







C. Analysis of relationship between impedance and moisture content

According to the analysis above, the final test condition has been studied yet. Thus data in the first minute were gathered, as shown in the figure 6.

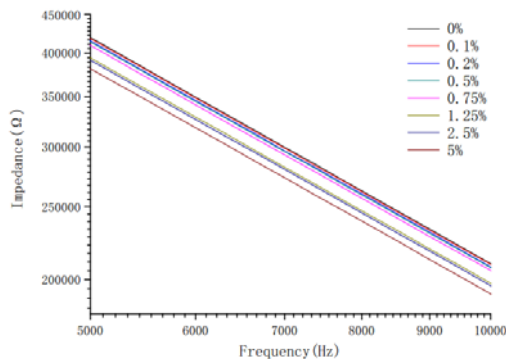


Figure 6. Impedance of different kinds of oil

The illustration above shows significant differences of impedance characteristic with the increase of moisture content. Overall, impedance is in inverse ratio to the moisture content. The relationship between impedance and moisture content can be built to describe the actual effect on lubricating oil that influenced by moisture [7].

For this frequency band, correlation between impedance and moisture is much more closer as a whole, so any frequency could be selected to make mathematical models of the relationship. Therefore, 6 points were selected as the characteristic frequencies to fit the equation of two variables. The fitting equations were given in the following table.

TABLE 2 EQUATION BETWEEN IMPEDANCE AND MOISTURE CONTENT

Frequency (Hz)	Fitting equation
5165	$y = 407334.11421 - 22864.46724x + 5776.55054x^2 - 544.88554x$
6012	$y = 349964.66975 - 19312.5804x + 4811.8512x^2 - 448.13226x$
7362	$y = 286097.05952 - 15376.19475x + 3725.56277x^2 - 341.07263x$
8146	$y = 258549.13286 - 13847.02896x + 3339.95402x^2 - 301.9696x$
9014	$y = 233733.8526 - 12799.87353x + 3222.92404x^2 - 304.30224x$
10494	$y = 200803.48789 - 10439.03904x + 2452.85961x^2 - 219.82726x$

Where y represents impedance of lubricating oil of different moisture content, x represents moisture content of lubricating oil.

For each equation, it can be used to evaluate the pollution level of lubricating oil. According to national standard GB/T260, impedance method can reflect whether it is needed for replacing the oil through these equations. Because of the statistic error, the system error and the error of data processing, the equation needs to be corrected through a large number of experiments combined with the requirement of industry.

IV. CONCLUSIONS

Moisture can change the electrical properties of lubricating oil. As a result, impedance varies obviously with the increase of moisture content. Through a series of experiments about the optimum measurement conditions including perturbation amplitude, scanning frequency and test time, results show that, the test data is more stable if the perturbation amplitude is greater than 1mA, correlation coefficient between impedance and moisture content is less than -0.92 when the frequency ranges from 5k Hz to 10 KHz, and impedance method can get fast and accurate determination of water content of the oil in the first minute. Equations about the relationship between impedance and moisture content have been established, and this relationship can be used to analyze the pollution level of lubricating oil. Moreover, much more studies with improved experimental designs are still needed to go on evaluating this method.

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