Non-Contact Ultrasound
PLASTICS, RUBBER AND FOAM ANALYSIS

Application Note AN-305-2

SecondWave™ M510 Ultrasonic Analysis System
Introduction

Contact or water immersion ultrasound does provide significant information about materials quality and properties. But, it cannot be applied to the early stages of materials formation - when they are tacky or fragile. It is also not reliable for materials that are porous, liquid sensitive, or when any type of contact with a material is cumbersome. Non-Contact Ultrasound (NCU) is the most desirable choice for such applications.

Ultran has been working to facilitate NCU since 1978. In 1997, Ultran created internationally patented piezoelectric transducers characterized by phenomenal efficiency in air and other gases with frequencies from 50 kHz to 5.0 MHz. Complementing the NCU transducers are Ultran’s equally novel ultrasonic imaging systems and analyses software. The SecondWave™ M510 is a focused non-contact ultrasonic analysis system that is customer-friendly and understands the significance of materials testing and analysis, including the speeds required to accomplish a task.

The M510 supports through transmission, same-side and pulse-echo techniques. M510 single and multi-channel systems have been fully configured and installed for on-line (production line) and off-line (benchtop) QC analysis of plastics and rubber from uncured to cured stages and finished products.

M510 Capabilities

- Inhomogeneous mixing of elastomers and additives
- High resolution defect detection in tires, plastic, foams, and composites
- Applicable to very thick and attenuative materials
- Density/porosity, and mechanical properties

SecondWave™ M510 Components

NCU Transducers

Ultran’s transducers boast the highest efficiency devices among non-contact transducers – approaching those of conventional contact transducers. Frequency Range: 50 kHz - 5.0 MHz. Active dimensions: 1.0 mm - 500mm. with planar, point, parabolic, and compound beam geometry. Robust lightweight construction.

Scanning: Vertical or horizontal acoustic bench, single or multi-transducer multi-axis scanning frames.

System Instrumentation

4U industrial grade unit incorporating Intel Core2 Quad processors, 2 GB RAM, RAID5 Serial ATA hard drives and redundant power supplies. Integrated are:

- **Pulser:** PCI-based 375V RF toneburst pulser with 50 kHz to 5 MHz range, adjustable bursts, voltage and PRF.
- **Receiver:** Internal 1-8 channel low-noise amplifier with 80 dB gain and 10 MHz bandwidth, multi-value low and high pass filters.
- **DAQ:** 14 bit Analog to Digital Converter with 50 MHz sample rate and on-board 256 MB storage. Multi-axis encoder inputs for motion synchronized acquisition.

Software

- **SecondWave™ Studio:** Windows XP-based A-Scan and C-Scan software with user-friendly GUI. Displays rolling single and multi-channel C-Scans. Capture and storage of full-wave data for scans. Project Manager with multiple access levels. SQL Database integration.
- **SecondWave™ Research Studio:** C-Scan and A-Scan post-processing software. Generates cross-sectional material profiles. Parametric correlation to determine material density, porosity and fiber orientation. Image processing functions to find and highlight defects.
Non-contact ultrasound techniques

Direct transmission

Same side transmitter-receiver – pitch-catch

Single transducer – pulse-echo

Quantitative detectability example

Detection of side drilled holes (varying from 0.5 to 6.3 mm) in 10 mm PMMA with direct NCU transmission – 1.0 MHz
Observations and case studies by direct transmission and same side NCU imaging

All images are raw, without special or post-signal processing, and in most cases no signal averaging was used

Plastic sheets and tiles – overt defect detection and texture evaluation – figures 1 and 4

Fig. 1. 1.5 mm side drilled hole in 10 mm polystyrene. 1.0 MHz

Fig. 2. 1.5 mm plastic grain filled polyester. 500 kHz

Fig. 3. Fiber orientation in SMC panel. 500 kHz.

Fig. 4. Anisotropic behavior in SMC panels. 500 kHz.
Rubber and tire – Heterogeneous mixing, hardness, defects, etc. – figures 5 to 9

Fig. 5. 10 mm poorly mixed rubber. 500 kHz.

Fig. 6. 7 mm silica filled rubber with subtle variations. 1.0 MHz.

Fig. 7. 1 mm rubber varying in hardness – left 10D, right 20 D. 1.0 MHz

Fig. 8. Steel belted tire section. Top: 1.0 MHz. Middle: 500 kHz

Fig. 9. Tire section without re-enforcement. 1.0 MHz
Polymer foams – texture and defects – figures 10 to 14.

Fig. 10. 80 mm polyurethane foam with porosity/density variations. 140 kHz

Fig. 11. 150 mm polyurethane foam with gross defects 140 kHz

Fig. 12. High resolution imaging of 100 mm polyurethane foam varying in density, also with internal defects. 200 kHz

Fig. 13. High resolution imaging of 19 mm polystyrene foam varying in density. 200 kHz

Fig. 14. Surface texture of a fine celled foam. 3.0 MHz
Thin Polystyrene Foams (Fig 15) – Defect Detection and Texture Analysis

Multi-layer rocket motor insulation (Fig 16)
Conclusions

Ultran’s SecondWave™ M510 ultrasonic imaging and analysis system is characterized by a wide range of frequencies from 50 kHz to 5.0 MHz. This makes it possible to apply non-contact ultrasound (NCU) plastics and rubber products all the way from early stages of their formation to finished products. The M510 is a powerful tool for materials process analysis and QC, directly saving you cost, energy, and materials, besides assuring the quality and reliability of your materials.

What Ultran provides

We supply complete NCU systems suitable for customers’ needs. These include specifically designed transducer libraries so that our customers can start characterizing all their materials from Day 1.

Ultran also supplies custom NCU systems geared for production (online) configured to customers’ applications and environment of testing.

Under agreements, Ultran will transfer science and technology - targeted to customer needs. We offer hands-on training to all our customers.

We maintain a fully-stocked ultrasound materials analytical laboratory and we are fully equipped to provide feasibility, in-depth analysis, and R&D for our customers.