Research on thickness measurement of ferromagnetic materials new characteristic quantities

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Abstract

This paper proposes a new method of pulsed eddy current thickness measurement based on a new characteristic quantity to address the problem that the pulsed eddy current detection signal can be affected by lift-off, resulting in inaccurate thickness measurements. Firstly, the principle of pulsed eddy current detection is introduced, the simulation model of Tx-Rx (Transmitter-Receiver) sensor is established, the differential signal characteristics of ferromagnetic materials are studied, and the relationship between the time and amplitude of the gradient minima time and the lift-off is discussed. Secondly, an experimental system is built and it is found that the gradient minima time is less affected by the lift-off and increases with the thickness of the differential specimen. Finally, a method of thickness measurement of ferromagnetic materials based on gradient minima is proposed.

1 Introduction

Pulsed eddy current is widely used to measure the thickness of ferromagnetic materials[1]. However, pulsed eddy current detection can be affected by lift-off due to variations in the thickness of the surface coating of the test object, irregularities in shape or sensor movement, introducing noise and affecting detection accuracy. It is therefore important to eliminate the effects of lift-off and extract valid specimen information.Based on the above research, this paper focuses on the analysis of the relationship between the differential signal minima time, amplitude and lift-off, and the relationship between the gradient minimum time and specimen thickness is obtained by testing. Finally, a thickness measurement method based on the gradient minima time is proposed to realize the thickness measurement of ferromagnetic materials under different lifting.

2 Characteristic analysis

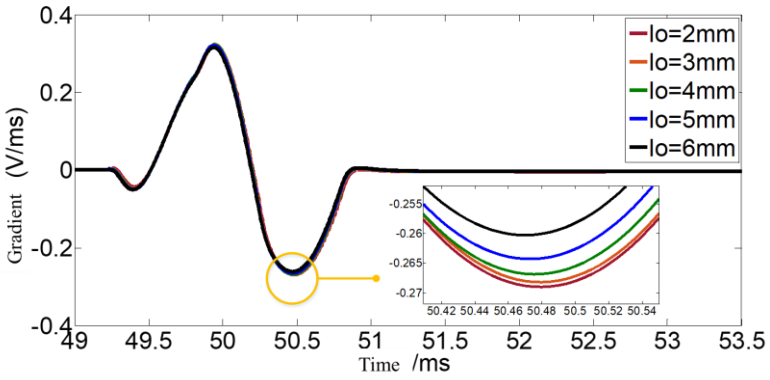


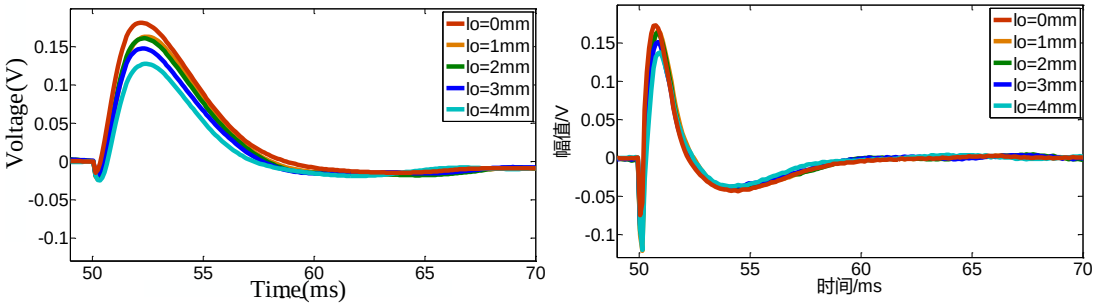
Fig. 1. Differential signal gradient

Table 1 The minimal value of the gradient

Lift-off(mm)	Gradient minima time(ms)	The minimal value of the gradient(V/ms)
2	50.48	-0.269
3	50.48	-0.268
4	50.48	-0.267
5	50.48	-0.264
6	50.48	-0.260

As can be seen in Figure 1, the gradient further reduces the effect of lift-off on the differential signal, and the difference in the gradient values of different lift-off differential signals is very small. According to the skin effect, the low harmonics in the square wave have a large penetration depth and are able to reflect the specimen thickness information. Whereas the low frequency signal has a long propagation time, corresponding to the descent process of the differential signal, the negative part of the differential signal gradient is analyzed. The minimal value of the gradient in the lower half-cycle indicates the maximum change occurs in the falling process of the differential signal, extracting the time and gradient value here as shown in Table 1. It can be seen from Table 1 that the gradient minima time is not affected by the lift-off. If the relationship between the gradient minima time and the thickness of the specimen can be determined during the inspection process, the effect of lift-off on the thickness measurement of ferromagnetic materials can be reduced.

3 Experimental study



(a)Differential signals (b)Differential signal gradients

Figure 2 Experimental results for 12mm and 4mm

Table 2 Gradient minima time for different thicknesses of specimens

Specimen thickness(mm)	Gradient minima time(ms)
2	53.15
4	54.15
6	54.65
8	54.95

As you can be seen from Figure 2, the difference signal after the gradient is less affected by the lift-off, and the difference signal gradients under different lift-offs almost coincide. difference signals of specimens with different thicknesses are also discussed, and the gradient minima times are given in Table 2. As Table 2 shows, the gradient minimum time has a monotone relationship with the thickness of specimens within the range of 2-8mm thickness, so it is a good characteristic value for thickness measurement. By extracting the correspondence between the minimum value of gradient and the known thickness, the fitting relation can be obtained.

Acknowledgements

Support by Jiangsu province science and technology project, industry foresight and key core technology: BE2021084 and Jiangsu Provincial Market Regulation Bureau science and technology project: KJ2022005.

References

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