MAST Inc.™

Ultrasonic Cure Monitoring System*

(Preliminary Specifications)

The Ultrasonic Cure monitoring system consists of the waveguide cure sensors and multi-channel digital ultrasonic system incorporating data acquisition and data processing. The Ultrasonic Cure Sensor (UCS) is based on the direct measurement of the Ultrasonic Relative Reflection Coefficient (UR^2C) at probe to resin interface via ultrasonic waveguide cure monitor sensor. The system supports continuous cure monitoring via unique sensing functions.

- Ultrasonic relative reflection coefficient resin cure sensing enables direct measure of the mechanical state (modulus) of a curing resin.
- The sensor system can be calibrated and enables quantitative final cure level tracking.
- The sensor design is robust, adaptable to wide range of manufacturing needs including autoclave, oven, room temperature or resin transfer processes.
- The probe design is inexpensive. All cure system transducers, cables and instrumentation are reusable.
- Sensor fundamental design is adaptable for active process control, using modern instrumentation and manufacturing configurations.

Ultrasonic reflection coefficient (URRC) cure sensor measures relative impedance change of the curing resin at the waveguide sensing interface. Impedance of resin (Z_{resin}) during cure is defined by density (ρ) and speed of sound (c) as:

$$\rho(\text{constant})\ c(\text{changing}) = Z_{resin}$$

The ultrasonic cure sensor (UCS) sensing system behaves as shown in Fig 1 where R is the reflection coefficient defined as sound reflected (E_R) divided by sound incident (E_I) to the interface ($R=E_R/E_I$), Z is acoustical impedance, ρ is density and c is velocity of sound.

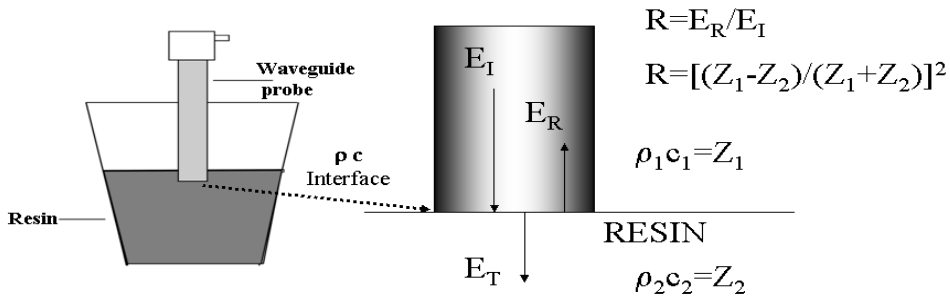

Fig 1 Schematic of the sensing set-up for UCS based on the wave-guide probe.

Sound speed change measurement is related to modulus (E) by simple relation $c = k\sqrt{E/\rho}$. Therefore change in impedance (Z_2) is caused by change in sound speed (c_2). Change in sound speed can be directly correlated to the resin material modulus change and the resin cure state is related to resin mechanical modulus.

Effects of temperature, pressure and variability of the transducers, instrumentation and sensing probe are independently calibrated allowing for absolute measurement of the cure state.

A variety of probes and application sensors are available to interface with the multi-channel ultrasonic data acquisition system.

* US patent 8,291,744 B2, other patents pending

The multi-channel digital ultrasonic system controls all ultrasonic functions and enables data collection and analysis. User friendly interface cure test screen is shown in Fig 2.

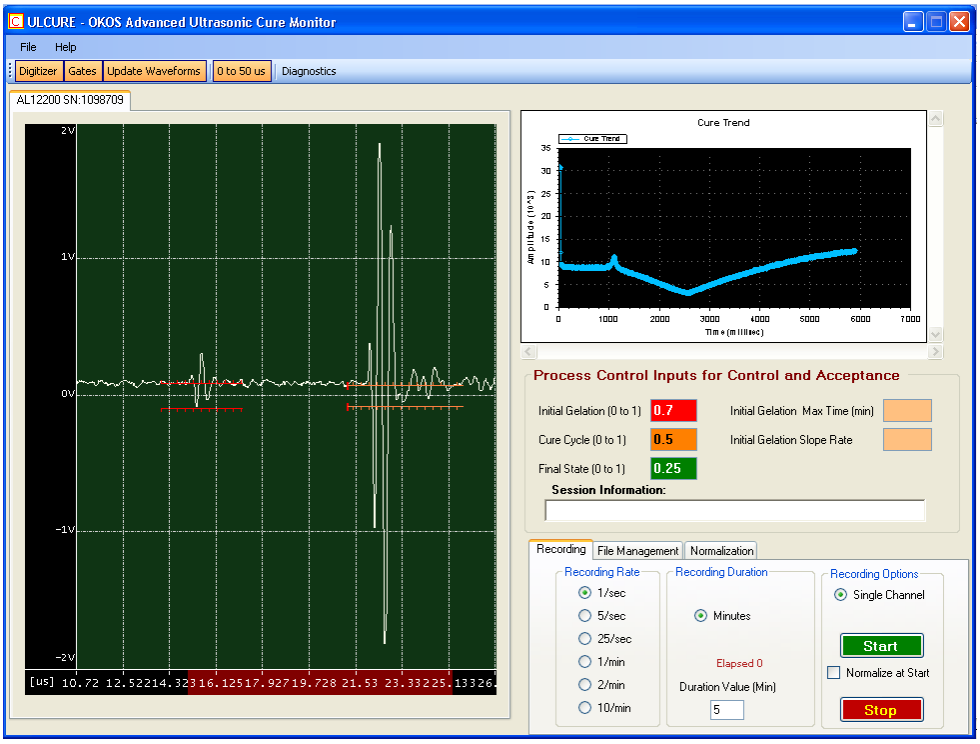

Fig. 2 Ultrasonic system user interface screen controlling all ultrasonic and data acquisition functions.

The system programming provides for sensor calibration modes and continuous visual cure data status. The system accepts preset cure parameter functions that can track and validate the cure process in real time

Ultrasonic data is automatically recorded using high sampling, high dynamic range digitizers with user controlled interface settings. The program can be run from preset test configurations or custom gate and data processing programs. Complete data is archived and available for independent post cure analysis. Additional system features include:

- As an option, the basic 2 channel system can be expanded to 64 or more channels
- Data can be exported to external computers, outside cure controllers.
- Data export is available in many formats and can be concurrent to monitoring process.
- Cure Controller PC can be remotely accessed for service, monitoring operations, storage and historical trend analysis.

FOR FURTHER INFORMATION CONTACT:
410-766-5002(phone), 410-766-5009(fax), info@mast-inc.com
www.mast-inc.com