Smartphone turns into eddy current instrument

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Abstract

The paper answers the question how to inspire young people for non-destructive testing using eddy current method.

In contrast to other non-destructive inspection methods eddy current is comparably complicated because of its missing conceivability. Nobody can feel electromagnetic fields or even the superposition of alternating fields.

Of course, it is possible to calculate these fields and the results for typical situations are well known. But for learning the method one need an easy to handle real instrument and simple reference pieces.

Every student uses a smartphone. These devices bring all components along needed for eddy currents. The audio interface lets transmit and receive alternating signals up to 20 kHz. Why not use for eddy currents?

We present an eddy current probe directly attachable to the audio jack and an app for eddy current inspection with all necessary components: xy-plane indication, frequency, gain, phase and filter setting and a recorder with post processing capabilities. Together with the probe simple reference pieces help to become familiar with probe handling and parameter setting.

1. Introduction

The basic idea is to use the sound system of handheld computers for eddy current applications. In addition to notebooks (1), even current smartphones have everything that is required for an eddy current instrument (2, 3). Their sound system is powerful enough to drive an eddy current probe up to frequencies of 20 kHz. Of course, the price of such a system is much lower than that of a professional stand-alone instrument. The usability corresponds to the gesture control known from many apps, which quickly becomes second nature to your trainees.

2. Hardware

2.1 Smartphone

An Android smartphone running Lollipop (API 21) or higher is required. The sound system and the processor capability define the result significantly. Best results were obtained with Samsung Galaxy or Note and Moto G series.

The probe is directly plugged to the audio jack of the phone. For that, the probe is equipped with electronics simulating a headset. The pin-out of the audio plug should match the selected phone.

The quality of the 4 pole audio jack plays an important role. Varying transition resistance from plug to jack is visible in the measurement result. To avoid such disturbances the probe's plug has gold plated pins.

Figure 1. Left: EddySmart kit consisting of the Smartphone (Galaxy Note 4), the reference set and an absolute probe. Right: Eddy current signals of different materials in the xy-plane on the smartphone screen.

2.2 Training

For serious training well suited reference pieces are required. The reference kid of EddySmart was put together basing on decades of experience. Figure 1 shows a complete kit.

2.2.1 Sorting

Round blanks and the aluminium body represent a broad conductivity and permeability spectrum. When the probe approaches the blanks so-called lift-off-lines of different length and orientation are drawn. The right part of Fig. 1 shows these lines. Basing on these two parameters the material can be identified. One learns about the influence of probe inclination and edge distance.

2.2.2 Surface cracks

Narrow slots represent surface cracks. Two references from different materials provide the opportunity to compare crack signals. One of them is made from well conducting aluminium and the other from weak conducting but slightly ferromagnetic stainless steel. For both materials optimal inspection parameters have to be found. Fig. 2 gives an idea of the signal pattern. The reference pieces may be removed from the aluminium body and be flipped to simulate hidden cracks.

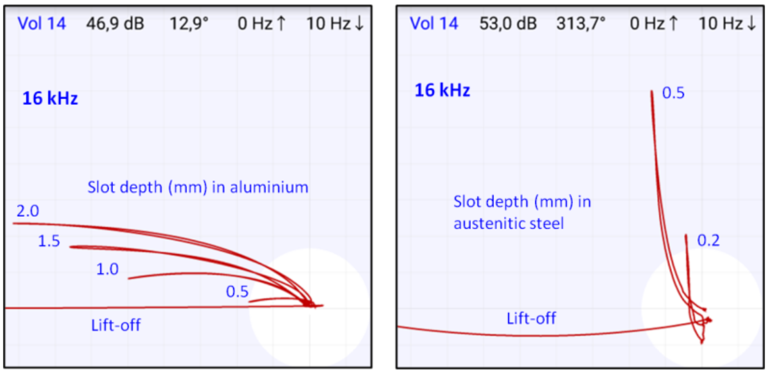

Figure 2. Surface crack inspection: Left: Slots of different depth in aluminium simulate surface cracks in highly conductive material. Right: Slots in austenitic steel represent cracks in poorly conductive but slightly ferromagnetic material.

2.2.3 Wall reductions

Wall reduction may be caused by corrosion or erosion at the inner side of a component but should be detected from the outer side. Eddy currents at low frequency are used to obtain high penetration depth. The according reference piece has milled grooves on the back side. The trainee learns to select a suited frequency according to the penetration depth and phase spreading. This is the basis for remaining wall thickness assessment. Fig. 3 shows this situation.

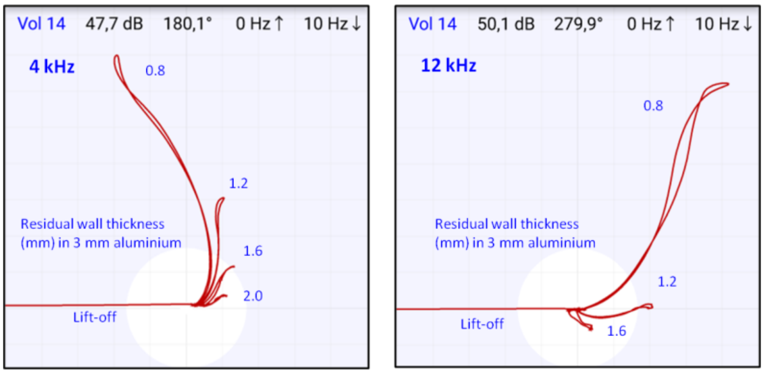

Figure 3. Wall reduction in aluminium: Left: At 4 kHz all reductions are well detectable. The phase spreading is mediocre. Right: At 12 kHz the phase spreading is significantly better but due to lower penetration not all reductions can be detected.

2. Handling

2.1 Inspection frequency

The frequency range starts at 1 kHz and ends at 20 kHz. The provided probe is tuned to this range. Foreign low frequency probes of transformer type are attachable using a special adapter cable with some electronics in it. The field strength of the probe is adjustable by the volume control of the phone. Overdrive will be indicated.

2.2 Balancing and offset

Figure 4 illustrates how to balance the instrument by tapping the balance circle at the origin of the xy-plane. The origin itself may be shifted according to the signal behavior to one of the nine highlighted points. This way, the area is best used for displaying the whole signal. While the origin in Figure 1 is located in the middle, it was shifted in Figure 2 to the lower right corner because the signals are oriented to the upper left-hand side.

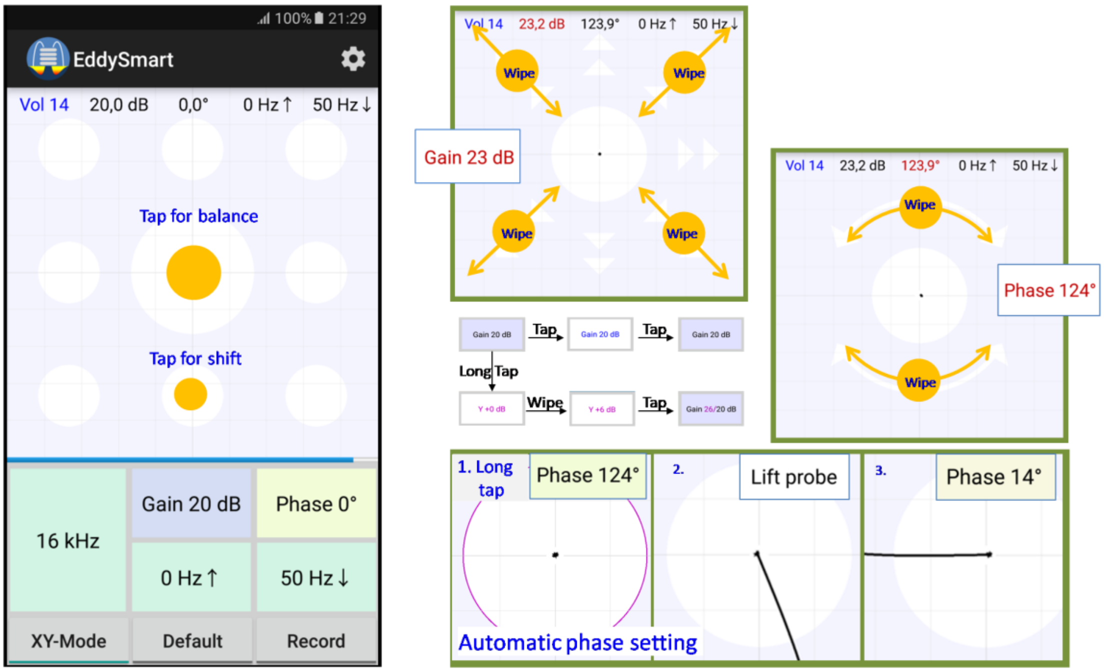

Figure 4. Left: Balancing and offset may be adjusted by tapping dedicated areas in the xy-plane. Right: Gain and phase are set by wiping gestures on the screen. Automatic lift-off setting will be initiated by long tap on the phase button. While lifting the probe the flying dot crosses the phase circle and the phase is turned accordingly.

2.3 Gain, y-spread and phase

The illustrated in Figure 4 wipe gestures will set gain, y-spread and phase. The corresponding values are displayed in the xy-plane as well as on the buttons. Automatic lift-off setting is initiated by long tapping the phase button. Lifting the probe, the signal path is turned when it crosses the phase circle.

2.4 High and low pass filters

High and low pass filtering can easily be studied. Students learn the signal reaction when the cut-off frequency changes. Both filters may be combined to a band pass filter.

2.5 Threshold

Automatic signal processing in eddy currents starts with thresholds. An easy horizontal threshold manually can be set at a level distinguishing between large and small cracks (slots in the reference piece). Figure 5 shows this kind of thresholds.

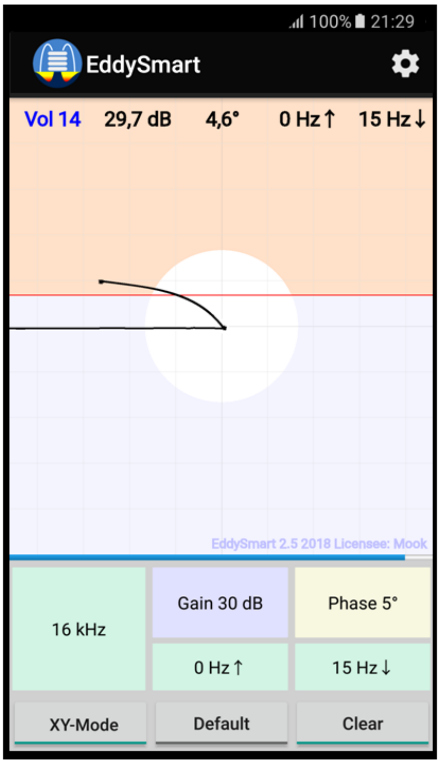

Figure 5. Threshold can distinguish between large and small cracks.

2.5 Default setting

Beginners often lose the flying dot from screen. Whether the gain is too high or the balance is not done. In this case they can press the default button setting the instrument to values that return the dot into the visible area.

2.6 XY- und Yt-Mode

Like other commercial eddy current instruments EddySmart provides the opportunity to display the y-component of the signal in time mode. Here, the filter setting may be carefully trained. This mode prepares the student for the work with automatic production line equipment.

2.7 Recorder

The recorder lets record the current signals for some seconds. After that time the indication may be manipulated to best visibility of the wanted signal. Phase, gain and y-spread can be set afterwards. Figure 6 shows such signals at the left-hand side.

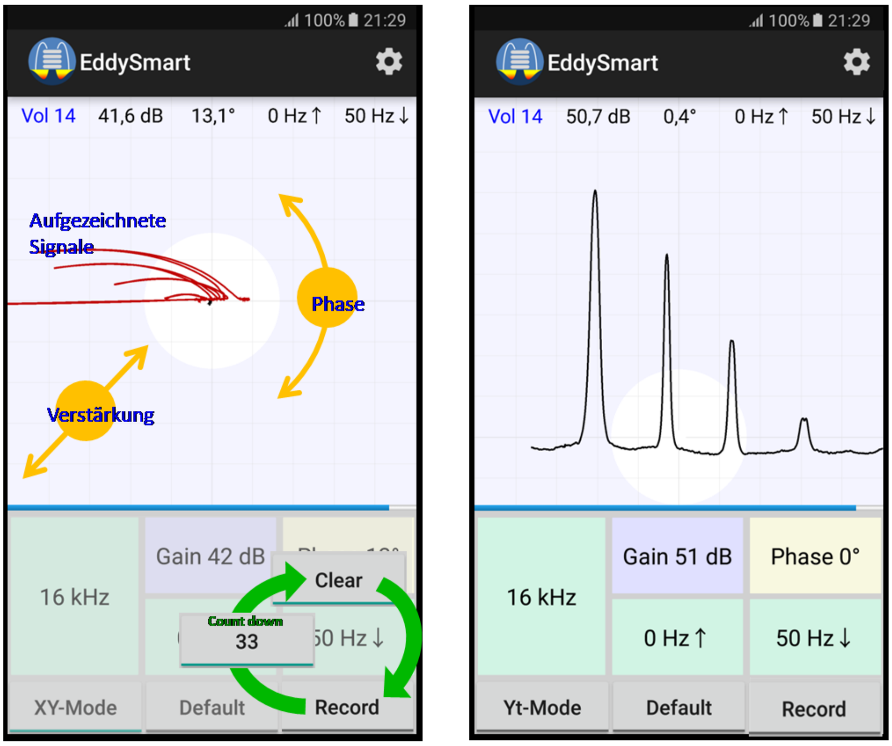

Figure 6. Left: The recorded signals may be manipulated afterwards for best visibility. Right: In yt-mode the time variation of the y component is shown.

3. Conclusion

EddySmart for Android provides an easy to handle eddy current instrument best suited for teaching and learning this NDT method. The main component is already owned by the students. The app can be transferred by USB stick, Bluetooth or e-mail. The sensor is quickly attached and the training can start. The references are suited for beginners to get an overview over this not easy to understand method.

References and footnotes

1. G Mook, “Eddy current inspection - learning by playing”, Insight 49 (12), pp. 733-736, 2007.
2. G Mook, J Simonin, “Eddy Current notebook and smartphone apps”, Proc. of the 14th Int. Conf. of the Slovenian Society for NDT, Sep. 4-6, 2017, Bernardin, Sloveni, pp. 135-143.

3. G Mook, J Simonin, “EddyCation für Android”, Proc. 62 of the Annual Conf. of DGZfP, Mai, 22-24, 2017, Koblenz, P28.