SIGNAL PROCESSING METHODS FOR DETECTION AND OF MATERIALS DEFECTS

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Abstract: In this paper, the pulse echo technique is used to characterize materials using ultrasound. The response received is treated by four different methods, namely, Hilbert transform of the cross-correlation function, the split spectrum processing (SSP) and wavelet transform. The performances are tested on synthetic signals in order to generalize the application of these methods for the detection of interfaces and therefore defects if they exist. The simulation results show that the application of these methods of signal processing allows the detection of interfaces and hence the location of faults and if necessary materials characterization. Indeed, the Hilbert transform allows detection of the envelope signal locating and meets interfaces. However, this approach ignores the sign gradients encountered because it considers only the absolute value. The cross-correlation function solves this problem of sign and gives a good location interfaces. The use of wavelet transform solves the problems encountered by the two other methods. Indeed, it allows a good location interfaces and therefore better detection of defects.

Index terms: Signal Processing, Detection, SSP, NDT.

1. INTRODUCTION

The NDT (Non Destructive Testing) play a very important role in the economy. They have become the essential tool for evaluating the mechanical properties of materials in order to detect defects. NDT techniques use ultrasonic transmission of the sound wave of high frequency for determining the characteristics of materials and detecting defects or to locate changes in the properties of these materials. Ultrasounds are sent into the room to control their thoughts on the various obstacles in the room can get an image of the inside of it.

In our work, considered the pulse-echo method (Figure 1) in which a piezoelectric transducer transmits ultrasonic energy. The signals reflected from the opposite side of the field, or discontinuity, empty or elements included in the material are received by the same transducer where energy converted into an electrical signal is processed by a computer and displayed on a screen. The display can show the relative thickness (depth), or localized defects. Also, one can calculate the speed of propagation determines the nature of the material if the latter is unknown and the position of different interfaces, so the size of the sample [1,2].

2. PROBLEM FORMULATION

The practical difficulty of extracting the information needed to characterize materials led to use different methods of signal processing [3]. In this paper, we used four methods. The composition reflects the signal interfaces conductivity encountered on the route of spread, since they are detected instantaneous a function of distance and speed of propagation of ultrasound. The objective is to determine the positions of these interfaces which would calculate the speed of propagation and parameters characterizing the material in question. The performances of these methods are analyzed on signal synthesis.

Figure 1. Pulse-echo method
3. SYNTHESIS SIGNALS

A signal representing interfaces conductivity, is convolution with a salvo representing the sine burst emitted by the ultrasonic transducer. The final resulting signal is the signal synthesis to test different methods.

3.1. Sinusoïdal Bursts

For sinusoidal bursts were selected for a window envelope of Blackman. This window is wide variable to control the length of the ultrasonic burst, and simulate the settings of the generator. The two rounds of synthesis used include 4 and 16 respectively periods sinusoids. Each period is sampled sinusoid 20 points. The bursts have been a total length of 80 and 160 samples, corresponding to 8 and 16 respectively. The total length of the signal is 1 000 samples, corresponding to 100.

3.2. Interfaces Signals

The interfaces are represented by peaks pulse composed of three successive samples (Figure 2)

3.3. Synthetic Signals short and long burst

The short burst is shorter than the distance separating the interfaces. The responses of different interfaces do not overlap. The long burst is longer than the distance separating the interfaces. The responses of the first two interfaces overlap, Figure 3. This type of signal is intended to test the ability of methods to locate interfaces.

4. SIGNAL PROCESSING METHODS

4.1. Hilbert Transform

4.1.1. Description and interest

This method is borrowed from the ultrasound technique that allows viewing of bodies by acoustic tracking interfaces. The signal, called "radio frequency (RF) issued by an ultrasound consists of a series of echoes, corresponding to various interfaces encountered. The identification of interfaces is obtained by demodulation and low-pass filtering of the signal. That is to take the envelope signal, regardless of the direction of change (loss of the sign) of acoustic reflexions arising in the various interfaces. It is a very simple way to obtain the position of these interfaces.

4.1.2. Results and interpretation

The transformed from Hilbert, to signals received, is shown in Figure

For the short burst, the three interfaces are located. When the round is longer than the distance between two interfaces, they are not solved properly, producing an artifact that suggests the presence of a third interface, nonexistent in reality. The longitudinal resolution of this method is limited by the length of the salvo used. The maximum envelope indicate the positions of various interfaces.

The use of the envelope signal is a low spatial resolution, the order of the length of the salute used. One way to improve the resolution is to reduce this length. This method does not reflect the sense of change signal, and hence ignore the sign gradients encountered.

4.2. Intercorrelation Function

4.2.1. Description and interest

The ultrasonic velocity measurements are useful to determine multiple parameters of the material, such as module Young and the coefficient of Fish. To do this, we use the correlation processing to calculate the time delay and have an accurate measurement of velocity. The signal interaction consists of a series of bursts offset against each other, with variations of amplitude and sign due to interfaces encountered. The location of maximum cross function is therefore likely to allow the location sequences for which these two signals show the most similarities, and therefore the direct measurement of distances between interfaces.
4.2.2. Results and interpretation
Figure 5 shows the result of calculating the function of cross-signals synthesis. For the short burst to signal the first two maxima are positive and one negative, which corresponds well with theoretical sense interfaces. For the long burst signal, the first two interfaces are not resolved because one up and this is because recovery bursts.

The function of this cross a spatial resolution of about the length of the salute used. This method returns the direction of variation gradients conductivity.

4.3. T Wavelet transform

4.3.1. Description and interest
The Wavelet transform Continue (TOC) carry a projection of the signal on a set of functions traditionally called “wavelets.” It defines two-dimensional space: the time-scale, in which the information signal will be represented. It can be defined by the coefficient of similarity between the signal and the wavelet used. The discrete wavelet transform (TOD) is obtained by sampling coefficients of scale and time. Obtaining bases discrete wavelet based on the theory of analysis multiresolution. AMR consists of a signal in its decomposition at different scales, approximations and detail. The basic idea of AMR based on the algorithm proposed by S. Mallat [4-6].

Figure 5. Cross-correlation Function of the synthetic signal Figure 5 Fonctions d'intercorrélation du signal de synthèse:
  a) salve courte  b) salve longue

The wavelets are used to locate the exact location of echoes (interfaces) and the elimination of noise if present. In our case, it was considered the wavelet basis Daubechies1 (db1) to Level 5 with a variation of scale of 1 to 32.

4.4.2. Results and interpretation
Figure 6 shows the effectiveness of wavelets which echoes the location of interfaces for the same signal to salve long.
5. CONCLUSION AND PERSPECTIVE

In this paper, we made a study of three methods of signal processing which are: Hilbert transform of the cross function and wavelet transform. The simulation results showed that Hilbert transform of the function and are sensitive to cross the length of the ultrasonic signal. Indeed, the location of interfaces is all the more better than the length of the signal is relatively short (less than the distance between two successive interfaces). The application of wavelet remedied this problem by allowing a location interfaces fairly accurate.

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It offers a basic change and levels for the analysis of the accuracy of interfaces. We note that our analysis on signal synthesis was a goal of widespread use of these methods can be applied on any material.

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