

Dielectric Sensing for Quantifying Water, Metal and Dust Contamination in Hydraulic Fluids

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Dielectric sensing has the potential to detect hydraulic fluid contamination and degradation which are major causes of hydraulic system failures. Dielectric sensors development requires an understanding of the variability in dielectric measurements across specific levels of contamination as well as across fluids and temperatures. Three petroleum-based fluids and one soybean oil-based fluid were analyzed using dielectric spectral measurements acquired across an electrical spectrum from 5 Hz to 13 MHz. An impedance analyzer and a liquid dielectric test fixture were used to collect the experimental data. Water, ISO medium test dust, and carbonyl iron contamination were introduced into the fluid at various concentrations. A split-block experimental design was used to acquire dielectric spectra at four different temperatures and three different contamination levels. A partial least square (PLS) and principle component regression (PCR) models were developed to relate dielectric values individual fluids to a specific type of contamination at four different temperatures. A genetic algorithm was also applied to identify the appropriate number of spectral bands required to achieve reasonable contamination prediction accuracy. The models predicted the water contamination at individual temperature levels with a good accuracy. Preliminary results also showed a good correlation between dielectric constant and iron contamination. Further analysis is in progress to develop models relating the dielectric constants to dust and iron contamination levels at various temperatures. The results from this work will be helpful in developing low cost sensors for early detection of typical contaminations in hydraulic fluids, providing opportunities to take early corrective action.