

# **ULTRASONIC CHARACTERISATION OF SOLID PIECES FORMED BY PRESSING**

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## 1. INTRODUCTION

Quality control of solid ceramic pieces for the 'foliation' defect is currently carried out using qualitative sonic characterisation, which consists of making the piece sound with a small hammer, with the appropriate characteristics, in order to thereby diagnose the quality of the piece through human hearing.

In this study, a non-destructive ultrasonic method based on the study of the transmission of high-frequency mechanical waves has been validated.

The wave propagates through the material at a speed that is a function of its nature [3]. The reduction in the speed at which the wave propagates is used in this study for detecting and characterising defects.

In the application for the quality control of materials [2], an attempt is made to assess how these waves are transmitted through solid bodies. The propagation through materials with a very elastic behaviour is better, it being of worse quality in materials that are not very dense and are incompressible like air. In this sense, the stud shows how ultrasonic inspection has been applied to solid ceramic pieces with two different typologies/compositions, in order to be able to parameterise their behaviour and, therefore, enable classifying their quality in the two groups or typologies.

## 2. PROCEDURE

### 2.1. Materials.

One typology is a ceramic material fired at 1200 °C, with a thickness of about 95 mm, and the other is a material tempered at 350°C with a thickness of about 99 mm.

In the manufacturing process of both pieces, which is performed by pressing, the accident known as foliation produces significant losses (defects). This accident occurs when internal micro-laminations form in the piece, so this method could be interesting for controlling the quality of these materials.

The samples analysed were cylindrical test specimens extracted from the pieces (with a height of 50 mm and a diameter of 46 mm), and the pieces themselves.

### 2.2. Equipment used.

We adapted the characteristics of an ultrasonic testing machine to the type and geometry of the materials studied. The ultrasound study requires an ultrasound receiving and generation source, considering the appropriate amplitude and frequency for the ultrasounds to propagate through the piece.

The voltage used was 400V. The wide band transducers used were V101

Panametrics Accuscan with a working frequency of 500 KHz. The signals are recorded and stored through an oscilloscope and specific software (Captul®, Matlab®).

### 2.3. Methodology.

A pulse centred at 500 kHz is sent from the emitter and it is introduced into the material by connecting the emitter-ceramic material surface to make the pulsed maximum energy pass inwards onto it. The coupling medium was high-density ultrasound gel. The wave that propagates through the material reaches the receiver and is amplified to about 40 dB [1, 3, 4].

It is then shown on the oscilloscope and is digitalised on the computer.

When the signal was analysed and interpreted using the Matlab® program, we choose the first three wave cut points with the signal's original horizontal one, which gave us  $t_0$ ,  $t_1$  and  $t_2$  respectively (as shown in figure 1). The study of this signal provides information on the state of the piece's interior.

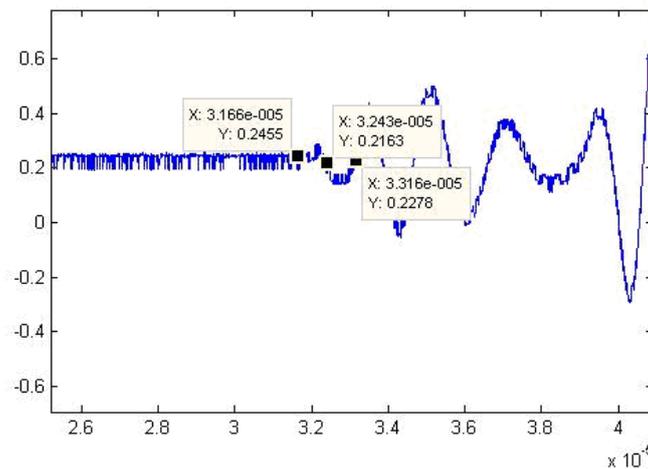


Figure 1. Ultrasound signal with the values  $t_0$ ,  $t_1$  and  $t_2$  [1].

The corrected velocity was the parameter chosen for classifying the materials, since it was more exact than the initial velocity and responds to the following equation:  $V_0 = e / (2t_1 - t_2)$ , while  $V_0 = e / t_0$ , where 'e' is piece thickness.

The *corrected velocity* was measured on the materials sonically classified as good and bad at various work stages:

- 1st, on cylindrical test specimens of the two materials.
- 2nd, directly on 60 pieces, 21 measurements being made on each one of them: 12 on 'width', 4 on the 'height', and 3 on the 'length'.
- 3rd, 3 measurements were made per piece in the direction of piece width.
- 4th, one single measurement was made in the centre of the piece in the piece 'width' direction.

### 3. RESULTS

The following graphs compare the velocity according to the three dimensions of the test specimens. Specimen width shows lower speeds, which indicates that this is the direction where the defects are, and the margin that exists between the speeds corresponding to the good and bad pieces is higher, which allows better discrimination.



Graph 1. Corrected velocities of the materials and the two qualities in the three dimensions [5].

All measurements made were mathematically processed, obtaining an average value and quadratic error of the 'corrected velocities'.

The values obtained through one single measurement in the centre of the piece are compared below, with the average of the 12 measurements made on piece. In both cases, the measurements were made in the piece 'width' dimension. The values shown are average values and their quadratic errors.

	FIRED MATERIAL		TEMPERED MATERIAL	
	GOOD QUALITY Measurement dimension Width		GOOD QUALITY Measurement dimension Width	
	Average value	Central value	Average value	Central value
Average	2203	2047	4099	4046
Quadratic error	51.1	43.2	32.1	36.0

Table 1. Average and central values and the quadratic errors of the good pieces.

Parameters relating to ultrasound propagation and the processing of the digital signals into which it was translated were found, and their thresholds were established. This allowed the pieces to be classified as a function of their quality. The corrected velocity of the ultrasounds was established as a parameter for assessing the material and it was determined what the sampling and the experimental set-up should be like in order to be able to classify the analysed pieces. The best position and the minimum number of measurements required for an optimum analysis were studied. A quantitative non-destructive method for quality control was thus fine-tuned for these types of solid pieces.

The tempered material displayed a better response to ultrasound pulse propagation than the fired material.

#### 4. CONCLUSIONS

Those pieces that exhibited a velocity that was higher than 4010 m/s for the material tempered at 350 °C and 2004 m/s for the material fired at 1200 °C are considered good. [5]

The ultrasound study validates the sonic classification of the material, and improves on it [5] due to its quantification, precision and objectivity.

The ultrasound study provides information on the state of the interior of the piece and is a non-destructive method.

The discontinuities at right angles to the sound beam are better detected, producing a more drastic reduction of the parameter used, velocity [5].

Tests need to be carried out directly on the pieces in the pressing direction, and it suffices for one single measurement in the centre of the piece to be made.

#### REFERENCES

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