NUMERICAL MODEL FOR NON-DESTRUCTIVE EDDY CURRENT AIR PROBE

Andrea Stubendekova, Ladislav Janousek

Department of Electromagnetic and Biomedical Engineering, Faculty of Electrical Engineering, University of Zilina, Zilina, Slovakia

Abstract

This article deals swept frequency eddy current nondestructive testing. A 2D numerical model of eddy current probe is created in COMSOL Multiphysics software. The probe has an air core and it is composed of two coils, one of them is the exciting and the other receiving. Frequency response of the probe positioned in air is calculated in a wide frequency range to simulate swept frequency technique. Measurement results are presented as well in order to evaluate the numerical model.

1 Eddy current method based on swept frequency

Eddy current method belongs to the electromagnetic methods and it is employed in non-destructive evaluation of conductive objects without impairing their structure. Principle of eddy current testing (ECT) is based on the phenomenon of electromagnetic induction. Presence of a conductor in a time-varying magnetic field gives rise to electromagnetic induction. Subsequently, this effect causes the induction of electrical voltage within the said conductor. Currents are induced in planes, which are perpendicular to the vector of the magnetic induction and because of shape of current lines they are called eddy currents, [1], [2].

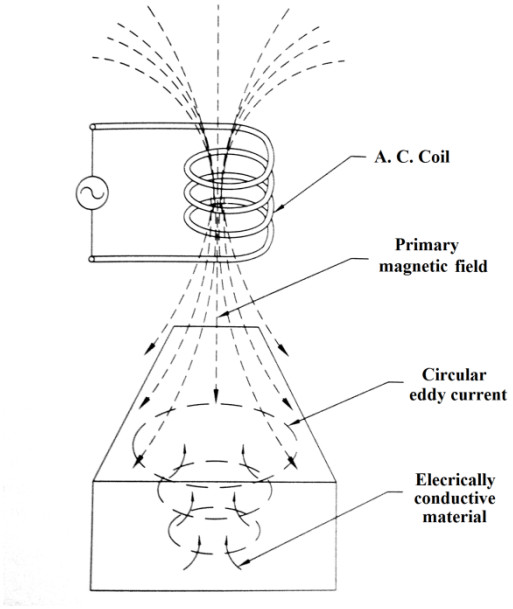

Figure 1: Principle of eddy current method, [1]

Swept frequency eddy current technique is an innovative method for evaluation of material cracks and other parameters especially in applications where a sensor needs to be fixed in a certain position. This newly developed technique allows acquisition of EC data in a wide range of frequencies. An eddy current probe is located firmly over an investigated material. Applications of measurements based on swept frequency are for example measuring the thickness of conductive coatings, measuring of differences between the cracks because of type of the defect (surface or subsurface defect), [3], [4].

2 Experiment and numerical simulation

Nowadays, there is a need to optimally design equipments for non-destructive testing in order to obtain required features of the system. Eddy current probes transfer information between an ECT instrument and a tested object. In order to design eddy probes it is of high advantage to numerically simulate their responses for various scenarios especially to gain high sensitivity, spatial resolution and signal to noise ratio for a specific application.

An air cored eddy current probe is investigated in this study. Probe is located in air and it consists from two multi turn coils - exciting and sensing coil. Distance between said coil is h = 0.7 mm. Measurement is performed by a probe itself in a range of frequencies $f \in$ < 7 MHz, 20 MHz >. This probe is powered by high frequency voltage generator. Output and input voltage is obtained from the oscilloscope at different frequencies. The result of this measurement is the ratio of these voltages u_2/u_1 dependent on frequency.

Numerical model is made in 2D axially symmetric dimension in COMSOL Multiphysics software. The dimensions of the applied probe are shown in Figure 2. Numerical model of the probe corresponds to the configuration and dimensions of real probe used in the measurement.

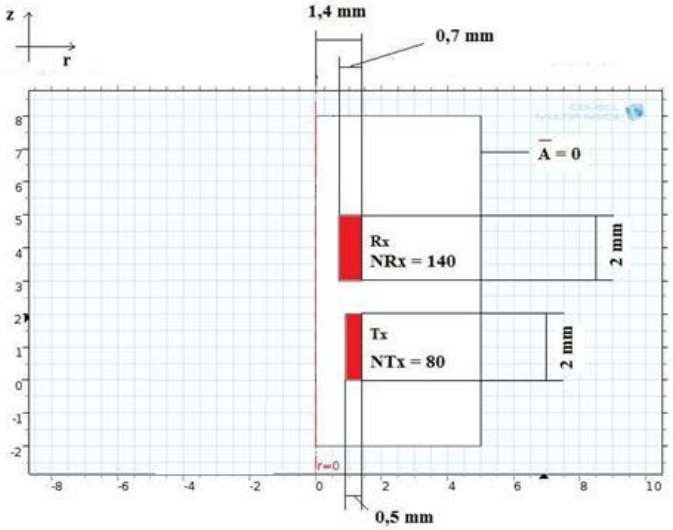

Figure 2: Configuration and dimensions of eddy current probe

According to a circuit model created in LTspice program a numerical 2D model is created in COMSOL Multiphysics software. Based on previous experiments it has been found out that it is necessary to consider the influence of the measurement chain parameters. Hence, the numerical model connects an analysis of electromagnetic field in frequency domain and the circuit model.

3 Results

Results of experiment and numerical simulation are displayed in Figure 3. Both the results show similar dependence. Therefore, it can be concluded that created model represents reality.

Differences are caused by several reasons, e. g. the number of generated measurements, uncertainty model input values, hence parameters of the material, elements of the equivalent circuit of the measurement chain, the configuration, dimensions and values of parameters of the coils.

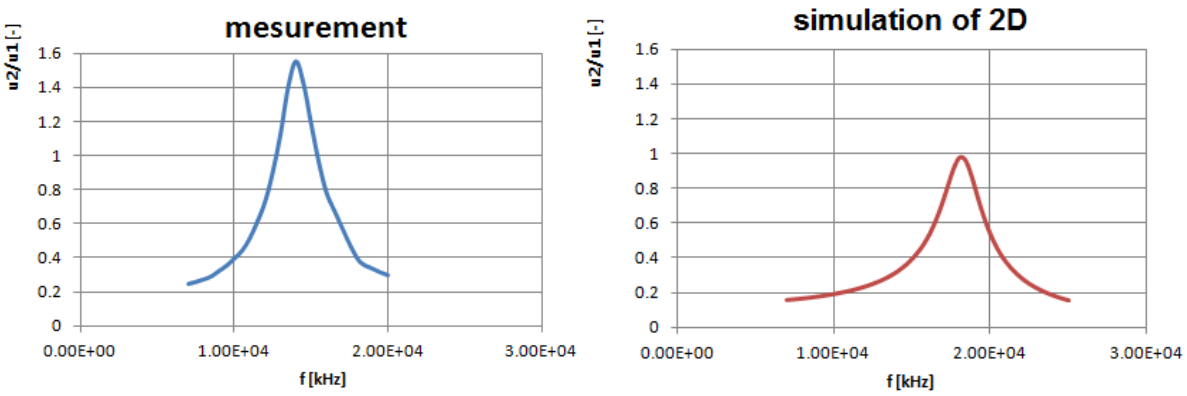

Figure 3: Frequency characteristic of probe itself

4 Conclusion

The article deals with an innovative eddy current method which is called swept frequency eddy current technique. This technique is suitable method for non-destructive inspection of material. Nowadays, diagnostic techniques require continuous monitoring of materials. It means that sensors must be installed firmly.

The purpose of this article is creation of suitable model of EC probe in 2D, which can be used for another measurements, e.g. measurement in 3D or measurements with similar probe. The creation of numerical model is based on circuit model from LTspice which take into account the influence of the measurement chain parameters.

Realized measurement and 2D simulation from COMSOL Multiphysiscs are effected with same type of probe and they offer the similar results. Consequently it can be concluded that technique of swept frequency is exploitable in the eddy current testing.

Acknowledgement

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References

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Andrea Stubendekova
Department of Electromagnetic and Biomedical Engineering
Faculty of Electrical Engineering
University of Zilina
Univerzitna 1, 010 26 Zilina
andrea.stubendekova@fel.uniza.sk
Phone: +421 41 513 5062

Ladislav Janousek
Department of Electromagnetic and Biomedical Engineering
Faculty of Electrical Engineering
University of Zilina
Univerzitna 1, 010 26 Zilina
ladislav.janousek@fel.uniza.sk
Phone: +421 41 513 2145