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# Ultrasonic Characterizations of Iron Casting with Different Heat Treatment Conditions

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**Abstract**

This research is focused on the ultrasonic characterizations based on wave velocity measurements for the iron casting materials with various heat treatment processes. The variation in the velocities of the ultrasonic waves can be further related to the residual stress state of the materials.

Specimens are prepared with six types of different heat treatment conditions, including furnace cooling (A), air cooling (N), water quench (WQ), oil quench (OQ),

water quench and temper (WQ/T) and finally oil quench followed by tempering (OQ/T). Longitudinal and surface wave speeds are measured for the samples with different heat treatment conditions of the iron castings. Here, a laser ultrasound technique (LUT) is used to measure the surface wave velocity in a precise way.

**Keywords**：laser ultrasound technique , residual stress , dispersion curve.

## 1. Introduction

A very important part for the development of high-precision machine parts relies on the high-precision machine tools. As a foundation for the machine tool, iron casting with stable dimension is crucial for building a high precision machine tool. Very common, the iron castings for the machine tools have complex shape and the thickness unevenness result the difference cooling rate. As a result, residual stress is formed after the solidification process. Without extra care, machining or long-term usage for the iron castings can cause deformation to affect the accuracy of the cutting machine tools.

This research approach to determination the behavior of the ultrasonic velocity in different heat treatment conditions has been presented. The results obtained can within the characterization of materials and determination of stress value through non-destructive testing.

## 2. Experimental setup Results and Discussions

A laser ultrasound technique (LUT) is used for the measurements of dispersions of surface waves propagating along the iron casting. Dispersion relations of surface wave propagating in iron casting with different heat treatment conditions. Included the furnace cooling (A), air cooling (N), water quench (WQ), oil quench (OQ),water quench and temper (WQ/T) and finally oil quench followed by tempering (OQ/T) are measured with a laser-generation / laser-detection laser ultrasound technique (LUT).

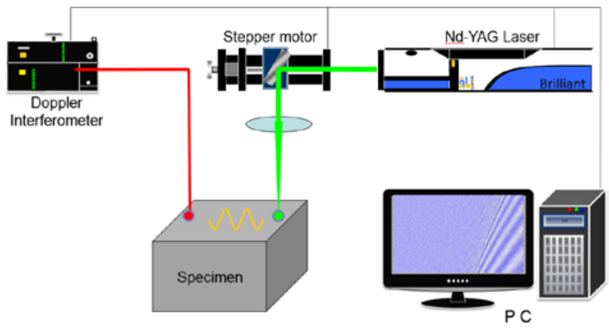


Fig. 1 Experimental configuration.

As shown in Fig. 1, the experimental configuration consists of a pulsed laser for generation of surface waves, a laser probe for detection. The excitation source is a Nd:YAG laser with a power power of approximately 100 mJ, a 532 nm wavelength, and a pulse duration of 6.6 ns. A laser Doppler optical receiver is applied to detect the surface waves. A B-scan scheme is used for the measurement of the dispersion behaviors of surface waves. The optical detector is located at a fixed point, while the generation laser beam is scanned in the axial direction. Along each of the paths there are 200 scanning steps with a step size of 0.05 mm.

By accumulating the 200 steps, the B-scan data in a gray scale format for the CGW.A two-dimensional fast Fourier transform (2D-FFT), first taken with respect to time and second with respect to scanned position, is used to obtain the dispersion spectra in the phase velocity versus temporal frequency (c-f) domain, where a ridge finding involving with peak-detection algorism is used to identify the surface modes. Fig. 2 shows the obtained dispersion spectra measured with the LUT for surface waves propagating in the iron casting.

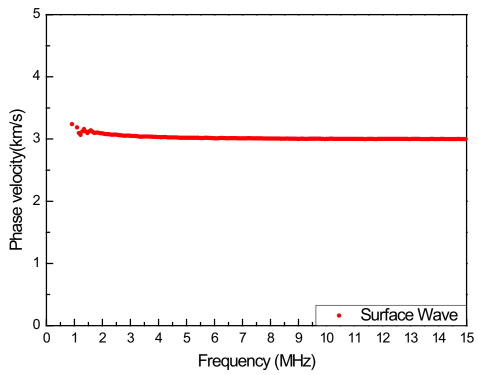


Fig. 2 Surface waves dispersion relation measured with the LUT.

## 3. Results and Discussions

Fig. 3 shows the measured surface wave dispersion spectra for the iron castings with different hear treatments.

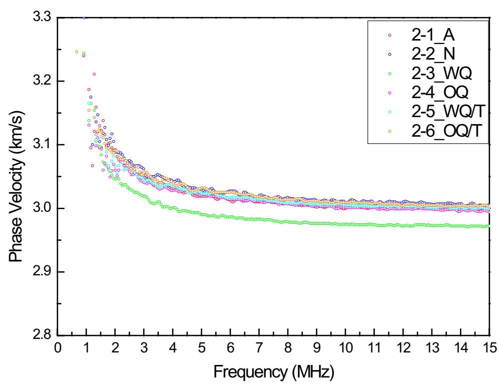


Fig. 3 Dispersion spectra for casting irons of different heat treatment conditions.

Fig. 4 shows the measured longitudinal and surface wave velocities for the six types of samples. It is shown that the surface wave velocity follows the same trend as the longitudinal wave speed for samples with different treatment. For both measurements, the iron casting with water quench (WQ) has the lowest velocity.

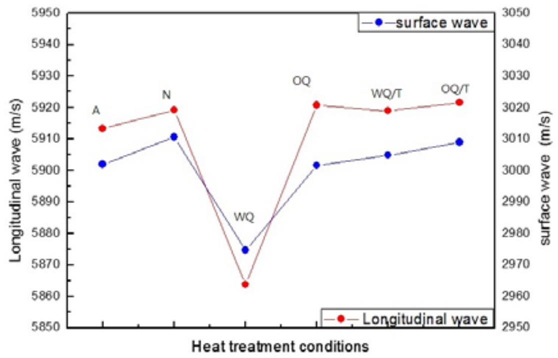


Fig. 4 Measured longitudinal and surface velocities in different heat treatment.

## 4. Conclusions

The agreement in the trend of longitudinal and surface velocities suggests both wavespeed measurements to be reliable and accurate. And the agreement in the trend of wave speeds regarding to different heat treatments indicate that the heat treatment is not limit to the skin area but deeply penetrating through the majority of the bulk materials.

This study is currently extended to observe the effects of residual stresses in the casting irons with different hear treatments.

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