so called scanning hodographs — diagrams showing how resistance and reactance of the receiving coil are changing depending on the activation frequency. The shape of the hodographs reflects influence of the main factors and thorough investigation of the shape as well as comparing the shapes with measurements made for standard objects can be quite useful. At the same time such approach is rather subjective and does not allow to carry out automatic measurements. It was also found out that for many real it does not allow to resolve several factors.

In the present study we propose a multivariate approach for solving the problem of interfering factors in eddy current testing. The general idea is to represent changes in resistance and reactance of the measuring system caused by different activating frequencies for a particular sample in a form of a spectrum and use multivariate techniques for finding hidden patterns in the changes, which may mainly reflect an influence of a particular factor.

In order to test the feasibility of the proposed approach we investigated a possibility to resolve at least two competing factors, namely a conductivity of a sample and a margin between the sample and a sensor. Besides that, an analysis of how the range of used frequencies influences the resolution results has been carried out.