DESIGN AND REALIZATION OF MEASURING COILS FOR DIAGNOSTICS QUANTITY OF NANOPARTICLES IN KEROSENE AND IDENTIFYING OF TYPE NATURAL OIL

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Abstract: The first part describes the design of the coil to detect the concentration of iron oxide nanoparticles (0.0 % to 0.5 %) in the kerosene sample using the impedance spectroscopy method. Test coil was designed for detecting and measuring the amount of particles in the experimental design for connection to an analyzer 4294As frequency range of 40 Hz to 110 MHz. Then the samples were measured in a resonator using a wave analyzer with a frequency range of 10 MHz to 20 GHz. In view of good results, this methodology was applied to the detection and recognition of different types of oils.

Keywords: coil, impedance spectroscopy, iron oxide, kerosene, nanoparticles, natural oil, oil, resonator, test coil, transformer oil.

1. INTRODUCTION

Currently still using the advantageous properties of different compounds nanoparticles. This article discusses the possibilities and principles of detection of iron oxide nanoparticles in kerosene, which would be usable for the control mechanisms of the Magnaglo Company. The company supplies different liquids with different volume amounts of the nanoparticles in the carrier liquids, such as e.g. kerosene, oil and the like. These liquids are used e.g. in the automotive industry in modern shock absorbers, which can set the stiffness of the shock absorbers using magnetic field.

1.1. IMPEDANCE SPECTROSCOPY

The amount of nanoparticles in solid and liquid material can cause changes in impedance and, therefore, it is theoretically possible to determine the quantity of nanoparticles in the base material. As a electronic element may be used a coil which can be measured current responses to the magnitude of electrical resistance of the system when is applied AC voltage and as a result is already system resistance (coil) the frequency-dependent and defined as impedance. Change of frequency dependence can be caused by a phase shift between voltage and current. Major structural changes can be achieved by connecting the voltage or electrical stress can be used for studying of electrochemical impedance spectroscopy. This spectroscopy investigates and describes volumetric and interfacial electrical properties of different types of solid or liquid materials. Principle of the method is based on principle when the electrode of system connects sinusoidal signal with a small amplitude and then measurement of the complex impedance depending on frequency or temperature. At first it is appropriate to measure wider range of frequencies to find an appropriate frequency for which differences can be detected by the system, and also to be to detect fast processes (charge transfer) and slow processes (caused by diffusion). That is why it is preferable to perform measurements at different frequencies from higher frequencies to lower ones [1].

1.2. KEROSENE AND NANOPARTICLES OF IRON OXIDE

A ferro-fluid could be described as a liquid, which is full of very small metal filings (mixing with liquid), which are neither deposited nor clumped together. If such a liquid is placed close to a strong magnetic field, then its properties will begin to change dramatically. Ferro-fluid enable the development of new technologies and equipment, e.g. can be used in specific control systems of heat transfer by means of a magnetic field in the so-called heat pipes [2].

Magnetic fluid can be defined as long-term stable dispersion – colloidal solution which its properties very similar correct colloidal solutions. The carrier liquid may be usually a mineral or silicone oil, kerosene, water etc. Solid particles are often iron oxides, e.g. Fe_3O_4 (magnetit) or Fe_2O_3 (maghemit). Typically, these ferromagnetic particles are randomly dispersed and randomly oriented throughout the volume of liquid. But when near will appear magnetic field so the particles are organize in the direction of the field lines, and the liquid with the particles is pulled in with the sharpest change of the magnetic field. Now shall verify application possibilities nanoparticles and their possible use in targeted navigation of active substances in the human body directly to the desired site to be treated. The automotive industry uses a the phenomenon that in the presence of a magnetic field significantly increases the viscosity of the magnetic fluid, which can therefore be used in the adaptive silencer systems of automobiles. Metal nanoparticles also improve heat dissipation, therefore are tested for use in distribution transformers. For now, do not talk much about another phenomenon where the element submersed into the magnetic fluid is in the magnetic field so ferro-hydrostatic buoyancy force (independent of the material), and under certain conditions (relationship between the density of solids and density of liquids, intensity of magnetic field and its gradient) allow to rise up the body from the bottom of vessel, eventually float and remain on the surface [2].

1.3. COIL WITH FERRITE CORE (ROD)

Ferrite cores are molded from a mixture of iron powder and the insulation material. Ferrites behave like other ferromagnetic materials, but thanks to the manufacturing process, they have very low electrical conductivity. Due to their low electrical conductivity, even at high frequencies do not arise the eddy current losses. Ferrites are used at frequencies up to 200 MHz, for tuned circuits up to 800 MHz. Unlike the cores of the metal plate, where the permeability decreases with frequency, and then the permeability of the ferrite cores is in a wide frequency range independent. The most common shapes cores are E, U, I, X and rods example from the company AMIDON [3].

1.4. NATURAL OILS

Polyunsaturated Omega-6 | Polyunsaturated Omega-3 | Saturated | Monounsaturated

Oil / Fat	Omega 6/3 Ratio	Lipid Composition	Smoke Point	
			°F	°C
Almond Oil	NA	18 9 73	420	216
Canola (Rapeseed) Oil	2	19 9 8 64	205	400
Corn Oil	46	56 14 29	450	232
Cottonseed Oil	270	54 27 19	420	216
Flaxseed Oil, unrefined	0.2	13 56 10 21	225	107
Olive Oil, extra virgin	12.5	10 14 75	375-405	190-207
Olive Oil, extra light	12.5	10 14 75	468	242
Palm Oil	47	9 51 39	455	235
Soybean Oil	7.5	53 7 16 24	460	238
Sunflower Oil	345	69 11 20	440	227

Figure 1: Comparison of Dietary Fats [4]

Synthetic esters are usually liquid polyol esters (POES) with the required dielectric properties. Their biodegradability is better than that of mineral oils. The advantage of synthetic esters is their excellent thermal stability and low temperature setting. The fundamental disadvantage of synthetic esters is their high price. A significant factor is the requirement to use alternative and regrown plants in large quantities in farming grown. Natural esters and primarily rapeseed oil were previously considered unsuitable, especially due to low oxidative stability. Liquids made from these seeds are composed of triglycerides. Triglyceride is a molecule of glycerol with three molecules bound him to fatty acids. Unsaturated fatty acids in the liquid exhibit lower oxidative stability and lower values of dynamic viscosity [5].

2. EXPERIMENTAL PART

2.1. DESIGN AND REALIZATION OF COIL FOR AGILENT 4294A

First attempts to be tested were coils wound from insulated copper wire of diameter 0.18 mm with 24 threads. Test coil was fixed externally onto the pipette, which has been used as a container in which were pouring samples pure kerosene and kerosene with different volumetric amounts of Fe_20_3 nanoparticles (0.1, 0.2, 0.25, 0.3 and 0.5%). The measurement was found that this coil is inappropriate because the frequency of maximum impedance did not change (was expected decrease maximum frequency with increasing amounts of nanoparticles). Therefore, it was necessary to modify this coil so that the increased diameter of the wire (0.6 mm), and to the pipette wind several times more threads. Expected results were discovered at the new coils (Fig. 2).

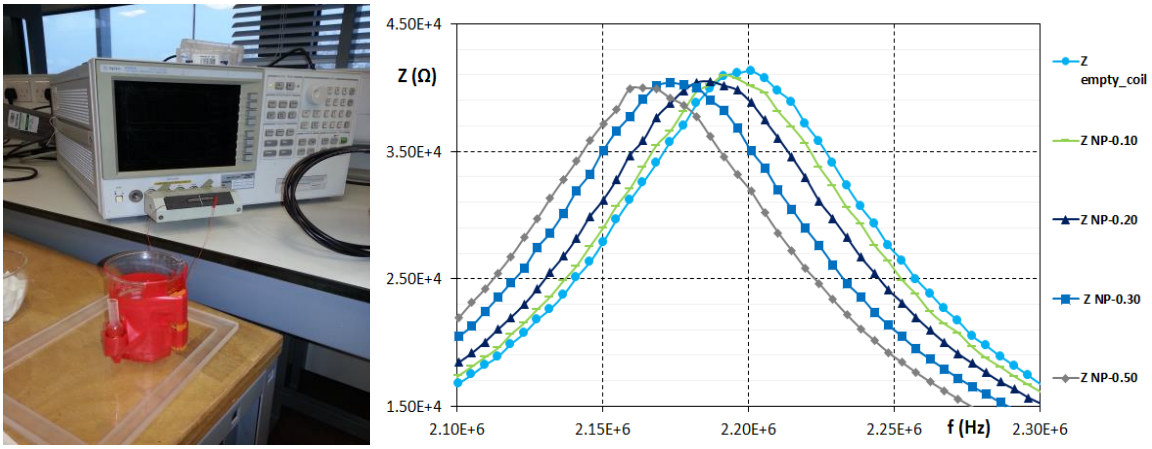

Figure 2: Experimental workplace with test coil and data measurement with analyzer Agilent 4294A

2.2. DESIGN OF METHOD FOR INSERTING THE SAMPLES INTO THE RESONATOR

The second method of examining quantities of nanoparticles in kerosene was performed at wave analyzer E8362B with frequency range from 10 MHz to 20 GHz. This was connected resonator into which it was possible to insert samples that can be measured in two different modes (effect of the electrical and magnetic fields). A sample of pure kerosene and kerosene with nanoparticles was sucked with a syringe which was mounted at the supply point tube (electrician tubing), which can be inserted into the working area of the resonator. The first measurements were performed at the site of action of the electric field. This measurement method is demonstrated to as unsuitable because the measured data did not change in depending on the concentration. The second method, which was done depending on the magnetic field emerged as correct. For this method had the largest value in the maximum resonance (parameter s21) pure samples of kerosene. With the increasing amount of nanoparticles, these maxima shifted leftward. Shift left was declining value of the frequency of these maxima. From these parameters it was possible to calculate values of the parameter

Q, real and imaginary components of the magnetic permeability. From these detected parameters susceptibility value of each sample can be calculated using the following three equations:

$$\frac{\Delta f}{\Delta BW} \cong function\,(\varepsilon *) \approx \frac{\varepsilon_2}{\varepsilon_1 - 1} \approx \frac{\mu_r''}{\mu_r' - 1}, \tag{1}$$

$$Q = \frac{\mu_r'}{\mu_r''}, \tag{2}$$

$$\mu_r' = (1 + \chi). \tag{3}$$

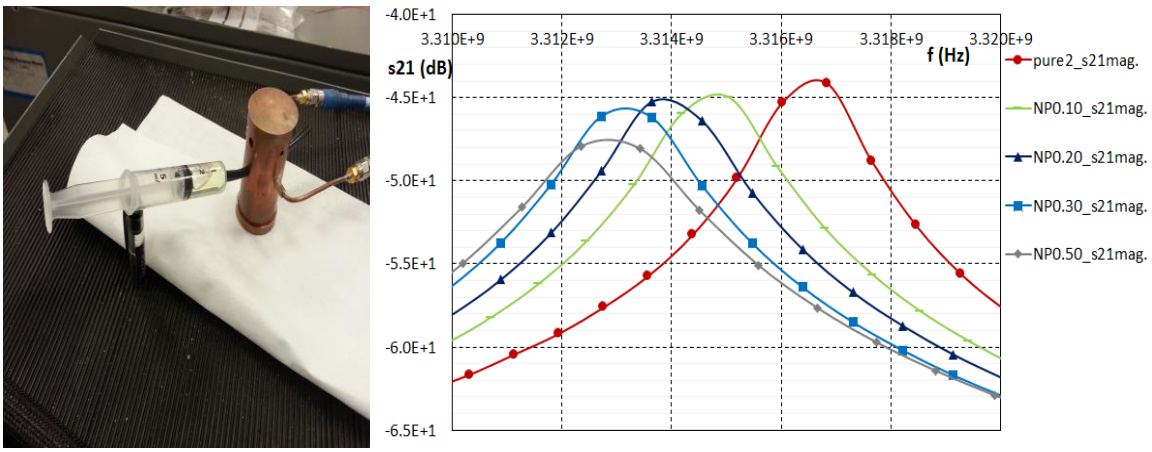

Figure 3: Method of filling the resonator and the data measured to wave analyzer

2.3. DESIGN OF EXPERIMENTAL SYSTEM FOR EXPLORING DIFFERENT TYPES OF OILS

Experience acquired at the University of Birmingham I tried applying the theme of my doctoral thesis, which deals mainly with properties of natural oils. The nanoparticles (Fe_2O_3) I replaced the ferrite rods, and perform measurements on the first assembly of coil (Fig. 4) with copper wire diameter of 1 mm. To measurements I used the analyzer HP 4284A with a frequency range of 20 Hz - 1 MHz. The graph shows results of some natural (sunflower, olive, peanut and ricin) and synthetically produced oils.

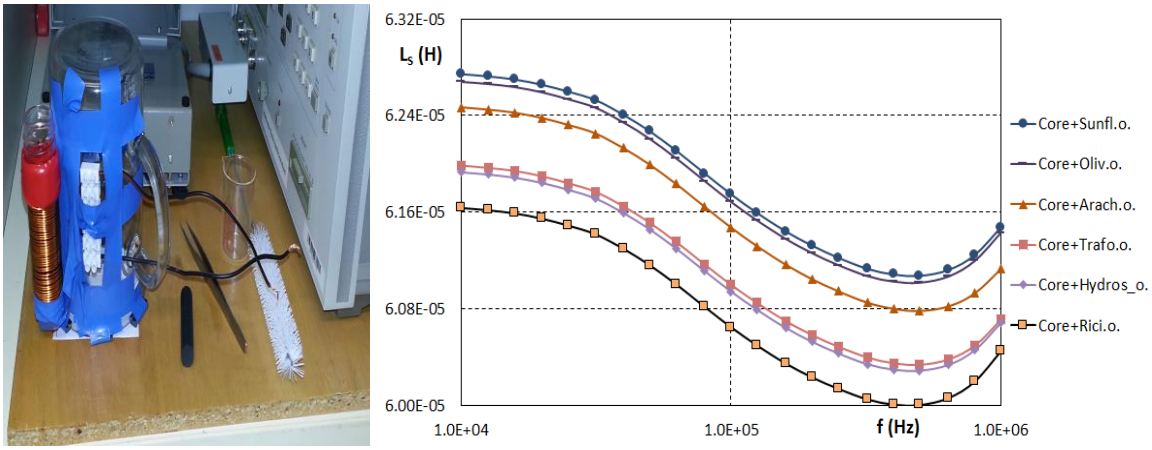

Figure 4: The test coil as a function of sample and the first test measurement

3. CONCLUSION

The first method with coil was reflected correct, to had more coil turns and before each measurement the sample was shaken in. Expected shift of the curve of impedance to the left with increase the concentration of nanoparticles has proved right. This method has shown the possibility of nanoparticle amount detection by using impedance spectroscopy. The downside of this approach is the necessity to manufacture a precisely defined measurement coil with exact parameters or the use of liquid standards for correct calibration, setting and parameter compensation, so the detection of the real nanoparticle amount in liquid could be precise.

In the second method it was shown that it is suitable only alternative measurement in a magnetic field. For repeatability measurement is need to ensure adequate quality tubes, because they used to use only went for two measurements due to softening of the material tubes. The results of this method it was possible demonstrate the decrease parameter Q with increasing amounts of nanoparticles and then the concentration from 0.1% - 0.5% susceptibility of value (χ) in the interval from 0.099082 to 0.275841. The second method (analyzer using higher measurement frequencies) allows to eliminate the drawbacks of the first. The advantage is in the simplicity of manufacture of the resonator with required parameters, smaller amount of measured sample and possibility of definition and calculation of the magnetic susceptibility for different amounts of nanoparticles in liquid.

The last method verified the same character of parameter L_S for natural and synthetically produced oils. Natural oils had higher parameter Ls. Only ricin oil had a smaller value probably because it has a very high viscosity in comparison with other oils. The last method is still in the verification process of feasibility study and repeatability of the measurement.

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